

Update of Landings, Discards and Survey Indices for Spiny Dogfish in 2018-2019

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Commercial Data

The stock of spiny dogfish encompasses the area from NAFO Subarea 2 through 6 (Labrador to North Carolina). This document summarizes the most recent information on spiny dogfish stock status in 2019 and catch data through 2018. Landings data include landings from US and distant water commercial fisheries, and US recreational landings. Discard information includes discards from US commercial fisheries estimated by the SBRM approach and US recreational fisheries. Estimates of dead discards are obtained by multiplying the discards by the gear-specific discard mortality rates.

Recreational landings and discards were obtained from the Marine Recreational Information Program (MRIP) <http://www.st.nmfs.noaa.gov/recreational-fisheries/access-data/run-a-data-query/index>. Canadian and distant water landings were obtained from the Northwest Atlantic Fisheries Organization (NAFO) catch statistics database (<https://www.nafo.int/Data/STATLANT>) for both spiny dogfish and unclassified dogfishes for NAFO Subareas 2-4.

Total landings are summarized in **Table 1** and **Figure 1**. US commercial landings decreased 22% from 8,919 mt in 2017 to 6,958 mt in 2018 (**Table 1**). Recreational landings and distant water fleet landings were negligible, totaling only 99 mt. Canadian landings have been less than 100 tons since 2009.

The value of commercial landings for 2017 is lower than the value in the 2018 report (Sosebee and Rago 2018) due to the correction of duplicate records in the database. The stochastic estimator was re-run for 2017 to see the impact of this change. The fishing mortality estimate with the reduced commercial landings changed from 0.202 to 0.168 while the SSB did not change.

The recreational catch estimates obtained from MRIP have been revised since the 2018 report. Although some changes are large for the landed portion (A+B1), (**Table 2, Figure 2**), the totals are still small relative to the commercial landings. The change for the discards (B2) was large and since 2003 was entirely in one direction with the new estimates increasing an average of 165% over that time period (**Table 2, Figure 3**). The stochastic estimator was re-run for the year with the second largest change (2014; the largest change was in 2013 for which no value of fishing mortality was estimated due to the missing 2014 survey) and for 2017. In 2014, the

fishing mortality increased from 0.214 to 0.239. The change in the MRIP estimates in 2017 along with the change in Virginia landings changed the fishing mortality to 0.173.

The precision of the recreational landings (catch types A and B1) in 2018 was relatively poor with Proportional Standard Errors of 69.8 and 53.1% respectively (Table 2). The precision of the discarded dogfish estimates (B2) was much better at 19.5%

The primary sources of commercial discards are otter trawls (3,938 mt; CV=9.7%) and sink gill nets (1,111 mt; CV=18.4%). Discards of spiny dogfish by scallop dredges (135 mt; CV=14.4%) and long lines (18 mt; CV=17.9%) are less important (Table 3). The trawl discards include the three observed trips and total commercial landings from the Max Retention Electronic Monitoring program since the discard to kept ratio was 0.0213 with the trips and 0.0210 without the trips. This resulted in a difference of 9 tons of trawl discards.

Total discards in 2018 of 8,999 mt were 11% less than the 10,157 mt in 2017 and 50% less than the previous 5 year average (Table 4, Figure 4). This value was the third lowest in the time series. Similar patterns were observed for dead discards. There were no major changes in the discarding patterns among fleets. The ratio of dead discards to landings of 45% in 2018 was similar to the last three years. The ratios of total discards to landings and total dead discards to landings exhibited a generally declining trend since 2004 (Figure 5). The total catch estimate in 2018 of 10,111 mt (Table 4) was 44% of the 2018 ABC of 23,045 mt.

Biological samples collected by port agents are used to estimate the size and sex composition of the spiny dogfish landings (Table 5). Overall landings are dominated by females, a trend that has persisted since the US EEZ fishery began (Figure 6). Most fishing takes place near shore where females are more abundant (Appendix 2). The fraction of male dogfish in the landings increased in 2018 to about 10%. About 2.8 million spiny dogfish were landed in 2018. This was a decrease of about 17% in total numbers landed since 2017 (Table 5).

Although sex ratios of discarded fish are dominated by females, they represent only 65% of total discards by weight (Table 6) compared to the 90% of landings. This difference is likely due to the males being discarded at a higher rate than females. On a numerical basis, about 62% of the female dogfish caught and killed in 2018 were landed (Tables 5 and 6). In contrast, only about 30% of male dogfish caught were landed.

Survey Data

The Northeast Fisheries Science Center (NEFSC) bottom trawl survey was delayed in 2016 however all of the core survey strata were completed. In contrast, mechanical problems on the FSV Bigelow in 2014 not only delayed the NEFSC spring bottom trawl survey but also resulted in the loss of critical survey strata in the Mid-Atlantic region. The potential effects of the delay in survey timing in 2016 on the abundance indices are unknown.

Survey estimates of relative abundance from Bigelow surveys were converted to Albatross-equivalent estimates using the methods described in Miller et al. (2010).

The three-point moving average of female spawning stock biomass estimates from 2009 to 2015 exceeded the female spawning stock biomass target (159,288 mt; Rago and Sosebee 2010). The biomass estimates increased in 2016 and it is unknown whether the delay in the 2016 survey made the estimate non-representative. Swept area abundance estimates for both male and female spiny dogfish decreased in 2017 compared to 2016 (Table 7, Figure 7). The female SSB estimate for 2017 of 24,400 mt was the lowest in the time series, likely the result of decreased availability to the survey since all size and sex classes decreased. There is no a priori reason to remove this value from the three-year average since the survey was conducted on time and covered all strata. The spatial distribution for 2017 was unusual since almost no dogfish were caught on Georges Bank (Sosebee and Rago 2018). The distribution in 2019 is similar to 2017 and 2018, however, the total survey catch was higher (Table 7). The 3-yr average of the mature female swept area biomass was 102 kt in 2018 and decreased to 83 kt in 2019 because the high 2016 value in the 3 year average was replaced by the lower survey biomass estimate from 2019. This is still above the biomass threshold and it would take a value lower than 24,400 mt in 2020 to cause an overfished condition next year. It is important to note that the comparisons with the biomass target and threshold are based on outputs of the stochastic model (which was not updated this year) rather than the simple 3-yr average. However, these quantities are closely correlated so the raw survey data provides a first approximation.

Pup production (Figure 8) in 2019 was below both the long term (1968-2018) mean (2.54 kg/tow) and median (1.64 kg/tow) values. The ratio of mature males to mature females increased five-fold (Figure 9) in 2017 but decreased to values similar to that of 2013-2016 in 2018 and 2019. The increase in 2017 may have been a year specific effect. The mean length of mature females has been relatively stable since 2011 above the average of 1997-2003 when recruitment was low (Figure 10). The mean length of pups (Figure 11) in 2017 and 2018 was near or above the long term mean and median values and well above the average of 1997-2003 when recruitment was low. The sizes of mature females and males have been maintained. (Figure 12). The size composition of sub adults is broadening and approaching distribution seen prior to major fisheries in 1990s.

References

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Table 1. Total spiny dogfish landings (mt, live) in NAFO Areas 2 to 6, 1962-2018.

Year	United States			Canada	Distant Water Fleets	Old Total Landings	New Total Landings
	Commercial	Old Recreational	New Recreational				
1962	235			0	0	235	235
1963	610			0	1	611	611
1964	730			0	16	746	746
1965	488			9	198	695	695
1966	578			39	9,389	10,006	10,006
1967	278			0	2,436	2,714	2,714
1968	158			0	4,404	4,562	4,562
1969	113			0	9,190	9,303	9,303
1970	106			19	5,640	5,765	5,765
1971	73			4	11,566	11,643	11,643
1972	69			3	23,991	24,063	24,063
1973	89			20	18,793	18,902	18,902
1974	127			36	24,513	24,676	24,676
1975	147			1	22,523	22,671	22,671
1976	550			3	16,788	17,341	17,341
1977	931			1	7,199	8,131	8,131
1978	828			84	622	1,534	1,534
1979	4,753			1,331	187	6,271	6,271
1980	4,085			660	599	5,344	5,344
1981	6,865	1,493	2,017	564	974	9,896	10,420
1982	5,411	70	56	389	364	6,234	6,220
1983	4,897	67	111		464	5,428	5,472
1984	4,450	91	102	2	391	4,935	4,945
1985	4,028	89	48	13	1,012	5,142	5,101
1986	2,748	182	236	20	368	3,318	3,371
1987	2,703	306	321	281	139	3,429	3,445
1988	3,105	359	348	1	647	4,112	4,101
1989	4,492	418	220	167	256	5,333	5,135
1990	14,731	179	215	1,309	393	16,611	16,648
1991	13,177	131	240	307	234	13,848	13,957
1992	16,858	215	173	868	67	18,008	17,966
1993	20,643	120	187	1,435	27	22,225	22,292
1994	18,798	155	146	1,820	2	20,774	20,766
1995	22,578	68	89	956	14	23,615	23,637
1996	27,136	25	27	431	236	27,827	27,830
1997	18,351	66	110	446	214	19,078	19,121
1998	20,628	39	36	1,055	607	22,329	22,326
1999	14,855	53	83	2,091	554	17,552	17,582
2000	9,257	5	4	2,741	402	12,405	12,404
2001	2,294	28	25	3,820	677	6,819	6,816
2002	2,199	205	358	3,584	474	6,462	6,614
2003	1,170	40	54	1,302	643	3,155	3,169
2004	982	105	357	2,362	330	3,778	4,030
2005	1,147	45	42	2,270	330	3,792	3,789
2006	2,249	94	74	2,439	10	4,792	4,772
2007	3,503	84	129	2,384	31	6,002	6,047
2008	4,108	214	236	1,572	131	6,025	6,048
2009	5,377	34	102	113	82	5,606	5,674
2010	5,440	21	12	6	127	5,594	5,585
2011	9,480	32	58	124	143	9,779	9,805
2012	10,660	19	45	65	137	10,881	10,907
2013	7,312	37	67	NA	61	7,410	7,440
2014	10,651	31	108	54	31	10,767	10,844
2015	8,663	39	44	1	23	8,726	8,731
2016	12,097	73	141	37	24	12,231	12,299
2017	8,735	81	130	54	0	8,870	8,919
2018	6,878	21	35	45	0	6,944	6,958

Table 2. Summary of spiny dogfish landings and discards based on revised Marine Recreational Information Program estimates. As in previous assessments, the average weight of landed and discarded spiny dogfish is assumed to be 2.5 kg. Discard mortality is assumed to be 20%. The percent change from the previous values is given for landings and dead discards.

Year	Catch in Numbers								Numbers		Weight			Estimates used in Previous assessments			
	Observed Harvest (A)	PSE	Reported Harvest (B1)	PSE	Released Alive (B2)	PSE	Total Catch A+B1+B2	PSE	Total Landings A+B1 (number)	Discards B2 (number)	Landings (A+B1) (mt)	Discards (B2) (mt)	Dead Discards (mt)	Landings (mt)	Discards (mt)	% change Landings	% change Discard
1981	1,540	56.5	805,317	65.9	128,652	26.2	935,509	57.1	806,857	128,652	2017	322	64	1,493	59	35.1	8.6
1982	13,193	55.5	9,398	33.6	161,147	43.4	183,738	39.4	22,591	161,147	56	403	81	70	70	-19.8	15.3
1983	14,579	50.4	29,826	48.4	294,107	21.1	338,512	19.7	44,405	294,107	111	735	147	67	108	65.5	36.2
1984	17,680	73.1	23,124	40.7	994,439	67.6	1,035,243	65.0	40,804	994,439	102	2486	497	91	85	11.7	486.4
1985	24,512	86.4	34,792	55.0	167,371	32.5	226,675	27.4	59,304	167,371	148	418	84	89	193	66.3	-56.6
1986	13,036	33.0	81,888	40.6	564,352	24.7	659,276	21.9	94,924	564,352	237	1411	282	183	237	29.5	18.8
1987	64,431	78.1	64,119	50.6	373,458	42.0	502,008	33.8	128,550	373,458	321	934	187	306	211	5.0	-11.6
1988	56,212	40.4	87,845	37.7	545,672	23.6	689,729	20.3	144,057	545,672	360	1364	273	360	175	0.0	55.7
1989	49,649	57.6	72,777	28.3	794,579	28.5	917,005	25.8	122,426	794,579	306	1986	397	419	270	-26.9	47.2
1990	55,501	41.6	71,655	35.2	753,649	20.3	880,805	19.4	127,156	753,649	318	1884	377	179	234	78.1	61.0
1991	81,441	29.6	53,394	35.9	1,040,163	18.4	1,174,998	16.9	134,835	1,040,163	337	2600	520	131	270	157.6	92.7
1992	123,555	48.6	32,165	27.4	523,665	16.0	679,385	15.7	155,720	523,665	389	1309	262	243	204	60.1	28.5
1993	38,093	34.3	40,403	42.4	778,604	19.7	857,100	18.1	78,496	778,604	196	1947	389	120	222	63.9	75.3
1994	13,890	40.4	44,574	58.6	593,746	22.4	652,210	20.9	58,464	593,746	146	1484	297	155	194	-5.6	53.3
1995	19,030	30.4	16,562	47.2	356,311	25.3	391,903	23.4	35,592	356,311	89	891	178	68	131	31.7	36.3
1996	6,753	44.0	4,365	68.8	186,192	19.4	197,310	18.6	11,118	186,192	28	465	93	26	66	7.5	41.4
1997	31,872	48.1	12,055	70.1	487,269	20.3	531,196	19.3	43,927	487,269	110	1218	244	66	169	65.1	44.4
1998	21,530	41.4	44,432	94.1	417,596	22.4	483,558	21.9	65,962	417,596	165	1044	209	61	122	171.7	71.2
1999	21,757	63.3	13,231	74.5	362,473	19.7	397,461	19.7	34,988	362,473	87	906	181	54	107	61.2	68.6
2000	1,640	44.0	96	85.7	335,904	24.6	337,640	24.5	1,736	335,904	4	840	168	5	138	-15.1	21.6
2001	6,751	56.3	3,352	68.5	1,153,341	12.5	1,163,444	12.4	10,103	1,153,341	25	2883	577	28	421	-10.0	36.9
2002	3,000	37.6	140,033	66.1	997,419	15.0	1,140,452	15.3	143,033	997,419	358	2494	499	205	335	74.5	49.0
2003	15,581	42.0	8,584	56.6	1,584,326	14.1	1,608,491	14.0	24,165	1,584,326	60	3961	792	40	600	52.2	32.1
2004	75,946	49.1	71,732	50.2	2,705,518	13.8	2,853,196	13.3	147,678	2,705,518	369	6764	1353	120	658	207.1	105.6
2005	8,811	41.4	10,001	42.8	1,983,774	19.3	2,002,586	19.2	18,812	1,983,774	47	4959	992	35	670	33.2	48.1
2006	7,980	40.1	23,195	61.2	2,336,176	13.9	2,367,351	13.8	31,175	2,336,176	78	5840	1168	80	710	-2.0	64.5
2007	3,319	62.0	48,365	63.3	2,413,174	14.0	2,464,858	13.8	51,684	2,413,174	129	6033	1207	86	779	49.9	55.0
2008	25,731	36.9	68,959	48.3	2,216,029	13.3	2,310,719	13.1	94,690	2,216,029	237	5540	1108	114	539	107.5	105.5
2009	9,216	42.2	33,972	39.0	2,885,331	14.8	2,928,519	14.6	43,188	2,885,331	108	7213	1443	43	516	152.8	179.6
2010	5,112	42.0	10,637	66.5	1,936,270	19.9	1,952,019	19.7	15,749	1,936,270	39	4841	968	16	395	145.0	145.0
2011	16,750	39.9	17,716	54.7	2,372,432	15.8	2,406,898	15.6	34,466	2,372,432	86	5931	1186	32	462	169.2	156.5
2012	6,629	68.7	12,719	81.7	1,726,341	27.6	1,745,689	27.3	19,348	1,726,341	48	4316	863	19	275	157.4	214.0
2013	20,326	56.2	55,131	73.0	4,803,736	19.0	4,879,193	19.3	75,457	4,803,736	189	12009	2402	37	531	414.2	352.7
2014	5,159	56.6	39,952	25.5	7,008,107	43.0	7,053,218	42.7	45,111	7,008,107	113	17520	3504	32	950	256.0	268.7
2015	9,173	56.7	16,379	62.9	1,711,330	22.3	1,736,882	22.0	25,552	1,711,330	64	4278	856	39	244	62.1	250.0
2016	35,052	80.7	43,877	62.6	3,630,248	26.1	3,709,177	25.8	78,929	3,630,248	197	9076	1815	73	625	169.8	190.2
2017	18,173	64.8	34,495	38.8	1,426,245	21.1	1,478,913	20.6	52,668	1,426,245	132	3566	713	81	183	62.4	289.1
2018	4604	69.8	16,864	53.1	1490265	19.5	1,511,733	19.2	21,468	1,490,265	54	3726	745	21	241	150.6	208.6

Table 3. Estimated total discards of spiny dogfish (mt) from commercial and recreational US fisheries, 1981-2018. The values for otter trawl and gill net from 1981-1989 are hindcast estimates (see SARC 43).

							Assumed Discard Mortality Rate					
							0.50	0.30	0.75	0.10	0.20	
Total Discards (mt)							Dead Discards					
Year	Otter Trawl	Sink Gill Net	Scallop Dredge	Line gear	Recreational	Total	Otter Trawl	Sink Gill Net	Scallop Dredge	Line gear	Recreational	Total Dead
1981	36,360	5,360	na	na	322	42,042	18,180	1,608	na	na	64	19,852
1982	42,910	4,454	na	na	403	47,767	21,455	1,336	na	na	81	22,872
1983	42,188	4,042	na	na	735	46,965	21,094	1,213	na	na	147	22,454
1984	39,625	4,918	na	na	2,486	47,029	19,813	1,475	na	na	497	21,785
1985	33,354	4,539	na	na	418	38,311	16,677	1,362	na	na	84	18,122
1986	31,745	4,883	na	na	1,411	38,039	15,873	1,465	na	na	282	17,620
1987	29,050	4,864	na	na	934	34,848	14,525	1,459	na	na	187	16,171
1988	28,951	5,132	na	na	1,364	35,447	14,476	1,540	na	na	273	16,288
1989	28,286	5,360	na	na	1,986	35,632	14,143	1,608	na	na	397	16,148
1990	34,242	6,062	na	na	1,884	42,188	17,121	1,819	na	na	377	19,316
1991	19,322	11,030	32	97	2,600	33,081	9,661	3,309	24	10	520	13,524
1992	32,617	5,953	827	650	1,309	41,356	16,309	1,786	620	65	262	19,041
1993	17,284	9,814	209	44	1,947	29,298	8,642	2,944	157	4	389	12,137
1994	13,908	2,887	723	na	1,484	19,002	6,954	866	542	na	297	8,659
1995	16,997	6,731	378	na	891	24,997	8,499	2,019	284	na	178	10,979
1996	9,402	3,890	121	na	465	13,878	4,701	1,167	91	na	93	6,052
1997	6,704	2,326	198	na	1,218	10,446	3,352	698	149	na	244	4,442
1998	5,268	1,965	120	na	1,044	8,397	2,634	590	90	na	209	3,522
1999	7,685	2,005	41	na	906	10,637	3,843	602	31	na	181	4,656
2000	2,728	4,684	14	na	840	8,266	1,364	1,405	11	na	168	2,948
2001	4,919	7,204	30	na	2,883	15,036	2,460	2,161	23	na	577	5,220
2002	5,540	4,997	58	4,015	2,494	17,104	2,770	1,499	44	402	499	5,213
2003	3,853	5,413	103	2	3,961	13,332	1,927	1,624	77	0	792	4,420
2004	8,299	4,031	53	497	6,764	19,644	4,150	1,209	40	50	1,353	6,801
2005	7,515	3,338	15	1,175	4,959	17,002	3,758	1,001	11	118	992	5,880
2006	7,773	3,369	14	131	5,840	17,127	3,886	1,011	10	13	1,168	6,088
2007	8,115	5,133	61	73	6,033	19,415	4,058	1,540	45	7	1,207	6,857
2008	5,604	4,864	237	260	5,540	16,505	2,802	1,459	178	26	1,108	5,573
2009	7,010	4,874	364	835	7,213	20,296	3,505	1,462	273	84	1,443	6,766
2010	5,564	2,385	196	509	4,841	13,494	2,782	716	147	51	968	4,663

Table 3 cont.

							Assumed Discard Mortality Rate					
							0.50	0.30	0.75	0.10	0.20	
Total Discards (mt)							Dead Discards					
Year	Otter Trawl	Sink Gill Net	Scallop Dredge	Line gear	Recreational	Total	Otter Trawl	Sink Gill Net	Scallop Dredge	Line gear	Recreational	Total Dead
2011	6,540	2,831	226	356	5,931	15,883	3,270	849	170	36	1,186	5,510
2012	6,687	2,959	432	172	4,316	14,567	3,344	888	324	17	863	5,436
2013	6,897	3,107	127	37	12,009	22,177	3,448	932	95	4	2,402	6,881
2014	8,070	2,388	108	17	17,520	28,104	4,035	716	81	2	3,504	8,338
2015	5,096	1,655	41	19	4,278	11,089	2,548	496	31	2	856	3,933
2016	5,084	1,941	120	165	9,076	16,386	2,542	582	90	17	1,815	5,046
2017	5,451	881	75	185	3,566	10,157	2,726	264	56	19	713	3,777
2018	3,928	1,111	135	101	3,726	8,999	1,964	333	101	10	745	3,153

Table 4. Total landings, discards and total catch for spiny dogfish, 1989-2018.

Year	Total Discard (mt)	Total Dead Discards (mt)	Total Landings (mt)	Dead Discard/ Landings	Total Discard / Landings	Total Catch (mt)
1989	35,632	16,148	5,135	3.00	6.56	21,353
1990	42,188	19,316	16,648	1.15	2.50	35,785
1991	33,081	13,524	13,957	0.96	2.30	27,122
1992	41,356	19,041	17,966	1.05	2.28	36,991
1993	29,298	12,137	22,292	0.54	1.28	34,194
1994	19,002	8,659	20,766	0.41	0.89	29,330
1995	24,997	10,979	23,637	0.46	1.05	34,547
1996	13,878	6,052	27,830	0.22	0.49	33,852
1997	10,446	4,442	19,121	0.23	0.53	23,443
1998	8,397	3,522	22,326	0.15	0.36	25,764
1999	10,637	4,656	17,582	0.26	0.58	22,134
2000	8,266	2,948	12,404	0.24	0.65	15,321
2001	15,036	5,220	6,816	0.74	2.09	11,882
2002	17,104	5,213	6,614	0.78	2.52	11,510
2003	13,332	4,420	3,169	1.34	3.92	7,380
2004	19,644	6,801	4,030	1.63	4.33	9,925
2005	17,002	5,880	3,789	1.47	4.10	9,382
2006	17,127	6,088	4,772	1.19	3.16	10,480
2007	19,415	6,857	6,047	1.08	2.95	12,512
2008	16,505	5,573	6,048	0.84	2.34	11,113
2009	20,296	6,766	5,674	1.05	2.85	11,503
2010	13,494	4,663	5,585	0.73	1.89	9,675
2011	15,883	5,510	9,805	0.56	1.62	15,315
2012	14,567	5,436	10,907	0.50	1.34	16,343
2013	22,177	6,881	7,440	0.92	2.98	14,321
2014	28,104	8,338	10,844	0.77	2.59	19,182
2015	11,089	3,933	8,731	0.45	1.27	12,664
2016	16,386	5,046	12,299	0.41	1.33	17,344
2017	10,157	3,777	8,919	0.42	1.14	12,696
2018	8,999	3,153	6,958	0.45	1.29	10,111

Table 5. Summary of estimated landings of US, Canadian and foreign fisheries by sex, 1982-2018. US recreational landings included. Estimated total weights based on sum of estimated weights from sampled length frequency distributions from port samples. Estimated weights computed for female as $W = \exp(-15.025)L^{3.606935}$ and males as $W = \exp(-13.002)L^{3.097787}$ with weight in kg and length in cm. "Samples" = number of measured dogfish.

Year	NMFS Biological Samples from Ports							Prorated Landings by Sex					
	Total Samples Males	Est Total Wt (kg) Males	Average Wt (kg) Males	Total Samples Females	Est Total Wt (kg) Females	Average Wt (kg) Females	Fraction Females by Weight	Total Landings (mt)	Est Landings (mt) of Males	Est Landings (mt) of Females	Number of Males Landed (000)	Number of Females Landed (000)	Total Numbers Landed (000)
1982	24	52.0	2.167	680	3,015.7	4.435	0.9830	6,220	106	6,128	49	1,382	1,431
1983				610	2,513.9	4.121	1.0000	5,472	0	5,428		1,317	1,317
1984	9	15.8	1.760	1,499	6,626.0	4.420	0.9976	4,945	12	4,923	7	1,114	1,120
1985	21	35.2	1.678	1,657	6,799.2	4.103	0.9948	5,101	27	5,116	16	1,247	1,263
1986	64	104.1	1.626	1,165	4,669.0	4.008	0.9782	3,371	72	3,246	44	810	854
1987	31	52.7	1.700	2,000	7,550.1	3.775	0.9931	3,445	24	3,406	14	902	916
1988	7	14.8	2.114	1,764	7,560.7	4.286	0.9980	4,101	8	4,104	4	957	961
1989	35	67.5	1.927	1,375	5,528.0	4.020	0.9879	5,135	64	5,269	33	1,311	1,344
1990	19	33.7	1.772	2,230	8,916.6	3.998	0.9962	16,648	63	16,549	35	4,139	4,174
1991	161	379.2	2.356	1,518	5,923.9	3.902	0.9398	13,957	833	13,015	354	3,335	3,689
1992	12	22.3	1.861	3,187	12,180.6	3.822	0.9982	17,966	33	17,975	18	4,703	4,721
1993	42	78.4	1.866	2,773	9,927.5	3.580	0.9922	22,292	174	22,051	93	6,159	6,253
1994	47	86.6	1.843	2,092	6,639.9	3.174	0.9871	20,766	267	20,507	145	6,461	6,606
1995	25	38.9	1.555	2,266	6,676.6	2.946	0.9942	23,637	137	23,479	88	7,969	8,056
1996	569	886.7	1.558	1,662	4,397.6	2.646	0.8322	27,830	4,669	23,158	2,996	8,752	11,749
1997	303	449.1	1.482	382	780.9	2.044	0.6349	19,121	6,966	12,112	4,700	5,925	10,625
1998	68	85.4	1.257	683	1,434.5	2.100	0.9438	22,326	1,255	21,073	999	10,034	11,033
1999	93	130.3	1.401	311	625.5	2.011	0.8276	17,582	3,026	14,527	2,160	7,223	9,382
2000	345	473.1	1.371	1,921	3,921.2	2.041	0.8923	12,404	1,335	11,069	974	5,423	6,397
2001	12	17.1	1.422	215	456.5	2.123	0.9640	6,816	246	6,573	173	3,096	3,269
2002	1	1.3	1.279	278	752.5	2.707	0.9983	6,614	11	6,451	9	2,383	2,392
2003	34	48.3	1.421	966	2,338.4	2.421	0.9798	3,169	64	3,091	45	1,277	1,322
2004	15	23.9	1.593	1,180	3,296.9	2.794	0.9928	4,030	27	3,751	17	1,343	1,360
2005	745	1018.7	1.367	2,065	5,196.0	2.516	0.8361	3,789	622	3,171	455	1,260	1,715
2006	646	924.4	1.431	4,211	10,382.9	2.466	0.9182	4,772	392	4,400	274	1,785	2,058
2007	507	720.7	1.421	2,865	7,514.8	2.623	0.9125	6,047	525	5,477	370	2,088	2,458
2008	236	342.0	1.449	2,925	7,973.8	2.726	0.9589	6,048	248	5,777	171	2,119	2,290
2009	472	696.6	1.476	3,378	9,161.6	2.712	0.9293	5,674	396	5,210	268	1,921	2,189
2010	821	1213.4	1.478	4,963	14,217.4	2.865	0.9214	5,585	439	5,146	297	1,796	2,094
2011	868	1109.9	1.279	4,800	12,786.8	2.664	0.9201	9,805	781	8,998	611	3,378	3,989
2012	213	371.8	1.746	3,763	10,727.9	2.851	0.9665	10,907	365	10,516	209	3,689	3,898
2013	450	736.7	1.637	5,441	16,258.3	2.988	0.9567	7,440	321	7,089	196	2,372	2,569
2014	546	830.6	1.521	4,505	13,198.1	2.930	0.9408	10,844	634	10,081	417	3,441	3,858
2015	1,164	1705.9	1.466	2,943	7,782.9	2.645	0.8202	8,731	1,569	7,157	1,070	2,706	3,777
2016	628	971.9	1.548	4,792	13,192.7	2.753	0.9314	12,299	844	11,455	545	4,161	4,706
2017	398	609.9	1.532	5,178	13,930.7	2.690	0.9581	8,919	374	8,545	244	3,176	3,420
2018	772	1179.8	1.528	3,861	10,210.0	2.644	0.8964	6,958	721	6,237	472	2,359	2,830
<i>formula</i>	<i>A</i>	<i>B</i>	$C=B/A$	<i>D</i>	<i>E</i>	$F=E/D$	$G=E/(E+B)$	<i>H</i>	$I=(1-G)*H$	$J=G*H$	$K=I/C$	$L=J/F$	$M=K+L$

Table 6. Summary of estimated discards of combined US fleets by sex, 1991-2018. Estimated total weights based on summation of estimated weights from sampled length frequency distributions. Estimated weights computed from length-weight regressions. Female $W = \exp(-15.025)L^{3.606935}$. Male $W = \exp(-13.002)L^{3.097787}$ with weight in kg and length in cm. "Samples" = number of measured dogfish that were discarded.

Year	NMFS Biological Samples from Observers							Prorated Discards by Sex					
	Total Samples Males	Est Total Wt (kg) Males	Average Wt (kg) Males	Total Samples Females	Est Total Wt (kg) Females	Average Wt (kg) Females	Fraction Females by Weight	Total Dead Discards (mt)	Est Landings (mt) of Males	Est Discards (mt) of Females	Number of Males Discarded (000)	Number of Females Discarded (000)	Total Numbers Discarded (000)
1991	376	463	1.231	894	2,350	2.628	0.8355	13,524	2,184	11,090	1,775	4,219	5,994
1992	449	504	1.123	632	1,090	1.724	0.6836	19,041	6,007	12,976	5,347	7,526	12,873
1993	57	62	1.087	130	414	3.184	0.8697	12,137	1,559	10,410	1,434	3,270	4,704
1994	207	207	1.001	747	1,397	1.870	0.8708	8,659	1,105	7,451	1,104	3,985	5,090
1995	2,191	2,342	1.069	2,384	3,064	1.285	0.5668	10,979	4,735	6,197	4,431	4,821	9,251
1996	1,643	1,833	1.115	1,370	2,013	1.469	0.5234	6,052	2,871	3,153	2,574	2,147	4,721
1997	1,359	1,391	1.024	1,427	2,070	1.451	0.5980	4,442	1,755	2,611	1,714	1,800	3,514
1998	1,289	1,320	1.024	1,463	1,939	1.326	0.5951	3,522	1,391	2,044	1,359	1,542	2,901
1999	447	440	0.984	870	1,808	2.078	0.8044	4,656	896	3,685	911	1,773	2,684
2000	423	568	1.343	1,498	3,207	2.141	0.8495	2,948	439	2,478	327	1,157	1,484
2001	650	842	1.295	2,987	7,377	2.470	0.8976	5,220	518	4,545	400	1,840	2,241
2002	1,293	1,819	1.407	5,880	13,899	2.364	0.8843	5,213	584	4,464	415	1,889	2,304
2003	4,711	5,367	1.139	12,826	27,210	2.121	0.8353	4,420	696	3,529	611	1,664	2,275
2004	10,878	14,480	1.331	28,583	64,771	2.266	0.8173	6,801	1,123	5,023	844	2,217	3,060
2005	7,470	9,450	1.265	13,024	28,593	2.195	0.7516	5,880	1,388	4,201	1,098	1,914	3,011
2006	4,512	5,449	1.208	7,041	14,559	2.068	0.7277	6,088	1,549	4,139	1,283	2,002	3,284
2007	3,955	5,183	1.310	9,830	24,621	2.505	0.8261	6,857	1,132	5,378	864	2,147	3,011
2008	3,096	3,969	1.282	6,140	14,857	2.420	0.7892	5,573	1,073	4,015	837	1,659	2,496
2009	1,719	2,088	1.215	3,083	6,849	2.221	0.7664	6,766	1,378	4,519	1,134	2,034	3,169
2010	1,634	2,190	1.340	2,086	4,994	2.394	0.6952	4,663	1,244	2,837	928	1,185	2,113
2011	2,286	2,920	1.278	2,428	5,864	2.415	0.6675	5,510	1,591	3,196	1,246	1,323	2,569
2012	734	1,010	1.376	1,384	3,302	2.386	0.7657	5,436	1,136	3,712	825	1,556	2,381
2013	448	381	0.850	701	1,210	1.725	0.7605	6,881	1,200	3,810	1,411	2,208	3,620
2014	743	786	1.058	784	1,428	1.822	0.6449	8,338	2,961	5,377	2,797	2,952	5,749
2015	750	938	1.251	559	1,050	1.878	0.5280	3,933	1,856	2,076	1,483	1,106	2,589
2016	384	469	1.222	314	611	1.945	0.5655	5,046	2,193	2,853	1,794	1,467	3,261
2017	1,271	1,653	1.301	1,535	2,481	1.616	0.6001	3,777	1,510	2,267	1,161	1,402	2,564
2018	1,240	1,220	0.984	1,625	2,302	1.416	0.6535	3,153	1,092	2,061	1,110	1,455	2,565
<i>formula</i>	<i>A</i>	<i>B</i>	$C=B/A$	<i>D</i>	<i>E</i>	$F=E/D$	$G=E/(E+B)$	<i>H</i>	$I=(1-G)*H$	$J=G*H$	$K=I/C$	$L=J/F$	$M=K+L$

Table 7. Biomass estimates for spiny dogfish (thousands of metric tons) based on area swept by NEFSC bottom trawl during spring surveys, 1968-2019. Estimate for 2014 not included as survey coverage was incomplete.

	Lengths \geq 80 cm			Lengths 36 to 79 cm			Length \leq 35 cm			All Lengths	3-pt Average Female SSB
	Females	Males	Total	Females	Males	Total	Females	Males	Total		
1968			41.4			110.4			1.52	153.3	
1969			27.4			69.3			0.66	97.3	
1970			36.7			33.0			3.19	72.9	
1971			103.8			27.6			2.76	134.2	
1972			126.6			145.9			1.55	274.1	
1973			178.7			165.3			2.58	346.5	
1974			221.9			179.6			2.66	404.1	
1975			105.1			125.0			3.97	234.0	
1976			96.3			120.8			1.20	218.3	
1977			77.3			68.0			0.53	145.9	
1978			87.4			131.2			1.24	219.8	
1979			52.3			18.6			1.82	72.7	
1980	104.7	15.3	168.1	16.8	72.2	123.5	0.32	0.39	0.84	292.4	
1981	266.5	24.4	293.8	25.5	75.1	100.6	2.14	2.80	5.06	399.5	
1982	454.0	34.6	488.6	61.6	143.3	204.9	0.48	0.69	1.17	694.6	275.1
1983	77.7	30.1	107.8	36.7	98.5	135.3	3.09	3.95	7.03	250.1	266.1
1984	115.6	27.5	143.1	33.4	88.0	121.4	0.14	0.21	0.35	264.9	215.8
1985	317.0	125.5	442.6	102.5	502.5	605.0	4.01	5.10	9.10	1056.7	170.1
1986	191.3	3.5	194.8	51.9	29.6	81.5	0.84	1.11	1.96	278.2	208.0
1987	219.1	90.5	309.6	61.5	171.7	233.1	2.46	4.76	7.22	550.0	242.5
1988	433.1	26.2	459.4	93.3	153.6	247.0	0.89	1.09	1.98	708.4	281.2
1989	162.1	40.5	202.6	100.4	158.2	258.6	1.14	1.54	2.68	463.9	271.5
1990	400.3	70.7	471.0	163.5	303.1	466.6	0.68	1.03	1.71	939.3	331.8
1991	220.4	30.0	250.3	108.4	186.3	294.7	0.98	1.43	2.41	547.4	260.9
1992	280.5	41.9	322.4	179.9	231.9	411.8	0.73	1.00	1.73	735.9	300.4
1993	234.6	27.8	262.5	104.1	198.5	302.6	0.55	0.65	1.21	566.3	245.2
1994	105.3	37.1	142.4	108.3	254.2	362.5	4.28	5.54	9.82	514.8	206.8
1995	102.4	29.5	131.9	154.0	174.5	328.5	0.25	0.35	0.59	460.9	147.5
1996	196.5	33.4	229.9	201.7	334.8	536.4	0.98	1.14	2.12	768.5	134.7
1997	83.7	17.5	101.2	205.2	209.1	414.3	0.05	0.05	0.10	515.5	127.5
1998	26.7	22.9	49.7	69.0	236.4	305.4	0.05	0.08	0.13	355.2	102.3
1999	62.7	20.4	83.1	140.8	256.4	397.2	0.02	0.03	0.05	480.4	57.7
2000	85.8	11.7	97.5	91.5	166.2	257.7	0.07	0.09	0.16	355.4	58.4
2001	56.7	16.7	73.4	71.4	160.5	231.9	0.04	0.03	0.07	305.4	68.4
2002	75.2	19.0	94.2	131.5	246.3	377.8	0.06	0.06	0.12	472.1	72.5
2003	64.5	22.5	87.1	125.5	256.3	381.8	0.13	0.14	0.27	469.1	65.5
2004	40.4	10.0	50.3	46.9	126.2	173.1	0.66	0.91	1.56	225.0	60.0
2005	55.8	30.8	86.6	59.8	294.7	354.5	0.28	0.42	0.69	441.9	53.6
2006	253.4	29.0	282.5	141.6	406.5	548.1	0.10	0.17	0.27	830.8	116.6
2007	158.0	18.9	176.9	73.6	227.6	301.1	0.23	0.32	0.56	478.6	155.8
2008	241.7	29.6	271.4	91.2	293.7	385.0	0.47	0.59	1.05	657.4	217.7

Table 7. cont.

	Lengths \geq 80 cm			Lengths 36 to 79 cm			Length \leq 35 cm			All Lengths	3-pt Average Female SSB
	Females	Males	Total	Females	Males	Total	Females	Males	Total		
2009	148.3	21.9	170.2	54.9	326.1	381.0	2.95	3.76	6.71	557.9	182.7
2010	160.6	18.3	178.8	64.0	287.3	351.3	1.15	1.44	2.59	532.7	183.5
2011	213.9	26.7	240.6	60.0	408.6	468.6	0.99	2.48	3.47	712.6	174.2
2012	350.0	44.7	394.7	94.5	617.7	712.2	4.03	5.02	9.05	1116.0	241.5
2013	143.8	56.5	200.3	131.5	439.0	570.4	5.19	6.40	11.59	782.3	235.9
2014	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2015	123.9	22.1	145.9	40.0	276.8	316.8	1.06	1.33	2.39	465.1	133.8
2016	184.9	29.5	214.4	119.9	429.4	549.3	1.30	1.81	3.11	766.9	154.4
2017	24.4	12.7	37.1	92.5	284.8	377.3	0.23	0.31	0.53	414.9	111.1
2018	97.7	23.7	121.4	134.4	306.3	440.6	0.72	0.77	1.48	563.6	102.4
2019	126.0	27.6	153.6	184.8	417.8	602.7	0.42	0.51	0.93	757.2	82.7

Notes: Total equals sum of males and females plus unsexed dogfish. Data for dogfish prior to 1980 are currently not available by sex. Data have been adjusted to AL IV equivalents using weight specific HB Bigelow calibration coefficients. Average SSB for 2015 is 2013 and 2015 only. Average for 2016 is 2015 and 2016 only. Average for 2017-2019 is done as in years prior to 2014.

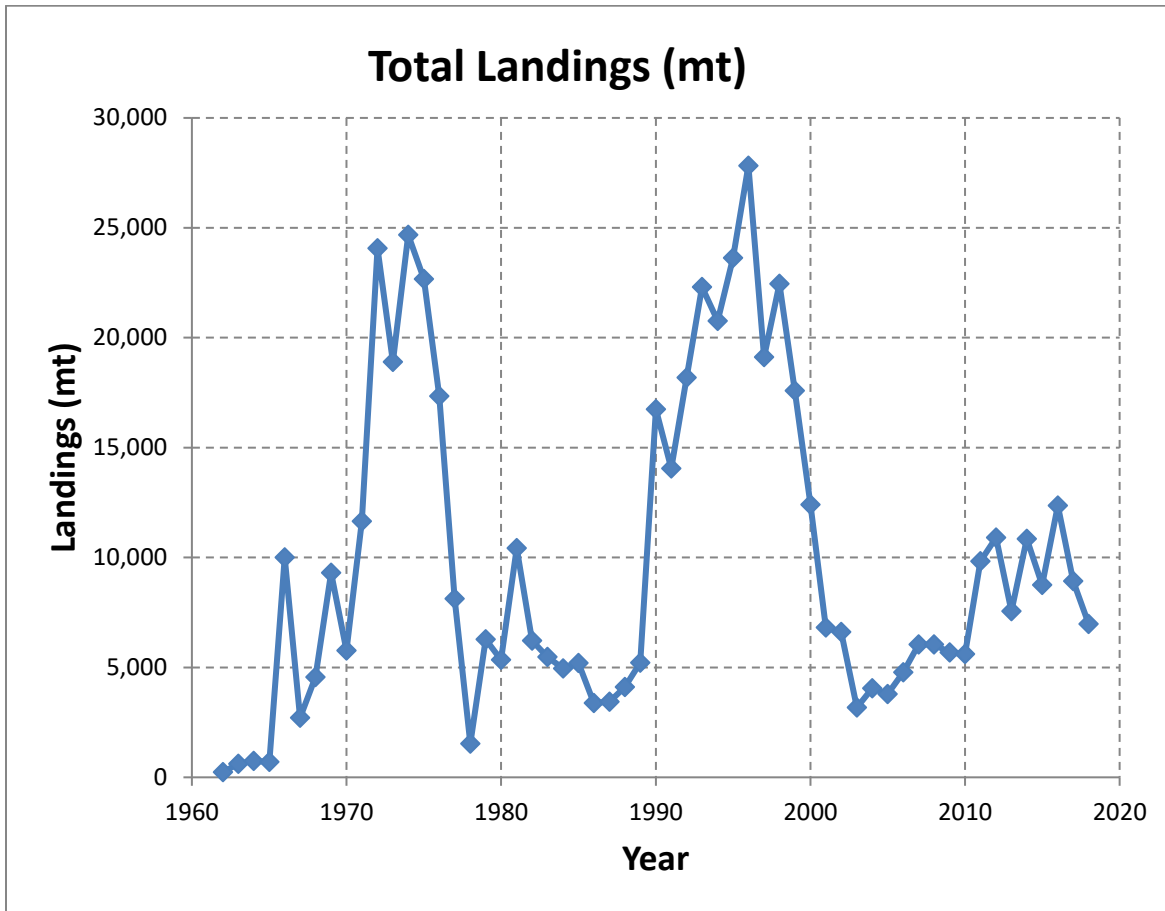


Figure 1. Estimated total landings (mt, live) of spiny dogfish in NAFO Areas 2 to 6, 1962-2018.

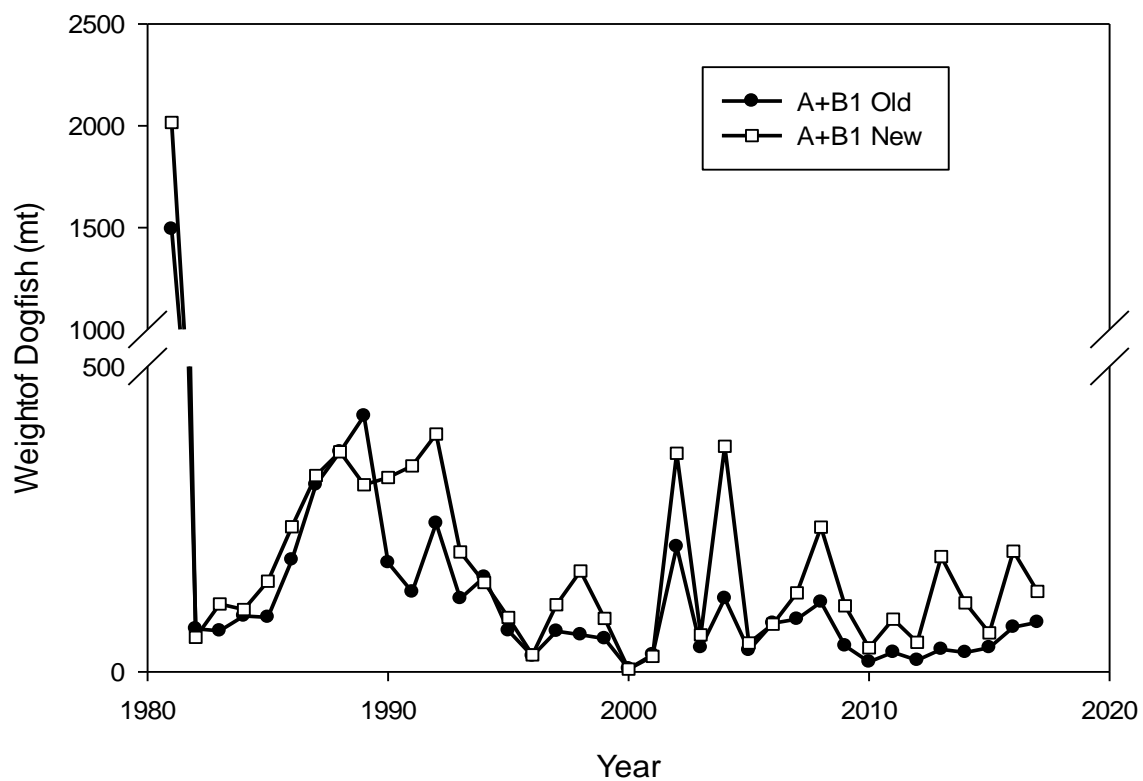
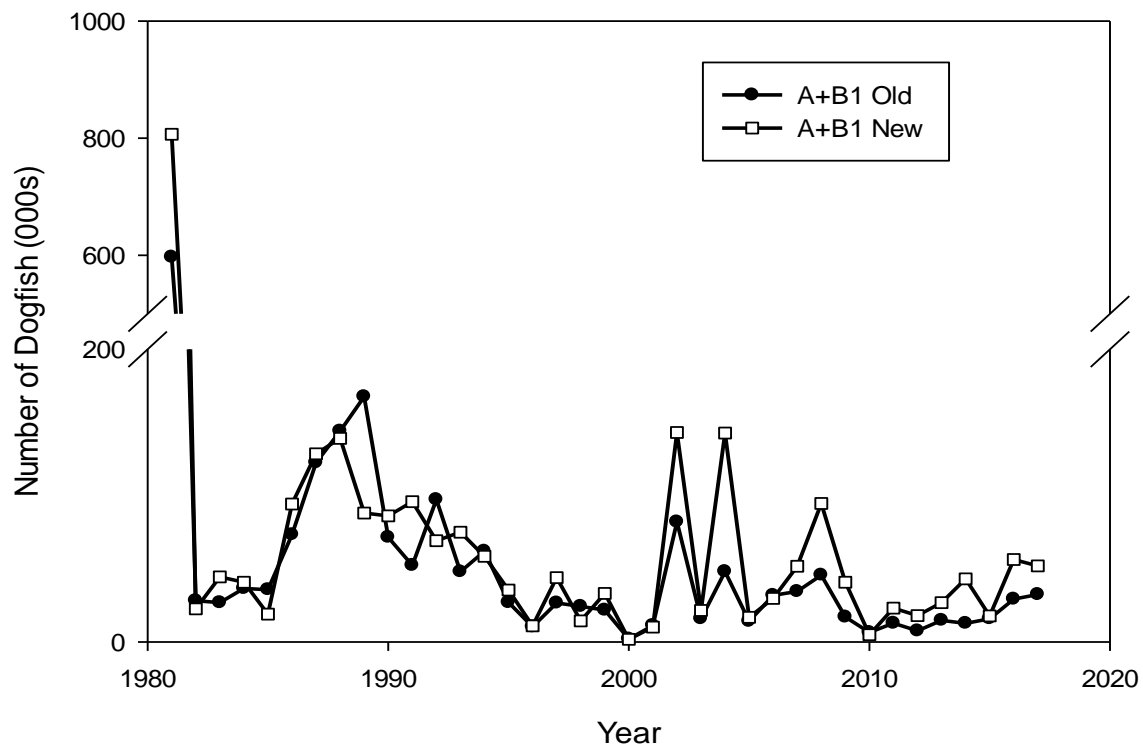


Figure 2. Comparison of old MRIP/MRFSS to new MRIP for landings with the top panel in numbers of fish and the lower panel in mt.

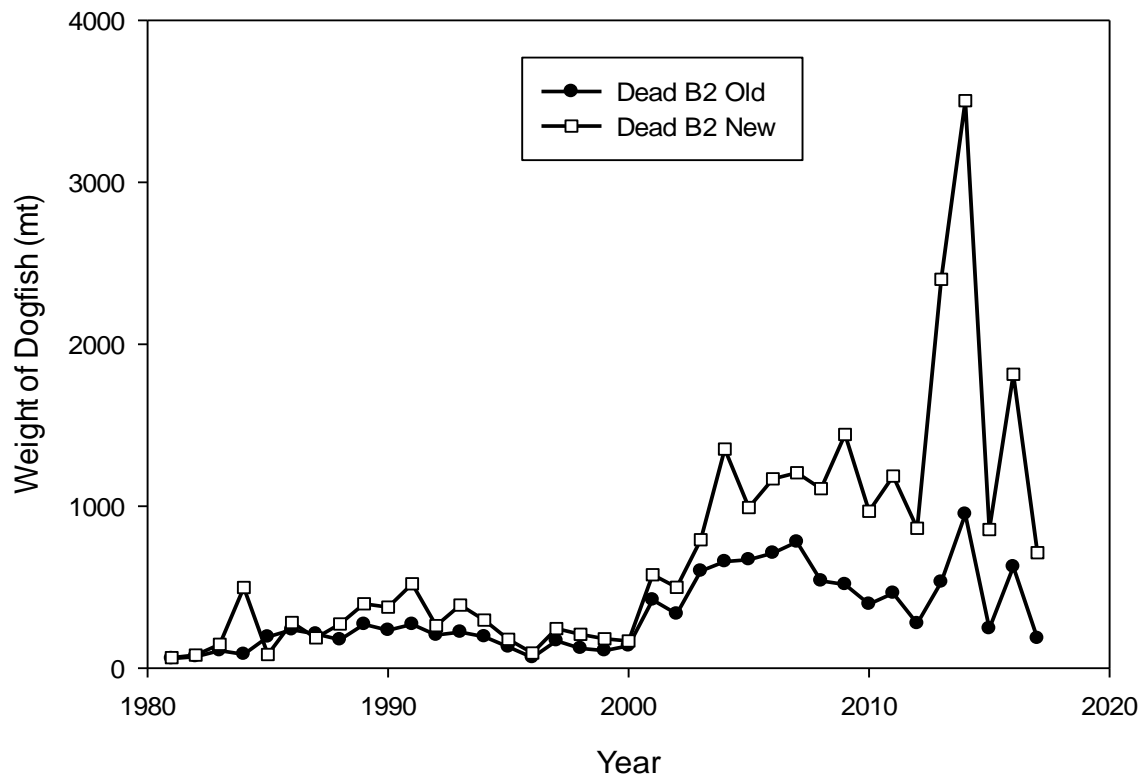
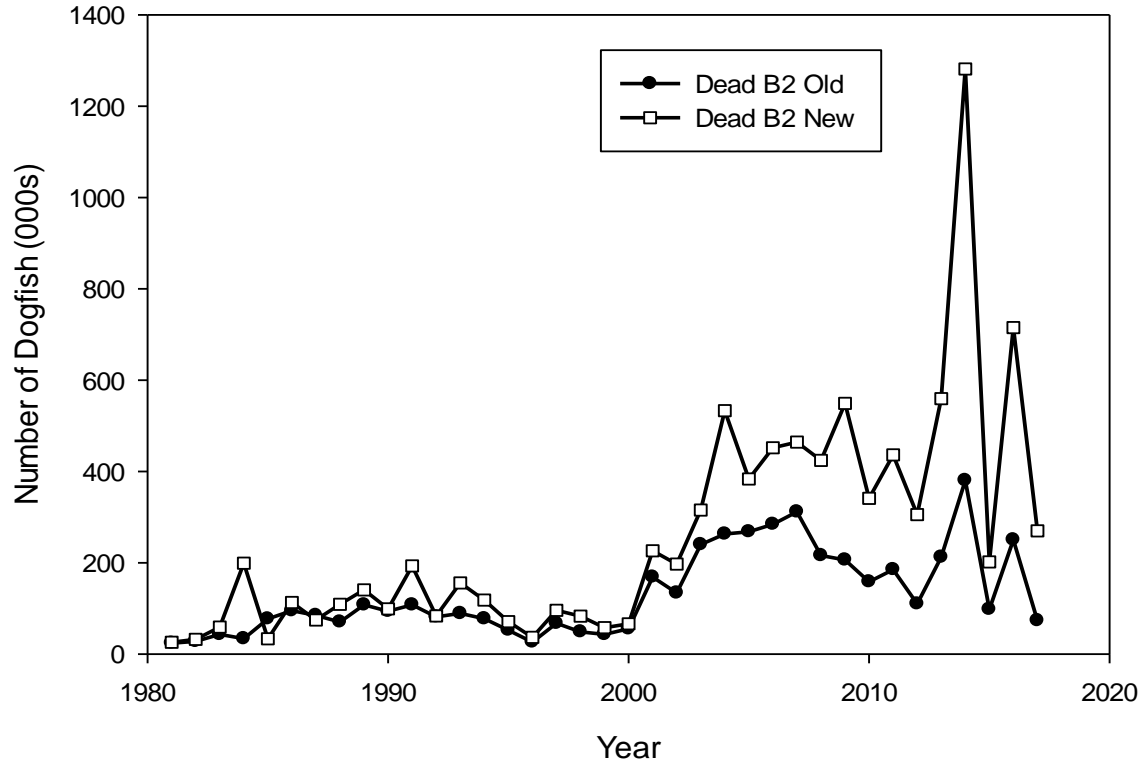


Figure 3. Comparison of old MRIP/MRFSS to new MRIP for discards with the top panel in numbers of fish and the lower panel in mt.

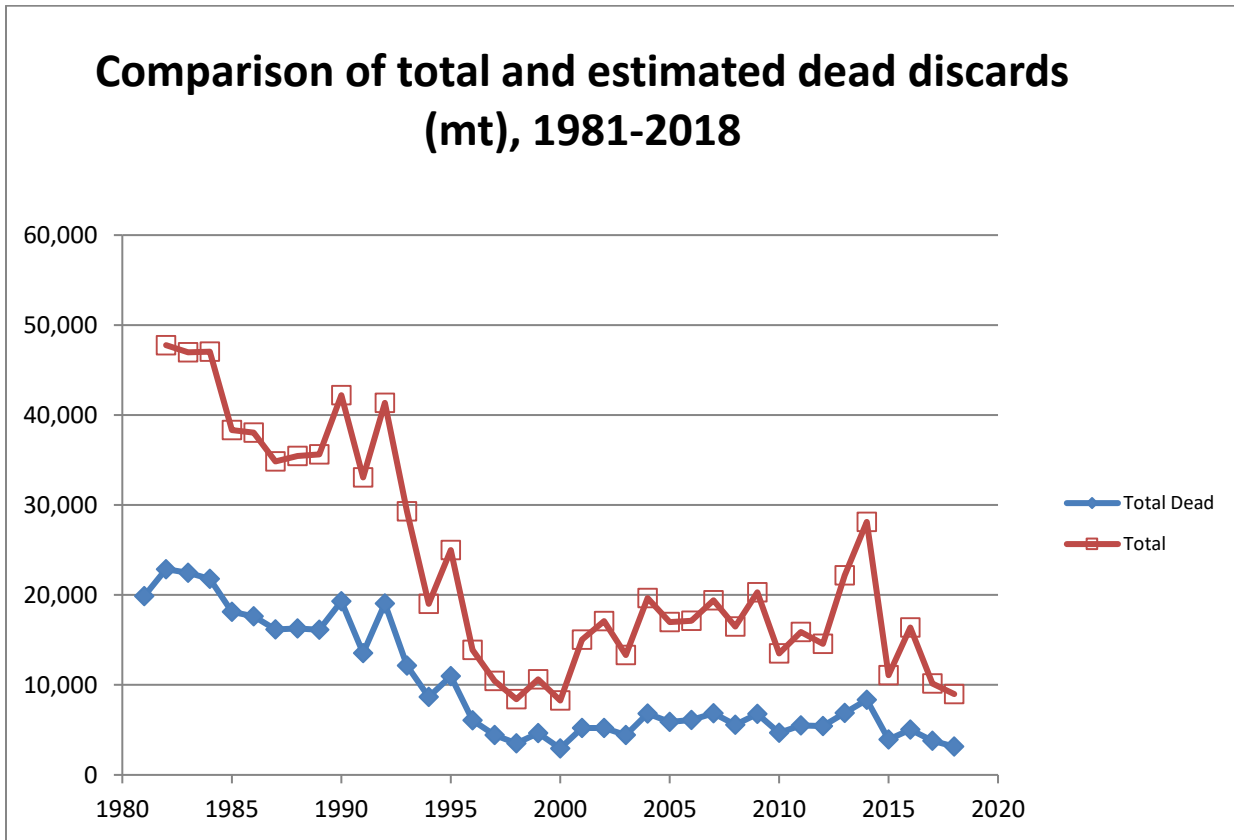


Figure 4. Estimated total and total dead discards in US, 1981-2018. Estimates for 1981 to 1989 are hindcast estimates rather than direct observations.

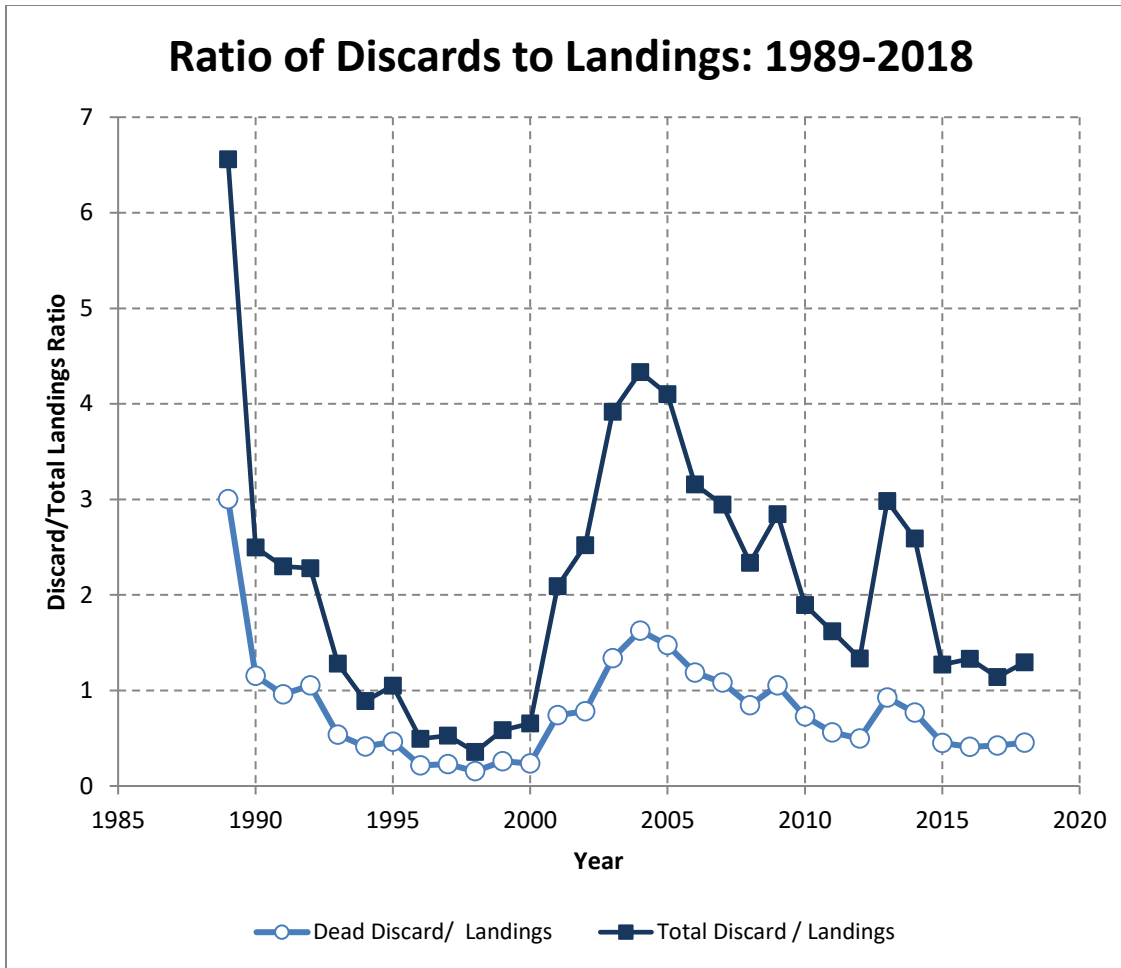


Figure 5. Trends in the ratio of total discards to landings and total dead discards to landings for spiny dogfish, 1989-2018.

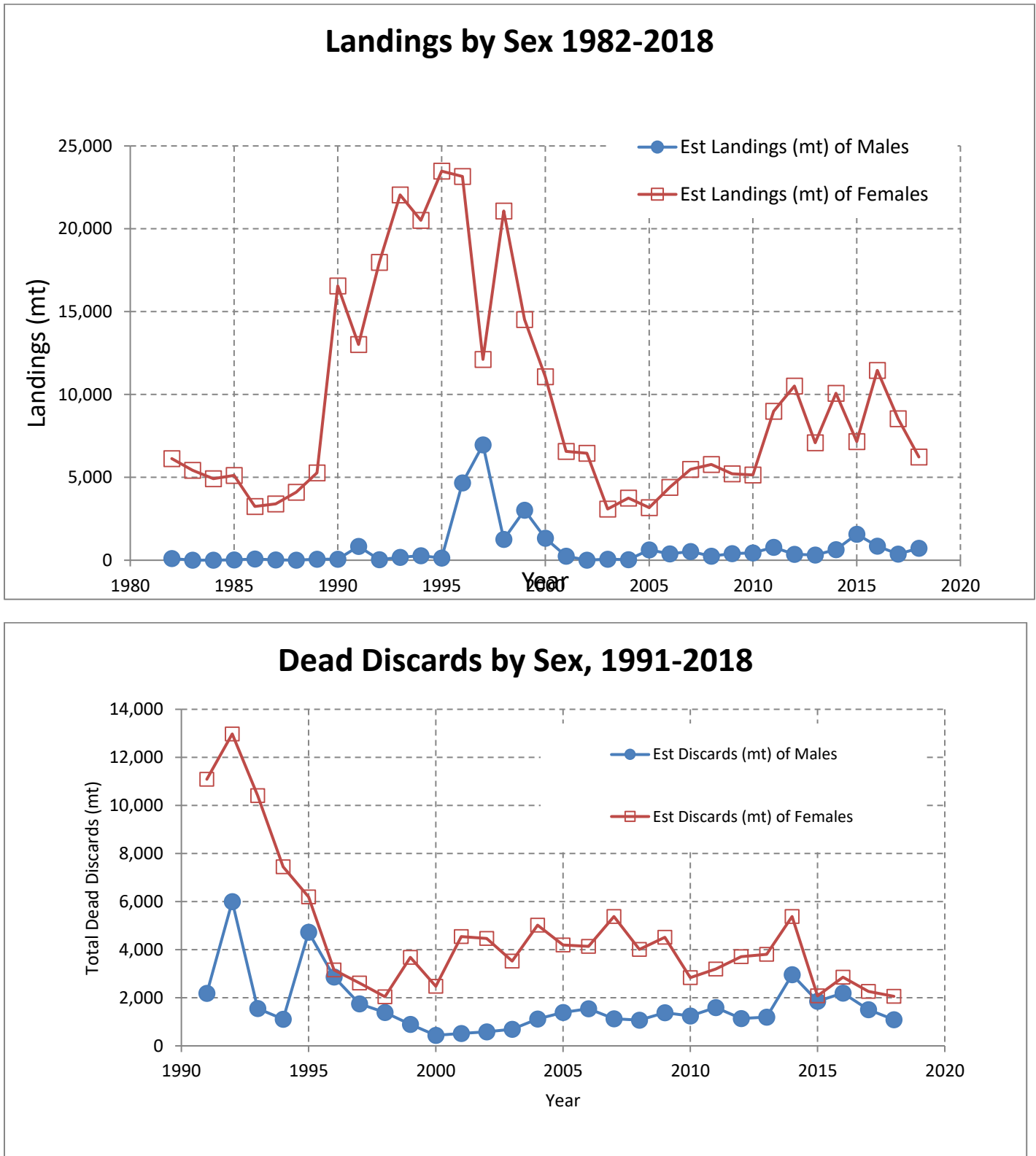


Figure 6. Estimated total landings, 1982-2018 (top) and total dead discards, 1991-2018 (bottom) in mt by sex.

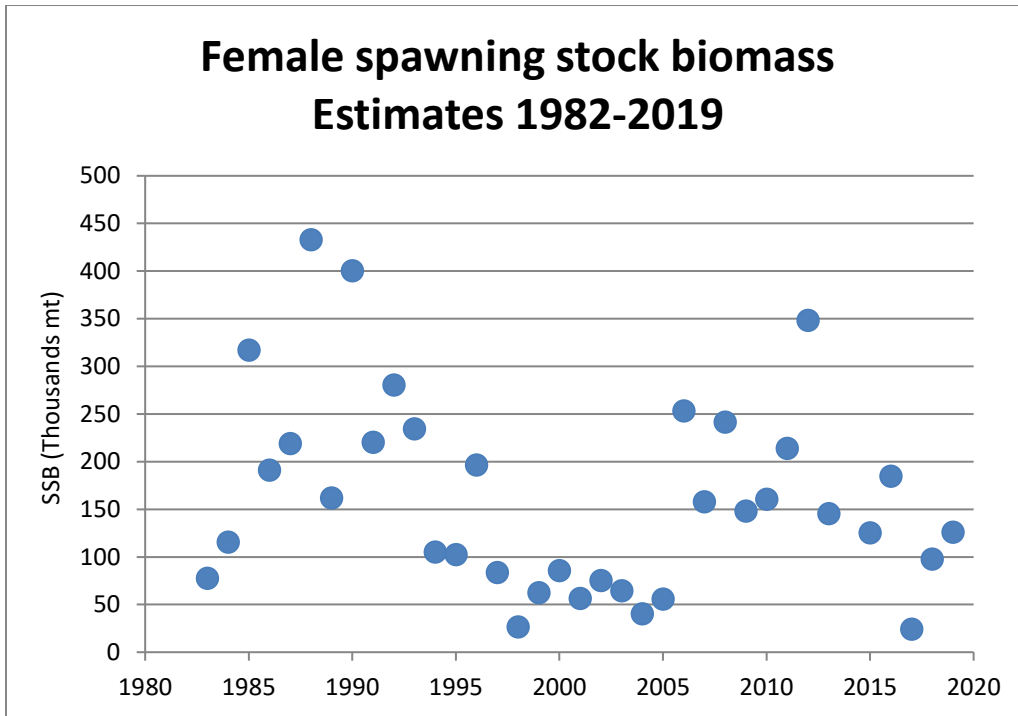


Figure 7. Swept area estimates of female mature biomass (≥ 80 cm) from the NEFSC spring survey from 1980-2019.

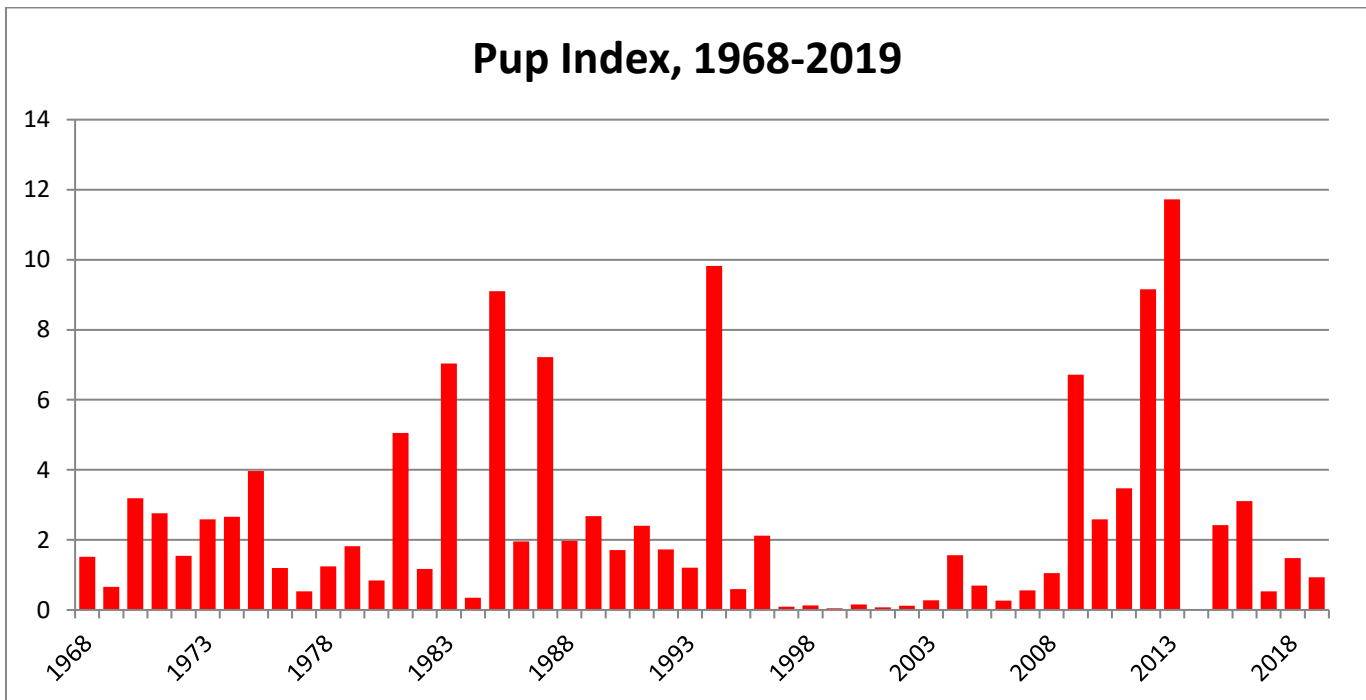


Figure 8. Estimated swept area biomass (mt) of total pups (spiny dogfish ≤ 35 cm) captured in the NEFSC spring bottom trawl survey, 1968-2019. Survey was incomplete in 2014; no estimate available.

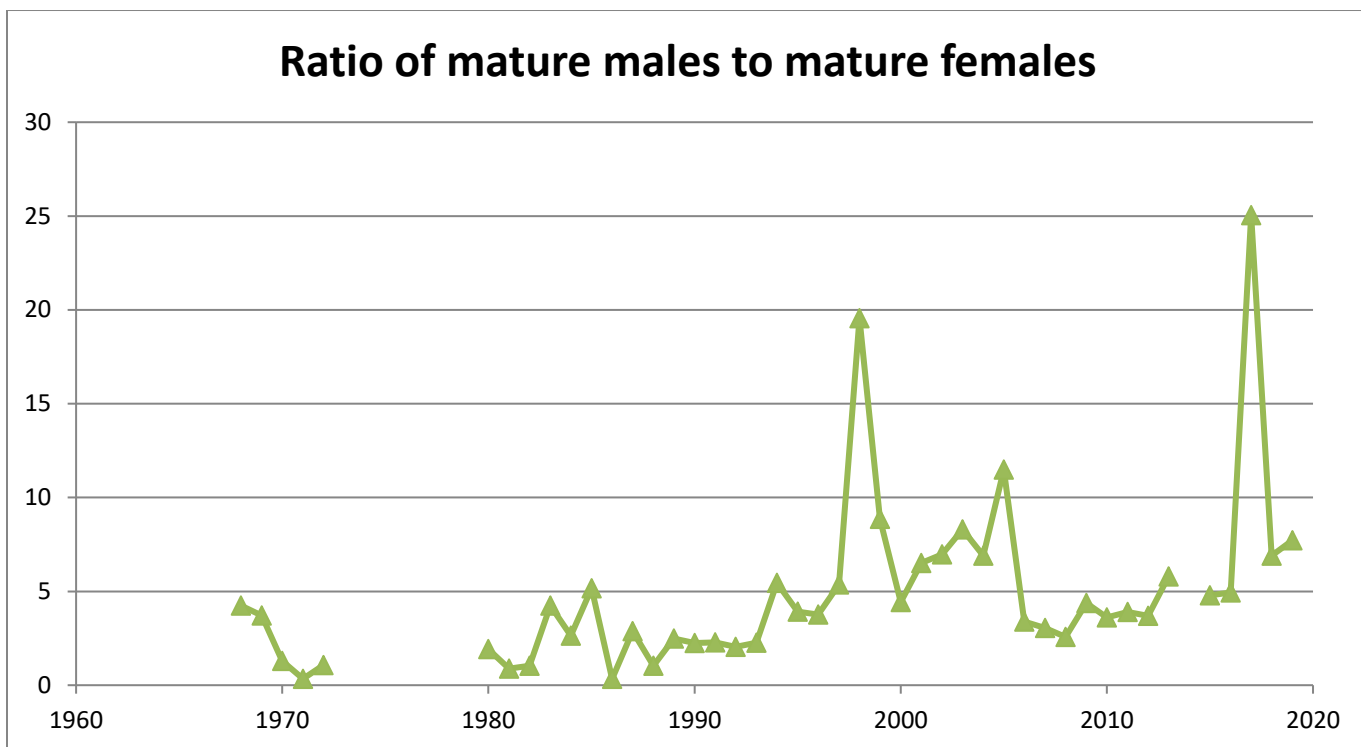


Figure 9. Annual ratios of mature males (≥ 60 cm) to mature females (≥ 80 cm) in NEFSC spring bottom trawl survey, 1968-1972, and 1980-2019. The 2014 survey was incomplete and no estimates were generated. Spiny dogfish sex was not recorded in the NEFSC database for 1973 to 1979.

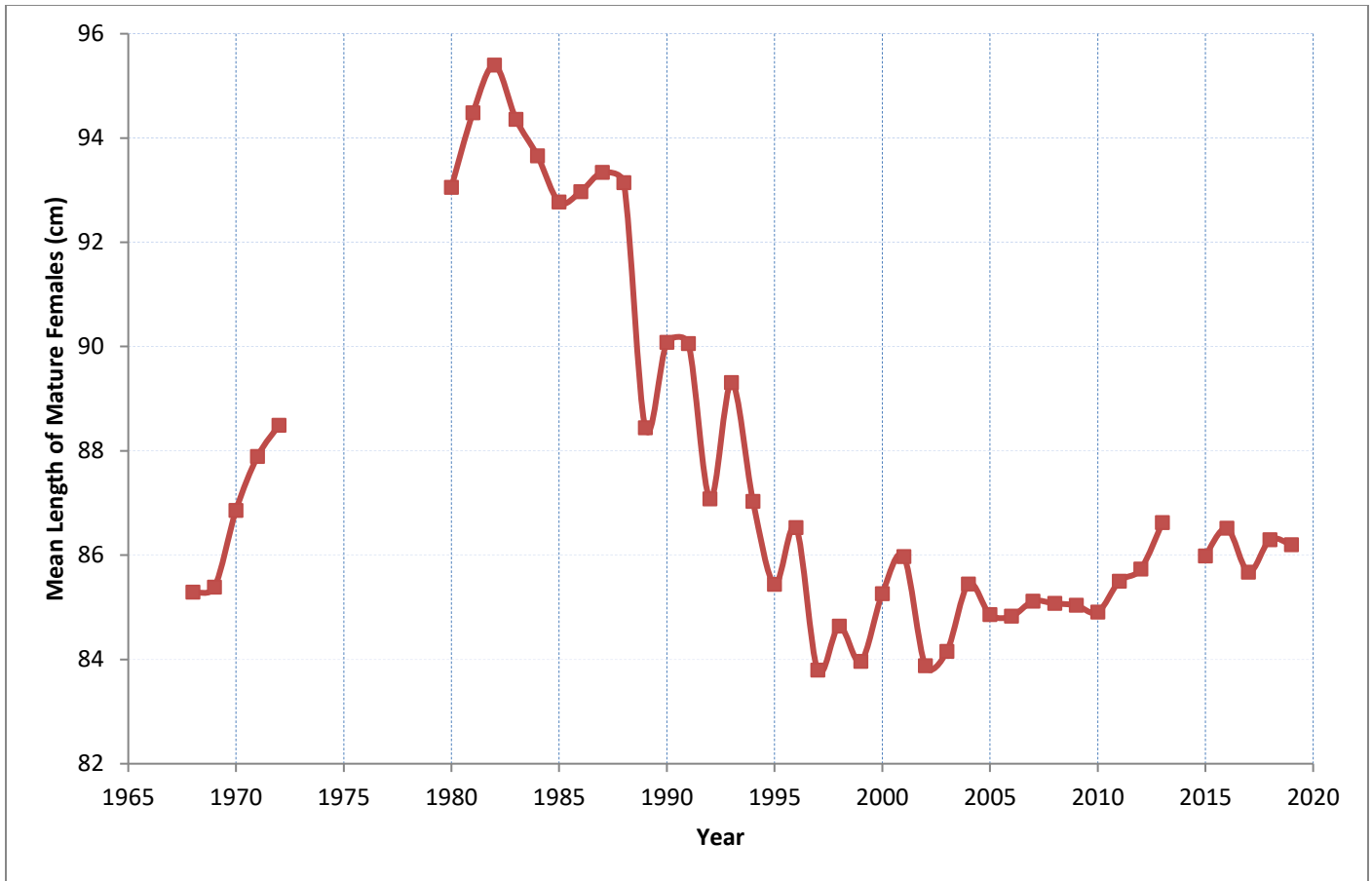


Figure 10. Mean Length of mature female spiny dogfish in NEFSC Spring bottom trawl survey, 1968-1972 and 1980-2019. Survey in 2014 was incomplete. Spiny dogfish sex was not recorded in the NEFSC database for 1973 to 1979.

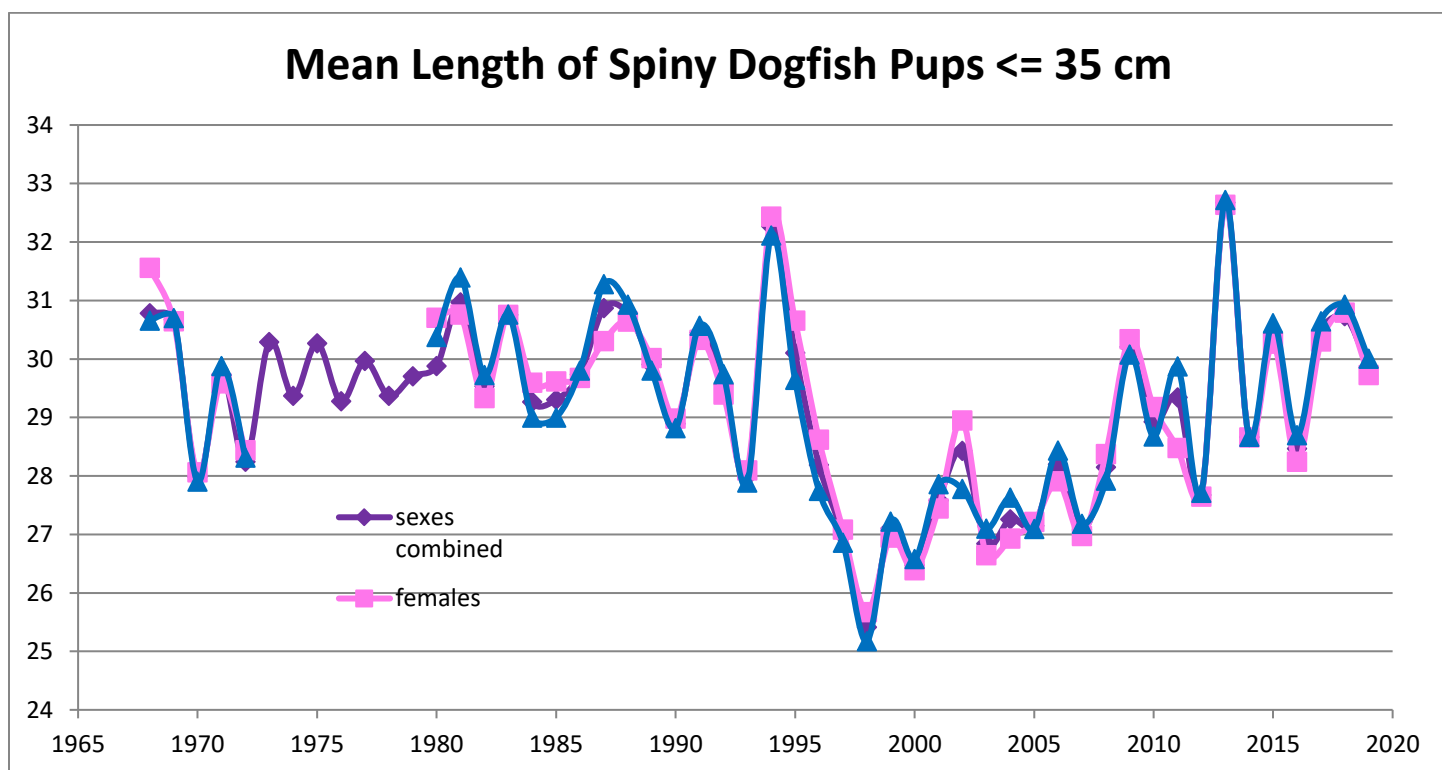


Figure 11. Mean length of male, female and sexes combined spiny dogfish pups (≤ 35 cm) in spring bottom trawl survey 1968-2019. Survey in 2014 was incomplete. Spiny dogfish sex was not recorded in the NEFSC database for 1973 to 1979.

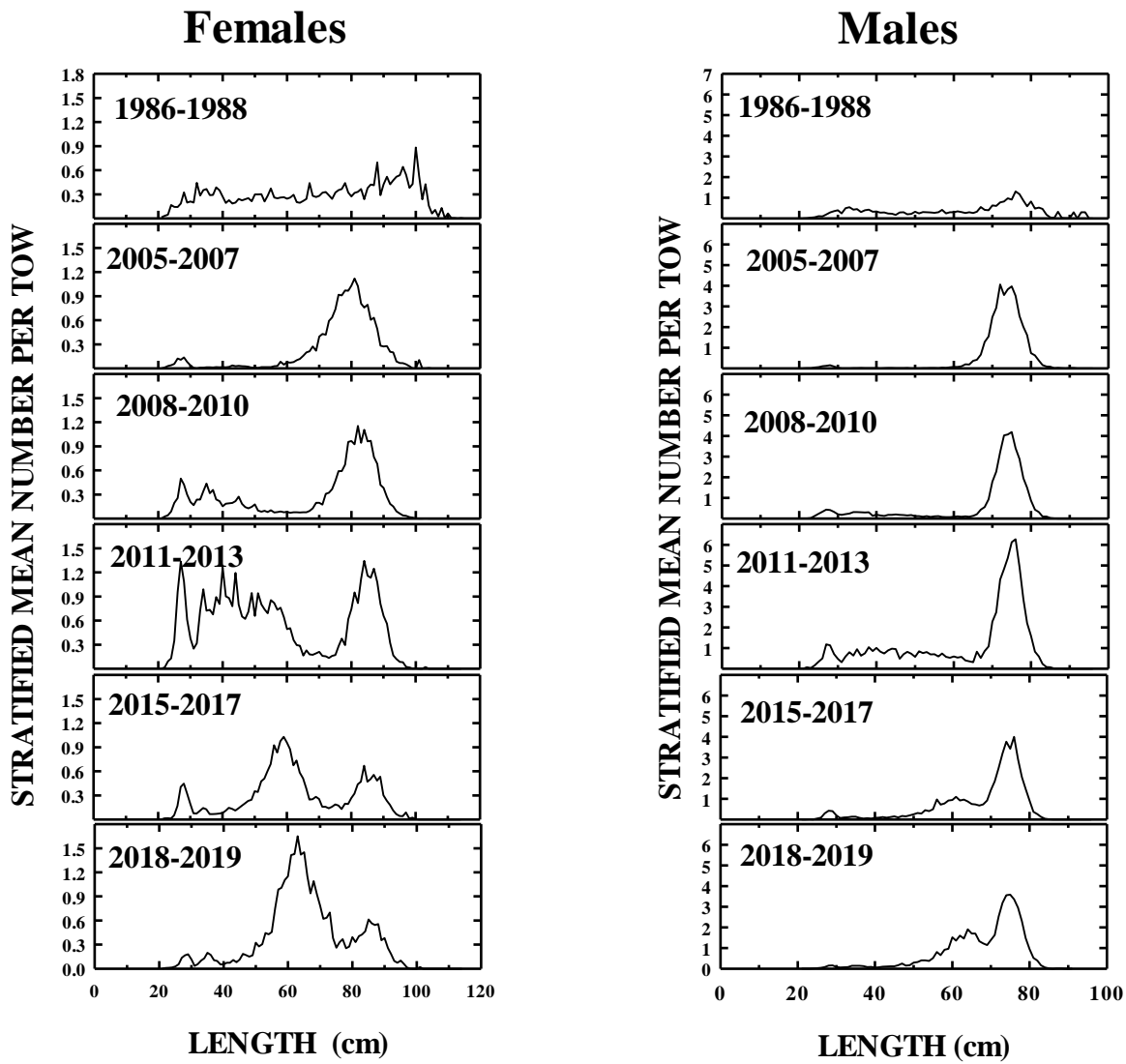


Figure 12. Composite size frequencies for female and male spiny dogfish in NEFSC spring bottom trawl survey. Survey was incomplete for 2014.

Appendix 1. Spatial Distribution of Commercial Landings

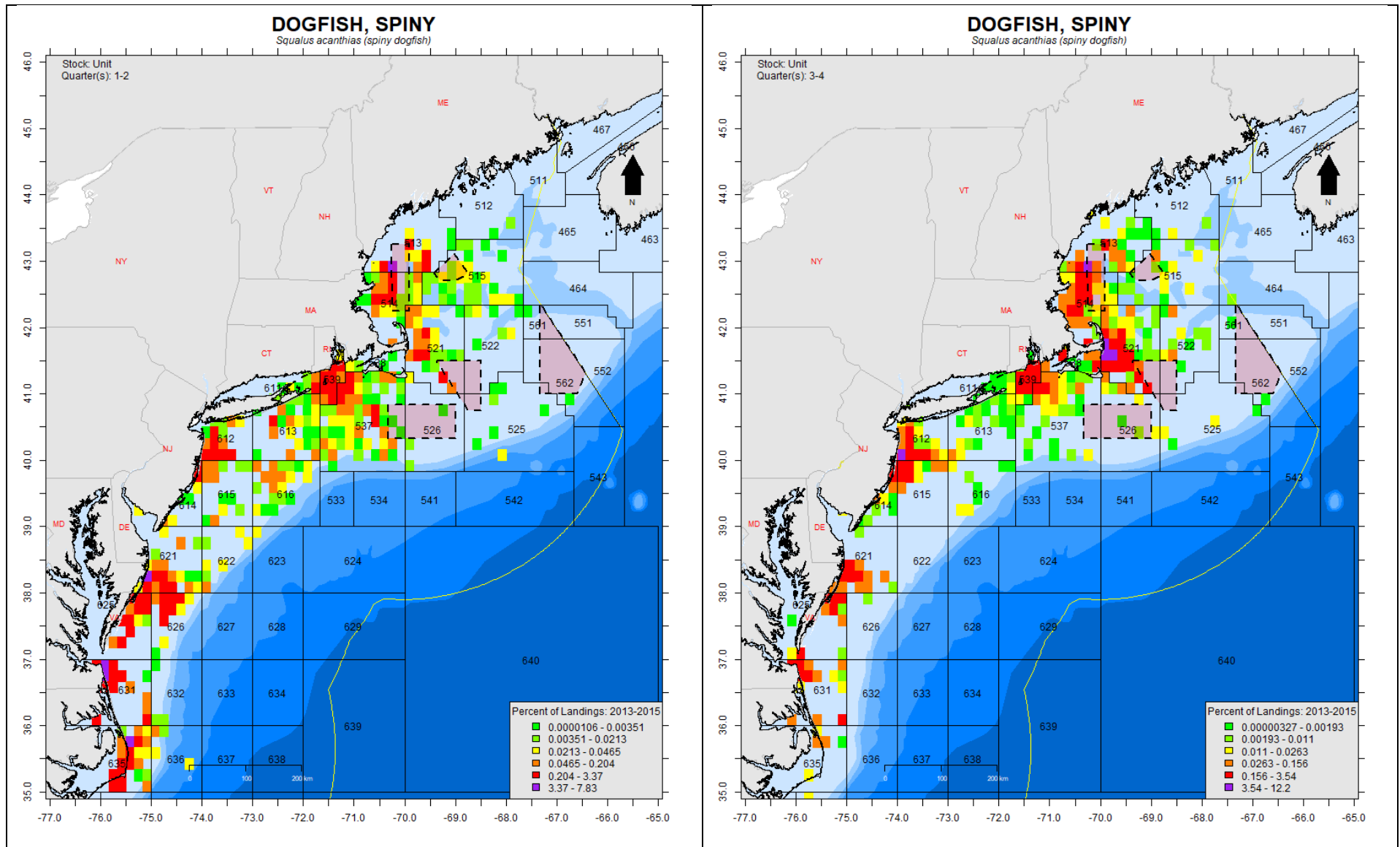


Fig 1. These maps represent commercial landings for DOGFISH, SPINY, *Squalus acanthias* from 2013-2015. Landings were reported via Dealer reports. Data have been restricted to dealer trips matched to a Vessel Trip Report (VTR) (ALEVEL=A) to ensure area information is as accurate as possible. Landings from quarters 1 and 2 are on the left (42.58% of total landings reported for these quarters) and landings from quarters 3 and 4 are in the right panel (78.57% of total landings reported for these quarters) Northeast Fisheries Science Center statistical areas are represented by numbered polygons and bathymetry is depicted in blue shading. Groundfish closed areas (dashed borders), and the Exclusive Economic Zone (yellow line) have been overlaid. Data queried on July 22, 2019.

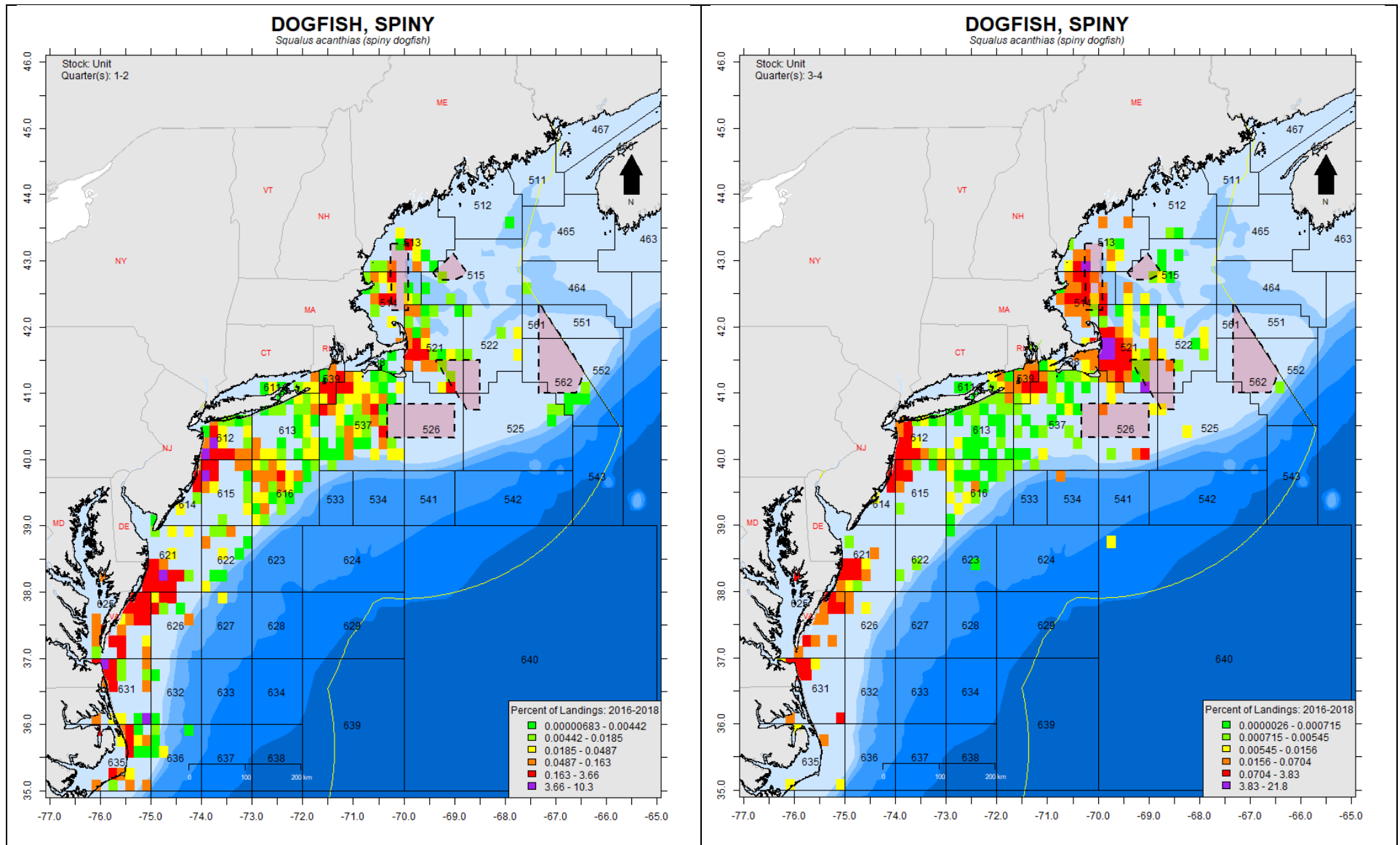
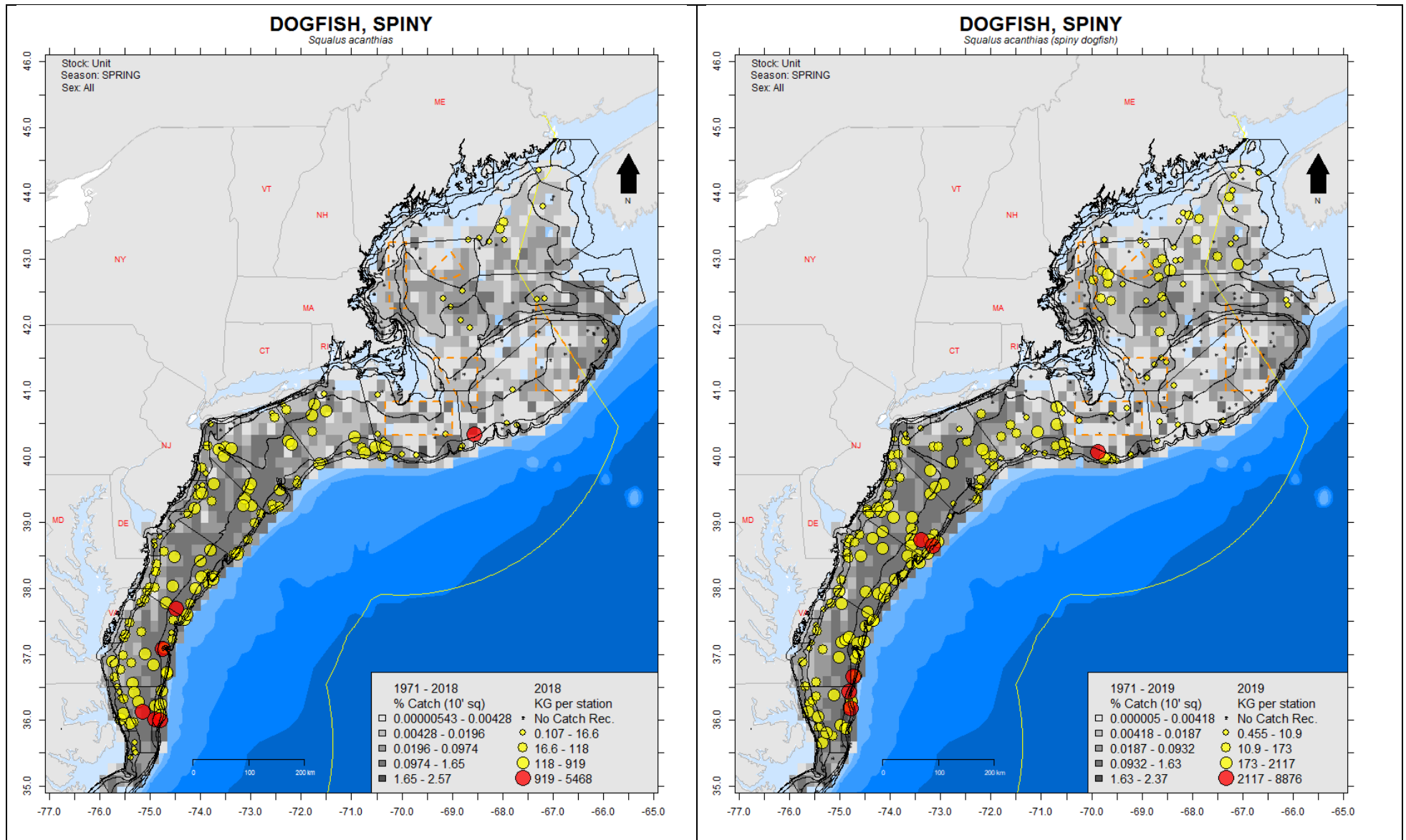
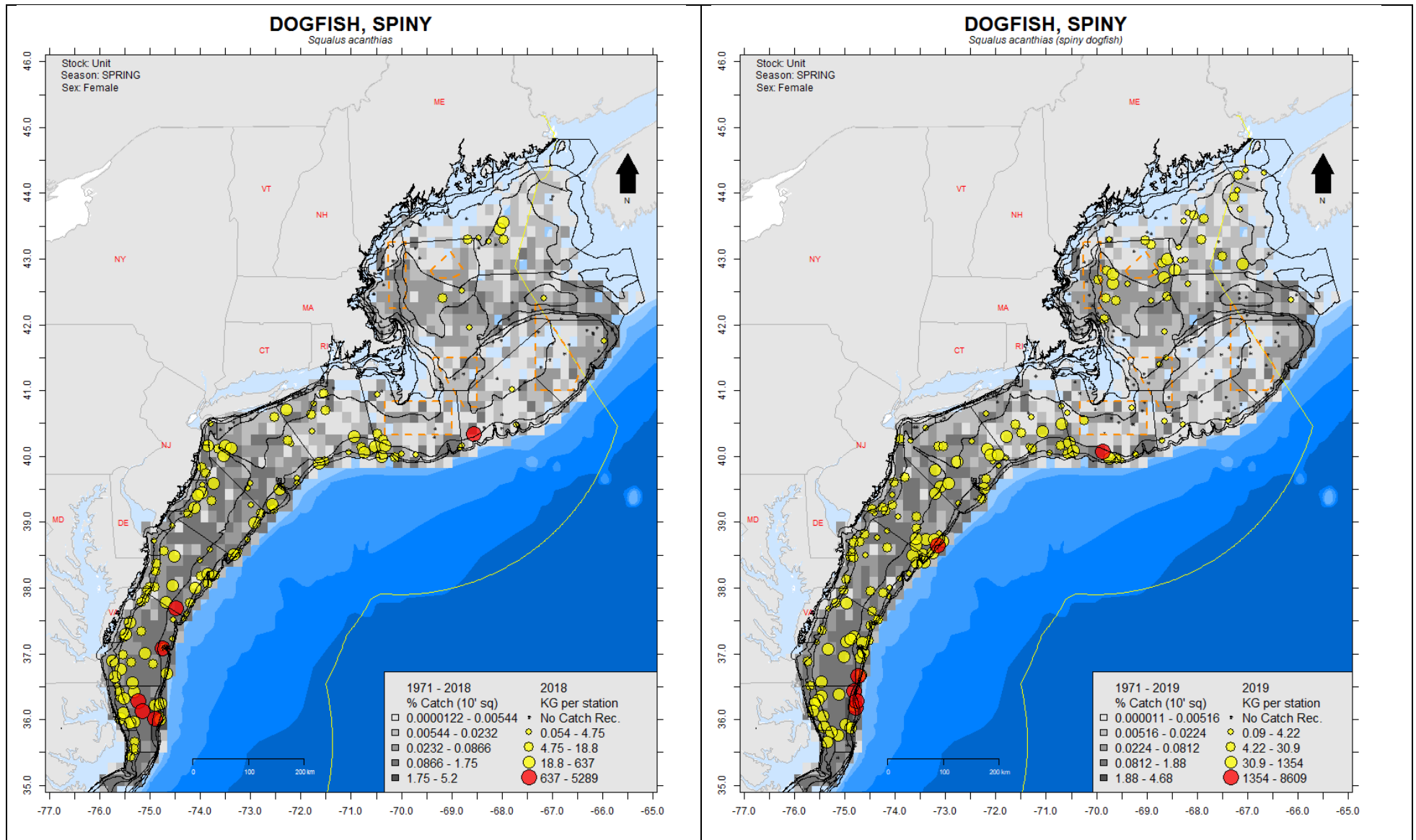


Fig 2. These maps represent commercial landings for DOGFISH, SPINY, *Squalus acanthias* from 2016-2018. Landings were reported via Dealer reports. Data have been restricted to dealer trips matched to a Vessel Trip Report (VTR) (ALEVEL=A) to ensure area information is as accurate as possible. Landings from quarters 1 and 2 are on the left (67.24% of total landings reported for these quarters) and landings from quarters 3 and 4 are in the right panel (85.78% of total landings reported for these quarters) Northeast Fisheries Science Center statistical areas are represented by numbered polygons and bathymetry is depicted in blue shading. Groundfish closed areas (dashed borders), and the Exclusive Economic Zone (yellow line) have been overlaid. Data queried on July22, 2019.

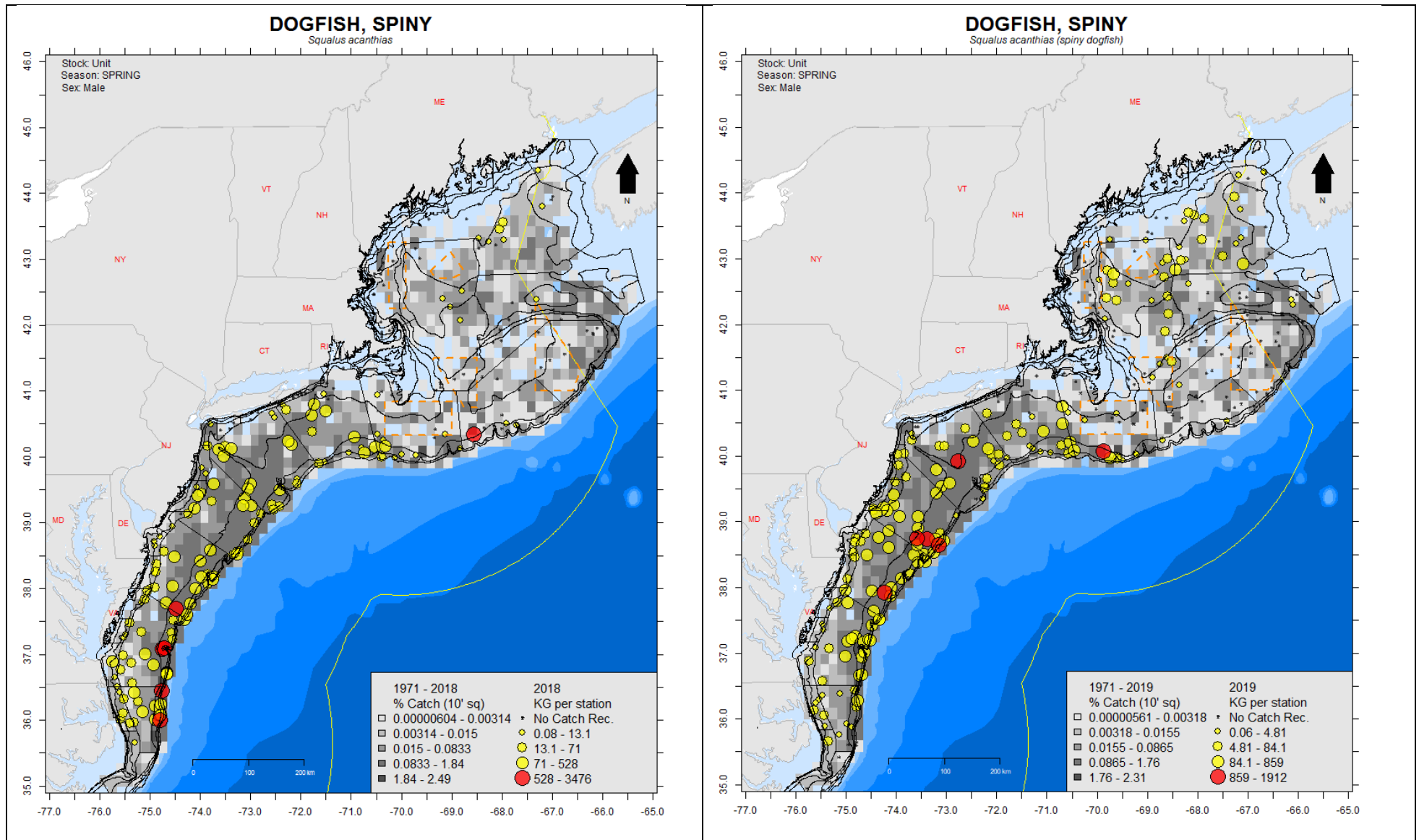
Appendix 2. Spatial Distribution of Survey Catches



These maps represent survey catches for DOGFISH, SPINY, *Squalus acanthias*. Catch includes both sexes. The shaded cells represent the percentage of catch per ten minute square for the spring NMFS NEFSC BOTTOM TRAWL SURVEY time series, from 1971 – 2018 (left panel) or 1971-2019 (right panel). The points represent catch weights for 2018 (left panel) and 2019 (right panel) of the spring NMFS NEFSC BOTTOM TRAWL SURVEY. The RED points show the locations of the 6 largest tows in the set. Weights have not been calibrated. Bathymetry is depicted in blue shading. Groundfish closed areas (dashed borders), and the Exclusive Economic Zone (yellow line) have been overlaid. Data queried on July 22, 2019.



These maps represent survey catches for DOGFISH, SPINY, *Squalus acanthias*. Only female catch is plotted. The shaded cells represent the percentage of catch per ten minute square for the spring NMFS NEFSC BOTTOM TRAWL SURVEY time series, from 1971 - 2018 (left panel) or 1971-2019 (right panel). The points represent catch weights for 2018 (left panel) and 2019 (right panel) of the spring NMFS NEFSC BOTTOM TRAWL SURVEY. The RED points show the locations of the 6 largest tows in the set. Weights have not been calibrated. Bathymetry is depicted in blue shading. Groundfish closed areas (dashed borders), and the Exclusive Economic Zone (yellow line) have been overlaid. Data queried on July 22, 2019.



These maps represent survey catches for DOGFISH, SPINY, *Squalus acanthias*. Only male catch is plotted. The shaded cells represent the percentage of catch per ten minute square for the spring NMFS NEFSC BOTTOM TRAWL SURVEY time series, from 1971 - 2018 (left panel) or 1971-2019 (right panel). The points represent catch weights for 2018 (left panel) and 2019 (right panel) of the spring NMFS NEFSC BOTTOM TRAWL SURVEY. The RED points show the locations of the 6 largest tows in the set. Weights have not been calibrated. Bathymetry is depicted in blue shading. Groundfish closed areas (dashed borders), and the Exclusive Economic Zone (yellow line) have been overlaid. Data queried on July 22, 2019

