Annual Report for Project # F18AF00068
(DMR# 3023)

Distribution and Abundance of Sport Fish in Maine Coastal Waters

Covering the period 1/1/18 through 12/31/18

By

Rebecca Peters, Joseph Wodjenski, Briony Donahue

March 30, 2019

Job 1. Maine-New Hampshire Inshore Trawl Survey

Introduction

The Maine-New Hampshire Inshore Trawl Survey (MENH Survey) is a collaborative partnership between commercial fishermen and state researchers to assess inshore fish stocks along the Maine and New Hampshire coasts. Collaborative research enables fishermen to contribute their knowledge and experience toward the progress of scientific data collection and ultimately to resource management decisions, and strengthens the trust between fishermen and scientists. Additional funding for the project, that covers the cost of the vessel charter, supplementary staff, travel expenses, and other miscellaneous expenses, comes through the National Marine Fisheries Service (NMFS).

Fishery-independent trawl surveys provide a baseline index of the distribution and relative abundance of a variety of fish and invertebrate species. As they continue on an annual basis, these surveys reflect trends in abundances of populations. Abundance indices derived from research trawl surveys that maintain consistent and standardized efforts can be utilized to enhance catch statistic based assessments, and together with additional research efforts, species specific population estimates are possible.

Goal and Objectives

The overall goal of this project is to continue the fishery-independent monitoring program in Maine and New Hampshire's inshore waters (9-146^{+} meters), which is now in its nineteenth year.

Specific objectives are:

- To document the distribution and relative abundance of marine sport fish in the nearshore Gulf of Maine.
- To gather information on biological parameters (growth rates and reproduction).
- To collect environmental data, including temperature and salinity, that affect fish distribution.
- To develop recruitment indices for assessments of target species.
- To involve fishermen in scientific data collection.

Sample Design

The survey covers approximately 4520 nm^2 and utilizes a random stratified design, with four depth strata and five geographic regions (Figure 1).

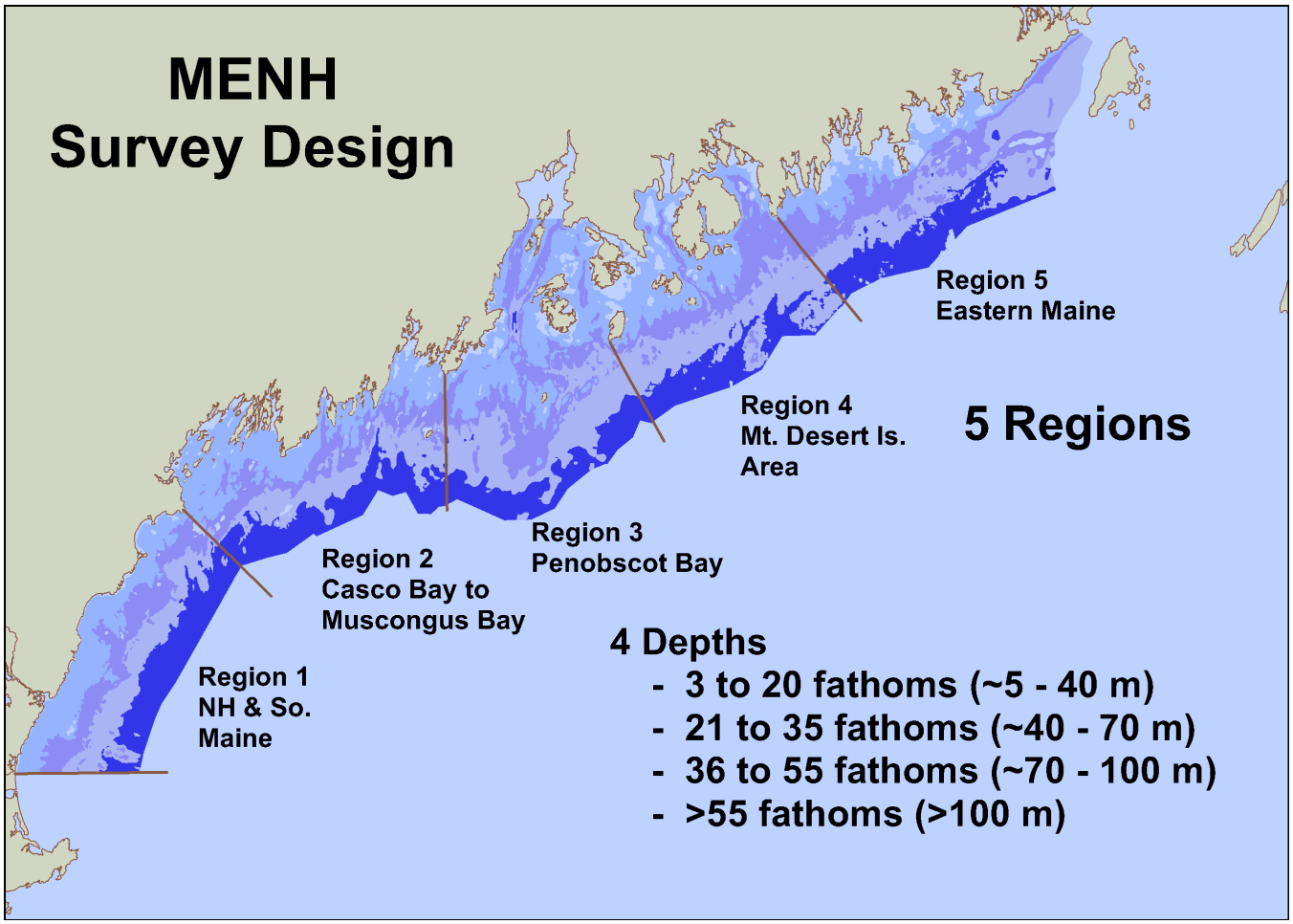

Figure 1: The 20 strata (5 regions and 4 depth strata) of the MENH Inshore Trawl Survey.

The inner boundary is defined by the shallowest depth that the 16.8-meter survey vessel can effectively sample (approximately 5.5 to 6 m). The deeper boundary loosely follows the 12-mile limit, and overlaps the inner depth strata surveyed by the NMFS in the Gulf of Maine (GOM). A target of 120 random stations is selected for sampling, with a sampling density of about 1 station / 40 nm^2.

Net

The net (Figure 2) is a modified version of the shrimp net design used in Maine waters designed to fish for a variety of near-bottom dwelling species without targeting any specific component. Robert Tetrault, the vessel's owner, and net designer Jeff Flagg designed the net to fish effectively, be easily maintained, and be towed by vessels ranging from 14 to 21 meters in length with nominal horsepower.

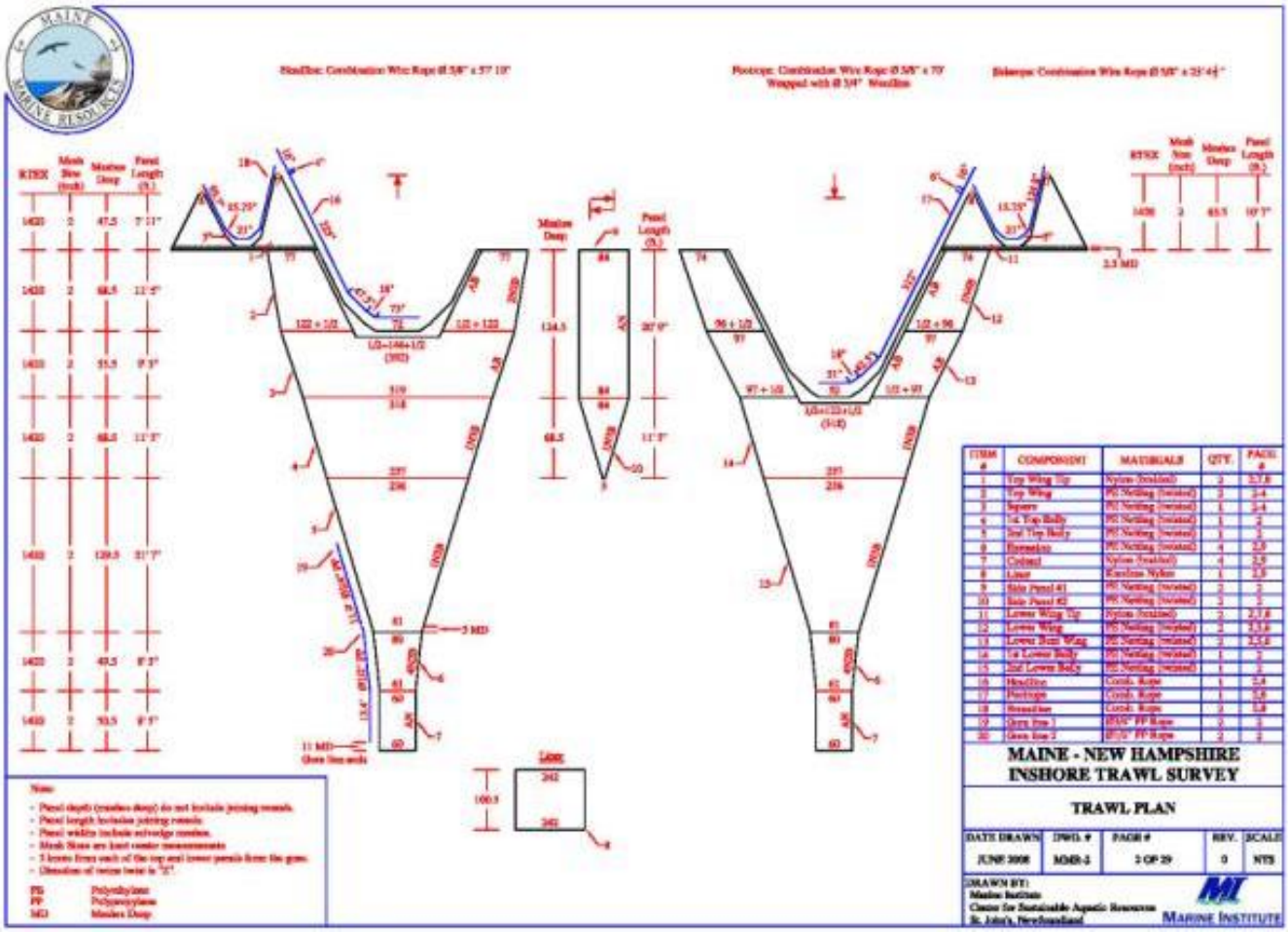

Figure 2: Netting plan for the MENH Research Trawl prepared by the Marine Institute at Memorial U., St. John's, Newfoundland.

Between surveys, the net is sent back to the manufacturer where it is returned to specification. Nets will be replaced as they age to keep the gear in good working condition and ensure consistency.

Public Notification

Due to the extensive fixed gear fisheries in the coastal waters of Maine and New Hampshire, the MENH Survey coordinates with these fishermen to accomplish sampling goals. To stay on a predictable schedule around which fisherman could plan, a conservative number of tows, usually five or six, are scheduled on any given day. Prior to each survey, all Class I, II and III lobster license holders are sent are sent a postcard to notify them of the start date of the survey and includes a link to the DMR's website where the daily schedule and images of tow locations are available. The postcard requests that gear be cleared from the tows on the scheduled day. In addition, we choose to work the first five good days of the week leaving two as make up days when weather or equipment problems prevent us from working. For "real time" information, we encourage fishermen to contact the trawl survey vessel on Channel 16 or 13. Finally, office and cell phone numbers of key survey staff are provided to fishermen in the mailings.

Sample Collection (Towing)

Before each tow, at least one pass, and often two passes, is made along each planned tow line. On each pass, the area is surveyed for fixed gear and the bottom sounded, horizontally and vertically, to identify possible obstructions. Where bottom is deemed towable and a route through gear identified, the net is dropped to the bottom. A target time of 20 minutes at 2.5 knots is a standard tow, but shorter tow times are accepted under certain circumstances. Location (GPS latitude and longitude), time, depth, direction, and duration are recorded for each tow. Bottom temperatures and salinities are collected at each station using a SeaBird™ Model SBE 19-plus CTD. Net configuration is constantly monitored using eSonar® hydro-acoustic sensors. Other environmental data such as wind, sea state, and weather are also recorded at each station. All tows are conducted during daylight hours.

Handling Catch

After each tow, the net is brought aboard and emptied onto a sorting table. All individuals are identified and sorted by species. All lobsters are immediately separated and processed while the rest of the catch is sorted.

Finfish lengths are measured as total central length to the nearest centimeter (cm). Crabs are measured using carapace length (cm). Squid are measured using mantle length (cm). All other invertebrates are enumerated. Aggregate weights are taken for all species. When catches are large (i.e. > ~200 individuals) a subsample of at least 100 representative individuals is taken, measured, and weighed. Total catch statistics are then expanded based on the total catch weight. All lobsters are normally measured; lobsters can be subsampled if the processing time would interfere with the scheduled tow completions.

Additional biological data are collected, including individual weights, sex, and maturity for selected groundfish species using the methods described in Burnett *et al*, 1989. Fish examined are designated as immature (I), developing (D), ripe (R), ripe/running (U), spent (S), or resting (T). When possible, all individuals selected are examined; a sub-sample is taken if the catch of a species is large. Hard parts for aging are collected and stomach contents are examined for a portion of these samples.

Discussion

In 2018, the spring and fall survey took place in May and October and 118 and 96 tows were completed, respectively, out of the scheduled 120 tows (Figure 3). Fish commonly caught in the MENH Survey include winter flounder, Atlantic cod, haddock, rainbow smelt, American shad, white hake, goosefish, Atlantic halibut, Acadian redfish, river herring, and Atlantic mackerel. Others seen in low numbers or infrequently are pollock, wolfish, bluefish, striped bass, and cusk. In addition to the catch of fish, the MENH Survey also catches important invertebrate prey species for sport fish such as American lobster, *Cancer* spp., and northern shrimp.

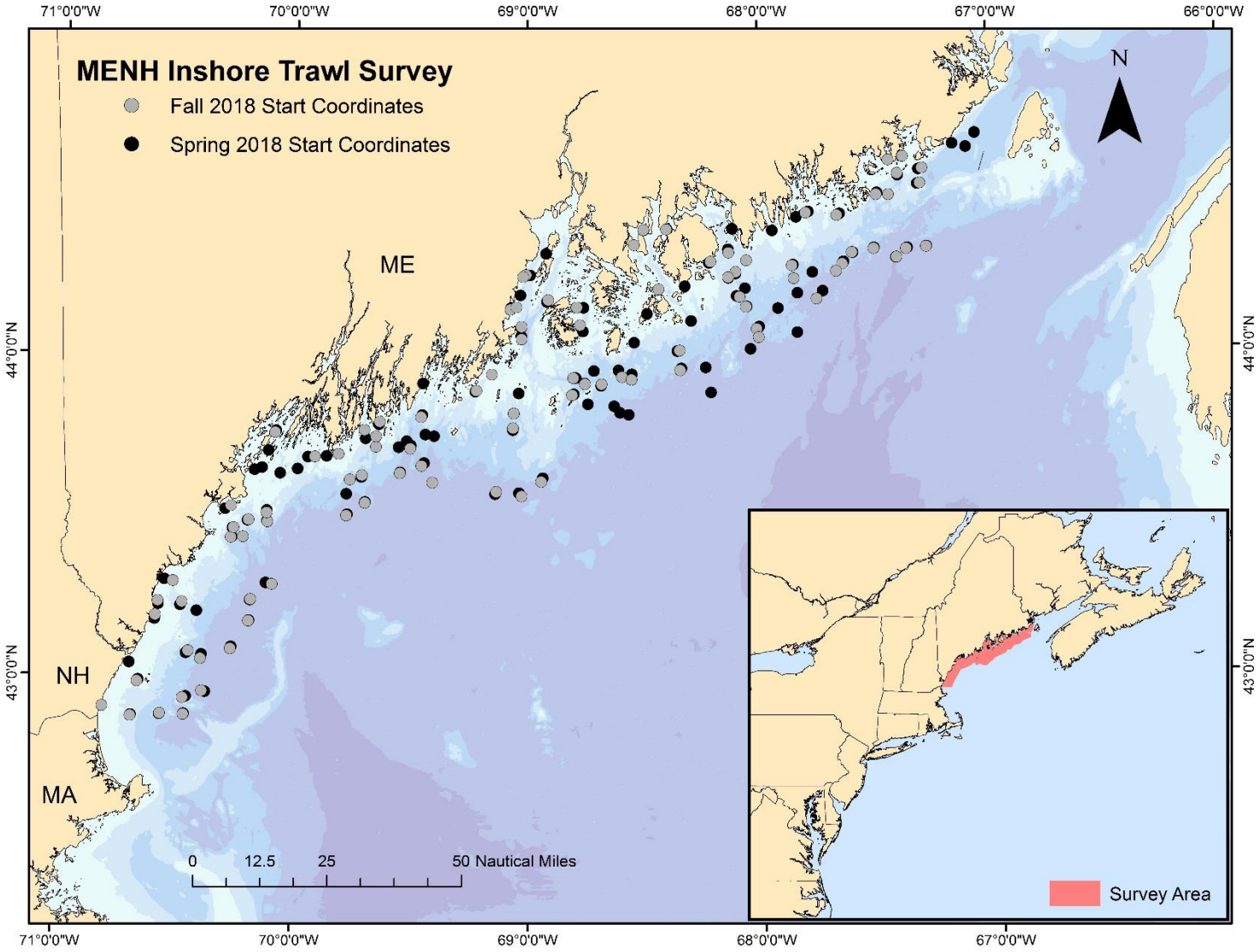

Figure 3: Stations sampled for the 2018 survey year.

Spring 2018 Summary

The spring survey began April 30, 2018 in Portsmouth, New Hampshire and was completed on June 1, 2018. A total of 118 tows out of the scheduled 120 were completed. This translates to a 98% completion rate, with an average of 4.72 tows per day. For Spring 2018, Maine DMR personnel participated on all five weeks of the survey. New Hampshire Fish and Game personnel participated in the first week of the survey as usual. Christine Lipsky and Julie Nieland from NOAA's NMFS protected species branch participated in weeks two and three of the survey to continue collection of groundfish stomachs for their alosine prey study.

The average yearly sea surface and sea bottom temperatures from the MENH survey show a slight positive trend over time (Figure 4) with the highest sea surface temperature occurring in 2013 and highest bottom temperature in 2012. In the Spring 2018 survey the average bottom temperature was 5.9°C, and ranged from 4.5°C to 11.4°C. Sea surface temperatures ranged from 5°C to 10.3°C with an average of 7.88°C. The average bottom and surface water temperatures were comparable to the previous spring survey in 2017. Average bottom temperatures for each region and stratum are provided in table 1.

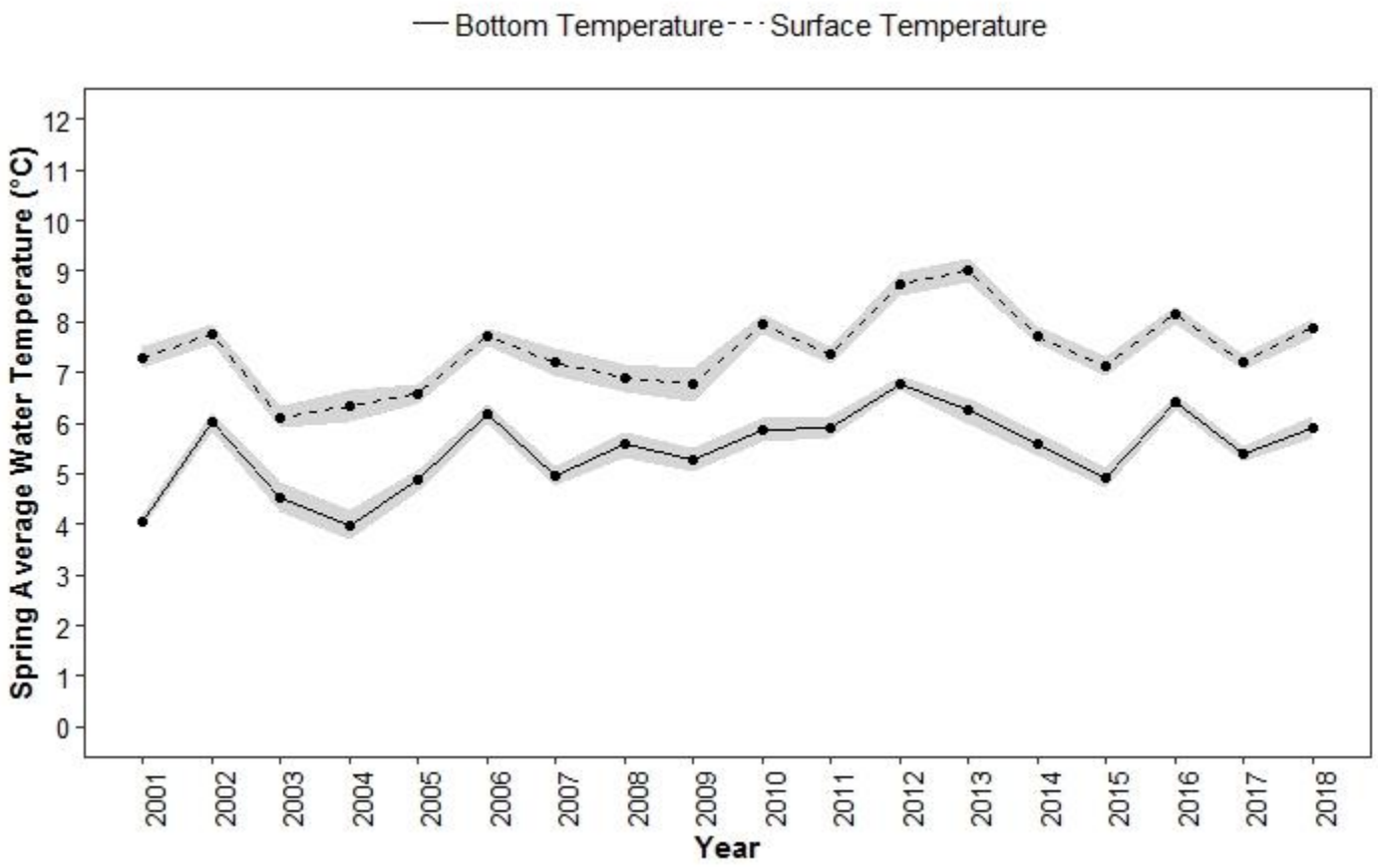

Figure 4: Average sea surface and near bottom water temperatures (°C) for spring surveys from 2001 to 2018. The shaded region is the 95% confidence interval for the average temperatures.

Table 1: Average near bottom temperature (°C) for the Spring 2018 survey

	REGION				
Stratum	**1**	**2**	**3**	**4**	**5**
1	6.0	6.2	6.6	7.8	7.6
2	4.6	4.8	5.3	6.1	6.7
3	4.7	4.8	5.4	6.2	6.7
4	5.3	5.0	5.2	7.0	7.6
Total	5.2	5.2	5.6	6.7	7.1

The volume of total mixed catch in spring 2018 varied from 1.98 kg to 385.04 kg per tow, with an average of 107.94 kg and a median of 89 kg. Figure 5 shows the average weight (kg) of the catch per tow for spring surveys since 2001. Spring 2018 catch weight has increased from 2017.

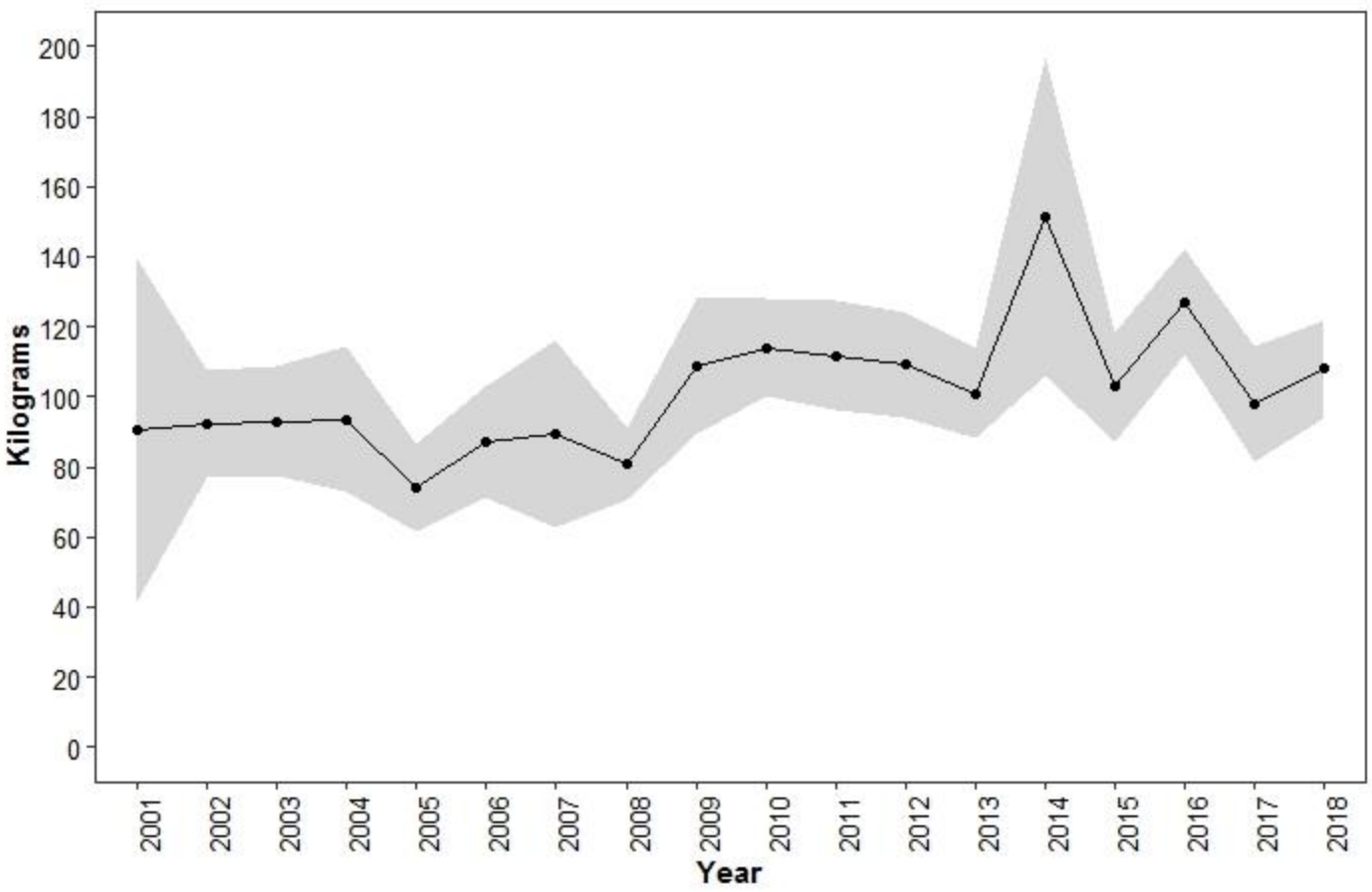

Figure 5: Average aggregate catch weight (kg) per tow for spring surveys for 2001-2018. The shaded region represents the 95% confidence interval.

Figure 6 illustrates species groups by portion of the total catch for each spring survey since 2001. The first year was fairly variable, but after that the herrings (Atlantic herring, river herring, and shad) compromised the largest portion of the total catch until the Spring 2011 survey. From 2011 to the most recent survey in 2018, lobsters and crabs, of which American lobsters are the major component of, have become the main portion of the catch. Gadoid fish have begun to increase, in large part due to the larger catches of silver hake (whiting) and haddock. Mixed shrimp catches and flatfish numbers have declined.

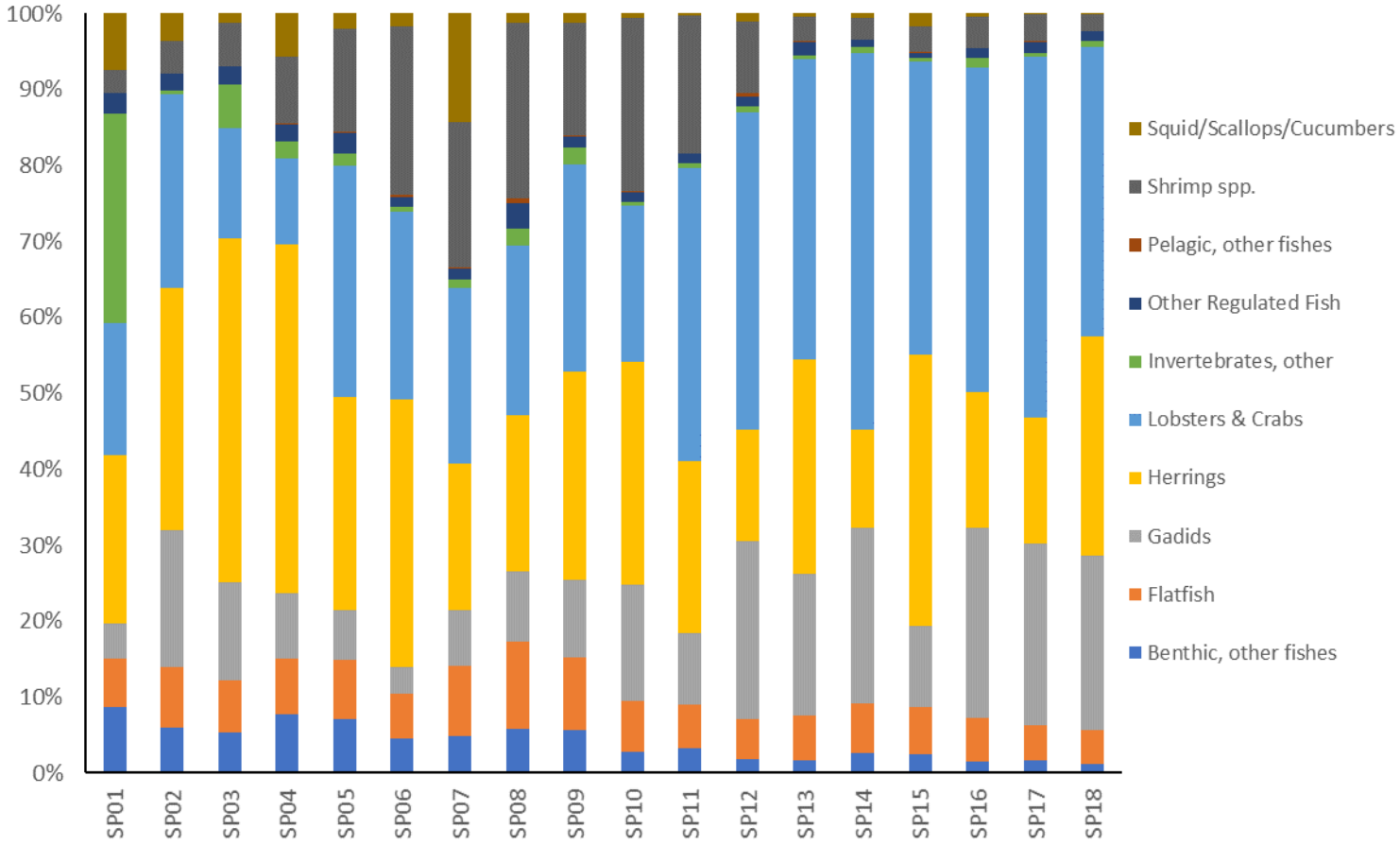

Figure 6: Percent of total catch weight apportioned by species groups and year for all spring surveys, 2001 through 2018.

Biological samples were collected on selected finfish species, based on seasonal abundance and available time between tows. In the Spring 2018 survey individual weights, otoliths, sex, and maturity stages were collected on selected individuals of cod, haddock, winter flounder, yellowtail flounder, goosefish, and American plaice (Table 2). Over 100 stomachs were collected as part of a collaboration with NMFS staff investigating alosids as prey species. Otoliths, sex, and maturity stages were also collected on Atlantic halibut for a NOAA Saltonstall-Kennedy funded study being conducted The Nature Conservancy.

Table 2: Spring 2018 species sampled for weights, sex, maturity, food habits, and aging

Number of Biological Samples Spring 2018				
Species	**Lengths**	**Weights/Sex/ Maturity Stage**	**Otoliths**	**Food Habits**
Atlantic cod	100	93	85	NA
Haddock	729	193	133	NA
American plaice	1248	518	380	NA
Yellowtail flounder	101	58	39	NA

Winter flounder	2165	481	336	NA
Goosefish	175	3	NA	NA
Atlantic halibut	16	16	11	NA

In spring 2018 the total number of species caught in the survey was 91, with a low of 4 and a high of 33 in any particular tow, and an average of 20 species per tow. Standardized mean number per tow (by strata and overall) for all species encountered in the Spring 2018 survey is reported in table 3.

Table 3: Average catch (number caught/tow) for each species caught in the Spring 2018 survey.

	DEPTH STRATUM				
COMMON NAME	**<=20 fa**	**21-35 fa**	**36-55 fa**	**>55 fa**	**OVERALL**
Acadian redfish	0.04	0.71	2.50	2.59	1.55
Alewife	266.91	626.92	213.93	106.09	295.88
Alligatorfish	0.04	3.30	0.72	0.04	1.00
American lobster	180.63	315.55	200.07	37.68	184.89
American plaice	0.64	7.11	16.80	16.37	10.79
American sand lance	0.84	0.00	0.00	0.00	0.19
American shad	0.38	8.16	3.16	2.18	3.44
Armored sea robin	0.00	0.04	0.00	0.00	0.01
Atlantic cod	0.99	0.84	0.99	0.75	0.90
Atlantic hagfish	0.00	0.00	0.00	0.04	0.01
Atlantic halibut	0.24	0.11	0.12	0.11	0.14
Atlantic herring	3404.84	1217.54	215.63	49.84	1136.68
Atlantic mackerel	0.00	0.11	0.11	0.04	0.07
Atlantic silverside	0.26	0.00	0.00	0.00	0.06
Atlantic soft pout	0.00	0.00	0.00	0.04	0.01
Atlantic sturgeon	0.04	0.00	0.00	0.00	0.01
Atlantic tomcod	0.04	0.00	0.00	0.00	0.01
Atlantic windowpane flounder	3.28	6.64	0.78	0.04	2.52
Atlantic witch flounder	0.00	0.74	7.45	21.73	7.48
Ax-head clam	0.00	0.00	0.00	0.04	0.01
Axius serratus	0.00	0.00	0.03	0.00	0.01
Barndoor skate	0.00	0.00	0.00	0.04	0.01
Blue mussel	0.48	0.10	0.05	0.00	0.15
Blueback herring	8.80	633.80	90.00	11.51	177.89
Bobtail squid	0.00	0.00	0.00	0.04	0.01
Brittle stars	0.27	0.12	0.16	0.15	0.17
Butterfish	0.23	0.70	0.05	0.04	0.24
Crangon shrimp	10.05	29.24	23.57	0.30	16.45
Cunner	0.09	0.55	0.05	0.00	0.16
Dichelo shrimp	26.75	697.65	777.10	303.38	478.84
Fourbeard rockling	0.07	1.02	2.75	3.73	1.97
Fourspot flounder	0.00	0.00	0.05	0.44	0.12

Friendly spine shrimp	0.00	0.04	0.00	0.00	0.01
Goosefish	0.15	1.14	2.04	2.59	1.53
Green sea urchin	0.16	0.00	0.03	0.00	0.05
Grenadiers	0.00	0.00	0.00	0.07	0.02
Gulf stream flounder	0.00	0.00	0.00	0.04	0.01
Haddock	0.19	3.84	2.52	19.86	6.26
Horse mussel	0.04	0.07	0.03	0.00	0.03
Jonah crab	0.96	1.78	2.26	2.83	1.99
Krill	0.00	0.31	18.24	6.19	7.21
Little skate	0.00	0.04	0.24	0.00	0.08
Long-finned squid	0.23	0.20	0.38	0.00	0.22
Longhorn sculpin	1.98	20.95	9.80	0.86	8.52
Lumpfish	0.15	0.37	0.41	0.26	0.31
Montagui shrimp	14.69	267.17	57.20	4.63	83.49
Northern cardita	0.00	0.00	0.24	0.11	0.10
Northern quahog	0.00	0.00	0.05	0.07	0.03
Northern sea star	0.00	0.10	0.00	0.00	0.02
Northern shrimp	0.00	1.86	97.57	474.21	139.52
Northern stone crab	0.00	0.00	0.00	0.04	0.01
Norwegian shrimp	0.00	0.00	0.00	0.67	0.15
Ocean pout	0.00	0.33	1.68	2.04	1.07
Octopus unclass.	0.00	0.00	0.17	0.53	0.17
Pandalus propinquus	0.00	0.00	0.00	0.19	0.04
Pearlsides	0.00	0.00	0.05	0.26	0.08
Pink glass shrimp	0.00	0.00	0.00	26.59	6.08
Pollock	0.00	0.78	0.05	0.07	0.21
Radiated shanny	0.08	0.09	0.07	0.00	0.06
Rainbow smelt	3.92	0.19	0.00	0.00	0.94
Rat-tail cucumber	0.00	0.04	0.00	0.00	0.01
Red crab	0.00	0.00	0.00	0.19	0.04
Red hake	5.66	32.81	35.16	39.41	28.85
Rock crab	3.08	0.74	0.08	0.07	0.92
Sand dollar	0.07	0.00	0.00	0.00	0.02
Sculptured shrimp	0.08	0.00	0.00	0.00	0.02
Sea anemone	0.84	0.72	0.32	0.59	0.59
Sea cucumber	0.43	0.00	0.00	0.00	0.10
Sea raven	0.20	0.12	0.87	0.00	0.35
Sea scallop	0.15	0.30	0.08	0.96	0.35
Sea sponges*	0.00	0.07	0.00	0.19	0.06
Short-finned squid	0.09	0.32	0.34	0.41	0.29
Shorthorn sculpin	0.16	0.04	0.00	0.00	0.05
Shrimp unclass.*	0.00	0.26	0.03	0.00	0.07
Silver hake	11.36	182.53	646.97	1178.07	516.79
Smooth skate	0.00	0.00	0.61	1.85	0.61

Snailfish inquiline	0.00	0.00	0.03	0.00	0.01
Snake blenny	0.00	1.02	0.20	0.04	0.30
Snow crab	0.00	0.00	0.00	0.11	0.03
Spiny dogfish	0.00	0.00	0.00	0.96	0.22
Spiny lebbeid	0.68	0.03	0.00	0.11	0.19
Spotted hake	0.00	0.00	0.03	0.00	0.01
Thorny skate	0.00	0.00	0.16	0.63	0.19
Toad crab	3.14	1.67	0.23	0.11	1.20
Waved astarte	0.00	0.00	2.32	0.93	0.94
White hake	0.33	4.75	12.93	11.27	7.80
Winter flounder	37.03	24.81	15.83	2.45	19.68
Winter skate	0.00	0.30	0.03	0.00	0.08
Wolf eelpout	0.00	0.00	0.03	0.07	0.03
Wrymouth	0.00	0.12	0.14	0.16	0.11
Yellowtail flounder	0.11	1.18	1.25	0.78	0.87

Fall 2018 Summary

The fall survey began October 1, 2018 in Portsmouth, New Hampshire and finished on November 2, 2018 off of Lubec, Maine. Ninety-six tows were completed out of the scheduled 120. This translates to an 80% completion rate, with an average of 3.8 tows per day. For the Fall 2018 survey Maine DMR personnel participated on all five weeks of the survey. New Hampshire Fish and Game personnel participated in the first week of the survey. Brandon Ellingson and Graham Goulette from NOAA's NMFS participated in weeks two and three of the survey to continue collection of groundfish stomach samples for their study investigating alosids as important prey species for groundfish.

Average near bottom water temperature in the Fall 2018 survey was 11.15°C, and ranged from 6.6°C to 15.6°C. Sea surface temperatures ranged from 10.2°C to 17°C with an average of 12.95°C. The average near bottom temperature was warmer than the Fall 2017 survey average of 10.4°C, but the average surface temperature was cooler than the Fall 2017 survey of 13.65°C. Figure 7 shows a slight increase in sea surface and near bottom water temperatures since the start of the survey in fall 2000. Average bottom temperatures for each region and stratum are provided in table 4.

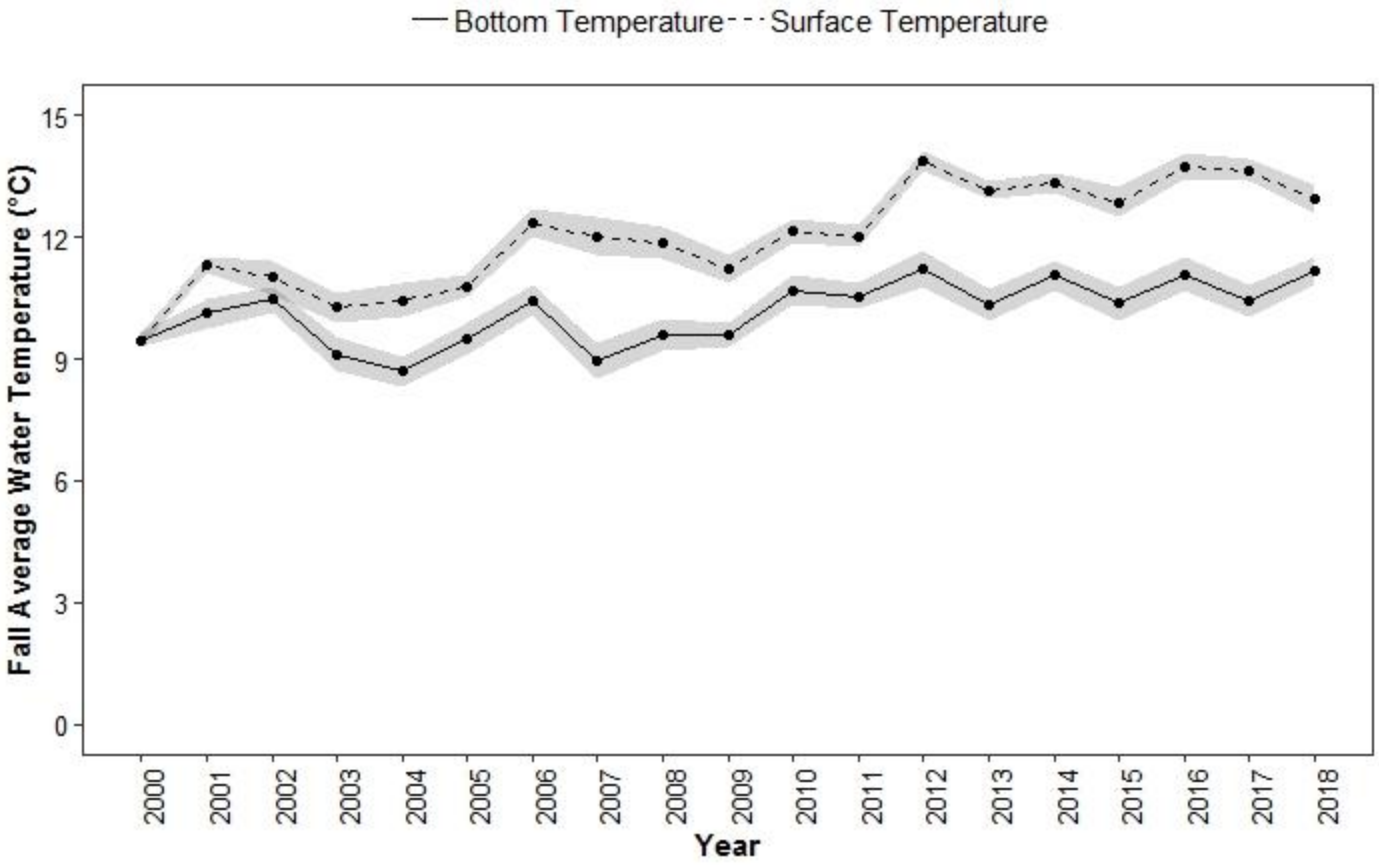

Figure 7: Average sea surface and near bottom water temperature (°C) for the fall surveys from 2000 to 2018. The shaded is the 95% confidence interval for the average temperatures.

Table 4: Average near bottom water temperature (°C) in the Fall 2018 survey.

	REGION				
Stratum	**1**	**2**	**3**	**4**	**5**
1	14.4	13.3	12.8	11.8	10.5
2	11.0	11.8	13.2	11.3	10.9
3	9.3	11.0	11.9	11.0	11.0
4	7.4	9.8	10.1	10.5	10.4
Total	10.5	11.2	12.2	11.2	10.7

The volume of total mixed catch in the Fall 2018 survey varied from 18.9 kg to 732.7 kg per tow, with an average of 205.6 kg and a median of 166.1 kg per tow. Figure 8 shows the average weight (kg) of the catch per tow for fall surveys since 2000. Fall 2018 survey aggregate catch weight increased from fall 2017.

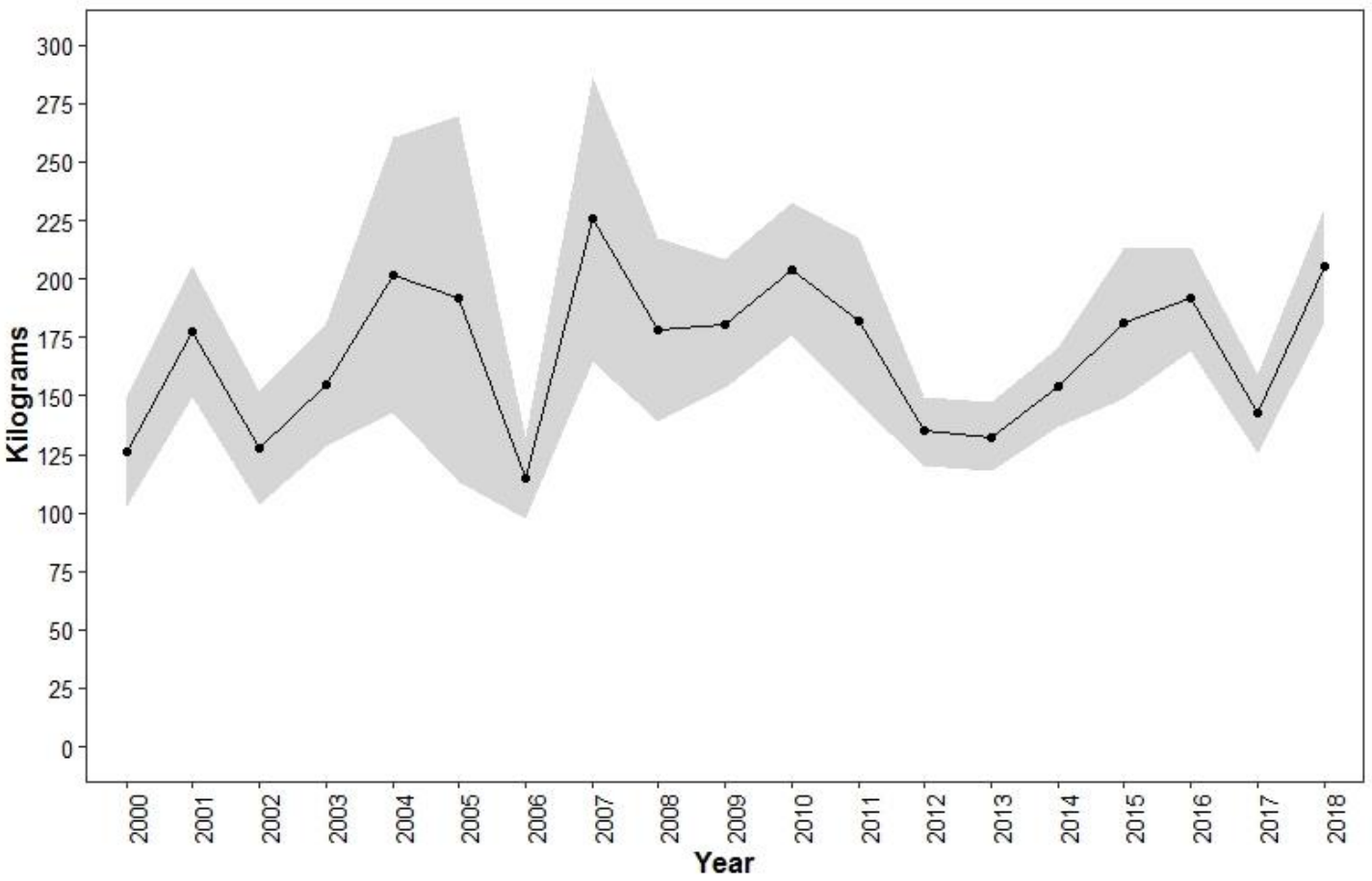

Figure 8: Average aggregate catch weight (kg) per tow for fall surveys for 2000-2018. The shaded region represents the 95% confidence interval.

Figure 9 illustrates species groups by portion of the total catch weight for each fall survey since 2000. The catch weight in the first years of the fall survey was variable, but in more recent years the total catch weight was mostly comprised of lobsters and crabs, herrings, and gadids. After the Fall 2015 survey, the catch weight of herring species began to decrease, and in fall 2018 gadids and lobster and crabs were a main portion of the total catch weight. Catch weight of flatfish has remained constant over the years.

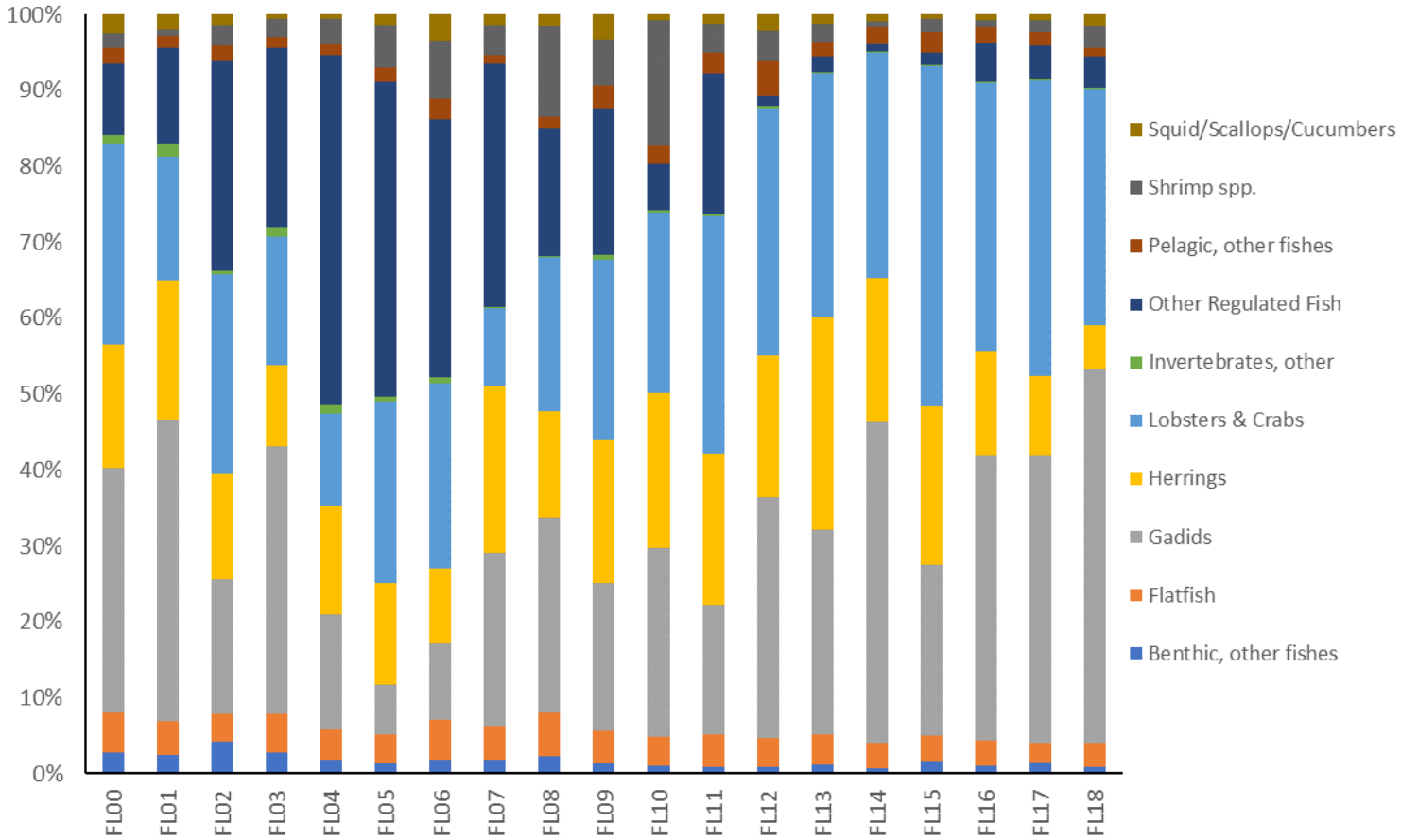

Figure 9: Percent of total catch weight apportioned by species groups and year for all fall surveys, 2000 through 2018.

Biological samples were collected on selected finfish species, based on seasonal abundance and available time between tows. In the Fall 2018 survey individual weights, otoliths, sex, and maturity stages were collected on selected individuals of cod, haddock, white hake, witch flounder, and goosefish (table 5). Over 100 stomachs were collected as part of a collaboration with NMFS staff investigating alosids as prey species. Otoliths, sex, and maturity stages were also collected on Atlantic halibut for a NOAA Saltonstall-Kennedy funded study being conducted by The Nature Conservancy.

Table 5: Fall 2018 species sampled for weights, sex, maturity, food habits, and aging

Number of Biological Samples Fall 2018				
Species	**Lengths**	**Weights/Sex/ Maturity Stage**	**Otoliths**	**Food Habits**
Atlantic cod	30	23	22	NA
Haddock	812	196	119	NA
White Hake	5875	472	227	NA
Witch Flounder	1053	249	142	NA
Goosefish	269	44	NA	NA

Atlantic halibut	21	21	20	NA

In the Fall 2018 survey a total of 90 distinct species were caught during the survey, with a low of 10 and a high of 30 in any tow, and an average of 19 species per tow. Standardized mean number per tow (by strata and overall) for all species encountered in the Fall 2018 survey is reported in table 6.

Table 6: Average catch (number caught/tow) for each species caught in the Fall 2018 survey.

	DEPTH STRATUM				
COMMON NAME	**<= 20 fa**	**21-35 fa**	**36-55 fa**	**>55 fa**	**OVERALL**
Acadian redfish	0.72	9.54	49.41	22.45	21.78
Alewife	1070.54	196.70	37.60	18.62	325.89
Alligatorfish	0.06	0.15	0.33	0.00	0.14
American lobster	349.63	477.80	303.37	44.37	288.34
American plaice	0.13	7.79	22.81	41.14	18.44
American shad	2.23	2.54	1.69	0.04	1.60
Argentine herring	0.21	0.00	0.00	0.00	0.05
Atlantic cod	0.95	0.31	0.11	0.13	0.37
Atlantic hagfish	0.00	0.00	0.00	0.56	0.14
Atlantic halibut	0.94	0.05	0.07	0.04	0.28
Atlantic herring	643.47	50.59	5.54	1.55	173.88
Atlantic mackerel	20.20	14.68	1.36	0.29	8.72
Atlantic moonfish	0.84	0.00	0.00	0.00	0.21
Atlantic silverside	1.78	0.10	0.04	0.13	0.51
Atlantic sturgeon	0.14	0.12	0.04	0.00	0.07
Atlantic tomcod	0.13	0.05	0.00	0.00	0.04
Ax-head clam	0.00	0.00	0.00	0.04	0.01
Barnacle	0.00	0.00	0.00	0.05	0.01
Barndoor skate	0.00	0.05	0.00	0.12	0.04
Blue mussel	0.10	0.59	0.00	0.08	0.17
Blueback herring	5.27	0.00	0.16	0.25	1.42
bluefish	0.35	0.00	0.00	0.00	0.09
Brittle star	0.08	0.14	0.22	0.00	0.11
Butterfish	336.63	81.77	37.09	2.78	113.17
Clearnose skate	0.00	0.00	0.00	0.21	0.05
Crangon shrimp	22.11	2.13	2.87	0.13	6.83
Cunner	1.47	1.27	0.04	0.00	0.66
Daubed shanny	0.06	0.00	0.00	0.00	0.01
Dichelo shrimp	34.01	199.25	186.72	231.00	162.35
Fourbeard rockling	0.41	1.60	1.77	4.10	1.98
Fourspot flounder	0.05	0.27	0.49	0.13	0.24
Goosefish	0.38	2.74	3.02	5.75	2.98
Green sea urchin	0.19	0.00	0.00	0.00	0.05
Haddock	5.83	0.90	6.65	25.13	9.81
Hermit crab*	0.00	0.00	0.15	0.00	0.04

Horse mussel	0.11	0.14	0.00	0.00	0.06
Jonah crab	2.65	3.59	3.87	7.30	4.36
Krill	0.00	0.19	0.04	0.56	0.19
Little skate	0.17	0.37	0.64	0.25	0.37
Long finned squid	0.08	0.08	0.07	0.00	0.06
Longhorn sculpin	1.60	9.27	5.12	0.17	3.91
Lumpfish	0.04	0.06	0.34	0.45	0.23
Montagui shrimp	62.69	27.29	1.85	1.99	22.66
Northern cardita	0.00	0.00	0.15	0.00	0.04
Northern kingfish	0.04	0.00	0.00	0.00	0.01
Northern quahog	0.11	0.00	0.00	0.00	0.03
Northern searobin	0.04	0.00	0.00	0.00	0.01
Northern shrimp	0.00	0.10	1.86	53.31	13.87
Ocean pout	0.00	0.05	0.26	0.38	0.18
Ocean quahog	0.06	0.00	0.22	0.00	0.08
Octopus uclass*	0.00	0.00	0.04	1.93	0.49
Pandalus propinquus	0.00	0.00	0.00	0.97	0.24
Pearlsides	0.00	0.00	1.44	0.00	0.41
Pink glass shrimp	0.00	0.00	0.00	4.41	1.10
Pollock	0.08	0.00	0.00	0.00	0.02
Rainbow smelt	15.59	0.25	0.00	0.00	3.95
Rat-tail cucumber	0.09	0.34	0.00	0.00	0.10
Red hake	10.67	46.19	98.03	152.90	78.57
Rock Crab	4.80	0.54	0.19	0.00	1.37
Sand dollar*	0.93	0.16	0.00	0.00	0.27
Scup	0.00	0.00	0.04	0.00	0.01
Sea anemone	0.76	0.27	0.19	1.18	0.60
Sea cucumber	0.06	0.00	0.00	0.00	0.01
Sea raven	0.15	0.29	0.46	0.04	0.24
Sea scallop	0.04	0.26	0.30	0.99	0.40
Sea sponges*	2.26	0.40	0.04	0.08	0.68
Short finned squid	11.54	26.70	30.37	33.26	25.58
Shorthorn sculpin	0.17	0.00	0.00	0.00	0.04
Shrimp	0.00	0.00	0.04	0.00	0.01
Silver hake	1164.19	1806.80	2113.29	1076.02	1549.65
Smooth skate	0.00	0.00	0.04	2.75	0.70
Snake blenny	0.04	0.00	0.00	0.00	0.01
Snow crab	0.00	0.00	0.00	0.04	0.01
Spider crab*	0.00	0.00	0.00	0.13	0.03
Spiny dogfish	0.00	0.26	0.15	16.11	4.12
Spiny lebbeid	0.06	0.23	0.41	0.00	0.18
Spotted hake	0.17	0.12	0.12	0.05	0.11
Striped searobin	0.04	0.00	0.00	0.04	0.02
Thorny skate	0.00	0.00	0.00	0.67	0.17

Toad crab	1.49	1.20	0.30	0.00	0.72
Waved astarte	0.00	0.05	1.00	2.21	0.84
White hake	97.13	82.47	70.39	67.62	79.03
Windowpane flounder	7.07	8.68	3.03	0.04	4.53
Winter flounder	83.76	47.73	33.84	9.36	43.24
Winter skate	0.08	0.21	0.22	0.00	0.13
Witch flounder	0.00	3.34	13.41	27.90	11.48
Wolf eelpout	0.00	0.00	0.00	0.05	0.01
Wrymouth	0.00	0.41	0.19	0.21	0.20
Yellowtail flounder	0.71	4.03	0.67	0.08	1.27

*Averages here do not represent true numbers, all individual are not always enumerated.

Selected Sport Fish Species

Winter Flounder

Historically, winter flounder was one of the more important groundfish sought in Maine waters. Their abundance declined in the recent past to the point that none were reported in the recreational fishery from 2005 through 2012. Since then few have been reported caught in Maine waters (MEDMR pers. Comm.).

Spring

Average catch of winter flounder in the spring trawl survey gradually increased up until 2014, when it peaked. Since 2014, average winter flounder catch has been declining (Figure 10). The stratified mean weight of the catch follows a similar trend as the stratified mean catch. A larger portion of the catch was seen in the western region of the survey, with large catches of winter flounder occurring in inshore survey areas in regions 4 and 5. In the eastern region of the survey larger catches were seen in Casco Bay (Figure 12).

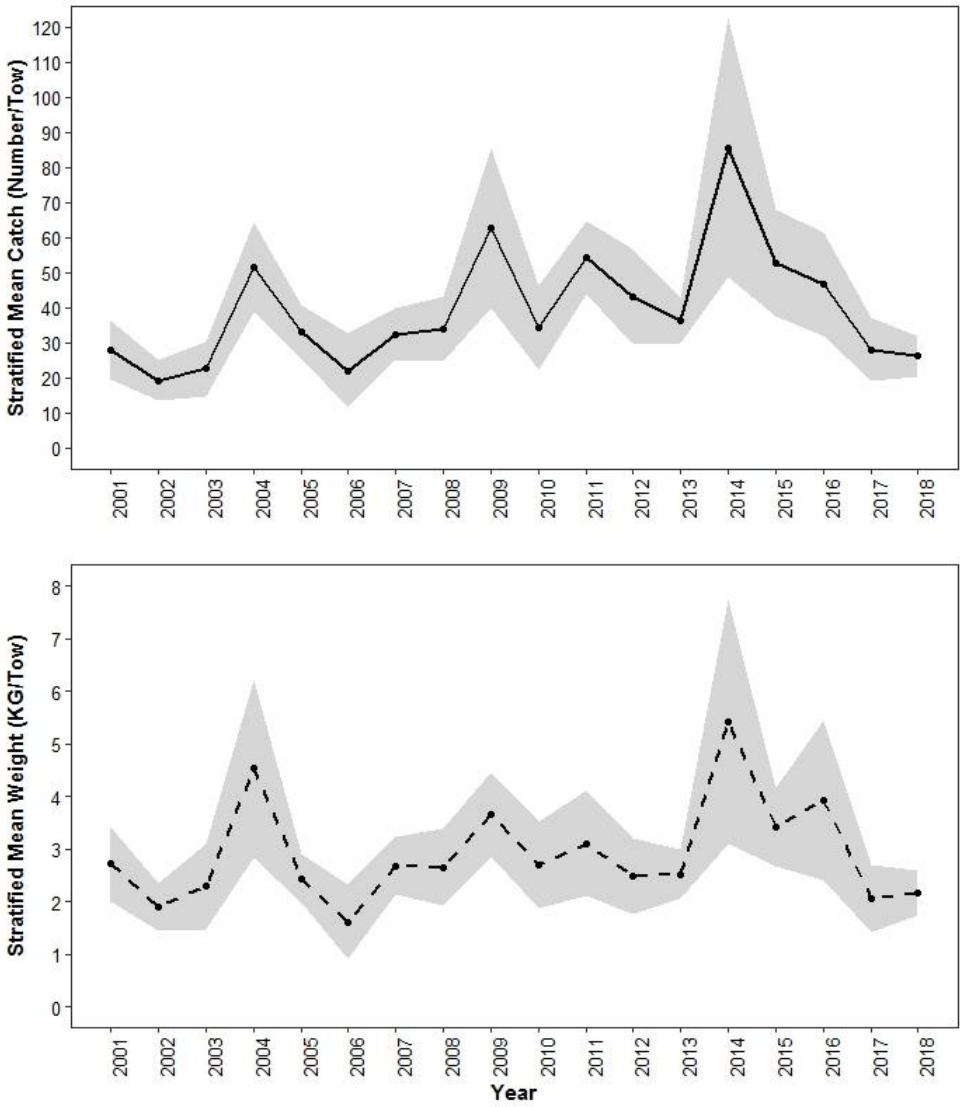

Figure 10: Stratified mean catch (top) and weight (bottom) for winter flounder from the spring survey from 2001 to 2018. The shaded region in each plot indicates the 95% confidence interval.

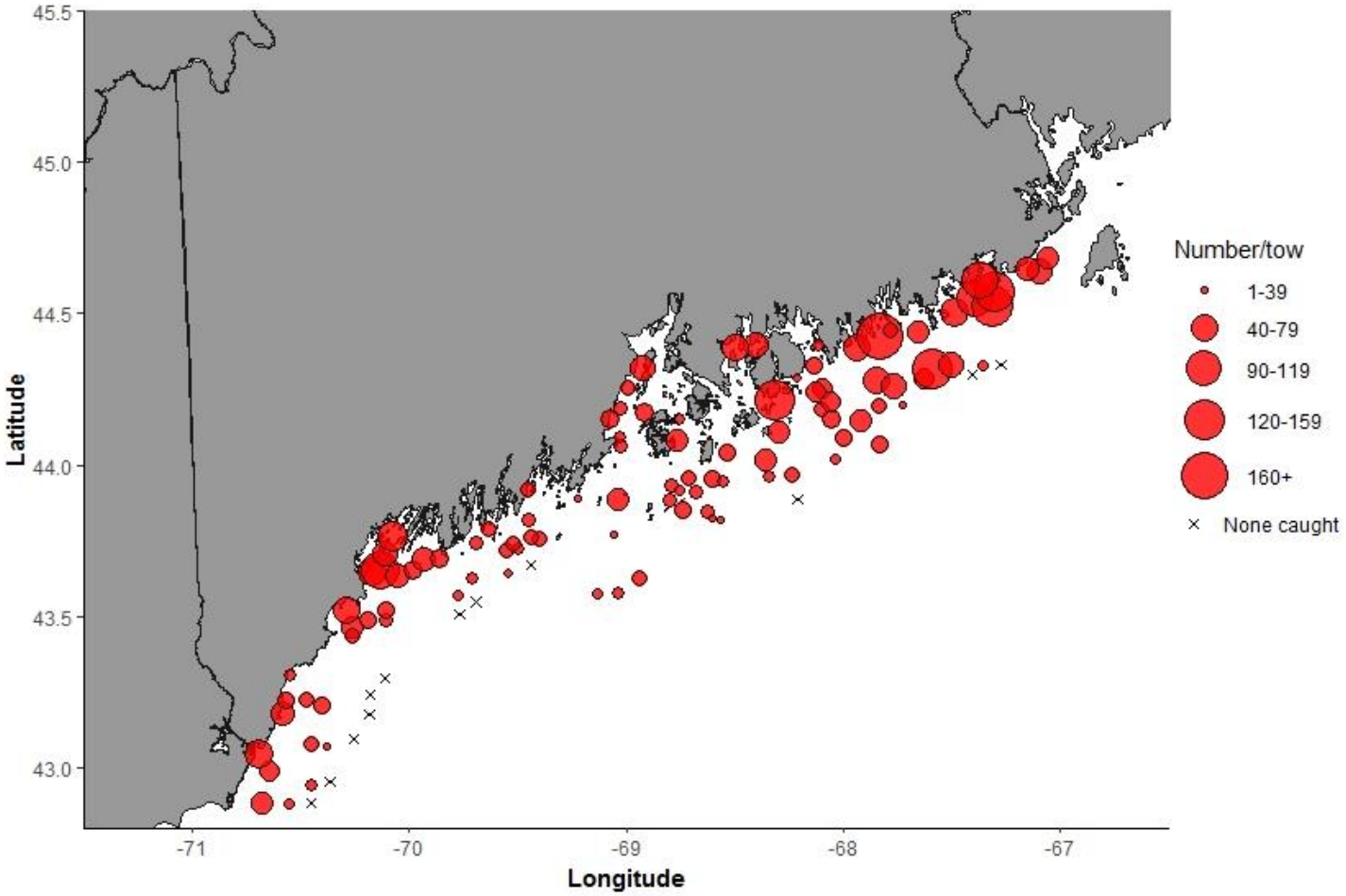

Figure 11: Distribution of winter flounder catch in the Spring 2018 survey.

The size range of winter flounder caught in the spring surveys have been consistent over the years. Most of the winter flounder caught in the survey are less than 25 cm in centerline length (Figure 12).

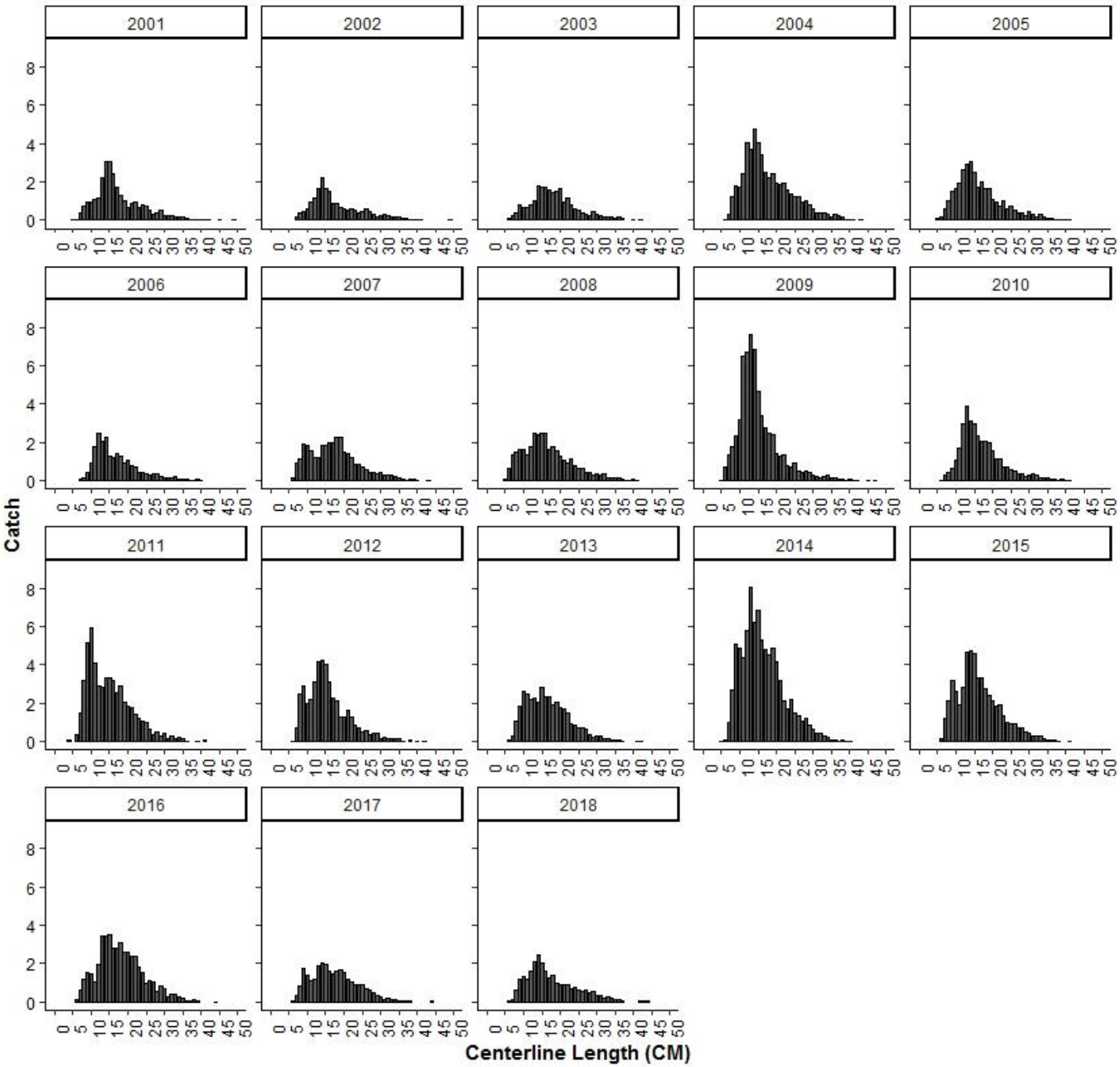

Figure 12: Length frequency distribution of winter flounder caught in the spring trawl surveys from 2001 to 2018.

In each spring survey a select number of winter flounder are examined for age and maturity. In the Spring 2018 survey more female immature fish were observed throughout the survey area (Figure 13). Mature (developing, ripe, ripe and running, spent, and resting stages) females were observed mostly in regions 4 and 5.

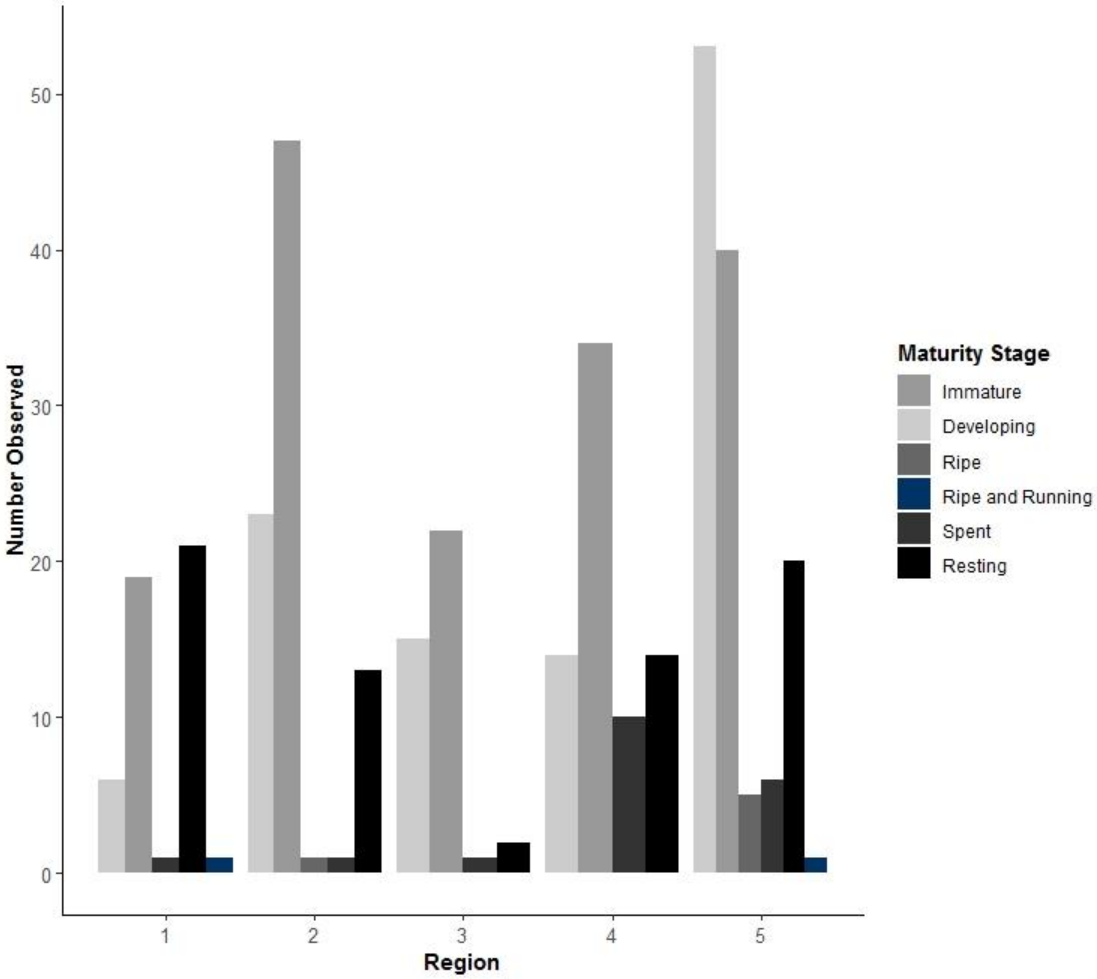

Figure 13: Stages of maturity observed in female winter flounder samples from the Spring 2018 trawl survey.

Fall

The average catch of winter flounder in the fall surveys is comparable to the spring surveys. The average catch of winter flounder gradually increased and peaked in 2010. After the peak in catch in 2010, average catch decreased until 2014 where it the began to increase gradually until 2016 (Figure 14). Average catch has then fluctuated since 2016, and has increased from 2017 to 2018. The majority of winter flounder catch in the Fall 2018 survey occurred in inshore waters in regions 4 and 5 (Figure 15).

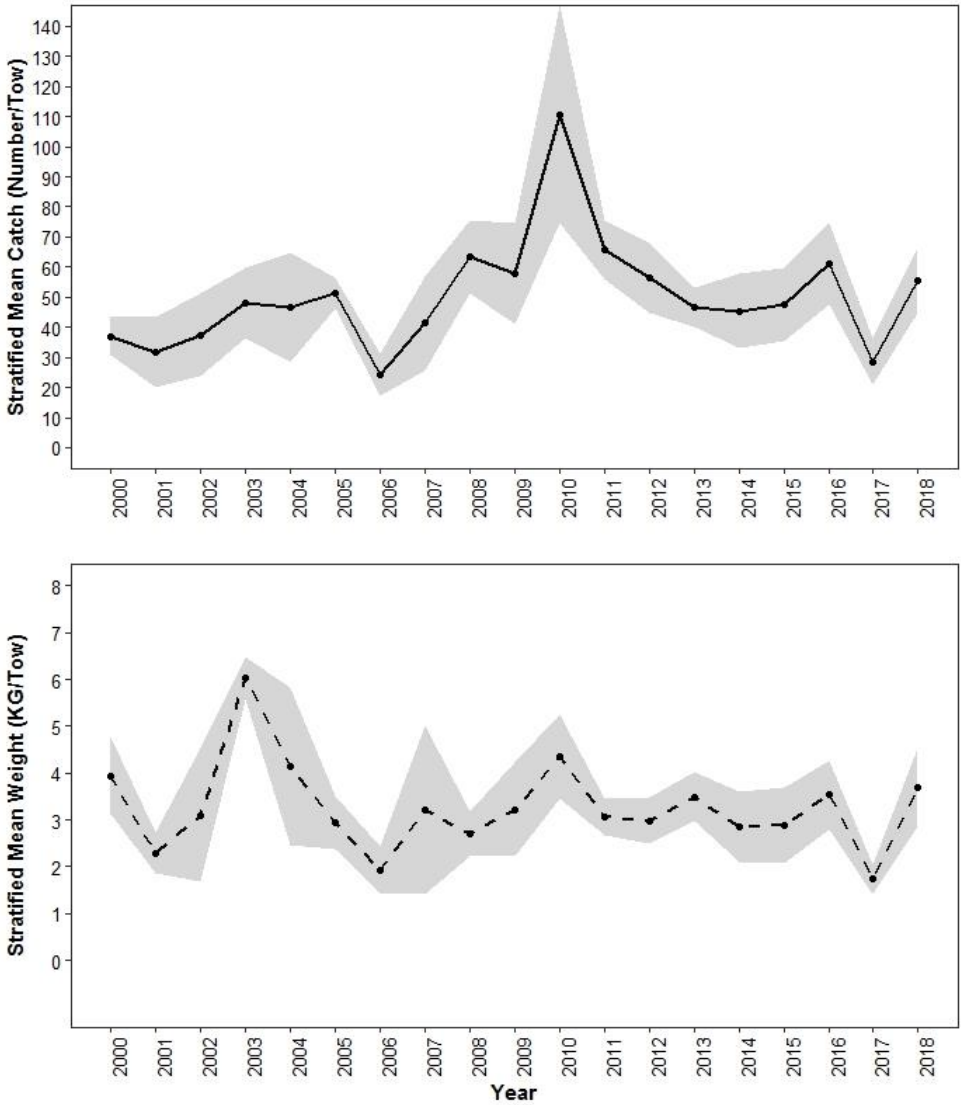

Figure 14: Stratified mean catch (top) and weight (bottom) for winter flounder from the fall surveys from 2000-2018. The shaded region in each plot indicates the 95% confidence interval.

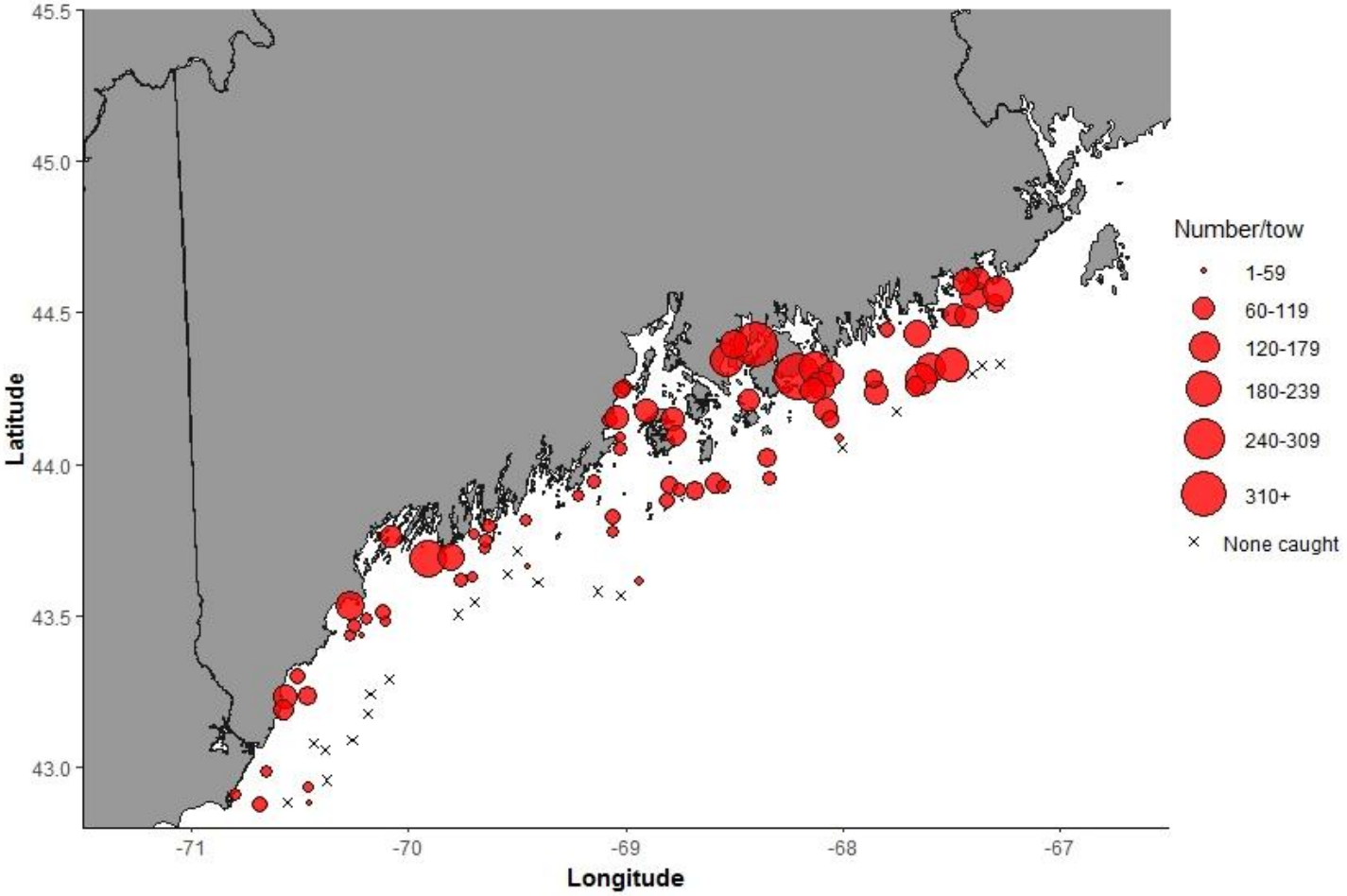

Figure 15: Distribution of winter flounder catch in the Fall 2018 survey.

Lengths of winter flounder caught in the fall survey are similar to those caught in the spring survey. Smaller sized (<25 cm total length) winter flounder make up most of the catch in fall surveys, and in 2018 more fish less than 10 cm were observed (Figure 16).

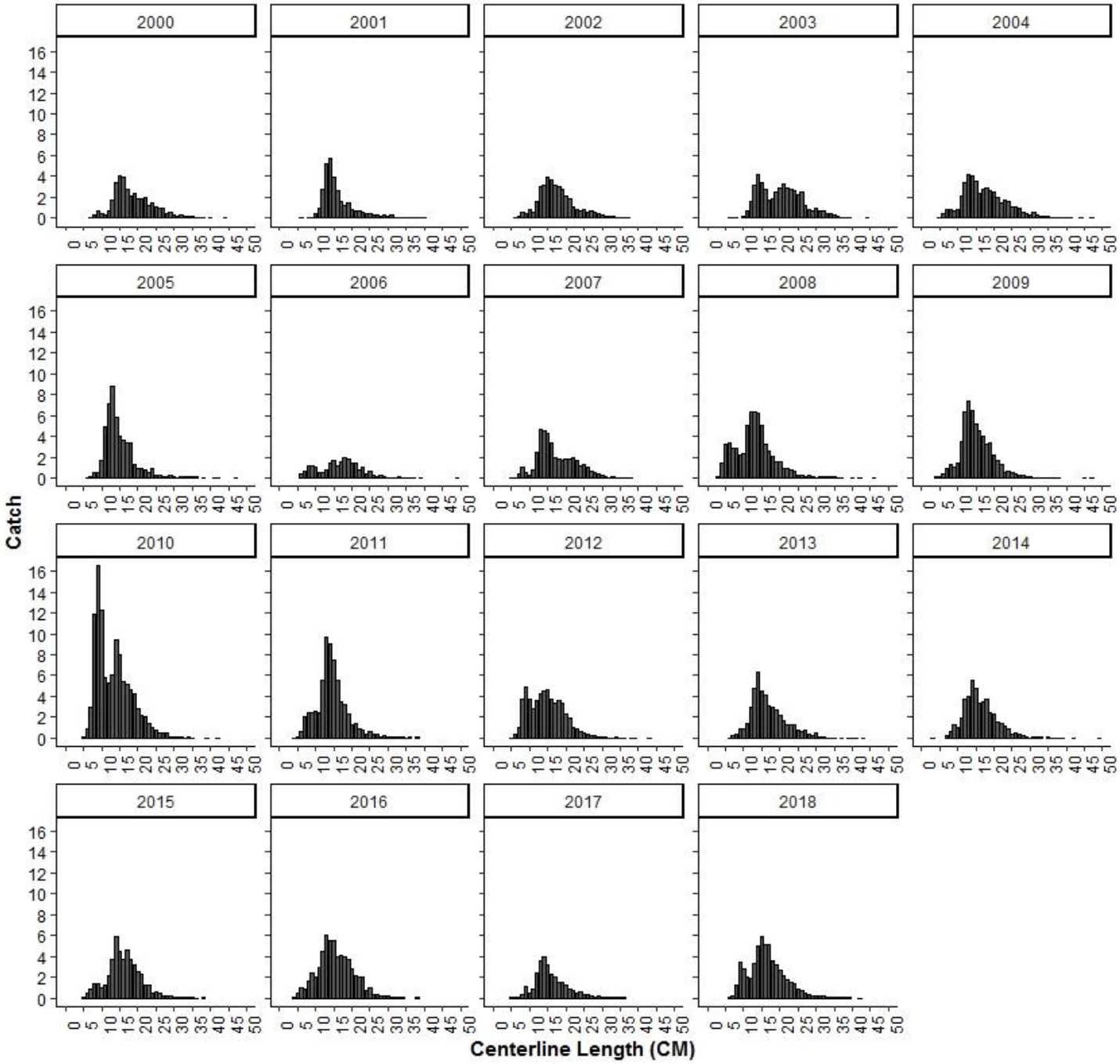

Figure 16: Length frequency distribution of winter flounder caught in the fall surveys from 2000 to 2018.

Atlantic cod

Spring

Atlantic cod are not seen as frequently in the MENH Survey as other gadids, such as haddock or hake. Average catch of Atlantic cod has fluctuated over the time series of the survey and has remained relatively stable since 2015 (Figure 17). In the Spring 2018 survey more cod were caught in regions 3, 4, and 5 of the survey area (Figure 18).

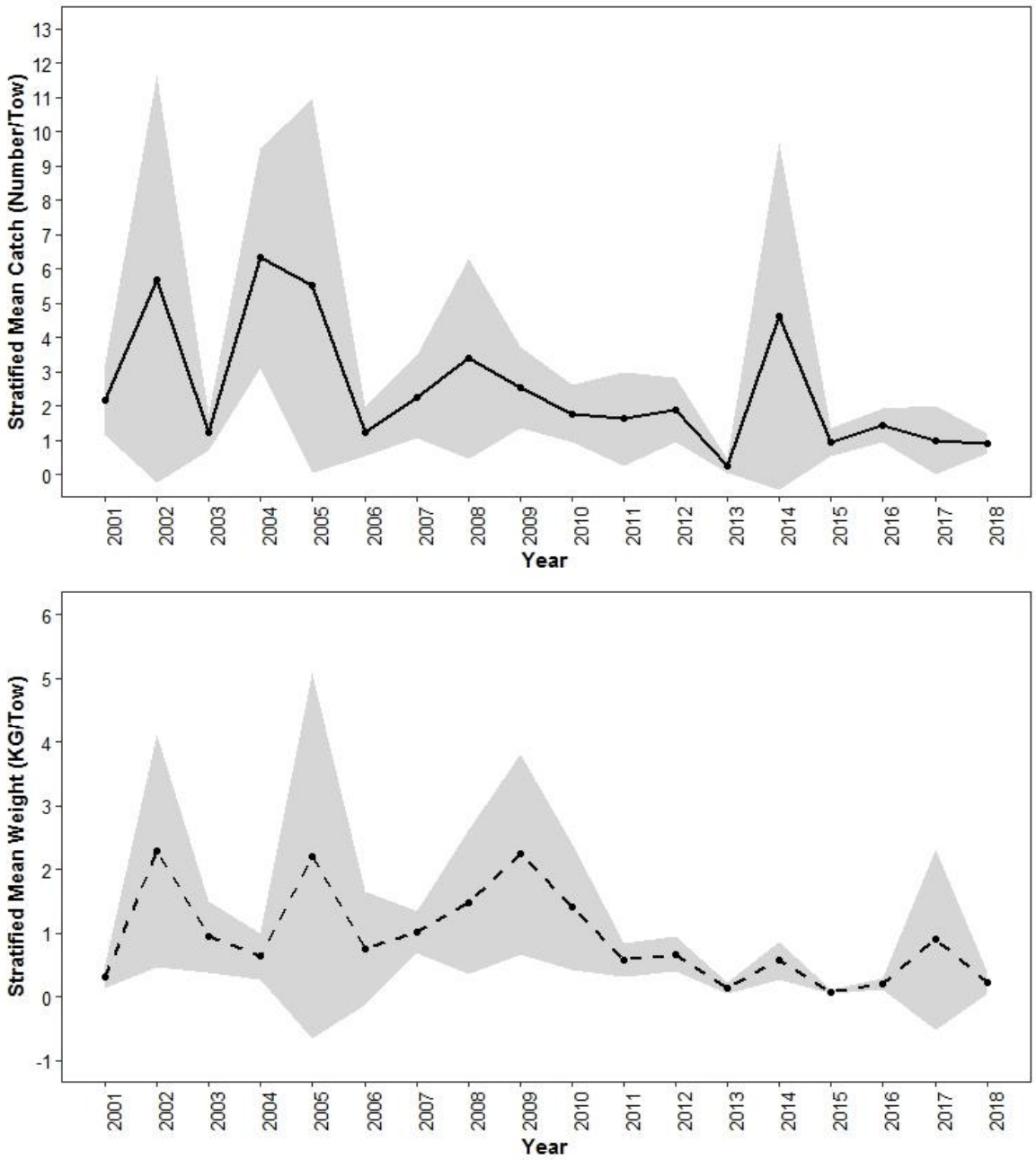

Figure 17: Stratified mean catch (top) and weight (bottom) for Atlantic cod from the spring surveys from 2001-2018. The shaded region in each plot indicates the 95% confidence interval.

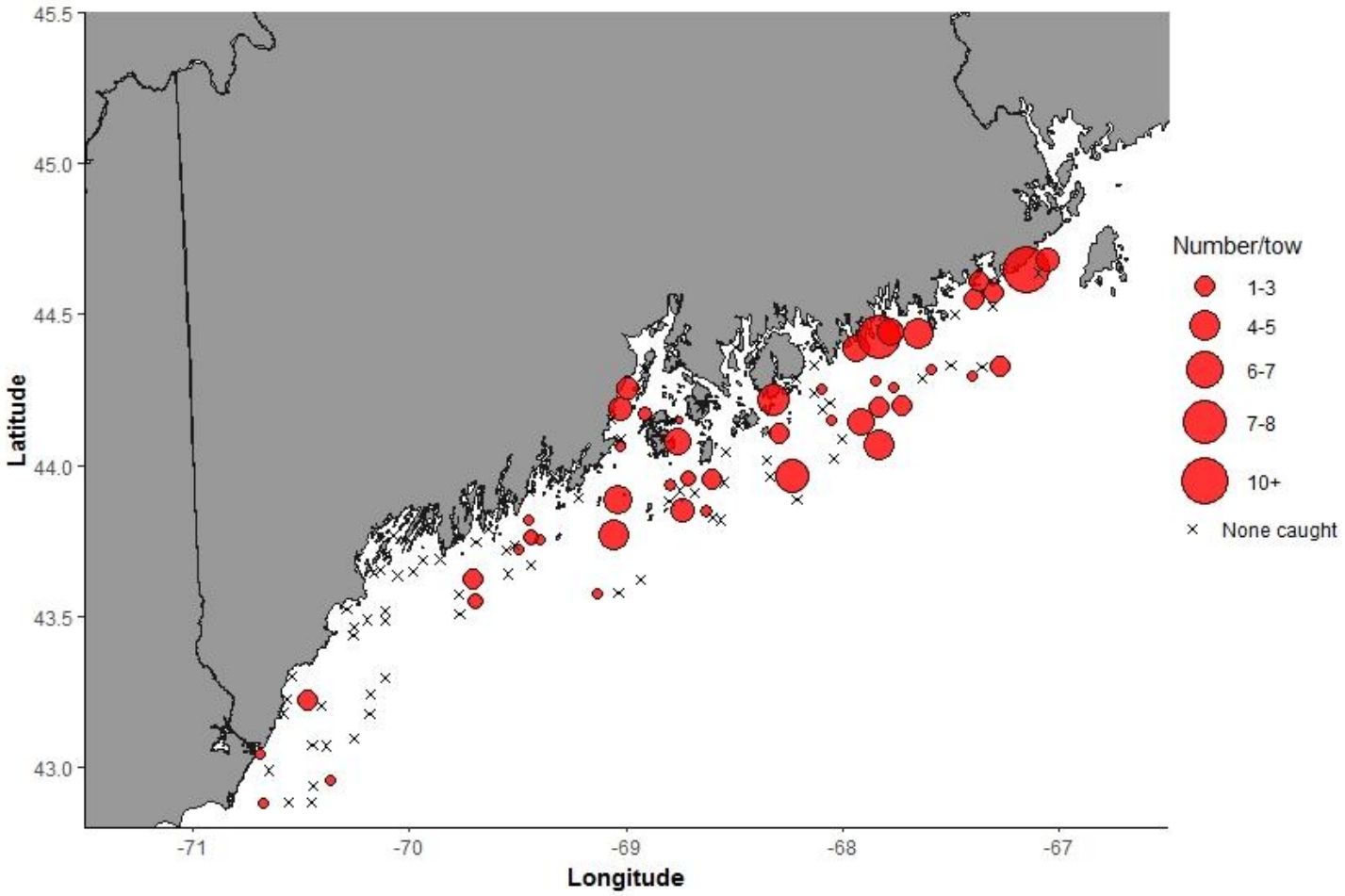

Figure 18: Distribution of cod catch in the Spring 2018 survey.

The sizes of cod caught in the spring surveys have remained fairly constant over the time series. Cod less than 20 cm in length are most common, and in 2018 less larger individuals of cod were observed when compared to past spring surveys (Figure 19).

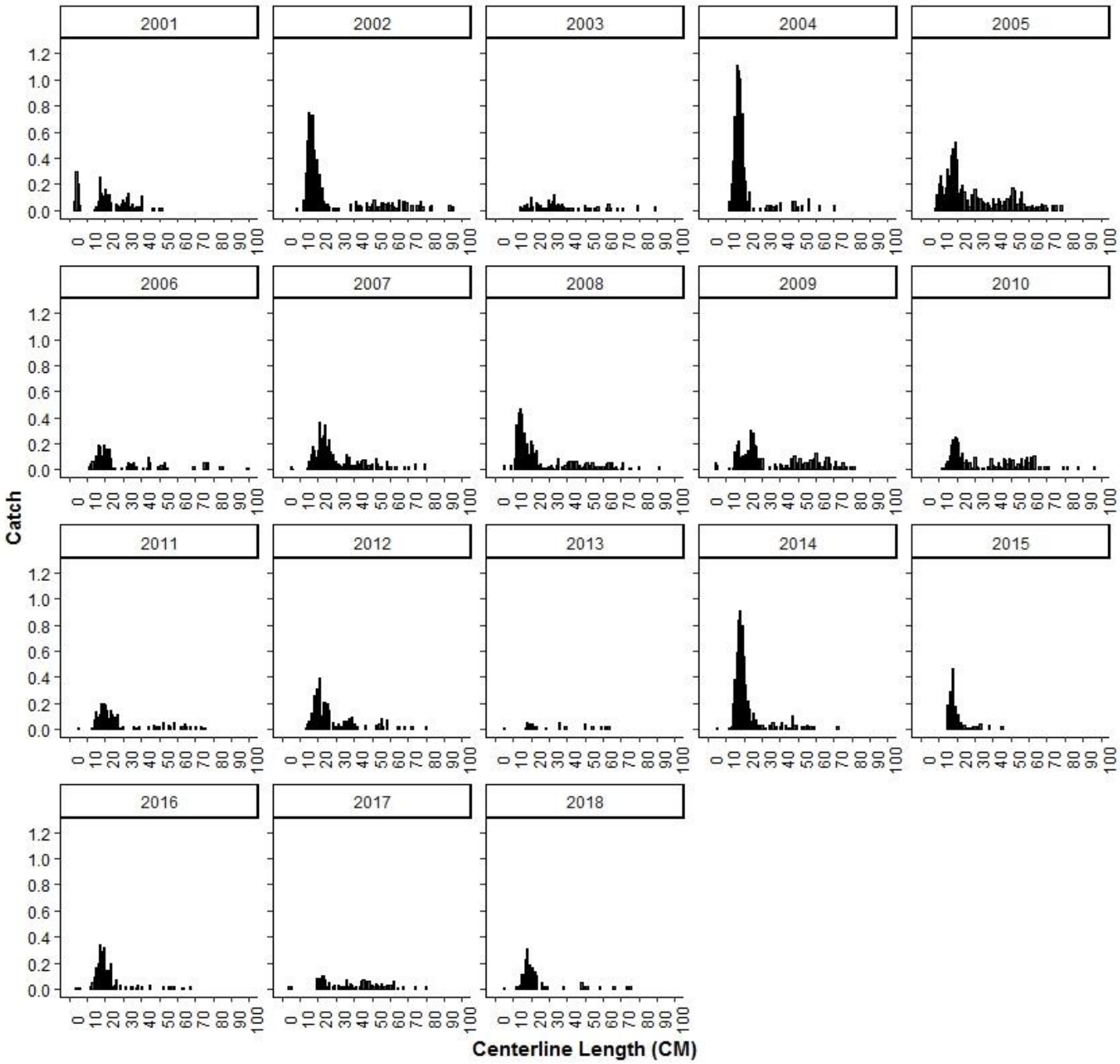

Figure 19: Length frequency distributions of Atlantic cod caught in the spring surveys from 2001 to 2018.

Fall

Average catch of Atlantic cod in the fall survey has been low since the beginning of the survey in 2000, and fewer cod are caught in the fall survey when compared to the spring. Average catch of cod was higher from 2003 to 2005, but then declined and remained low since 2008. In the Fall 2018 survey, average cod catch was lower than in 2017, but was similar to the catch seen in 2016 (Figure 20). The highest catch of cod occurred in waters off of Mount Desert Island, Maine in the western region of the trawl survey (Figure 21). There was little to no catch of cod in the eastern region (regions 1 and 2) of the survey (Figure 21).

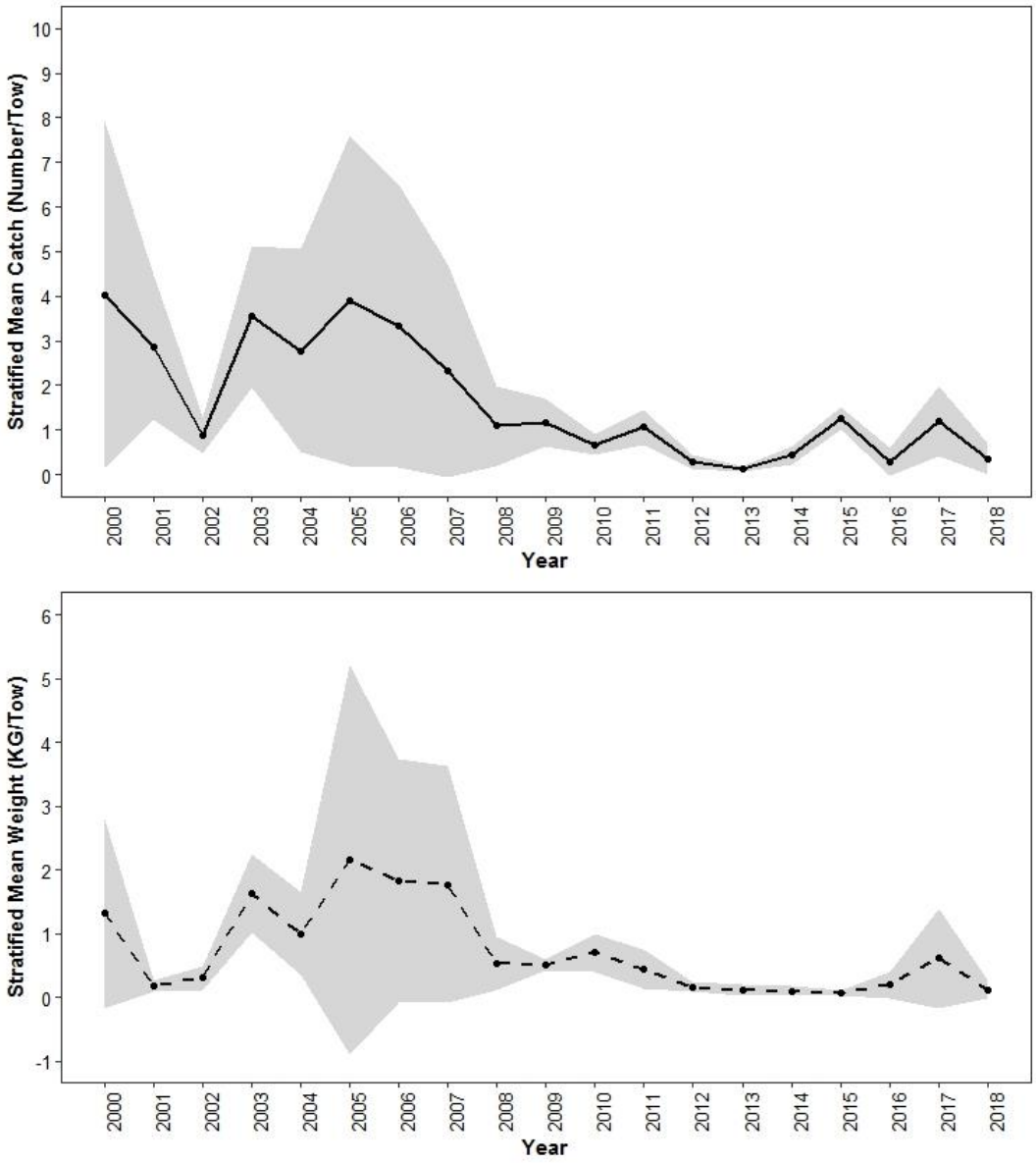

Figure 20: Stratified mean catch (top) and weight (bottom) for Atlantic cod from the fall surveys from 2000-2018. The shaded region in each plot indicates the 95% confidence interval.

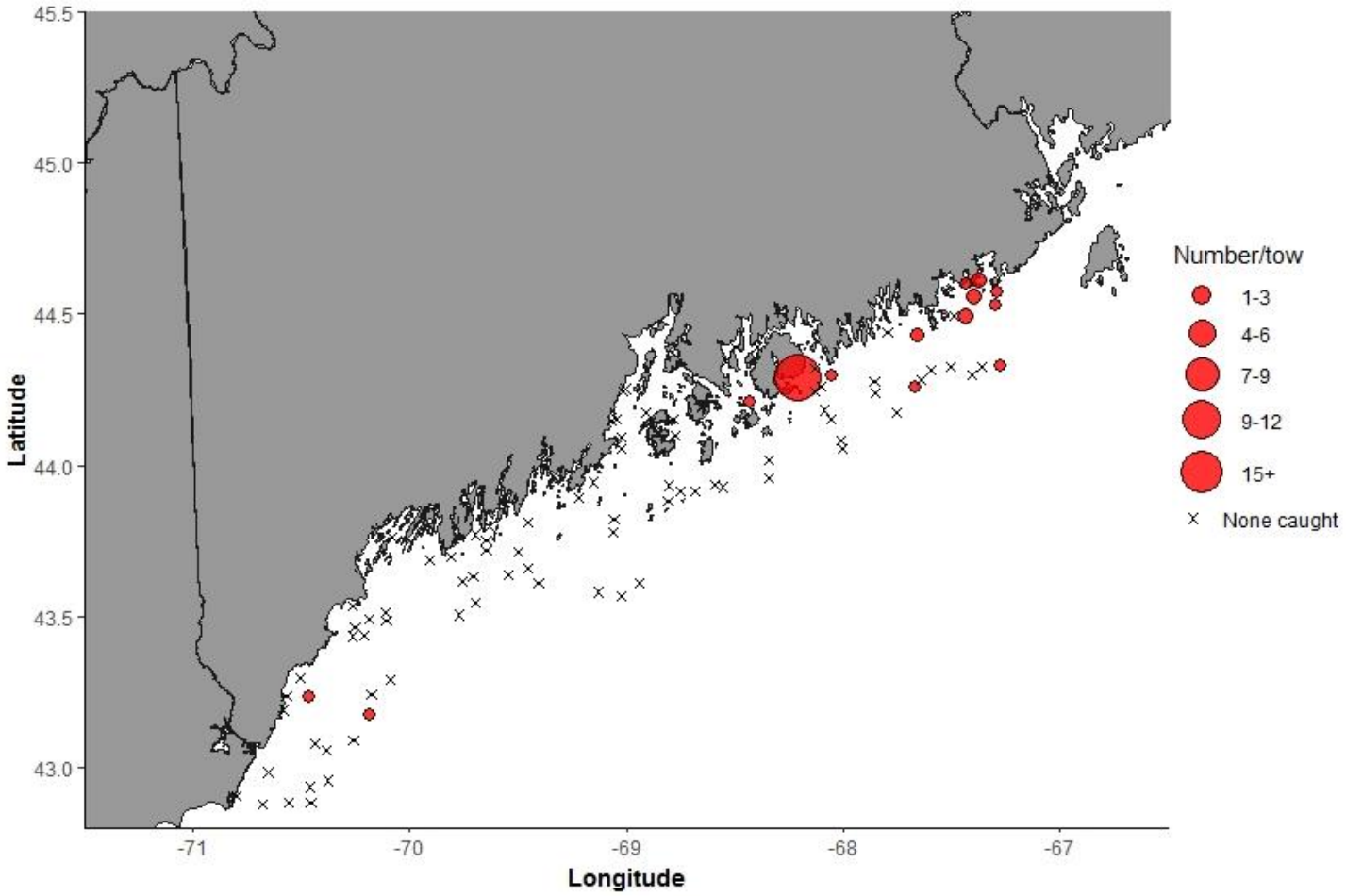

Figure 21: Distribution of Atlantic cod catch in the Fall 2018 survey.

The lengths of cod caught in the fall surveys are similar to the spring surveys, with the dominate size range caught less than 20 cm (Figure 22). In the beginning of the survey larger cod (greater than 30 cm) were caught, however, as the survey continued, catch of larger cod declined and was very low in the Fall 2018 survey.

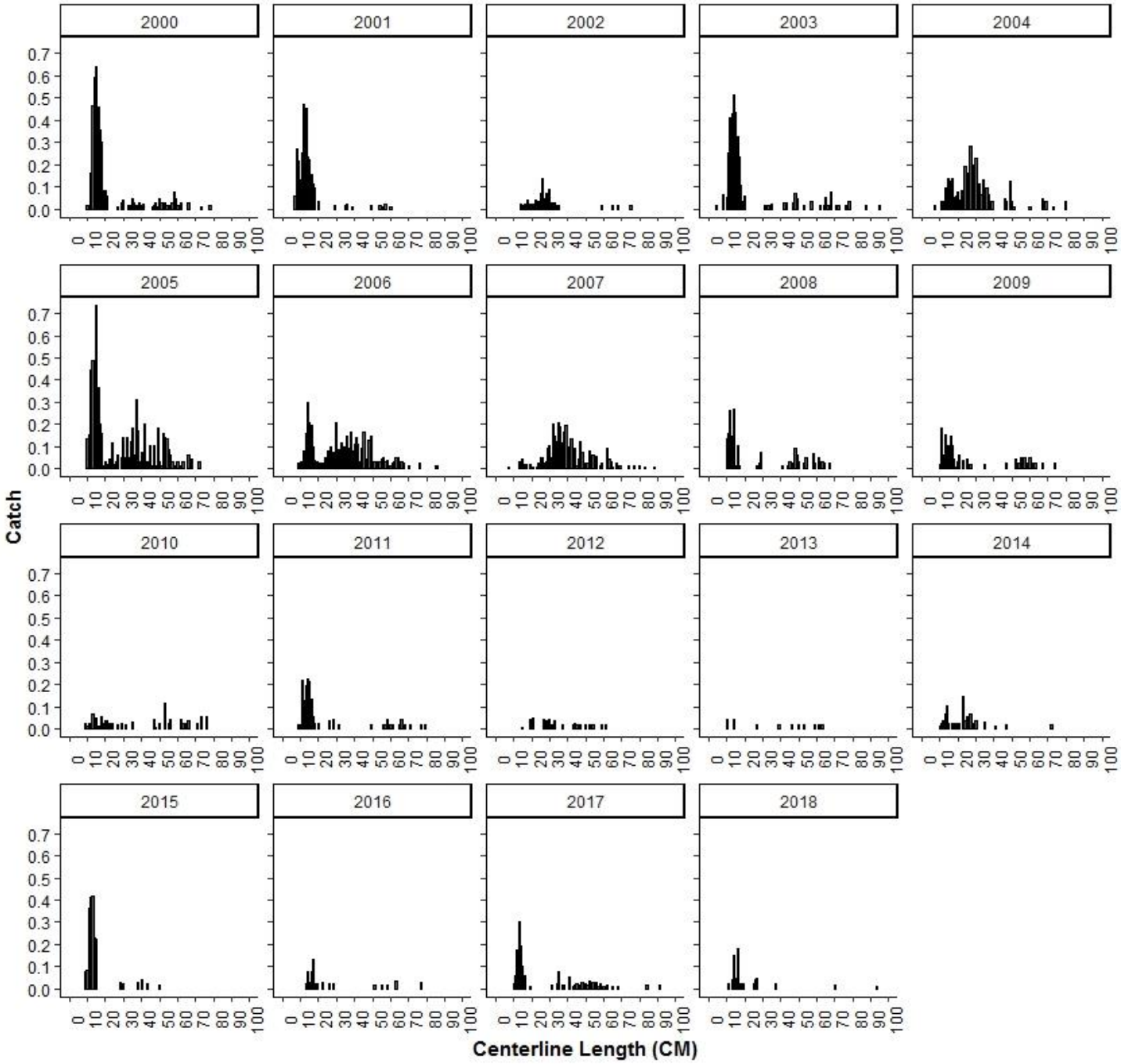

Figure 22: Length frequency distributions of Atlantic cod caught in the fall surveys from 2000 to 2018.

Maturity data for cod is collected in both the spring and fall trawl surveys. In the 2018 surveys more immature fish were observed than mature (maturity stages: developing, ripe, ripe and running, spent, or resting) and more female than male cod were observed (Figure 23). Since there was less cod caught in the fall survey less fish were examined for maturity than the spring survey. All immature fish observed in the 2018 surveys were less than 40 cm (Figure 23).

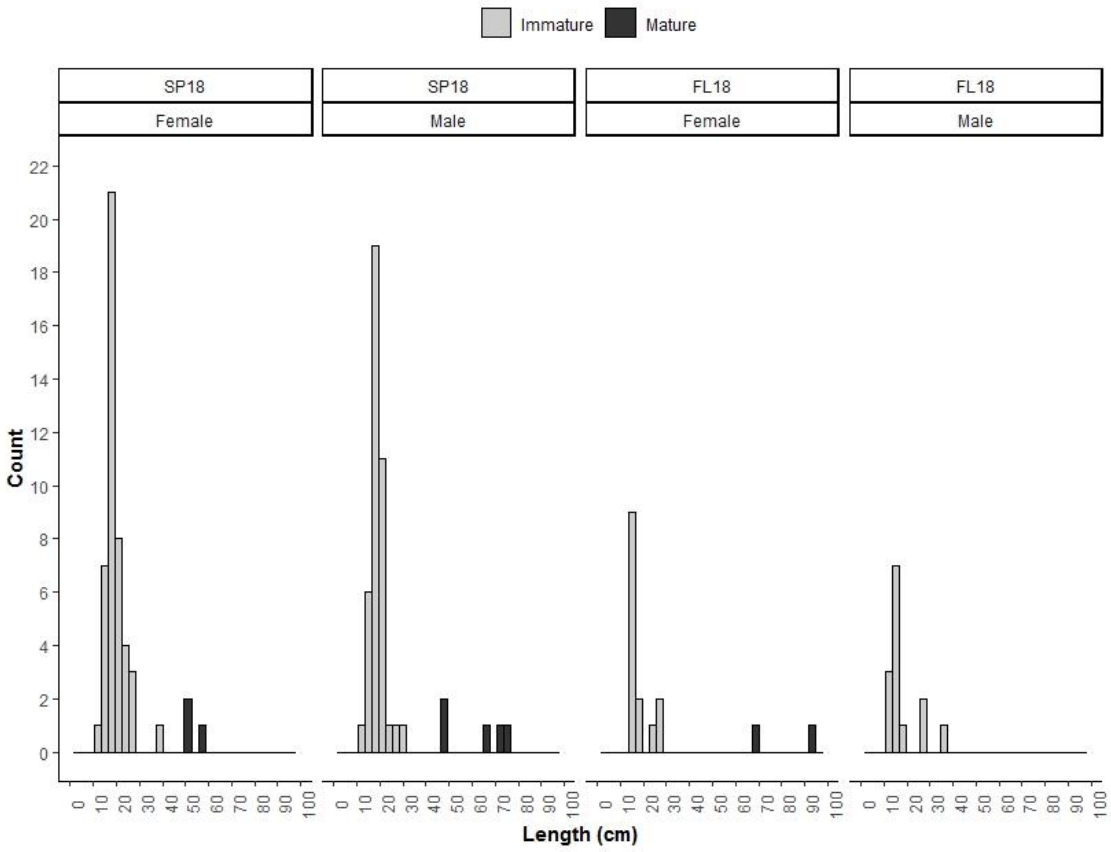

Figure 23: Lengths (cm) of male and female immature and mature cod caught in the Spring and Fall 2018 surveys.

Haddock

Spring

In the start of the spring surveys average catch of haddock was relatively low. In the Spring 2014 survey, average catch increased dramatically and is still the highest average catch seen in the spring survey time series. After 2014, average catch decreased, but has remained higher than past average catch before the peak in 2014. Average catch of haddock has remained stable since 2015, and the 2018 average catch did not differ much than the average catch in the Spring 2017 survey (Figure 24). Even though average catch has remained relatively stable since 2015, the average weight of haddock has increased and continued to increase in 2018 (Figure 24). Catch of haddock was higher in regions 1 and 2, off the coast of New Hampshire and southern Maine, than regions 3, 4, and 5 (Figure 25).

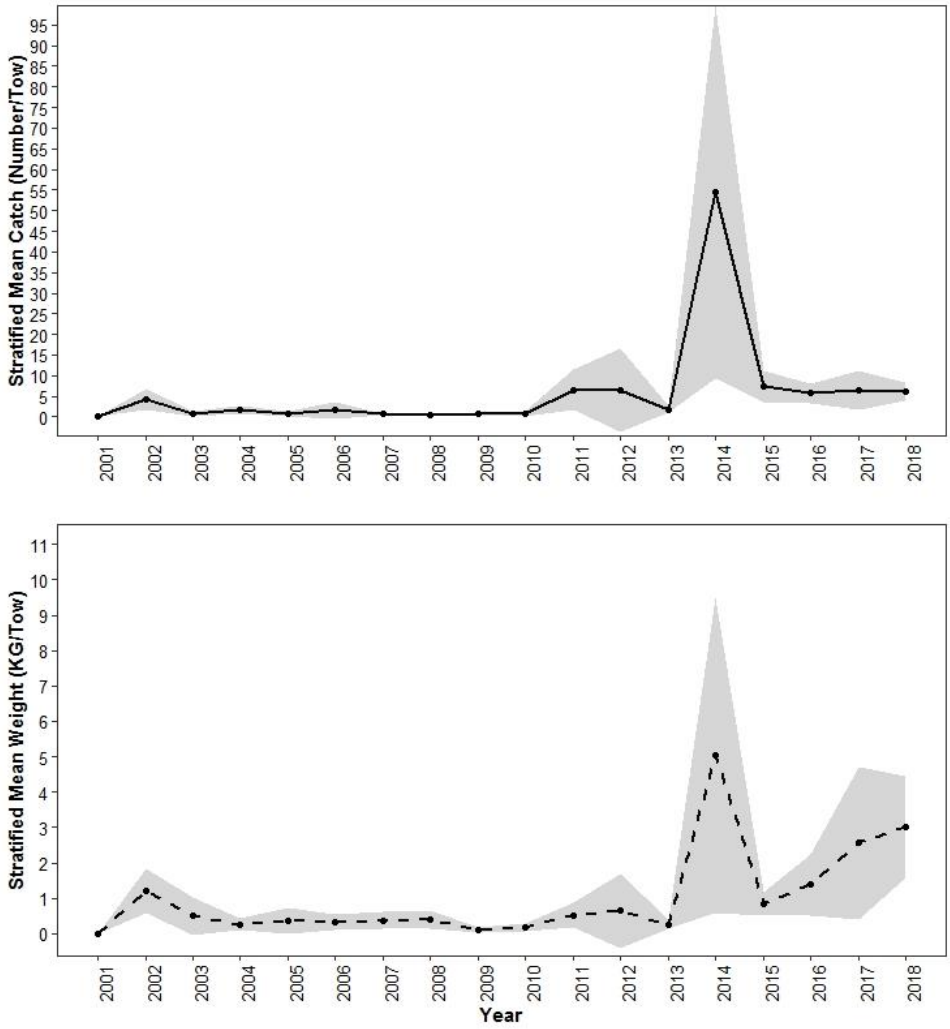

Figure 24: Stratified mean catch (top) and weight (bottom) for haddock from the spring surveys from 2001-2018. The shaded region in each plot represents the 95% confidence interval.

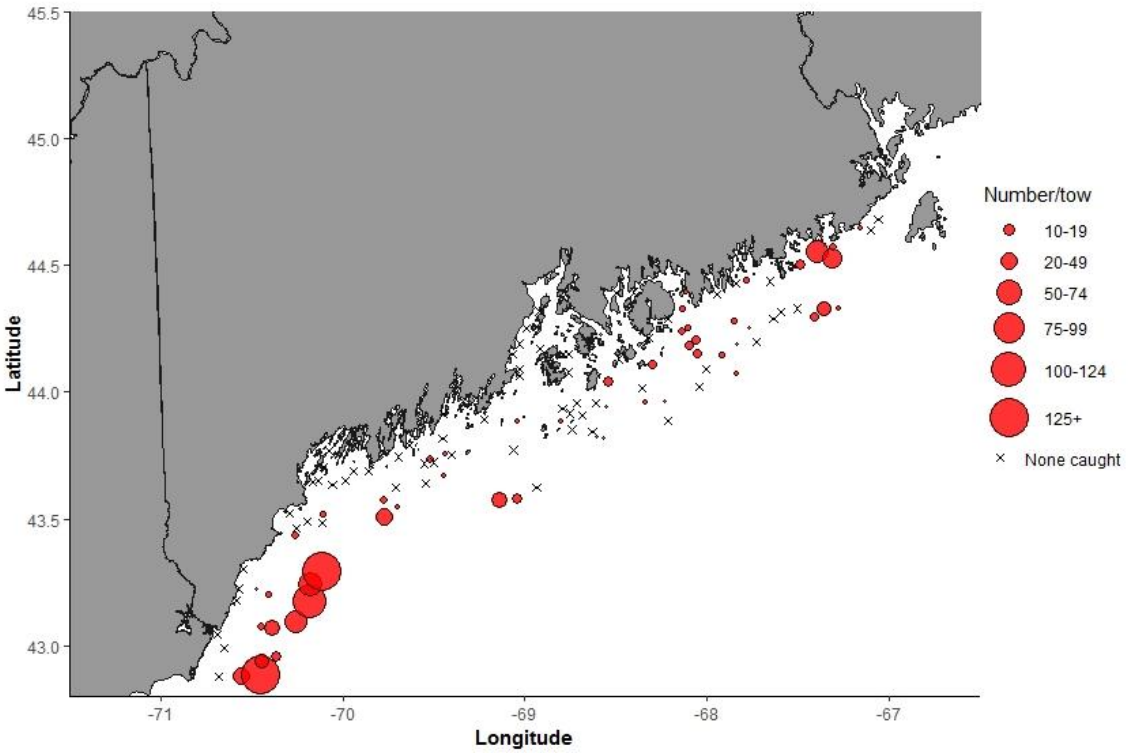

Figure 25: Distribution of haddock catch in the Spring 2018 survey.

Before the start of the trend in increasing average catch weight, lengths of haddock caught in the survey were mostly below 30 cm (Figure 26). Starting in 2015, catch of larger sized haddock, greater than 30 cm, increased and continued to increase in the Spring 2018 survey (Figure 26). The increase of larger sized haddock may explain why the average catch weight has increased in the survey even though average catch of haddock has shown no increasing trend.

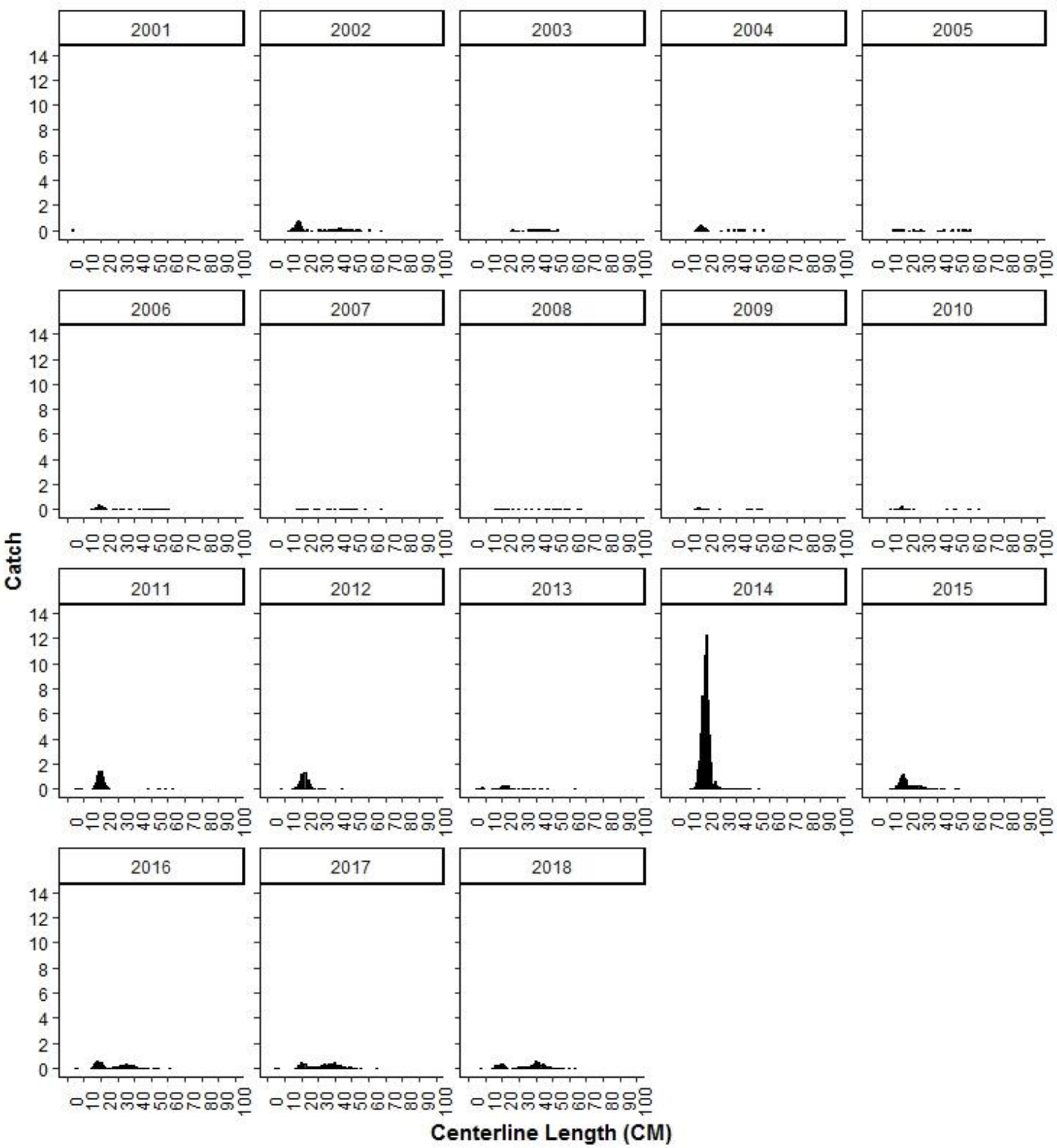

Figure 26: Length frequency distributions of haddock caught in the spring surveys from 2001 to 2018.

Fall

In start of the fall MENH Survey average catch of haddock was relatively low and similar to the spring catch. Starting in 2009, average catch of haddock began to increase and peaked in 2014. After the peak in 2014, average catch of haddock has decreased but remained higher than earlier years of the survey (Figure 27).

Average catch of haddock slightly increased in the Fall 2018 survey when compared to the Fall 2017 survey. Average catch weight increased in 2018 and is the highest in the time series so far. The distribution of haddock catch varied in fall 2018. Larger catches were seen in deeper portions of regions 1, 2, and 3, but were seen in shallower waters of regions 4 and 5 (Figure 28).

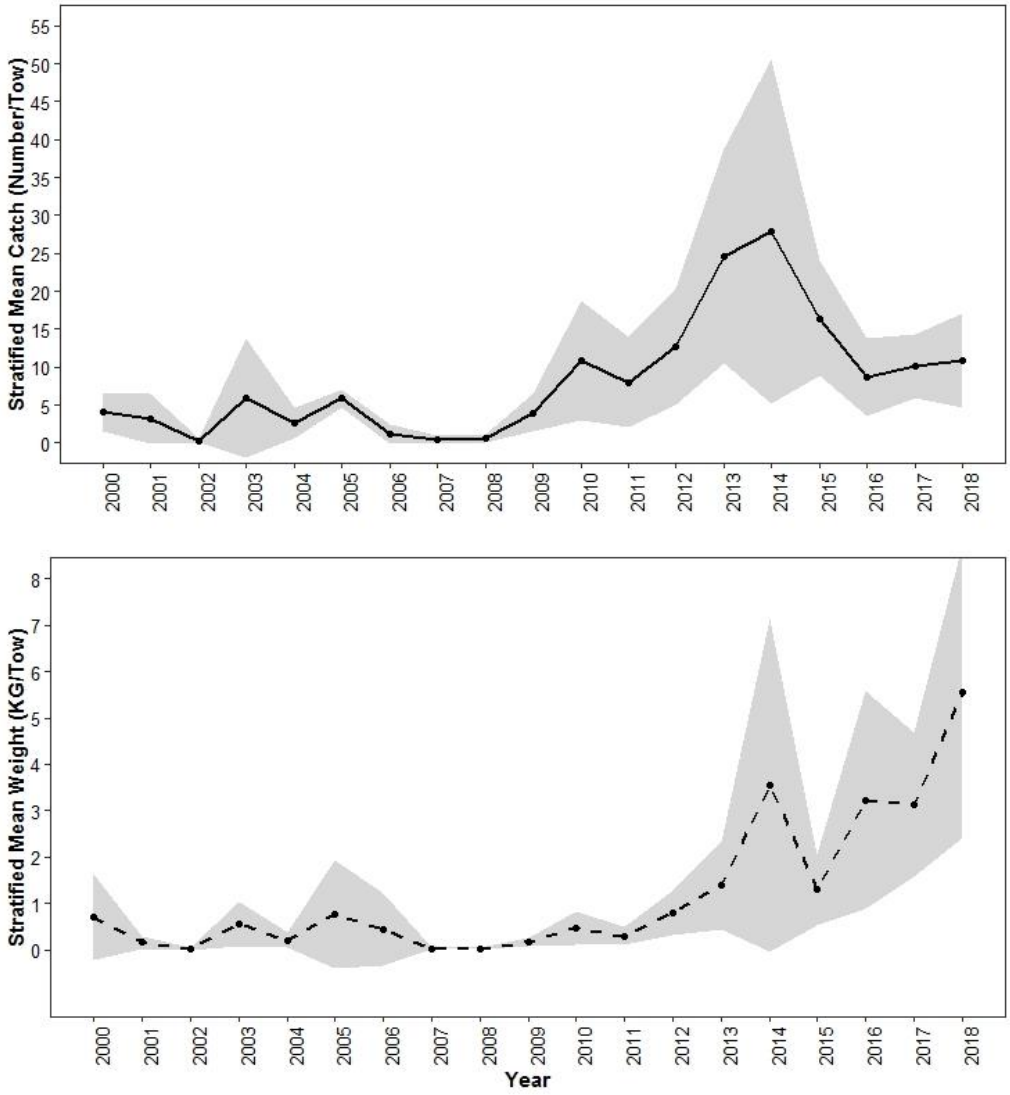

Figure 27: Stratified mean catch (top) and weight (bottom) for haddock from the fall surveys from 2000 to 2018. The shaded region in each plot indicates the 95% confidence interval.

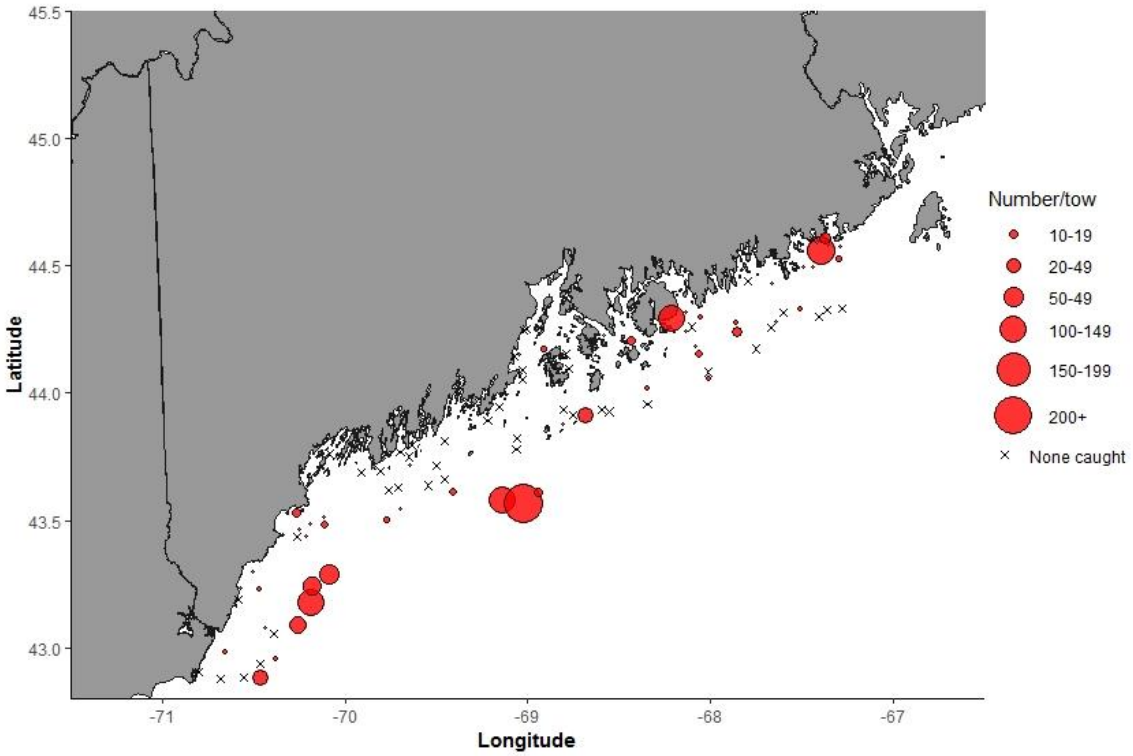

Figure 28: Distribution of haddock catch in the Fall 2018 survey.

Similar to the spring surveys, the predominant lengths of haddock observed in earlier years of the survey were below 30 cm. Starting in 2015, catch of larger haddock (> 30cm) began to increase, and in the Fall 2018 survey two size ranges, 0-20 cm and 35-50 cm, dominated the catch (Figure 29). This increase in catch of larger sized haddock explains why there is a large increase in average catch weight in the fall surveys without a large increase in average catch.

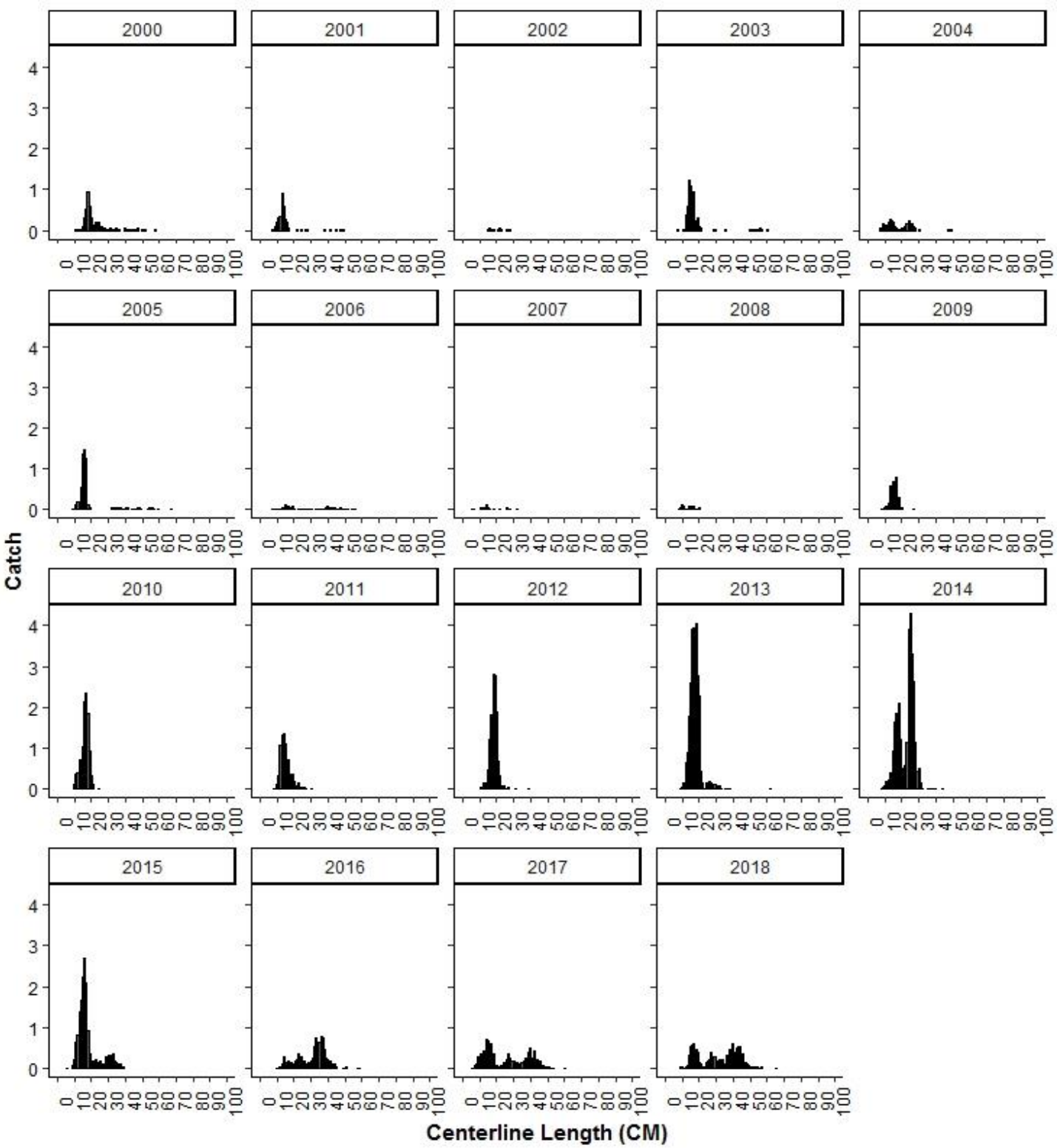

Figure 29: Length frequency distributions of haddock caught in the fall surveys from 2000 to 2018.

Maturity data for haddock is collected in both the spring and fall surveys each year. Figure 30A shows the maturity data collected for females in the spring and fall surveys in 2018, and figure 30B shows maturity data for males in the spring and fall survey in 2018. In the spring survey all maturity stages were observed while in the fall only immature and resting males and females were seen (Figure 30A and B). The spring surveys cover

the spawning period (February to May) determined from Burnett *et al*. 1989, which explains why all maturity stages were observed in the spring, while in the fall only immature and resting maturity stages were observed. In the spring, female haddock above 35 cm were all mature (maturity stages: developing, ripe, ripe and running, spent, and resting) and most males above 30 cm were mature. In the fall there was a more distinct break between lengths of immature and mature males and females. For females and males in the fall all fish with lengths below 30 cm were immature (Figure 30 A and B).

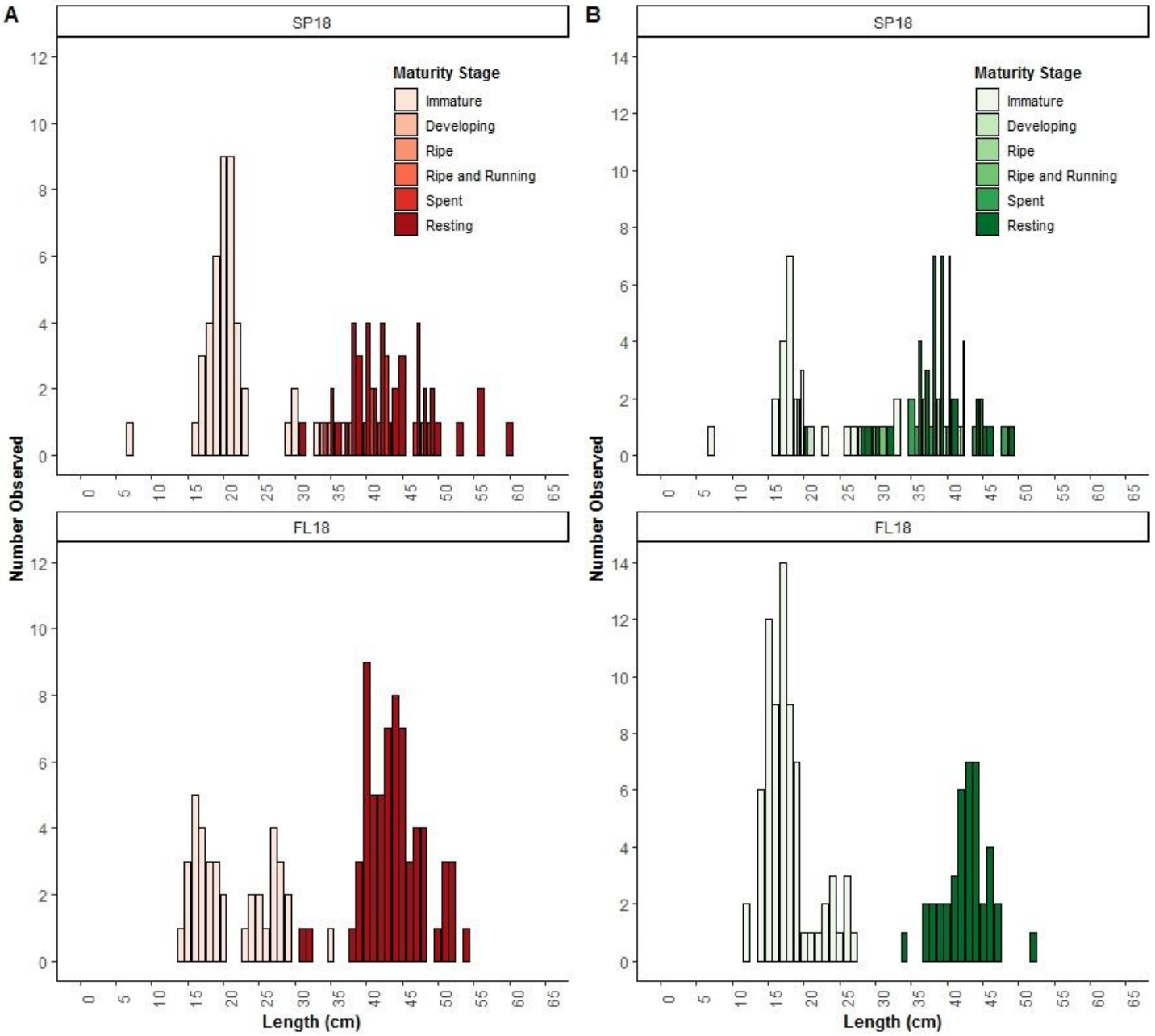

Figure 30: Maturity stages observed at each length in the spring and fall survey for both females (A) and males (B).

White Hake

Spring

White hake average catch has fluctuated over the spring survey time series and average catch is lower in the spring when compared to the fall. There was an increase of average catch and weight from the 2017 survey to the 2018 survey (Figure 31). White hake are more commonly caught in regions 4 and 5 of the survey when compared to regions 1, 2, and 3 (Figure 32).

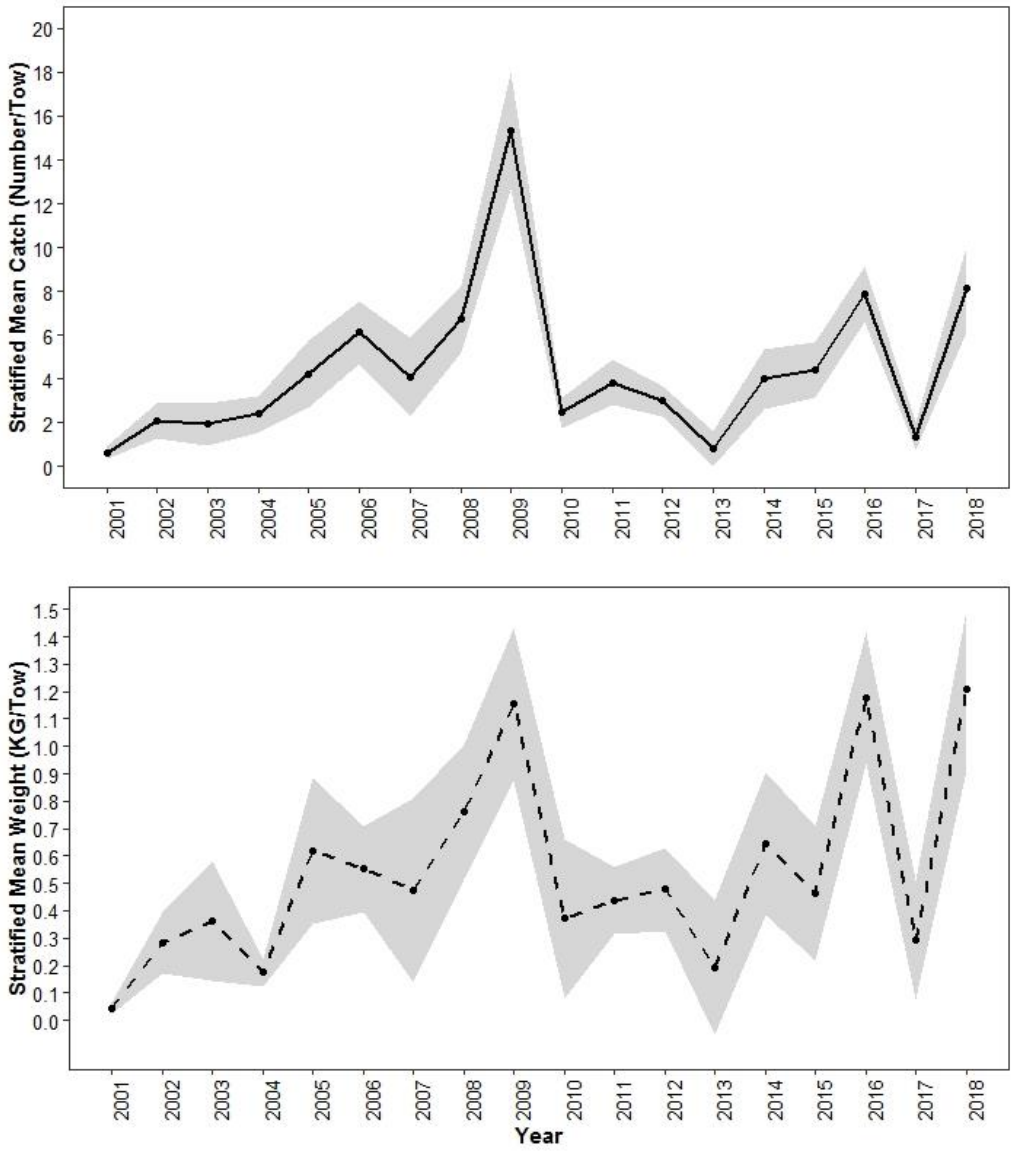

Figure 31: Stratified mean catch (top) and weight (bottom) for white hake from the spring surveys from 2001-2018. The shaded region in each plot indicates the 95% confidence interval.

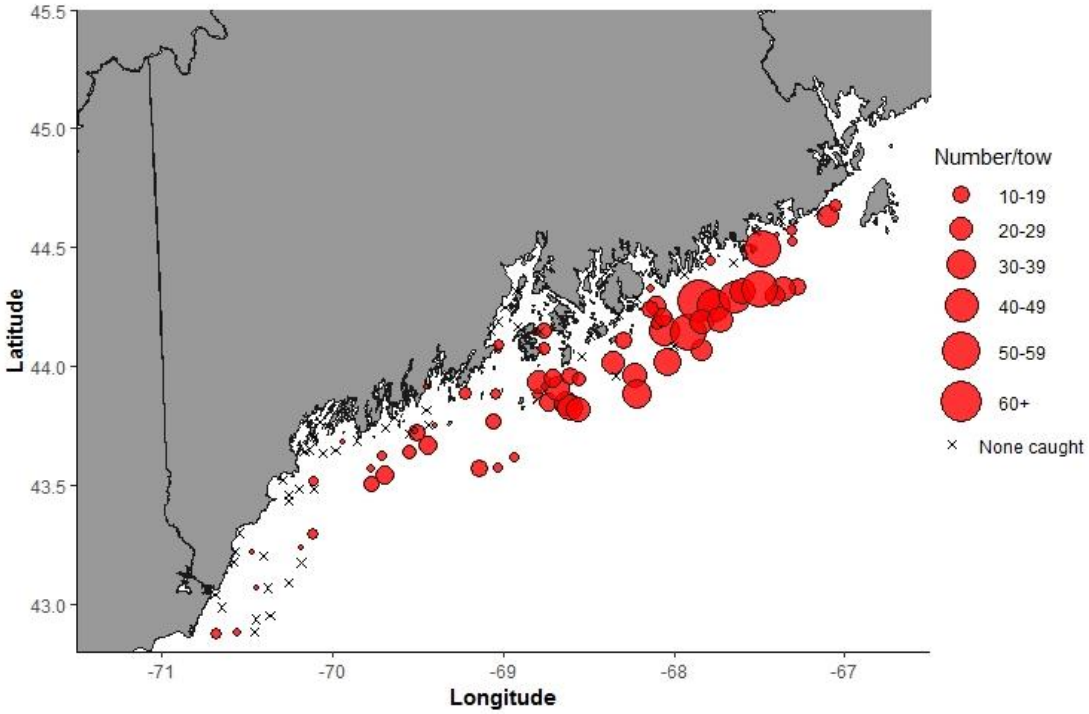

Figure 32: Distribution of white hake catch in the Spring 2018 survey.

Most of the white hake caught in the spring surveys are juvenile fish, with the majority of the lengths observed below 40 cm (Figure 33). The size range of white hake caught in the spring surveys has remained stable over the survey time series.

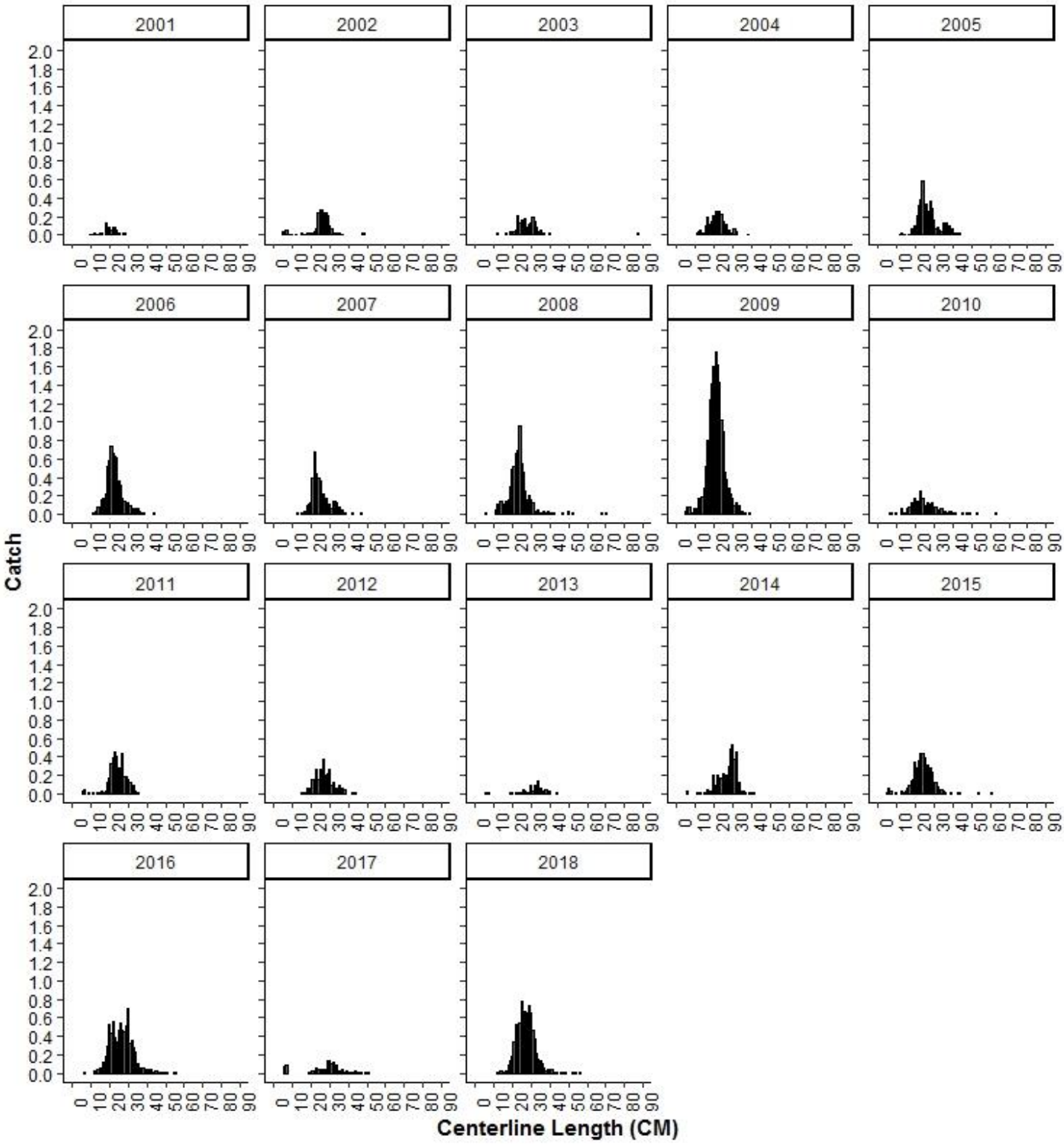

Figure 33: Length frequency distribution of white hake in the spring surveys from 2001 to 2018.

Fall

Average catch of white hake in the fall surveys is larger than the spring surveys. Average catch has fluctuated over the fall survey time series, and the average catch increased in 2018 (Figure 34). Average catch weight has

also fluctuated over the time series, but increased dramatically from the Fall 2017 to the Fall 2018 survey, possibly due to larger sized white hake observed in the Fall 2018 survey (Figure 34). White hake was caught in almost every tow in 2018, but larger catches occurred in regions 3, 4, and 5 (Figure 35).

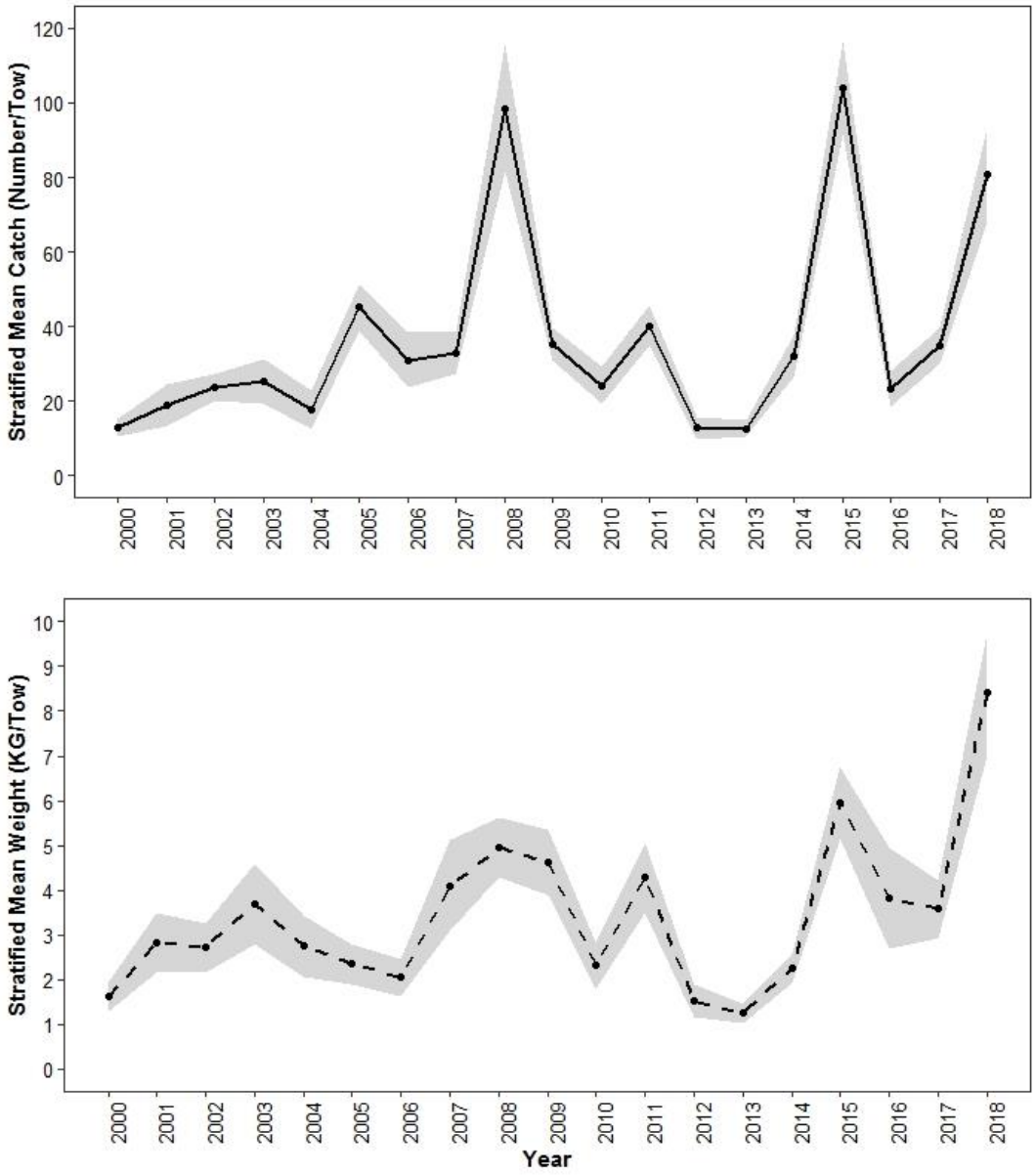

Figure 34: Stratified mean catch (top) and weight (bottom) for white hake from the fall surveys from 2000-2018. The shaded region in each plot indicates the 95% confidence interval.

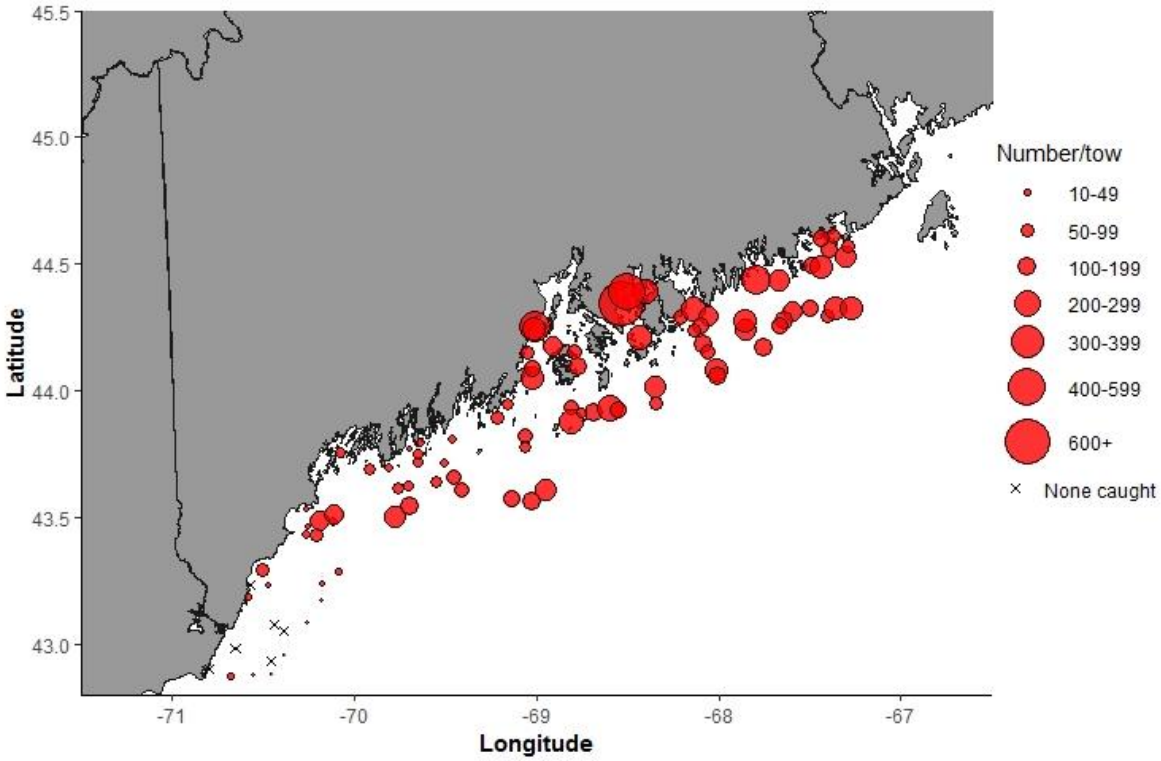

Figure 35: Distribution of white hake catch in the Fall 2018 survey.

Before the Fall 2018 survey, the majority of white hake sampled in the fall survey were juvenile fish less than 30 cm, with a small number of larger fish observed in some surveys. Even though most of white hake sampled in the Fall 2018 survey were less than 30 cm, more white hake larger than 30 cm were sampled during this survey than any past fall survey (Figure 36).

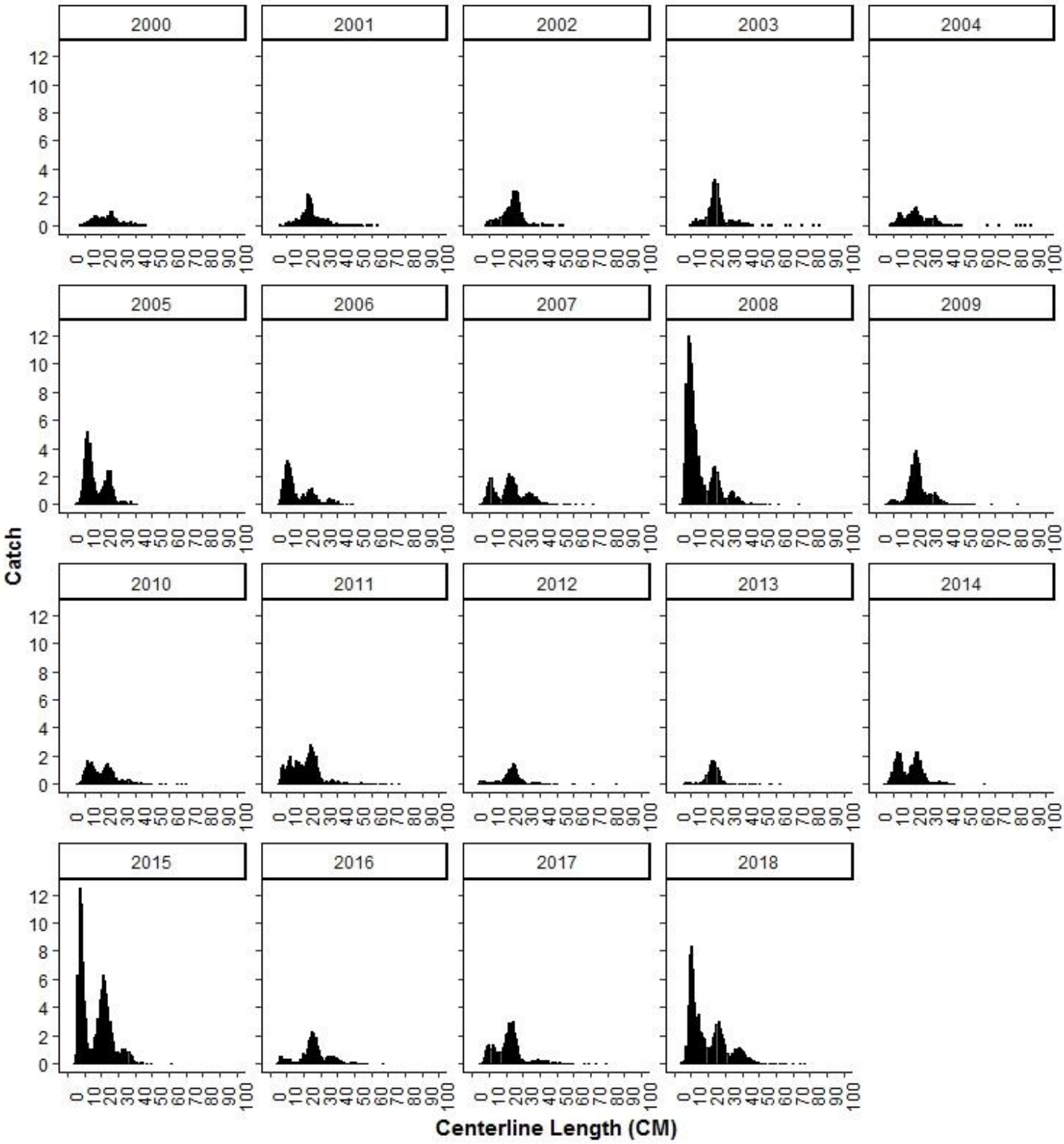

Figure 36: Length frequency distributions of white hake in the fall surveys from 2000 to 2018.

In each fall survey a select number of white hake are sampled for maturity information. The majority of female and male white hake sampled in the Fall 2018 survey were immature and less than 46 cm (Figure 37). Some females under 45 cm were mature, but a majority of the mature female white hake were greater than 50 cm. Mature males were seen at lengths of 37 cm to 65 cm, with all males greater than 45 cm mature.

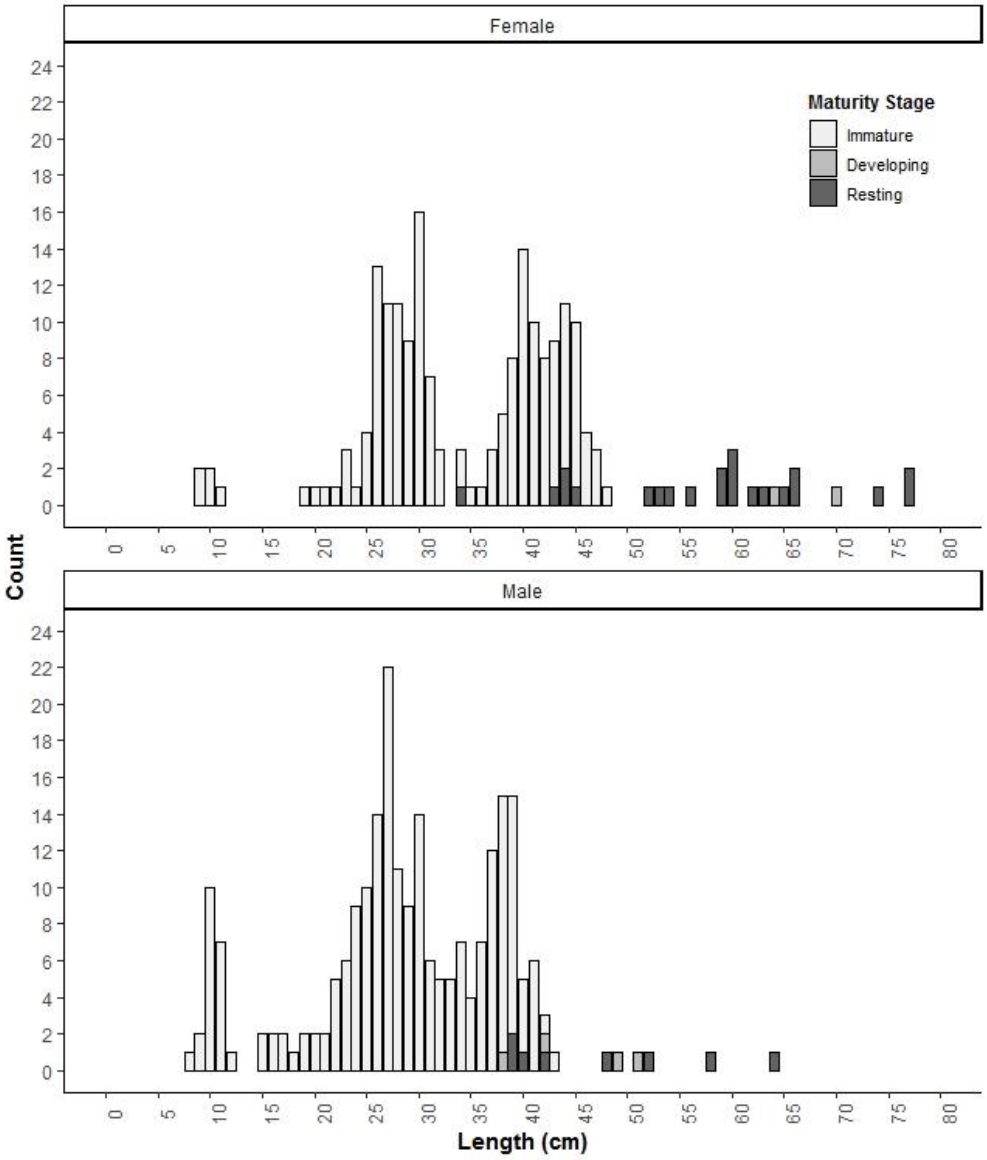

Figure 37: Maturity stages at each length from females (top) and males (bottom) collected in the Fall 2018 survey.

Rainbow Smelt

In Maine, rainbow smelt are a prized sport fish that are harvested primarily in the winter by ice fishing. As these anadromous fish move into streams to spawn in the spring, they are harvested primarily by dip nets. In the MENH survey rainbow smelt are caught mostly in the fall in the shallowest depth (< 20 fathoms) stratum (Figure 38).

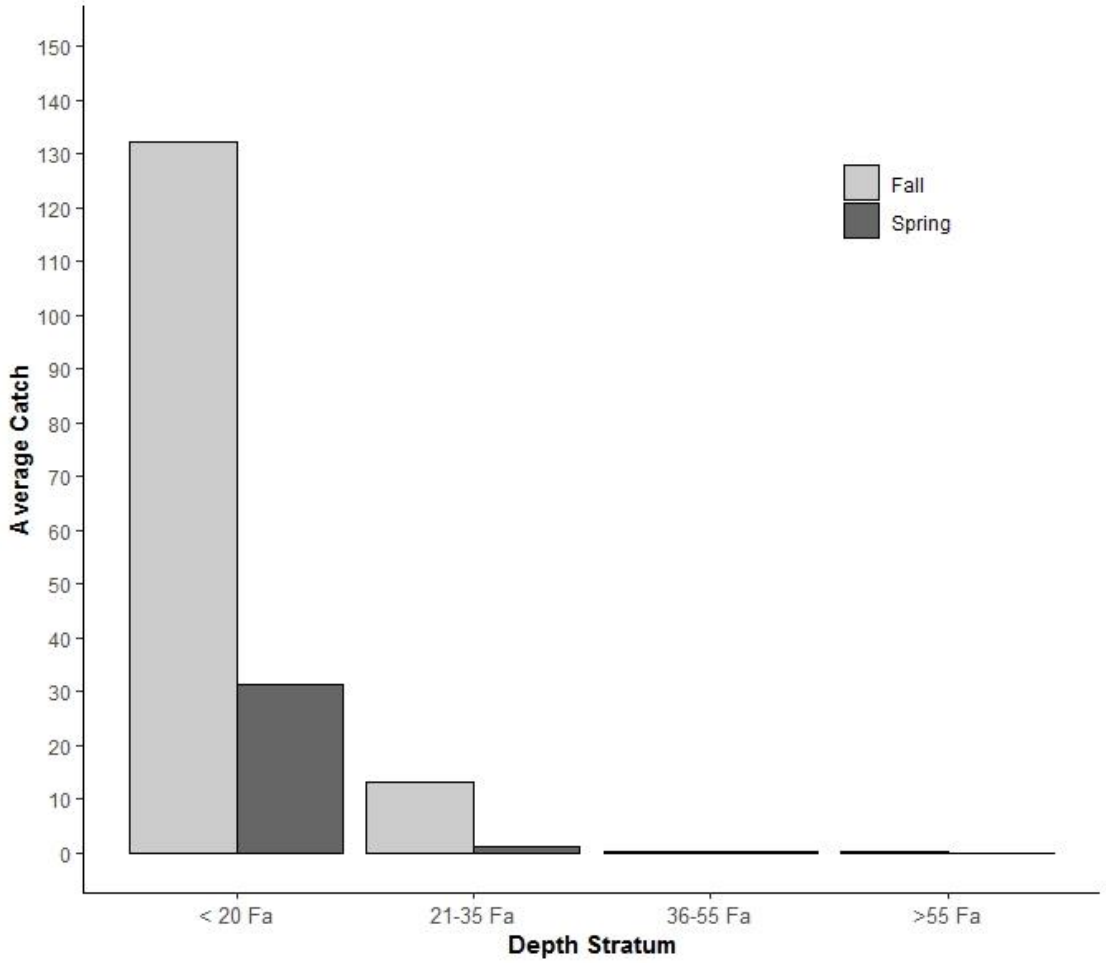

Figure 38: Average number per tow by depth stratum of rainbow smelt in the spring (2001-2018) and fall (2000-2018) surveys.

Spring

Average catch of rainbow smelt in the spring surveys has remained consistently low since 2009 (Figure 39). The number of rainbow smelt caught in the survey peaked in 2008, but has remained low since. In the Spring 2018 survey, catch occurred primarily in areas closest to the shore, with the largest catch occurring in Saco Bay (Figure 40). The presence of smelt in the spring survey may be related to the timing of their spring run as they move into estuaries.

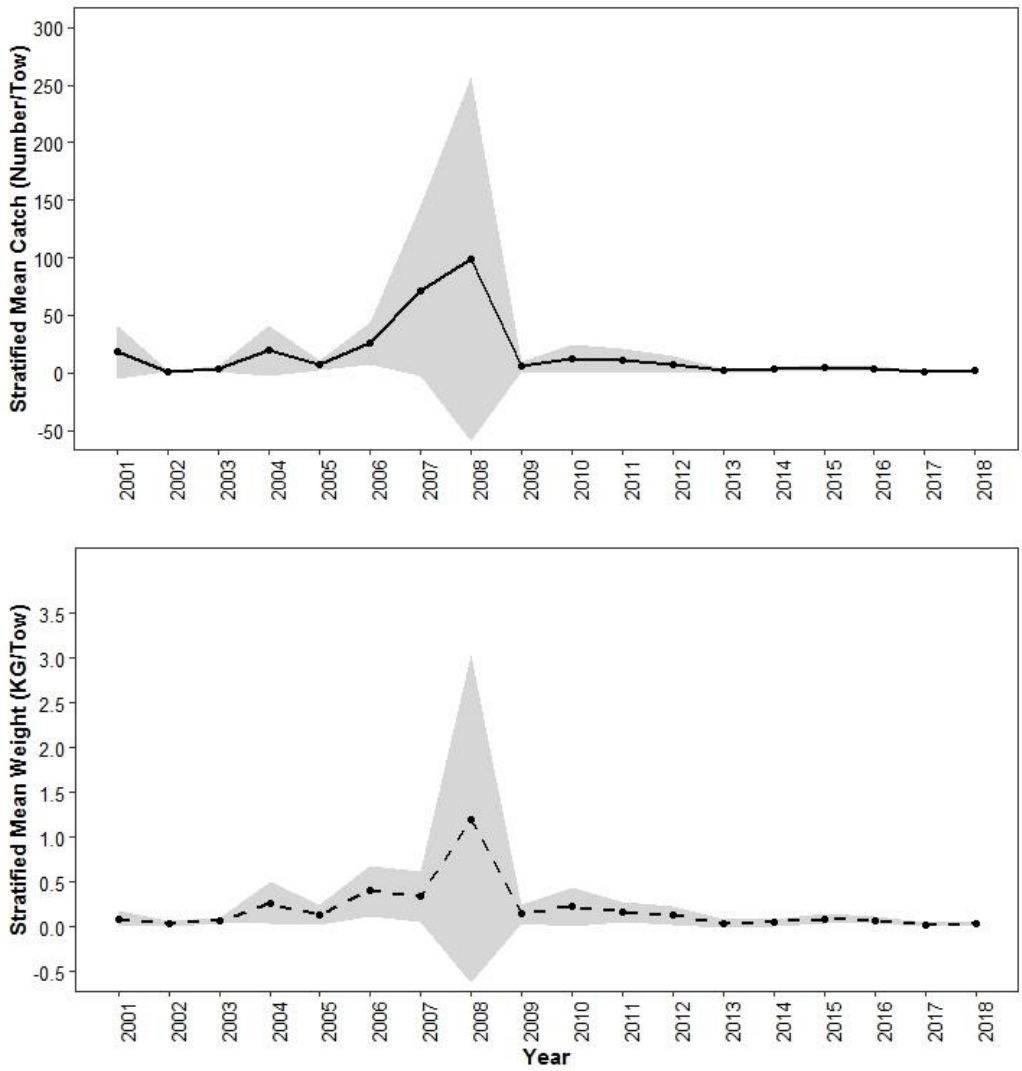

Figure 39: Stratified mean catch (top) and weight (bottom) for rainbow smelt from the spring surveys from 2001-2018. The shaded regions in each plot indicates the 95% confidence interval.

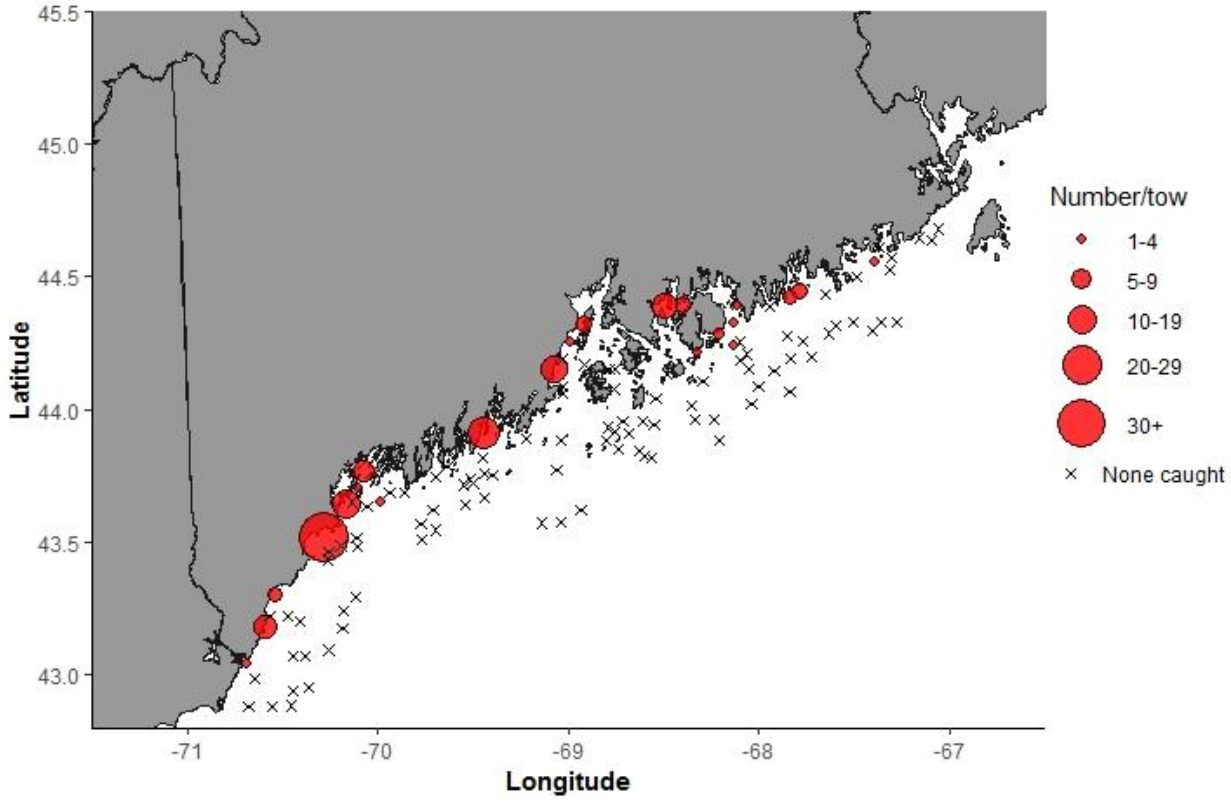

Figure 40: Distribution of rainbow smelt catch in the Spring 2018 survey.

Since the start of the spring survey in 2001, sizes of smelt observed in the survey were between 5 and 20 cm (Figure 41). When catch of rainbow smelt peaked in 2008 two size classes of smelt were caught, 7 to 12 cm and 15 to 20 cm. Since that peak, those two size classes are still caught, but in the low numbers (Figure 41).

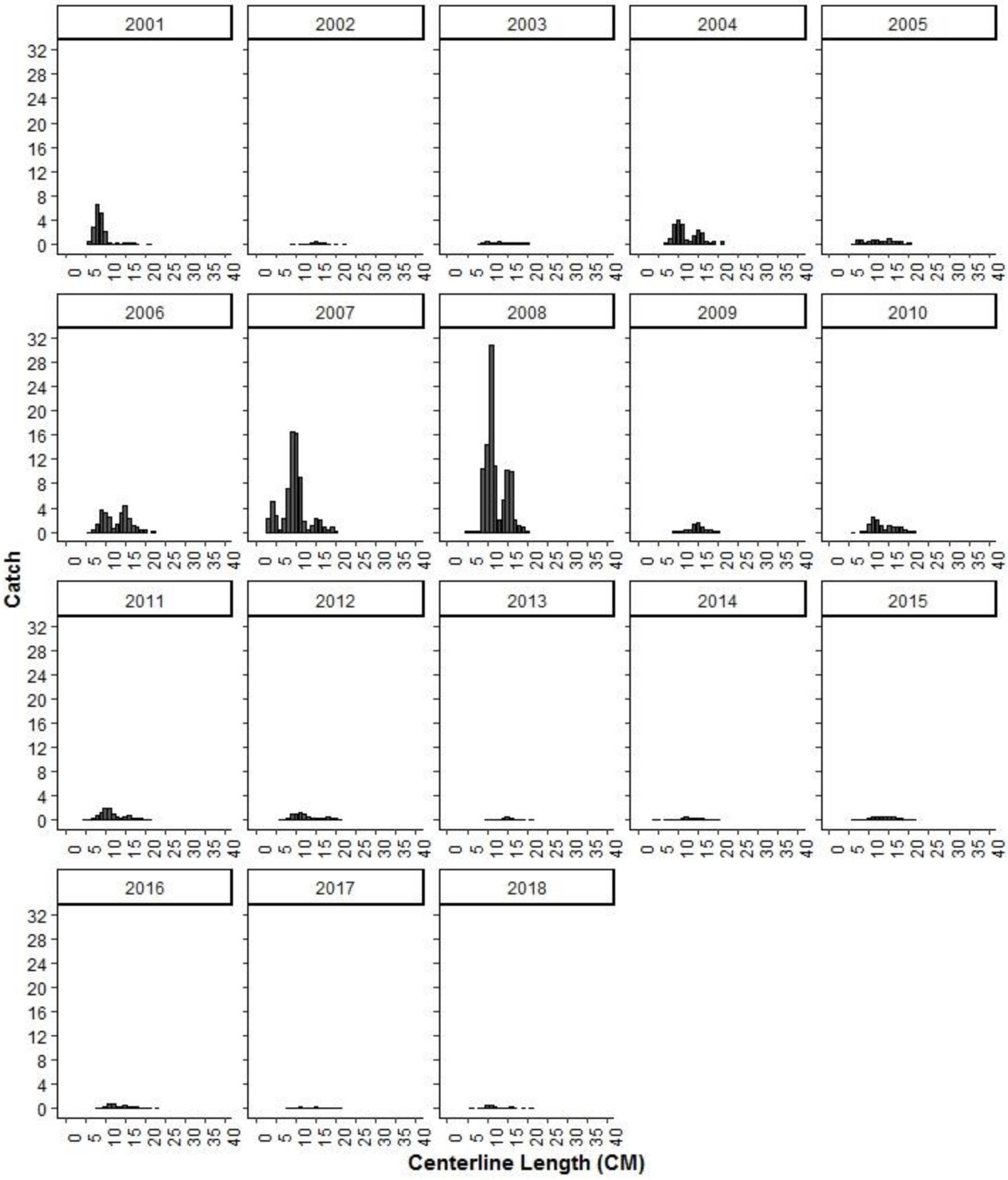

Figure 41: Length frequency distribution of rainbow smelt in the spring surveys from 2001 to 2018.

Fall

Catch of smelt are higher in the fall surveys when compared to the spring. Average catch has fluctuated since the start of the fall surveys in 2000, but there has been a decreasing trend since the peak catch in 2005 which continued in the 2018 survey (Figure 42). Catch in the 2018 survey was concentrated in inshore areas near Mt. Desert Island in region 4 of the survey (Figure 43).

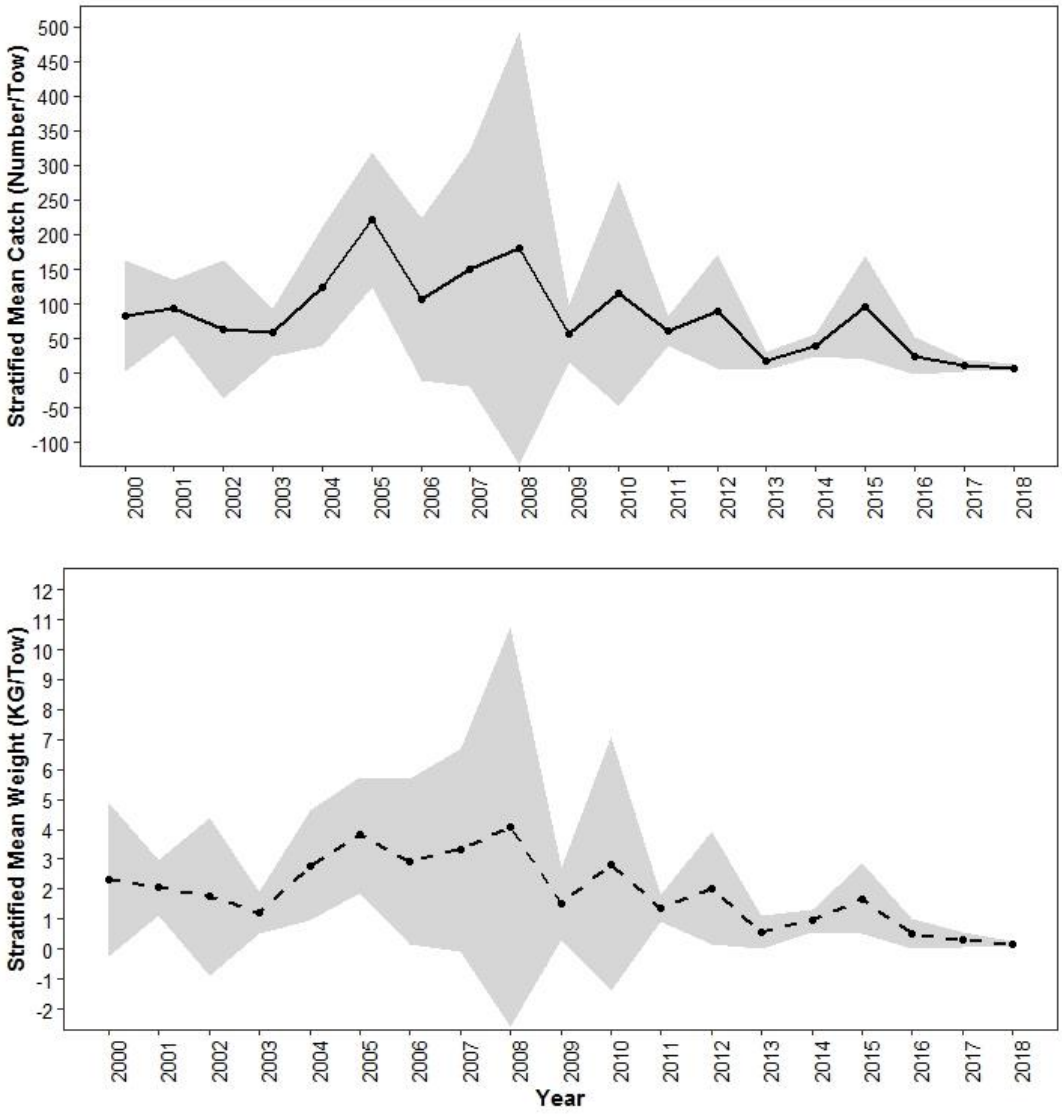

Figure 42: Stratified mean catch (top) and weight (bottom) for rainbow smelt from the fall surveys from 2000-2018. The shaded region in each plot indicates the 95% confidence interval.

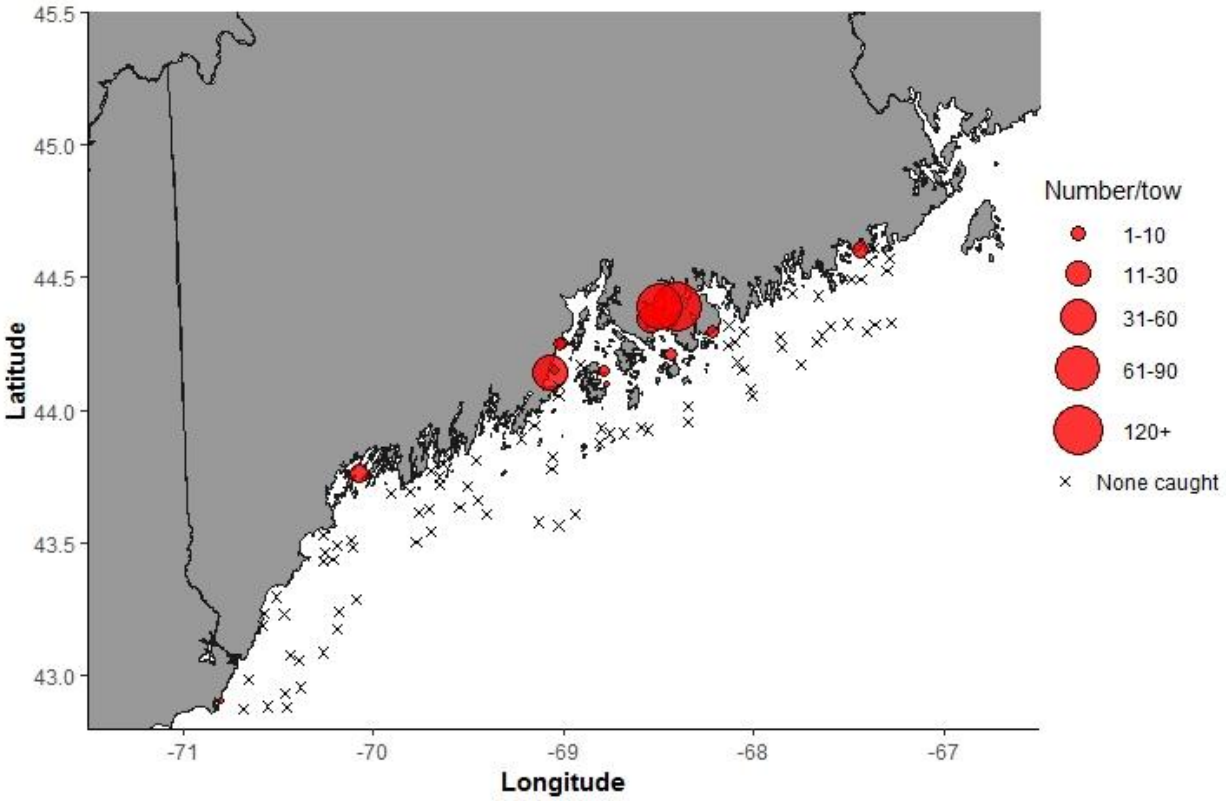

Figure 43: Distribution of rainbow smelt catch in the Fall 2018 survey.

Rainbow smelt between 5 and 25 cm are caught in the fall survey, with most of the smelt caught between 10 and 20 cm (Figure 44). In past surveys two size classes were caught (5 to 10 cm and 10 to 20 cm), however, in the two most recent surveys, that also have low average catch, the smaller size class is not present (Figure 44).

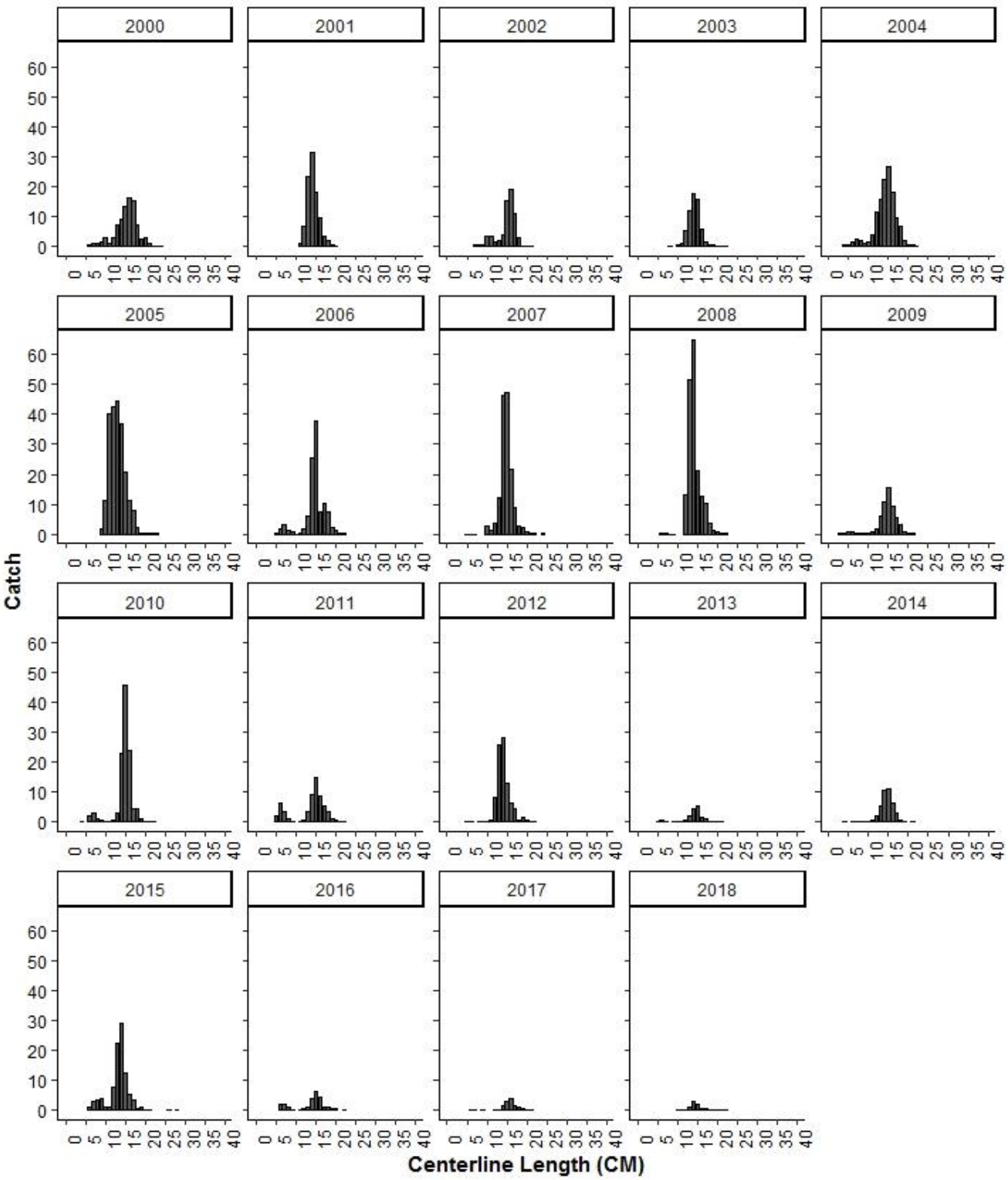

Figure 44: Length frequency distribution of rainbow smelt in the fall surveys from 2000 to 2018.

American Shad

American shad are caught in both spring and fall surveys of the MENH Survey. They are normally caught with other anadromous species such as Atlantic and river herring, but are not as common as those species. Even

though a bottom trawl survey may not be the optimum way to track an anadromous species like American shad, the data from the MENH Survey can provide valuable information on their relative abundance and size of the species that occur in the inshore waters in the Gulf of Maine.

Spring

Average catch of American shad in the spring surveys has fluctuated over time and has remained constant since 2015 (Figure 45). In the Spring 2018 survey, the largest catch of American shad occurred in inshore areas of region 2 (Figure 46).

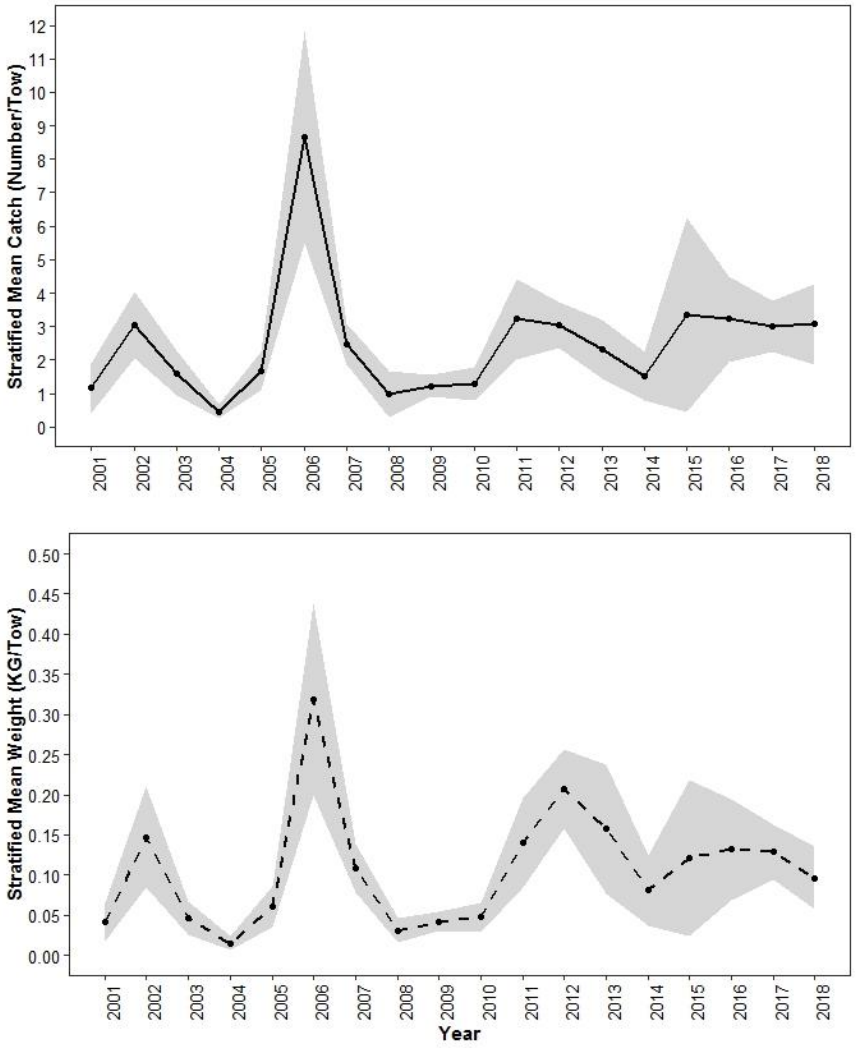

Figure 45: Stratified mean catch (top) and weight (bottom) for American shad from the spring surveys from 2001-2018. The shaded region in each plot indicates the 95% confidence interval.

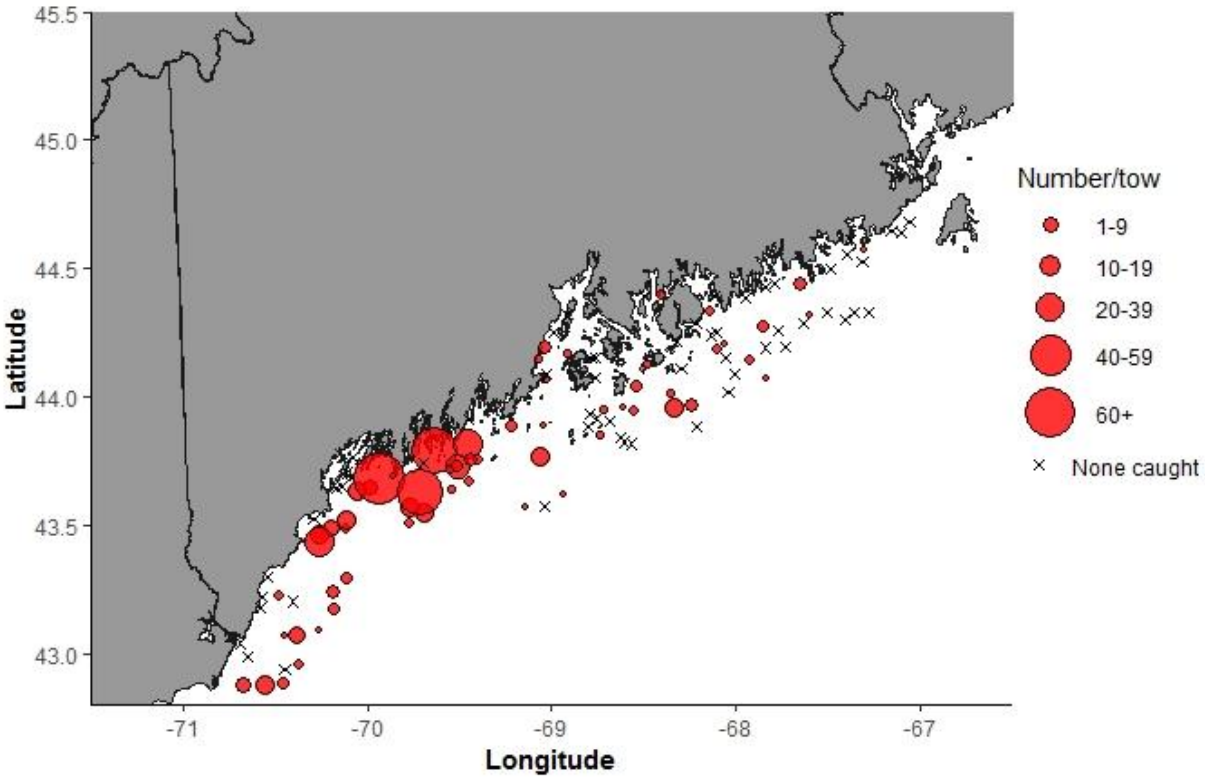

Figure 46: Distribution of American shad catch in the Spring 2018 survey.

Lengths of American shad caught in the spring surveys range between 7 and 25 cm, with most of the shad caught between 10 and 20 cm (Figure 47). Larger shad, greater than 30 cm, were seen in spring surveys in 2012, 2014, 2015, 2016, and 2017. Larger sized shad were absent in the Spring 2018 survey, and the size range observed was similar to the past years of 7 to 25 cm.

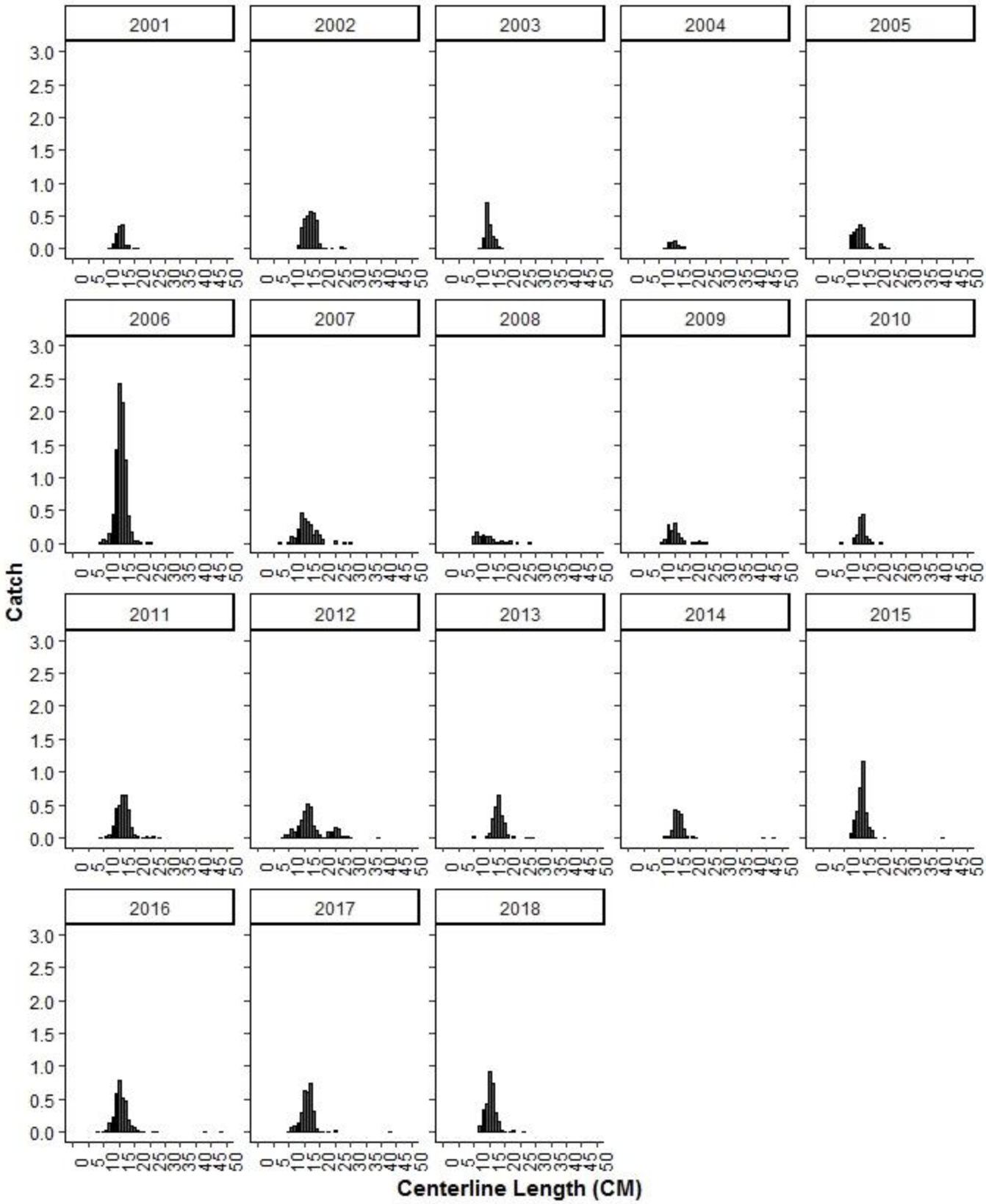

Figure 47: Length frequency distribution of American shad in the spring surveys from 2001 to 2018.

Fall

Average catch of American shad in the fall surveys has shown an interesting trend over time. Since the start of the survey in 2000, the average catch of American shad peaked every four years, and there has been a slight increase in those peak catches over time (Figure 48). In the Fall 2018 survey the largest catches occurred in inshore areas of regions 1, 2, and 3 (Figure 49).

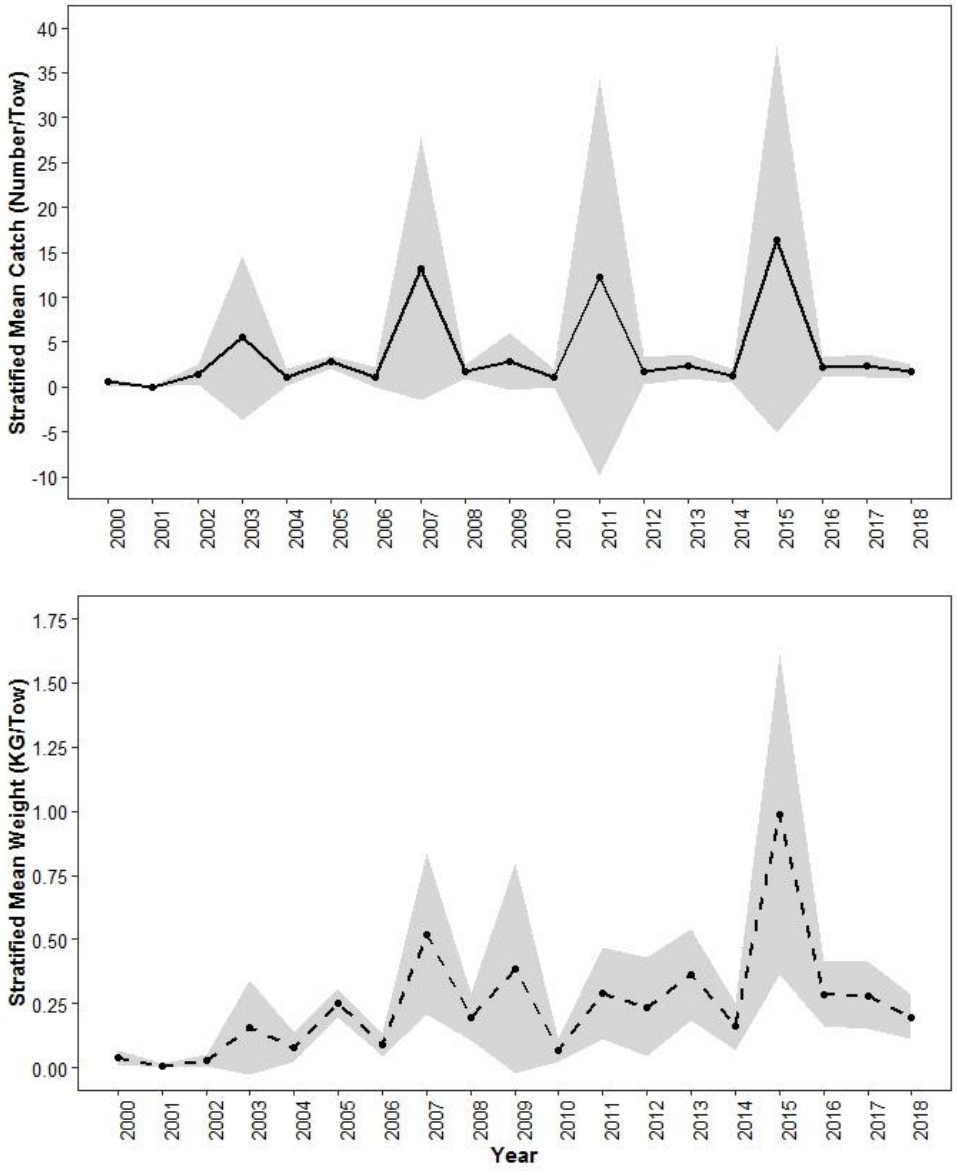

Figure 48: Stratified mean catch (top) and weight (bottom) for American shad from the fall surveys from 2000 to 2018. The shaded region in each plot indicates the 95% confidence interval.

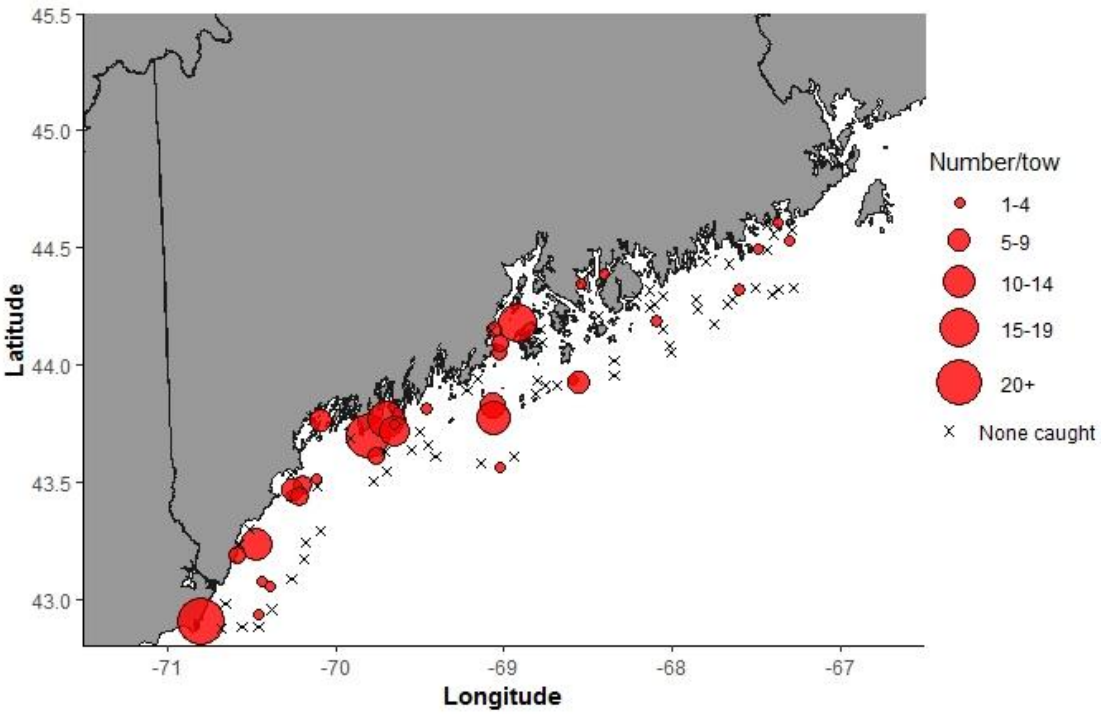

Figure 49: Distribution of American shad catch in the Fall 2018 survey.

The size range of American shad in the fall surveys can potentially explain the trend seen in the average catch over time. There are two size classes of American shad caught in the fall surveys, 7 to 15 cm and 20 to 30 cm (Figure 50). In most years of the fall survey catch at these lengths are low, except for the years when average catch peaks. During these years (2003 ,2007, 2011, and 2015) a large number of small American shad (<12cm) are caught and another smaller peak in catch occurs for sizes 20 to 30 cm. The 2003, 2007, 2011, and 2015 may be strong spawning years which produce a strong year class for American shad in Maine waters. Since American shad return to their natal rivers to spawn around four years of age (Collette and Klein-MacPhee 2002), the peak in catch every four years could be the shad produced from those strong year classes returning to their natal river to spawn.

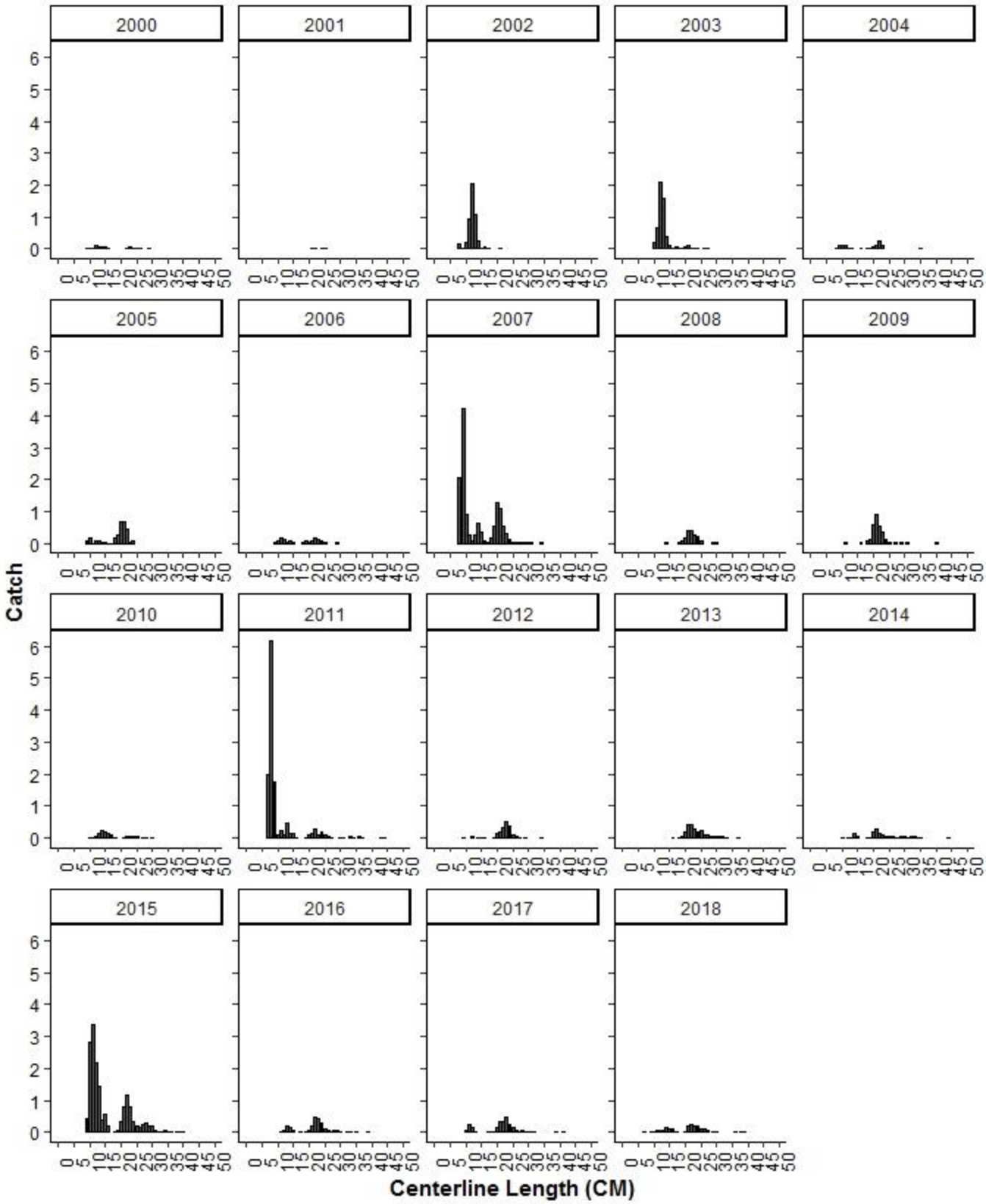

Figure 50: Length frequency distribution of American shad in the fall surveys from 2000 to 2018.

References

Burnett, J., L. O'Brien, R. K. Mayo, J. A. Darde, and M. Bohan. 1989. Finfish maturity sampling and classification schemes used during Northeast Fisheries Science Center bottom trawl surveys, 1963–1989. Northeast Fisheries Science Center, 166 Water Street, Woods Hole, MA 02543-1026, NOAA Tech. Mem., NMFS-F/ NEC-76, 14 p

Collette, B. B., and G. Klein-MacPhee, editors. 2002. Bigelow and Schroeder's Fishes of the Gulf of Maine, 3rd edition. Smithsonian Institution Press, Washington, D.C.