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Effect of variable wing spread on NEFSC bottom trawl survey index estimates for summer flounder

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ABSTRACT

In response to concern about the performance of the fishing gear on the NEFSC bottom trawl survey, we calculated alternative survey index estimates for summer flounder for spring 2009 to spring 2018. We evaluated the impact of three adjustments to the catch per tow data: 1) adjusting for sweep efficiency, 2) adjusting for sweep efficiency and tow-specific area swept, and 3) adjusting for sweep efficiency, tow-specific area swept, and gear efficiency depending on wing spread. If wing spread data were not present, we derived estimated wing spread using door spread data if possible; if neither wing spread nor door spread data were available, we assumed standard wing spread and maximum gear efficiency. The hypothesized gear efficiency by wing spread relationship was based on the opinions of industry members; no experiments were conducted and no data were available to estimate the relationship. A sensitivity analysis was conducted to evaluate the impact of the assumed relative efficiency relationship. Our findings indicate that the sweep efficiency adjustment increases the index estimates significantly, but that further accounting for tow-specific area swept does not impact results significantly. Results were sentitive to the assumptions associated with the hypothesized relative efficiency of the gear so this adjustment should be considered carefully.

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INTRODUCTION

The assessment for summer flounder (*Paralichthys dentatus*) uses data from commercial and recreational fisheries, several state research surveys, and the federal Northeast Fisheries Science Center (NEFSC) research survey to provide information on stock status (NEFSC 2013, Terceiro 2016). The standard approach to calculating NEFSC spring and fall survey indices assumes that the sweep is fully efficient at catching summer flounder and that all tows are equal in terms of area swept and gear performance. In other words, catchability is 1.00 for fish of all lengths, and all tows are assumed to sample an average area defined by the standard distance towed multiplied by the width of the fishing gear, which is assumed to perform consistently at every station. Catch is the only tow-specific information used in the calculation of the indices.

Recently, there has been some concern among industry members that the gear used by the NEFSC vessel since 2009, the FSV *Henry B. Bigelow*, does not perform optimally for several species, and does not perform equally across all tows. The concern surrounding sweep efficiency has been addressed with three (2015-2017) sweep studies carried out with a twin trawl vessel to estimate the relative efficiency of the *Bigelow* rockhopper sweep for several flatfish species (Miller *et al*. 2018). Regarding consistency across tows, the concern is that the spread of the net wings (Politis *et al.*, 2014), varies depending on the depth of the station. Wing spread is presumably optimal for stations within some intermediate depth range, but extreme depths are thought to impact the configuration of the gear causing it to be under spread at shallow stations, and over spread at deep stations. In addition, the distance towed for representative tows can vary between 1.284 km and 2.204 km based on the tolerance limits for tow duration (16-21 minutes) and speed over ground (2.6-3.4 knots; Politis *et al.*, 2014). Thus, the true area swept varies across stations and the gear efficiency for the shallow and deep stations might be compromised, which would impact the catch, and in turn the survey indices.

This working paper presents alternative NEFSC spring and fall survey indices for summer flounder that account for tow-specific area swept and hypothesized effects of wing spread on gear efficiency. Estimates of aggregate mean weight and mean number per tow, mean number per tow at age, and absolute swept area number (SWAN) indices are provided for spring 2009 to spring 2018 along with a comparison to standard NEFSC indices and indices incorporating results from the sweep studies to allow for the evaluation of the sensitivity of the indices to gear performance.

METHODS

This analysis uses NEFSC spring and fall bottom trawl survey data collected during the spring 2009 to spring 2018, for valid stations (i.e., TOGA code ≤132X) with audited data (Politis *et al.*, 2014). The spring strata set included offshore strata 1-12 and 61-76, and the fall strata set included offshore strata 1, 5, 9, 61, 65, 69, and 73, and inshore strata 1-61 (Appendix figure 1). Fall 2017 data were lacking because the vessel did not sample the summer flounder strata during that survey so there are no results for that season. Since all data were collected using the *Bigelow*, the data were not calibrated to units of the previous vessel (R/V *Albatrosss IV*).

We calculated area swept per tow as the distance towed multiplied by the wing spread. In some cases, wing spread data were missing and had to be imputed. If door spread data were available, we calculated wing spread using the results of a regression of wing spread to door spread based

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on spring 2009 to spring 2018 NEFSC survey data for valid stations with audited data from all inshore and offshore strata (4 outliers removed from data; wing spread = 0.28936*door spread + 3.12836; R^2 = .827). If neither wing nor door spread data were available, we applied the average tow area swept (using distance towed = 1.852 km and wing width = 12.6 m, such that average area swept = 0.0233352 km^2).

We prepared five data sets. The first consisted of the standard (SD) uncalibrated data set, as described above. The other four data sets had different adjustments made to the catch data. We applied estimates of rochopper sweep catchability at length (SSq, Miller *et al*. 2018; Table 1, Figure 1) to the catch data in the base SD data set to produce a sweep study (SS) adjusted data set. Next we applied a second (cumulative) adjustment to the SS data set, by mutliplying the catch from each station by the ratio of the average area swept per tow to the area swept at the specific station to produce an area swept (AS) adjusted data set.

The last two data sets accounted for differing efficiency depending on wing spread. Here, we applied a third cumulative adjustment to the AS catch to account for hypothesized variability in gear efficiencies at different wing spreads. We used two different hypothesized relative efficiency relationships, one for summer flounder (Table 2a, Figure 2a), and one for yellowtail flounder (*Limanda ferruginea*; Table 2b, Figure 2b) to provide insight on the sensibility of the results to the relationship. Each relationship had a hypothetically optimal wing spread range where efficiency value was set to 1.0 (i.e., 100% efficient) and tows with wing spread outside this range were assigned an efficiency <1.0, decreasing as the wing spread got further from the full efficiency range. Note that the target wing spread for the *Bigelow* gear is 12.0-13.0 m by design (P.J. Politis, personal commun.), so station data were classified in 1-meter wing spread bins centered around 12.0-13.0 m, as follows: […; 11.0-11.9 m; 12.0-13.0 m; 13.1-14.0 m; …]. For summer flounder, tows with wing spread 13.1-14.0 m were considered to be fully efficient and efficiency decreased rapidly for tows with wing spread above or below this range. For yellowtail flounder, full efficiency was set to occur when wing spread was 12.0-13.0 m, with a more gentle decrease in efficiency as wing spread departed from this range. It is important to consider that the hypothesized relative efficiency relationships were based on input from members of the industry. No experiments were conducted and no data were available to estimate these relationships. We used recorded wing spread when available to determine relative efficiency for each tow, or regression-derived wing spread if wing spread data were not available but door spread data were. Tows with missing wing spread and missing door spread data were assigned an efficiency of 1.0. Once all tows had an efficiency value, we divided the AS catch per tow by the hypothesized relative efficiency of the tow, resulting in a summer flounder efficiency (Seff) and yellowtail efficiency (Yeff) adjusted data sets.

The following table summarizes the data sets and adjustments:

Data set	Adjustment(s)
Standard (SD)	None
Sweep study (SS)	SSq
Area swept (AS)	SSq + tow area swept
Summer flounder efficiency (Seff)	SSq + tow area swept + summer flounder relative efficiency
Yellowtail flounder efficiency (Yeff)	SSq + tow area swept + yellowtail flounder relative efficiency

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Once all data sets were created, we derived the alternative index estimates (i.e., aggregate stratified mean weight and mean number per tow, mean number per tow at age, and SWAN indices at age) for each of the five data sets using the standard calculation approach. For the aggregate indices, we first calculated simple point estimates, and then bootstrapped the data to generate estimates with 90% confidence intervals. Note that for all the adjusted data sets (SS, AS, Seff, and Yeff), the uncertainty associated with SSq and that associated with filling missing wing spread and area swept information are not captured in the confidence bounds and thus the true uncertainty would be slightly greater. To derive SWAN index estimates, we multiplied the estimates at age by the ratio of the total area swept for the survey (nm^2) to the average tow area swept ($0.0233352\ km^2 * 0.2915533496 = 0.00680345572\ nm^2$).

RESULTS

In total, the analysis used data from 1,203 stations in the spring and 859 stations in the fall (Table 3, Figures 3 and 4). Data summaries are presented with the stations grouped in 1-meter wing spread bins.

In the spring, almost half (44%) of the stations had wing spread between 12.0 m and 13.0 m, and 73% of the stations had wing spread between 12.0 m and 14.0 m (Table 3a). In the fall, 37% of stations had wing spread between 11.0 m and 11.9 m, and 63% of the stations had wing spread between 10.0 m and 11.9 m (Table 3b). A much larger proportion of stations had wing spread < 12.0 m in the fall (33.8%) compared to the spring (1.3%). On average 7% of the spring 2009-2018 stations were missing wing spread data (Table 3a), with the highest proportion missing in 2014 (32%) and 2017 (16%); all 2015 and 2018 stations had wing spread data available. For the fall survey, 6% of the fall 2009-2016 stations were missing wing spread data (Table 3b), with the highest proportion missing in 2011 (25%) and 2012 (13%); all 2014 and 2015 stations had wing spread data available.

Mean depth averaged 76 m in the spring and 43 m in the fall for tows with wing spread between 12.0 m and 13.0 m, and 41-121 m in the spring and 32-47 m in the fall for tows with wing spread between 11.0 m and 14.0 m (Table 3, Figure 5). Tows with narrow wing spread (<11.0 m) occurred at depths averaging 33 m in the spring and 25 m in the fall, and tows with wide wing spread (>14.0 m) occurred at depths averaging 264 m in the spring and 40 m in the fall.

Sampling of the summer flounder strata was well distributed across the strata sets in each season (Figures 3a and 4a). Tows with narrow wing spread (<11.0 m) were generally located closer to shore [i.e., offshore strata 1, 5, 9, 61, 65, 69, and 73 in the spring (Figures 3bc), and inshore strata in the fall (Figures 4bc)]. Tows with wide wing spread (>14.0 m) were located near the shelf edge in the spring (i.e., offshore strata 3-4, 7-8, 11-12, 63-64, 67-68, 71-72, and 75-76; Figures 3gh). There were only 6 tows with wide wing spread in the fall (Table 3b); 5 were located in Cape Cod Bay (i.e., inshore strata 59-61) and 1 was in offshore stratum 9 (Figures 4gh). Tows with missing wing spread were distributed across each region (Figures 3i and 4i).

Sampling resulted in positive summer flounder catch for stations with average depth 20-150 m in the spring and 15-40 m in the fall (Figure 5).

As mentioned above, a majority of the stations in each region had recorded wing spread data that could be used directly. Door spread information was available for 92% of the spring stations with missing wing spread data, and 83% of the fall stations (Table 4). Wing spread for tows at these

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stations was estimated using the wing spread to door spread regression described above. Overall, only about 1% of the total number of stations had neither wing spread nor door spread data, in which case average area swept and gear efficiency of 1.0 were assumed.

Estimates of NEFSC survey aggregate stratified mean weight and stratified mean number per tow are presented in Table 5 and Figure 6. In all cases, the standard SD (i.e., using non-adjusted data) estimates were the lowest of the 4 sets of results (SD, SS, AS, Seff). Applying the SSq adjustment rescaled the estimates up significantly (i.e., SS versus SD). The average increase in biomass point estimates was 83.7% in the spring and 70.0% in the fall, while the average increase in abundance point estimates was 111.8% in the spring, and 139.7% in the fall. In contrast, applying the additional tow-specific area swept adjustment (i.e., AS data) did not modify the estimates much further. Differences between the AS and SS estimates were generally small in the spring (i.e., less than +/- 5%) and a bit larger in the fall (i.e., averaging +10.3% for biomass and +12.5% for abundance). Note that the tow area swept adjustment could result in AS index estimates that were either larger or smaller than the SS estimates, however all fall AS estimates were larger than the SS indices. Nevertheless, all AS and SS aggregate estimates confidence intervals overlapped indicating that the estimates were not significantly different from each other.

Applying the final summer flounder hypothesized relative efficiency adjustment to the data produced aggregate index estimates (Seff) that differed from the AS results to varying degrees depending on year and season. Since the efficiency adjustment could only rescale the catch per tow upward (as for the SSq adjustment), Seff estimates were always larger than AS estimates. In the spring (Table 5ab, Figure 6ab), the average increase in index point estimate was 10.9% for biomass per tow and 13.9% for abundance per tow. Confidence intervals from the spring Seff bootstrapped estimates overlapped with confidence intervals from AS and SS estimates in every year indicating that the Seff results were not significantly different from the AS and SS estimates for that season. In the fall (Table 5cd, Figure 6cd), applying the additional hypothesized relative efficiency adjustment to the data had a significant impact in several years. On average, the index point estimates increased by 87.5% for biomass per tow and 103.1% for abundance per tow, however the departure from the AS results was not uniform across years. The Seff index estimates were significantly different from the AS and SS results in 2012, 2013, 2015, and 2016 for biomass per tow, and in 2010-2015 for abundance per tow. The largest differences occurred in 2012, where the Seff point estimate was larger than the AS estimate by 249.0% for biomass per tow, and by 236.0% for abundance per tow.

Point estimates of NEFSC survey stratified mean number per tow at age (Tables 6 and 7, Figures 7 and 8) generally indicated similar patterns as seen with the aggregate estimates discussed above. For all ages and seasons, the SD estimates were the lowest, followed by the pair of SS and AS index estimates (which were very close in most years), and finally the Seff estimates falling above. Again, in the spring (Table 6, Figure 7), the Seff results did not seem to differ significantly from the SS and AS results, while in the fall (Table 7, Figure 8) the summer flounder hypothesized relative efficiency adjustment had a greater impact, especially in some years (e.g., 2011-2013).

Absolute swept area numbers (SWAN) at age were calculated for each season and are presented in Tables 8 and 9, and Figures 9 and 10. In the spring a total area of 27,855 nm^2 was surveyed in all years except in 2009 (27,664 nm^2) and 2014 (22,623 nm^2). In the fall, 17,924 nm^2 were surveyed in all years except in 2010, when the total area was 17,572 nm^2. Because the total

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survey area was almost constant across all years for each season, the SWAN index at age results are essentially the same as the relative stratified mean number per tow at age results (Tables 6 and 7, Figures 7 and 8), simply on a different scale.

The sensitivity analysis using data adjusted according to the yellowtail flounder hypothesized relative efficiency relationship (instead of the summer flounder relationship) indicated that index estimates were sensitive to the efficiency relationship. Aggregate stratified mean weight and mean number per tow estimates using the Yeff data set are presented in Table 10 and Figure 11. Compared to the Seff results, the Yeff estimates are generally closer to the AS results. In the spring (Table 10a, Figure 11ab), the average increase in index point estimate was 6.4% for biomass per tow and 7.6% for abundance per tow. In the fall (Table 10b, Figure 11cd), the index point estimates increased by 22.3% for biomass per tow and 27.7% for abundance per tow on average. Contrary to the Seff results, confidence intervals from the Yeff bootstrapped estimates overlapped with confidence intervals from AS and SS estimates in almost every year indicating that the Yeff results were not significantly different from the AS and SS estimates for either season. Results for the index estimates at age (Table 11, Figures 12 and 13) and SWAN index estimates (Table 12, Figures 14 and 15) also indicate that Yeff results are closer to the SS and AS estimates than the Seff results.

DISCUSSION

We calculated alternative NEFSC survey index estimates for summer flounder for spring 2009 to spring 2018. We evaluated the impact of three adjustments to the catch per tow data: 1) adjusting for sweep efficiency, 2) adjusting for sweep efficiency and tow-specific area swept, and 3) adjusting for sweep efficiency, tow-specific area swept, and gear efficiency depending on wing spread. Results indicate that the sweep efficiency adjustment significantly increases index estimates, however accounting for tow-specific area swept does not alter results further significantly. In contrast, applying a hypothesized relative efficiency adjustment for summer flounder to the catch data does have a significant impact on results in the fall. Moreover, we found that results were sensitive to the choice of the relative efficiency relationship.

There were adequate recorded wing spread data for most of the stations considered in these analyses. When wing spread data were absent, door spread information was available in most cases such that relatively well-informed estimates of wing spread could be derived using regression analysis; very few stations were assigned the average area swept and maximum gear efficiency due to missing wing spread and missing door spread data. Nevertheless, one should note that the available wing spread and door spread data are mean values of sensor readings, which have associated variability that was not considered in this paper.

Applying the sweep study efficiency (SSq) had a significant impact on the indices; however since this adjustment was not the primary focus of this paper we will not discuss it further. Next, the small differences between the SS estimates and the AS estimates imply that the tow-specific area swept adjustment to the catch per tow data did not alter the data significantly. The ratio of the average area swept per tow to the area towed at the specific station was close to 1.0 for many stations (mean = 0.99, std dev = 0.07 across all spring stations, and mean = 1.14 with std dev = 0.16 across all fall stations) indicating that actual area swept at each station is quite close to the theoretical average area swept (i.e., 0.0233352 km^2). Fall stations tended to have more tow-

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specific area swept values that were smaller than the theoretical average, thus catch data were adjusted upward more often, resulting in AS indices that were larger than the SS estimates in all years for that season.

Applying the additional adjustement to account for differences in hypothesized summer flounder relative efficiency depending on wing swept (Seff) yielded index estimates that generally moved further away from the SS and AS estimates, especially for the fall. However applying the yellowtail flounder hypothesized relative efficiency relationship (Yeff) did not create such a drastic difference. This is due to the difference in shape of the two hypothesized relative efficiency relationships (Table 2, Figure 2). The optimal for summer flounder is set between 13.1-14.0 m wing spread (instead of 12.0-13.0 m for yellowtail flounder), and outside this range the efficiency drops off quickly and more drastically than for yellowtail. As soon as the tow wing spread is out of the 13.1-14.0 m range, the Seff correction causes a big increase in the catch. In the fall, many more stations had a narrow wing spread (Figure 5), where 33.8 % of stations have wing spread < 12.0 m, compared to 1.3% in the spring. This explains the seasonal difference in the results and impact of the summer flounder efficiency adjustment. Because the yellowtail flounder efficiency relationship is centered on the 12.0-13.0 m range and the drop in efficiency is less as wing spread departs from that range, results using the Yeff adjustment are closer to the SS and AS scenarios.

It is important to remember that the relative efficiency to wing spread relationships used for these analyses are not based on data, but rather on 'best guess' estimates of how efficiently the *Bigelow* gear performs with different wing spreads. The hypothesized efficiency relationships used here show a relatively dramatic drop in efficiency once the wing spread departs from the assumed full efficiency range; these relationships cannot be confirmed at this time. The drop in efficiency on either side of the central wing spread range results in a large adjustment to the catch for tows at the lower and upper end of the wing spread range. Thus, a single tow can affect the index estimates with the relative efficiency adjustment significantly. Because of the subjective nature underlying the hypothesized efficiency relationships, results from the analyses for the Seff and Yeff data sets should be considered as a theoretical exploration, not as reliable findings based on measured gear efficiency data.

Finally, one should note that the relative efficiency adjustments are related to the sweep study efficiency (SSq) correction, and that the proposed relative efficiency relationships were thought of independently of the SSq. Since these two correction factors are related, any further work should consider how the relative efficiency relationships (that depend on wing spread) might be modified in light of the existing SSq factors (which are specific to the sweep and are applied by length).

CONCLUSION

Despite the caveats mentioned above, the analyses presented here are informative. While adjustments to catch per tow can be applied to the NEFSC spring and fall bottom trawl data, our results show that accounting for tow-specific area swept does not alter the index estimates significantly for summer flounder for spring 2009 to spring 2018. However, varying gear efficiency depending on wing spread does have a significant impact. Any hypothesized relative efficiency adjustment should be applied with caution and results interpreted with care.

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TABLES

Table 1. Summer flounder rockhopper catchability (SSq) by length. These coefficients were developed based on data from three (2015-2017) sweep studies carried out with a twin trawl vessel (Miller et al. 2018).

Length (cm)	SSq
15	0.015198
16	0.020080
17	0.026521
18	0.035004
19	0.046156
20	0.060780
21	0.079907
22	0.104844
23	0.137097
24	0.177842
25	0.227682
26	0.286201
27	0.351414
28	0.419309
29	0.483709
30	0.538288
31	0.580165
32	0.608491
33	0.624003
34	0.628651
35	0.625151
36	0.616547
37	0.605192
38	0.592259
39	0.578759
40	0.565624
41	0.553706
42	0.543785
43	0.536582
44	0.532297
45	0.530577
46	0.531083

Length (cm)	SSq
47	0.533504
48	0.537547
49	0.542926
50	0.549356
51	0.556565
52	0.564290
53	0.572257
54	0.580173
55	0.587731
56	0.594607
57	0.600501
58	0.605503
59	0.609975
60	0.614294
61	0.618850
62	0.624043
63	0.630289
64	0.637998
65	0.647398
66	0.658638
67	0.671886
68	0.687334
69	0.705204
70	0.725748
71	0.749209
72	0.775572
73	0.804717
74	0.836499
75	0.870742
76	0.907223
77	0.945669
47	0.533504

Table 2. Hypothesized relative efficiency of the NEFSC survey vessel FSV Henry B. Bigelow *by wing spread bin for summer flounder (a) and yellowtail flounder (b). Note that these values area based on input from members of the industry; there are no available data to inform this relationship objectively. Spring 2009 to spring 2018 summer flounder data wing spread range is 8.3 – 16.0 m.*

(a)

Wing spread bin (m)	Relative efficiency
8.0 – 8.9	0.10
9.0 – 9.9	0.10
10.0 – 10.9	0.40
11.0 – 11.9	0.75
12.0 – 13.0	0.90
13.1 – 14.0	1.00
14.1 – 15.0	0.90
15.1 – 16.0	0.70
16.1 – 17.0	0.20
17.1 – 18.0	0.05

(b)

Wing spread bin (m)	Relative efficiency
8.0 – 8.9	0.47
9.0 – 9.9	0.55
10.0 – 10.9	0.65
11.0 – 11.9	0.85
12.0 – 13.0	1.00
13.1 – 14.0	0.90
14.1 – 15.0	0.80
15.1 – 16.0	0.70
16.1 – 17.0	0.60
17.1 – 18.0	0.50

Table 3. Number of stations by wing spread bin from the 2009-2018 NEFSC spring (a) and 2009-2017 NEFSC fall (b) surveys for summer flounder. 'Missing' indicates wing spread data were not available. Mean wing spread and mean station depth are provided for each bin, with standard deviation in parentheses.

(a)

Wing spread bin (m)	**<10.0**	**10.0–10.9**	**11.0-11.9**	**12.0-13.0**	**13.1-14.0**	**14.1-15.0**	**>15.0**	**Missing**	**Total**
Mean wing spread (m)	*9.7 (0.1)*	*10.6 (0.2)*	*11.6 (0.2)*	*12.6 (0.3)*	*13.4 (0.3)*	*14.5 (0.2)*	*15.4 (0.3)*	*.*	***12.9 (0.9)***
Mean station depth (m)	*30 (4)*	*37 (14)*	*41 (17)*	*76 (37)*	*121 (67)*	*220 (70)*	*309 (44)*	*82 (71)*	***98 (70)***
2009	0	1	11	56	44	7	3	7	**129**
2010	0	1	5	46	63	12	0	9	**136**
2011	1	3	15	57	23	9	5	11	**124**
2012	0	1	17	62	32	7	0	2	**121**
2013	1	3	20	60	31	5	0	7	**127**
2014	0	1	4	26	25	6	3	30	**95**
2015	0	1	9	55	43	17	0	0	**125**
2016	0	1	8	57	44	9	0	1	**120**
2017	0	0	10	48	34	12	2	20	**126**
2018	0	2	22	62	14	0	0	0	**100**
Total	**2**	**14**	**121**	**529**	**353**	**84**	**13**	**87**	**1,203**

Table 3. Continued.

(b)

Wing spread bin (m)	**<10.0**	**10.0–10.9**	**11.0-11.9**	**12.0-13.0**	**13.1-14.0**	**14.1-15.0**	**>15.0**	**Missing**	**Total**
Mean wing spread (m)	*9.5 (0.4)*	*10.5 (0.3)*	*11.4 (0.3)*	*12.4 (0.3)*	*13.4 (0.3)*	*14.4 (0.3)*	*.*	*.*	***11.3 (1.0)***
Mean station depth (m)	*24 (6)*	*26 (7)*	*32 (8)*	*43 (10)*	*47 (9)*	*47 (9)*	*.*	*32 (10)*	***32 (11)***
2009	1	9	54	31	5	1	0	5	**106**
2010	2	34	45	19	3	0	0	1	**104**
2011	19	32	19	9	1	0	0	26	**106**
2012	27	34	23	4	5	1	0	14	**108**
2013	9	28	33	27	4	4	0	5	**110**
2014	3	22	44	34	5	0	0	0	**108**
2015	3	28	55	20	2	0	0	0	**108**
2016	4	35	43	23	2	0	0	2	**109**
2017	.	.	.	.	.	.	.	.	**.**
Total	**68**	**222**	**316**	**167**	**27**	**6**	**0**	**53**	**859**

Table 4. Total number of stations, and number of stations with and without wing spread ('Wing', 'No wing') and door spread data ('Door', 'No door') from the 2009-2018 NEFSC spring and 2009-2016 NEFSC fall surveys for summer flounder.

	Spring				Fall			
	Total	Wing	No wing		**Total**	Wing	No wing	
			Door	No door			Door	No door
2009	**129**	122	5	2	**106**	101	5	0
2010	**136**	127	9	0	**104**	103	1	0
2011	**124**	113	8	3	**106**	80	22	4
2012	**121**	119	1	1	**108**	94	9	5
2013	**127**	120	7	0	**110**	105	5	0
2014	**95**	65	30	0	**108**	108	0	0
2015	**125**	125	0	0	**108**	108	0	0
2016	**120**	119	0	1	**109**	107	2	0
2017	**126**	106	20	0	**.**	.	.	.
2018	**100**	100	0	0				
Total	**1203**	**1116**	**80**	**7**	**859**	**806**	**44**	**9**

Table 5. NEFSC survey aggregate stratified mean weight (i.e., biomass) and mean number (i.e., abundance) per tow point estimates (left 4 columns) and bootstrapped estimates with 90% confidence intervals (CI; right 12 columns) for summer flounder for spring 2009-2018 (a) and (b), and fall 2009-2017 (c) and (d), for the standard data (SD), and sweep study (SS), area swept (AS), and summer flounder efficiency (Seff) adjusted data.

(a)

	Biomass (kg) point estimates				**Biomass (kg) bootstrapped estimates with 90% CI**											
Year	**SD**	**SS**	**AS**	**Seff**	**SD**	*lower*	*upper*	**SS**	*lower*	*upper*	**AS**	*lower*	*upper*	**Seff**	*lower*	*upper*
2009	3.5	7.0	6.9	7.8	3.6	*3.0*	*4.1*	7.0	*5.9*	*8.1*	6.9	*5.9*	*7.9*	7.8	*6.6*	*8.8*
2010	4.8	8.8	8.6	9.0	4.8	*4.1*	*5.5*	8.8	*7.6*	*10.1*	8.5	*7.3*	*9.8*	8.9	*7.6*	*10.3*
2011	4.9	9.0	8.8	9.7	4.9	*4.3*	*5.6*	9.0	*7.7*	*10.2*	8.8	*7.6*	*10.0*	9.7	*8.4*	*10.9*
2012	5.1	8.9	9.1	10.3	5.1	*4.2*	*6.0*	8.9	*7.3*	*10.4*	9.1	*7.4*	*10.7*	10.2	*8.4*	*12.1*
2013	4.5	8.5	8.7	9.9	4.5	*4.0*	*5.1*	8.5	*7.6*	*9.6*	8.7	*7.8*	*9.8*	9.9	*8.8*	*11.1*
2014	3.7	6.6	6.3	6.7	3.7	*2.9*	*4.6*	6.6	*5.2*	*8.2*	6.3	*5.0*	*7.7*	6.7	*5.4*	*8.2*
2015	4.7	8.9	8.7	9.2	4.7	*3.8*	*5.6*	8.8	*7.1*	*10.7*	8.7	*6.9*	*10.5*	9.2	*7.4*	*11.1*
2016	2.9	5.1	5.0	5.6	2.9	*2.4*	*3.3*	5.1	*4.3*	*5.8*	5.0	*4.3*	*5.8*	5.6	*4.7*	*6.3*
2017	2.5	4.6	4.4	4.8	2.5	*2.2*	*2.9*	4.6	*4.0*	*5.2*	4.4	*3.8*	*5.0*	4.8	*4.1*	*5.4*
2018	4.7	8.4	8.7	10.5	4.7	*2.9*	*6.6*	8.3	*5.4*	*11.4*	8.7	*5.6*	*11.9*	10.5	*6.5*	*14.7*

(b)

	Abundance (number) point estimates				**Abundance (number) bootstrapped estimates with 90% CI**											
Year	**SD**	**SS**	**AS**	**Seff**	**SD**	*lower*	*upper*	**SS**	*lower*	*upper*	**AS**	*lower*	*upper*	**Seff**	*lower*	*upper*
2009	5.7	14.7	15.0	18.9	5.7	*4.9*	*6.4*	14.7	*12.0*	*17.7*	15.0	*12.1*	*18.1*	18.8	*14.6*	*23.4*
2010	7.2	14.8	14.4	15.2	7.1	*6.2*	*8.1*	14.8	*12.8*	*16.8*	14.4	*12.4*	*16.4*	15.2	*13.1*	*17.3*
2011	8.2	15.8	15.6	17.5	8.2	*6.7*	*9.6*	15.8	*12.8*	*18.8*	15.6	*12.7*	*18.5*	17.5	*14.5*	*20.5*
2012	6.7	11.8	12.2	13.9	6.7	*5.6*	*7.8*	11.8	*10.0*	*13.8*	12.1	*10.2*	*14.3*	13.9	*11.7*	*16.2*
2013	5.8	12.8	13.4	16.5	5.8	*5.1*	*6.5*	12.8	*11.3*	*14.5*	13.4	*11.7*	*15.2*	16.5	*13.9*	*19.3*
2014	4.3	8.0	7.7	8.4	4.3	*3.5*	*5.2*	8.0	*6.5*	*9.7*	7.7	*6.3*	*9.3*	8.4	*6.9*	*10.0*
2015	8.2	20.1	19.9	21.1	8.2	*6.1*	*10.5*	19.9	*14.7*	*25.7*	19.6	*14.5*	*25.5*	20.9	*15.8*	*26.8*
2016	3.4	6.1	6.1	6.8	3.4	*2.9*	*3.9*	6.1	*5.3*	*7.0*	6.1	*5.3*	*6.9*	6.9	*5.9*	*7.8*
2017	3.5	7.6	7.3	8.0	3.4	*3.0*	*3.9*	7.5	*6.4*	*8.7*	7.3	*6.2*	*8.4*	8.0	*6.7*	*9.2*
2018	5.1	12.1	12.7	15.5	5.1	*4.0*	*6.2*	12.1	*9.7*	*14.6*	12.6	*10.2*	*15.3*	15.4	*12.3*	*18.8*

Table 5. Continued.

(c)

	Biomass (kg) point estimates				Biomass (kg) bootstrapped estimates with 90% CI											
Year	**SD**	**SS**	**AS**	**Seff**	**SD**	*lower*	*upper*	**SS**	*lower*	*upper*	**AS**	*lower*	*upper*	**Seff**	*lower*	*upper*
2009	6.7	11.6	12.2	16.4	6.7	*5.3*	*8.4*	11.7	*9.3*	*14.4*	12.3	*9.8*	*15.1*	16.4	*13.3*	*19.8*
2010	3.4	5.8	6.3	9.3	3.4	*2.6*	*4.2*	5.8	*4.5*	*7.0*	6.3	*4.9*	*7.6*	9.3	*7.4*	*11.2*
2011	7.9	12.6	13.7	24.8	7.9	*4.6*	*11.3*	12.5	*7.5*	*17.8*	13.6	*8.4*	*19.4*	24.7	*18.0*	*31.7*
2012	4.9	8.5	10.4	36.3	5.0	*3.3*	*6.8*	8.6	*5.9*	*11.4*	10.4	*7.3*	*13.8*	36.5	*24.2*	*50.0*
2013	4.7	7.9	8.4	18.1	4.7	*3.8*	*5.6*	7.9	*6.4*	*9.3*	8.4	*7.0*	*9.7*	18.0	*13.4*	*23.1*
2014	5.5	9.3	10.0	13.5	5.5	*4.5*	*6.6*	9.4	*7.8*	*11.0*	10.0	*8.3*	*11.8*	13.6	*11.4*	*15.9*
2015	5.0	8.1	9.1	16.8	5.0	*3.7*	*6.4*	8.1	*6.1*	*10.2*	9.1	*6.8*	*11.5*	16.8	*12.3*	*21.4*
2016	3.8	7.0	7.8	11.9	3.8	*3.0*	*4.7*	6.9	*5.6*	*8.3*	7.7	*6.2*	*9.2*	11.8	*9.8*	*14.0*
2017	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

(d)

	Abundance (number) point estimates				Abundance (number) bootstrapped estimates with 90% CI											
Year	**SD**	**SS**	**AS**	**Seff**	**SD**	*lower*	*upper*	**SS**	*lower*	*upper*	**AS**	*lower*	*upper*	**Seff**	*lower*	*upper*
2009	9.2	18.2	19.3	27.7	9.2	*7.1*	*11.6*	18.3	*14.4*	*22.5*	19.4	*15.4*	*24.0*	27.8	*21.8*	*34.4*
2010	4.9	9.1	10.1	16.1	4.9	*4.0*	*5.9*	9.0	*7.4*	*10.7*	10.0	*8.2*	*11.9*	16.1	*13.3*	*18.8*
2011	7.8	14.1	16.0	40.0	7.7	*5.6*	*9.9*	14.0	*10.2*	*17.7*	15.9	*11.8*	*20.0*	39.8	*31.2*	*47.7*
2012	5.6	16.3	20.3	68.2	5.6	*4.1*	*7.3*	16.4	*12.1*	*20.7*	20.4	*15.0*	*26.0*	68.5	*52.0*	*85.2*
2013	4.8	8.8	9.6	22.8	4.8	*4.0*	*5.6*	8.8	*7.4*	*10.3*	9.6	*8.2*	*11.0*	22.7	*17.4*	*28.0*
2014	7.1	15.3	16.9	27.1	7.1	*5.7*	*8.6*	15.4	*12.7*	*18.2*	16.9	*14.0*	*19.9*	27.2	*22.7*	*31.9*
2015	5.6	10.5	11.9	21.7	5.6	*4.5*	*6.9*	10.5	*8.5*	*12.8*	11.9	*9.5*	*14.5*	21.7	*17.3*	*26.6*
2016	4.5	21.4	23.9	37.3	4.4	*3.6*	*5.3*	21.4	*14.8*	*27.7*	23.9	*16.7*	*30.8*	37.3	*27.3*	*47.1*
2017	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 6. NEFSC survey stratified mean number per tow at age point estimates for summer flounder for spring 2009-2018, for the standard data (SD), and sweep study (SS), area swept (AS), and summer flounder efficiency (Seff) adjusted data.

2009	1	2	3	4	5	6	7	8	9	10+	Total
SD	1.77	1.55	1.13	0.60	0.39	0.11	0.05	0.03	0.02	0.01	5.66
SS	7.99	2.60	2.02	1.10	0.68	0.18	0.08	0.05	0.03	0.01	14.74
AS	8.43	2.55	1.99	1.07	0.65	0.17	0.07	0.04	0.03	0.01	15.01
Seff	11.67	2.84	2.18	1.16	0.69	0.18	0.08	0.05	0.03	0.01	18.88

2010	1	2	3	4	5	6	7	8	9	10+	Total
SD	1.94	1.87	1.52	0.94	0.47	0.20	0.10	0.06	0.02	0.03	7.15
SS	5.77	3.12	2.70	1.73	0.84	0.33	0.16	0.10	0.03	0.04	14.82
AS	5.66	3.01	2.60	1.67	0.81	0.32	0.16	0.09	0.03	0.04	14.39
Seff	6.09	3.15	2.72	1.74	0.85	0.33	0.16	0.10	0.03	0.04	15.22

2011	1	2	3	4	5	6	7	8	9	10+	Total
SD	1.48	2.44	2.18	1.06	0.63	0.16	0.08	0.06	0.04	0.04	8.17
SS	4.32	4.06	3.71	1.94	1.14	0.27	0.13	0.10	0.06	0.06	15.79
AS	4.31	4.02	3.68	1.92	1.11	0.26	0.12	0.09	0.06	0.06	15.62
Seff	4.98	4.44	4.07	2.12	1.22	0.28	0.13	0.10	0.06	0.06	17.46

2012	1	2	3	4	5	6	7	8	9	10+	Total
SD	0.48	1.07	2.61	1.46	0.60	0.24	0.11	0.05	0.02	0.03	6.69
SS	1.17	1.81	4.37	2.67	1.07	0.41	0.17	0.08	0.03	0.05	11.83
AS	1.22	1.87	4.52	2.74	1.09	0.42	0.18	0.09	0.03	0.05	12.19
Seff	1.40	2.15	5.23	3.11	1.21	0.46	0.19	0.09	0.03	0.05	13.93

2013	1	2	3	4	5	6	7	8	9	10+	Total
SD	0.81	0.76	1.44	1.85	0.57	0.23	0.08	0.04	0.01	0.02	5.81
SS	3.92	1.39	2.51	3.37	1.01	0.39	0.13	0.07	0.02	0.03	12.83
AS	4.28	1.45	2.58	3.45	1.02	0.39	0.13	0.07	0.02	0.03	13.42
Seff	6.12	1.69	2.94	3.91	1.13	0.43	0.14	0.08	0.02	0.03	16.49

2014	1	2	3	4	5	6	7	8	9	10+	Total
SD	0.44	0.64	0.94	1.17	0.82	0.14	0.07	0.02	0.01	0.02	4.27
SS	1.23	1.14	1.61	2.14	1.46	0.23	0.12	0.03	0.02	0.02	7.99
AS	1.24	1.12	1.56	2.04	1.38	0.21	0.11	0.03	0.02	0.02	7.73
Seff	1.38	1.22	1.69	2.20	1.46	0.22	0.11	0.03	0.02	0.02	8.36

Table 6. Continued.

2015	1	2	3	4	5	6	7	8	9	10+	Total
SD	2.70	1.96	1.49	0.89	0.52	0.33	0.16	0.07	0.04	0.07	8.23
SS	9.68	3.92	2.59	1.60	0.94	0.57	0.28	0.12	0.05	0.11	19.85
AS	9.63	3.86	2.54	1.57	0.91	0.55	0.27	0.11	0.05	0.11	19.62
Seff	10.26	4.04	2.69	1.66	0.97	0.59	0.29	0.12	0.06	0.11	20.79

2016	1	2	3	4	5	6	7	8	9	10+	Total
SD	0.19	0.68	0.92	0.70	0.32	0.22	0.20	0.12	0.03	0.02	3.39
SS	0.46	1.23	1.62	1.25	0.57	0.39	0.35	0.20	0.04	0.03	6.13
AS	0.45	1.24	1.61	1.24	0.56	0.39	0.34	0.19	0.04	0.03	6.09
Seff	0.48	1.43	1.85	1.39	0.61	0.42	0.38	0.21	0.05	0.03	6.85

2017	1	2	3	4	5	6	7	8	9	10+	Total
SD	0.66	0.91	0.84	0.34	0.26	0.14	0.13	0.08	0.04	0.04	3.44
SS	2.61	1.65	1.49	0.61	0.46	0.25	0.22	0.13	0.07	0.07	7.56
AS	2.59	1.59	1.42	0.58	0.42	0.24	0.21	0.13	0.07	0.07	7.31
Seff	2.83	1.74	1.56	0.63	0.46	0.26	0.23	0.14	0.07	0.08	7.98

2018	1	2	3	4	5	6	7	8	9	10+	Total
SD	1.12	1.07	0.92	0.65	0.44	0.30	0.19	0.18	0.08	0.08	5.05
SS	5.00	1.83	1.62	1.16	0.77	0.49	0.31	0.29	0.13	0.13	11.73
AS	5.28	1.91	1.68	1.21	0.81	0.52	0.33	0.30	0.13	0.14	12.30
Seff	6.63	2.29	1.98	1.46	0.95	0.62	0.39	0.37	0.17	0.17	15.02

Table 7. NEFSC survey stratified mean number per tow at age point estimates for summer flounder for fall 2009-2017, for the standard data (SD), and sweep study (SS), area swept (AS), and summer flounder efficiency (Seff) adjusted data.

2009	0	1	2	3	4	5	6	7+	Total
SD	0.63	3.46	2.19	1.41	0.85	0.38	0.11	0.05	9.06
SS	3.27	5.91	3.82	2.57	1.52	0.66	0.18	0.08	18.00
AS	3.61	6.29	4.03	2.70	1.59	0.69	0.19	0.08	19.17
Seff	5.98	9.20	5.44	3.50	2.07	0.89	0.24	0.11	27.44

2010	0	1	2	3	4	5	6	7+	Total
SD	0.23	1.68	1.29	0.80	0.47	0.27	0.11	0.10	4.93
SS	0.92	2.91	2.16	1.42	0.85	0.47	0.18	0.15	9.06
AS	1.09	3.26	2.39	1.56	0.92	0.50	0.19	0.15	10.06
Seff	2.29	5.41	3.61	2.31	1.36	0.71	0.26	0.18	16.12

2011	0	1	2	3	4	5	6	7+	Total
SD	0.33	1.77	2.05	1.33	0.74	0.55	0.35	0.65	7.76
SS	1.29	2.94	3.51	2.41	1.37	0.95	0.58	1.00	14.06
AS	1.65	3.46	4.06	2.72	1.46	1.00	0.61	1.05	16.01
Seff	10.33	8.73	9.34	5.57	2.37	1.45	0.84	1.40	40.02

2012	0	1	2	3	4	5	6	7+	Total
SD	0.61	0.43	0.78	1.96	1.15	0.29	0.13	0.21	5.54
SS	7.57	0.73	1.30	3.48	2.11	0.50	0.22	0.31	16.22
AS	9.69	0.89	1.60	4.25	2.54	0.60	0.27	0.38	20.22
Seff	30.36	3.00	5.96	14.80	9.38	2.23	0.83	1.46	68.03

2013	0	1	2	3	4	5	6	7+	Total
SD	0.17	0.45	0.76	1.48	1.28	0.41	0.08	0.16	4.79
SS	0.61	0.85	1.28	2.65	2.35	0.71	0.13	0.23	8.79
AS	0.74	0.99	1.43	2.85	2.47	0.74	0.13	0.23	9.58
Seff	2.52	3.13	3.83	6.30	4.62	1.52	0.31	0.54	22.77

2014	0	1	2	3	4	5	6	7+	Total
SD	0.84	1.67	1.40	1.34	1.24	0.34	0.18	0.09	7.11
SS	4.10	3.01	2.39	2.41	2.27	0.59	0.30	0.14	15.21
AS	4.73	3.32	2.60	2.59	2.42	0.62	0.31	0.14	16.75
Seff	10.50	4.97	3.59	3.39	3.17	0.79	0.38	0.17	26.95

Table 7. Continued.

2015	0	1	2	3	4	5	6	7+	Total
SD	0.23	1.32	1.56	1.13	0.60	0.44	0.20	0.13	5.61
SS	1.07	2.35	2.69	2.03	1.09	0.75	0.33	0.21	10.52
AS	1.21	2.65	3.03	2.29	1.23	0.85	0.37	0.24	11.87
Seff	2.14	4.47	5.56	4.39	2.40	1.57	0.67	0.44	21.65

2016	0	1	2	3	4	5	6	7+	Total
SD	0.52	0.73	1.21	1.01	0.40	0.26	0.16	0.12	4.41
SS	11.00	4.55	2.14	1.82	0.71	0.45	0.27	0.22	21.16
AS	12.28	5.09	2.42	2.04	0.79	0.50	0.29	0.24	23.65
Seff	18.89	7.96	4.02	3.26	1.20	0.74	0.41	0.37	36.85

2017	0	1	2	3	4	5	6	7+	Total
SD									
SS	.	.	.	.	.	.	.	.	.
AS	.	.	.	.	.	.	.	.	.
Seff	.	.	.	.	.	.	.	.	.

Table 8. NEFSC survey absolute swept area numbers (SWAN) indices (000s) for summer flounder for spring 2009-2018, for the standard data (SD), and sweep study (SS), area swept (AS), and summer flounder efficiency (Seff) adjusted data.

2009	1	2	3	4	5	6	7	8	9	10+	Total
SD	7,208	6,296	4,593	2,432	1,578	452	200	118	89	29	22,995
SS	32,500	10,560	8,233	4,473	2,766	744	315	185	128	43	59,947
AS	34,266	10,376	8,078	4,344	2,649	702	294	176	122	42	61,049
Seff	47,457	11,531	8,849	4,705	2,825	738	305	189	130	45	76,772

2010	1	2	3	4	5	6	7	8	9	10+	Total
SD	7,961	7,660	6,223	3,843	1,915	802	418	255	88	63	29,287
SS	23,604	12,776	11,066	7,076	3,442	1,353	675	394	133	164	60,683
AS	23,163	12,331	10,647	6,822	3,327	1,310	653	385	130	158	58,926
Seff	24,940	12,898	11,130	7,124	3,480	1,363	673	414	134	164	62,321

2011	1	2	3	4	5	6	7	8	9	10+	Total
SD	6,051	10,007	8,938	4,343	2,584	656	313	240	168	150	33,467
SS	17,687	16,627	15,205	7,938	4,666	1,106	526	393	254	248	64,650
AS	17,629	16,452	15,064	7,845	4,558	1,055	504	374	241	235	63,957
Seff	20,370	18,161	16,669	8,688	5,008	1,128	543	397	256	249	71,470

2012	1	2	3	4	5	6	7	8	9	10+	Total
SD	1,950	4,387	10,699	5,983	2,473	1,003	461	223	83	72	27,403
SS	4,779	7,397	17,898	10,923	4,392	1,674	713	344	128	205	48,453
AS	4,979	7,645	18,489	11,201	4,457	1,705	725	355	127	206	49,889
Seff	5,721	8,793	21,424	12,722	4,958	1,878	792	388	132	215	57,023

2013	1	2	3	4	5	6	7	8	9	10+	Total
SD	3,297	3,095	5,898	7,594	2,335	937	309	177	58	20	23,793
SS	16,049	5,705	10,259	13,812	4,116	1,584	516	286	87	133	52,548
AS	17,525	5,922	10,550	14,121	4,184	1,605	523	292	87	130	54,940
Seff	25,049	6,915	12,025	15,997	4,641	1,750	569	321	92	137	67,495

2014	1	2	3	4	5	6	7	8	9	10+	Total
SD	1,450	2,134	3,118	3,901	2,718	455	242	80	34	16	14,189
SS	4,096	3,776	5,339	7,102	4,867	754	383	116	58	78	26,568
AS	4,111	3,733	5,180	6,784	4,591	702	356	108	58	67	25,690
Seff	4,578	4,068	5,615	7,332	4,853	735	373	114	65	67	27,801

Table 8. Continued.

2015	1	2	3	4	5	6	7	8	9	10+	Total
SD	11,066	8,016	6,093	3,651	2,146	1,331	669	268	148	79	33,674
SS	39,618	16,030	10,616	6,552	3,838	2,323	1,146	472	220	458	81,272
AS	39,447	15,820	10,398	6,417	3,745	2,266	1,117	462	216	440	80,328
Seff	42,005	16,545	11,013	6,803	3,961	2,407	1,192	491	233	465	85,114

2016	1	2	3	4	5	6	7	8	9	10+	Total
SD	759	2,776	3,751	2,878	1,319	897	821	493	106	44	13,866
SS	1,867	5,056	6,622	5,102	2,329	1,603	1,420	815	183	112	25,108
AS	1,837	5,069	6,609	5,062	2,294	1,586	1,408	798	177	113	24,952
Seff	1,966	5,872	7,555	5,691	2,505	1,734	1,537	860	188	125	28,033

2017	1	2	3	4	5	6	7	8	9	10+	Total
SD	2,693	3,708	3,452	1,406	1,062	586	529	319	165	146	14,082
SS	10,671	6,741	6,101	2,500	1,869	1,031	903	553	281	292	30,941
AS	10,624	6,498	5,821	2,362	1,738	975	855	519	270	282	29,941
Seff	11,579	7,119	6,378	2,562	1,872	1,078	940	564	288	308	32,687

2018	1	2	3	4	5	6	7	8	9	10+	Total
SD	4,572	4,380	3,783	2,677	1,811	1,243	779	751	317	229	20,654
SS	20,459	7,504	6,621	4,735	3,157	2,026	1,278	1,174	523	540	48,017
AS	21,609	7,824	6,867	4,950	3,299	2,116	1,334	1,241	548	561	50,349
Seff	27,144	9,380	8,113	5,961	3,891	2,525	1,595	1,508	686	682	61,485

Table 9. NEFSC survey absolute swept area numbers (SWAN) indices (000s) for summer flounder for fall 2009-2017, for the standard data (SD), and sweep study (SS), area swept (AS), and summer flounder efficiency (Seff) adjusted data.

2009	0	1	2	3	4	5	6	7+	Total
SD	1,652	9,106	5,780	3,702	2,230	993	282	137	23,881
SS	8,617	15,560	10,067	6,762	4,010	1,727	462	209	47,413
AS	9,500	16,573	10,628	7,103	4,190	1,810	488	222	50,514
Seff	15,761	24,229	14,333	9,223	5,458	2,345	632	298	72,280

2010	0	1	2	3	4	5	6	7+	Total
SD	593	4,336	3,323	2,055	1,202	697	280	247	12,733
SS	2,372	7,513	5,566	3,676	2,194	1,218	466	383	23,389
AS	2,806	8,425	6,161	4,032	2,380	1,300	493	387	25,985
Seff	5,910	13,961	9,332	5,966	3,512	1,835	670	453	41,639

2011	0	1	2	3	4	5	6	7+	Total
SD	863	4,663	5,406	3,498	1,962	1,441	912	1,711	20,456
SS	3,399	7,756	9,240	6,352	3,597	2,507	1,539	2,647	37,036
AS	4,352	9,115	10,701	7,163	3,846	2,629	1,613	2,753	42,173
Seff	27,208	22,994	24,607	14,677	6,251	3,813	2,203	3,682	105,434

2012	0	1	2	3	4	5	6	7+	Total
SD	1,606	1,121	2,048	5,154	3,017	753	353	544	14,594
SS	19,937	1,917	3,425	9,164	5,554	1,305	588	829	42,719
AS	25,532	2,334	4,226	11,185	6,705	1,591	705	1,001	53,278
Seff	79,989	7,900	15,711	38,996	24,719	5,882	2,187	3,836	179,219

2013	0	1	2	3	4	5	6	7+	Total
SD	448	1,198	1,992	3,887	3,371	1,093	213	423	12,624
SS	1,607	2,229	3,360	6,968	6,183	1,869	336	610	23,161
AS	1,953	2,615	3,764	7,496	6,511	1,954	346	607	25,245
Seff	6,637	8,237	10,098	16,590	12,174	4,009	824	1,426	59,994

2014	0	1	2	3	4	5	6	7+	Total
SD	2,219	4,408	3,680	3,518	3,279	908	486	239	18,736
SS	10,795	7,936	6,308	6,353	5,975	1,563	791	359	40,080
AS	12,470	8,753	6,850	6,819	6,383	1,643	830	375	44,123
Seff	27,673	13,085	9,446	8,935	8,344	2,076	1,009	435	71,002

Table 9. Continued.

2015	0	1	2	3	4	5	6	7+	Total
SD	606	3,481	4,102	2,979	1,580	1,162	529	352	14,791
SS	2,806	6,201	7,093	5,357	2,863	1,985	861	562	27,729
AS	3,199	6,974	7,994	6,038	3,230	2,229	967	636	31,266
Seff	5,642	11,786	14,648	11,573	6,327	4,135	1,771	1,169	57,049

2016	0	1	2	3	4	5	6	7+	Total
SD	1,370	1,916	3,179	2,672	1,059	679	429	328	11,631
SS	28,989	12,000	5,640	4,785	1,865	1,196	703	576	55,753
AS	32,354	13,402	6,363	5,370	2,076	1,328	770	642	62,305
Seff	49,770	20,963	10,590	8,587	3,164	1,958	1,073	966	97,072

2017	0	1	2	3	4	5	6	7+	Total
SD									
SS	.	.	.	.	.	.	.	.	.
AS	.	.	.	.	.	.	.	.	.
Seff	.	.	.	.	.	.	.	.	.

Table 10. NEFSC survey aggregate stratified mean weight (i.e., biomass) per tow and stratified mean number (i.e., abundance) per tow point estimates (Pt) and bootstrapped estimates (Boot) with 90% confidence intervals (lower, upper) for summer flounder for spring 2009-2018 (a) and fall 2009-2017 (b), for yellowtail flounder efficiency (Yeff) adjusted data.

(a)

	Biomass (kg)				**Abundance (number)**			
Year	**Pt**	**Boot**	*lower*	*upper*	**Pt**	**Boot**	*lower*	*upper*
2009	7.3	7.3	*6.2*	*8.4*	16.6	16.6	*13.1*	*20.3*
2010	9.3	9.3	*8.0*	*10.7*	15.7	15.7	*13.5*	*17.8*
2011	9.3	9.3	*8.0*	*10.5*	16.6	16.6	*13.5*	*19.6*
2012	9.7	9.6	*8.0*	*11.3*	12.9	12.9	*10.9*	*15.1*
2013	9.3	9.2	*8.2*	*10.4*	14.7	14.7	*12.7*	*16.7*
2014	6.8	6.8	*5.4*	*8.4*	8.3	8.3	*6.8*	*10.0*
2015	9.3	9.2	*7.4*	*11.2*	21.3	21.0	*15.4*	*27.5*
2016	5.3	5.3	*4.5*	*6.1*	6.5	6.5	*5.6*	*7.4*
2017	4.5	4.5	*3.9*	*5.2*	7.6	7.5	*6.4*	*8.7*
2018	9.4	9.4	*5.9*	*13.2*	13.8	13.8	*11.0*	*16.7*

(b)

	Biomass (kg)				**Abundance (number)**			
Year	**Pt**	**Boot**	*lower*	*upper*	**Pt**	**Boot**	*lower*	*upper*
2009	13.9	13.9	*11.2*	*17.0*	22.8	22.9	*18.1*	*28.3*
2010	7.5	7.5	*5.9*	*9.2*	12.5	12.4	*10.1*	*14.6*
2011	16.4	16.3	*10.9*	*22.2*	21.2	21.0	*15.9*	*26.4*
2012	15.0	15.2	*10.6*	*19.8*	30.4	30.6	*22.5*	*38.7*
2013	10.1	10.1	*8.4*	*11.7*	12.0	12.0	*10.4*	*13.6*
2014	11.1	11.2	*9.3*	*13.1*	20.3	20.4	*16.9*	*23.9*
2015	11.7	11.7	*8.7*	*14.9*	15.3	15.4	*12.2*	*18.8*
2016	9.5	9.4	*7.7*	*11.2*	29.6	29.7	*21.0*	*38.1*
2017	**.**	**.**	*.*	*.*	.	.	.	.

Table 11. NEFSC survey stratified mean number per tow at age point estimates for summer flounder for spring 2009-2018 (a) and fall 2009-2017 (b), for yellowtail flounder efficiency (Yeff) adjusted data.

(a)

Year	1	2	3	4	5	6	7	8	9	10+	Total
2009	9.73	2.67	2.09	1.13	0.69	0.18	0.08	0.05	0.03	0.01	16.65
2010	6.15	3.29	2.84	1.81	0.89	0.35	0.17	0.10	0.04	0.04	15.69
2011	4.70	4.21	3.85	2.01	1.18	0.28	0.13	0.10	0.06	0.06	16.57
2012	1.27	1.98	4.83	2.92	1.15	0.44	0.19	0.09	0.03	0.05	12.94
2013	4.99	1.54	2.73	3.65	1.08	0.41	0.13	0.07	0.02	0.03	14.66
2014	1.31	1.18	1.66	2.22	1.51	0.23	0.12	0.04	0.02	0.02	8.31
2015	10.31	4.15	2.70	1.66	0.97	0.59	0.29	0.12	0.05	0.11	20.96
2016	0.49	1.34	1.72	1.31	0.59	0.41	0.36	0.20	0.05	0.03	6.50
2017	2.67	1.64	1.47	0.60	0.44	0.25	0.22	0.13	0.07	0.07	7.56
2018	5.89	2.05	1.78	1.31	0.86	0.55	0.35	0.33	0.15	0.15	13.41

(b)

Year	0	1	2	3	4	5	6	7+	Total
2009	4.59	7.57	4.62	2.99	1.76	0.76	0.21	0.10	22.60
2010	1.53	4.09	2.88	1.87	1.09	0.59	0.22	0.17	12.45
2011	2.78	4.90	5.50	3.46	1.71	1.10	0.66	1.12	21.23
2012	15.05	1.27	2.35	6.11	3.65	0.89	0.38	0.57	30.26
2013	1.12	1.40	1.87	3.43	2.86	0.87	0.16	0.29	12.00
2014	6.62	3.94	2.96	2.87	2.64	0.66	0.33	0.15	20.16
2015	1.59	3.36	3.94	2.99	1.60	1.09	0.47	0.31	15.35
2016	15.23	6.33	3.03	2.52	0.96	0.61	0.35	0.30	29.32
2017	.	.	.	.	.	.	.	.	.

Table 12. NEFSC survey absolute swept area numbers (SWAN) indices (000s) for summer flounder for spring 2009-2018 (a) and fall 2009-2017 (b), for yellowtail flounder efficiency (Yeff) adjusted data.

(a)

Year	1	2	3	4	5	6	7	8	9	10+	Total
2009	39,572	10,840	8,480	4,589	2,792	745	316	185	128	44	67,690
2010	25,178	13,475	11,638	7,425	3,635	1,416	707	422	145	177	64,219
2011	19,231	17,247	15,742	8,238	4,824	1,128	536	397	256	249	67,848
2012	5,184	8,094	19,767	11,948	4,704	1,783	764	368	135	218	52,966
2013	20,413	6,306	11,197	14,938	4,413	1,687	549	307	92	138	60,039
2014	4,369	3,909	5,525	7,367	5,028	777	392	121	65	75	27,627
2015	42,220	16,994	11,052	6,809	3,978	2,395	1,187	488	224	467	85,813
2016	2,000	5,499	7,040	5,381	2,417	1,667	1,460	833	190	119	26,606
2017	10,926	6,707	6,028	2,452	1,804	1,008	896	539	282	299	30,941
2018	24,118	8,395	7,303	5,344	3,507	2,261	1,432	1,343	605	612	54,920

(b)

Year	0	1	2	3	4	5	6	7+	Total
2009	12,098	19,943	12,169	7,882	4,642	2,010	553	256	59,553
2010	3,962	10,560	7,446	4,823	2,821	1,530	574	439	32,155
2011	7,315	12,917	14,483	9,121	4,517	2,896	1,750	2,941	55,940
2012	39,641	3,344	6,187	16,103	9,608	2,336	1,001	1,489	79,709
2013	2,956	3,690	4,925	9,046	7,529	2,302	417	759	31,625
2014	17,436	10,384	7,803	7,550	6,954	1,740	869	386	53,123
2015	4,190	8,856	10,372	7,883	4,206	2,867	1,235	822	40,430
2016	40,121	16,687	7,976	6,651	2,527	1,595	910	780	77,247
2017	.	.	.	.	.	.	.	.	.

FIGURES

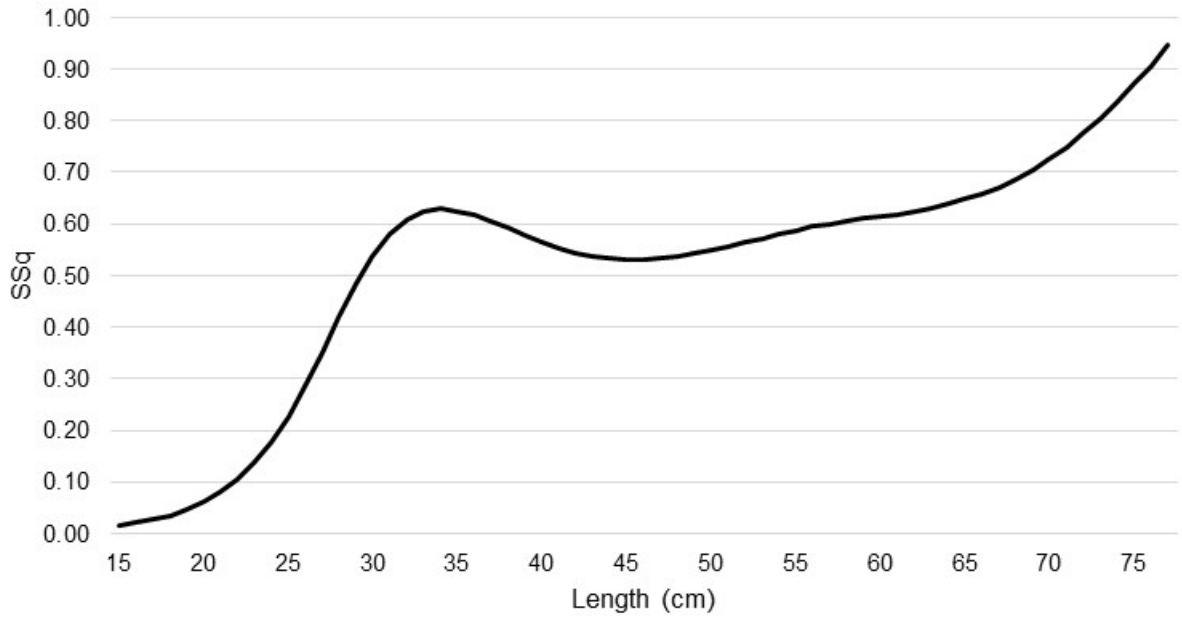
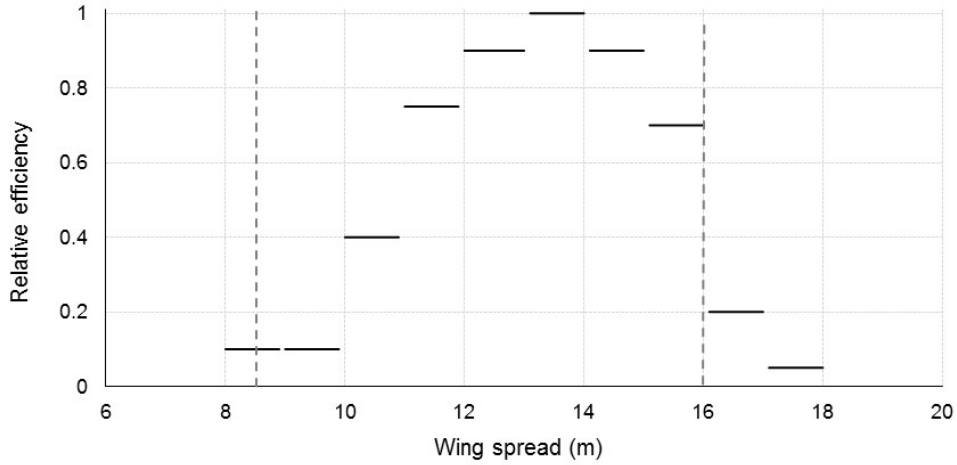
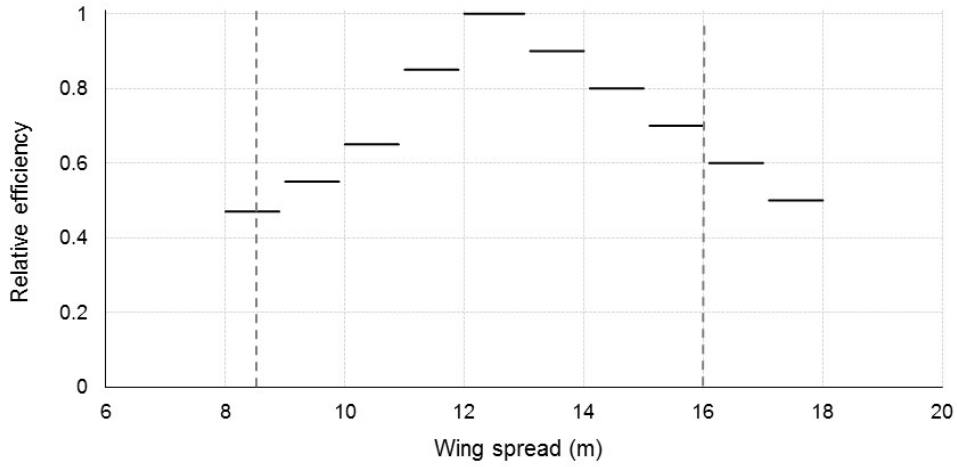


Figure 1. Summer flounder rockhopper catchability (SSq) by length. These coefficients were developed based on data from three (2015-2017) sweep studies carried out with a twin trawl vessel (Miller et al. 2018).

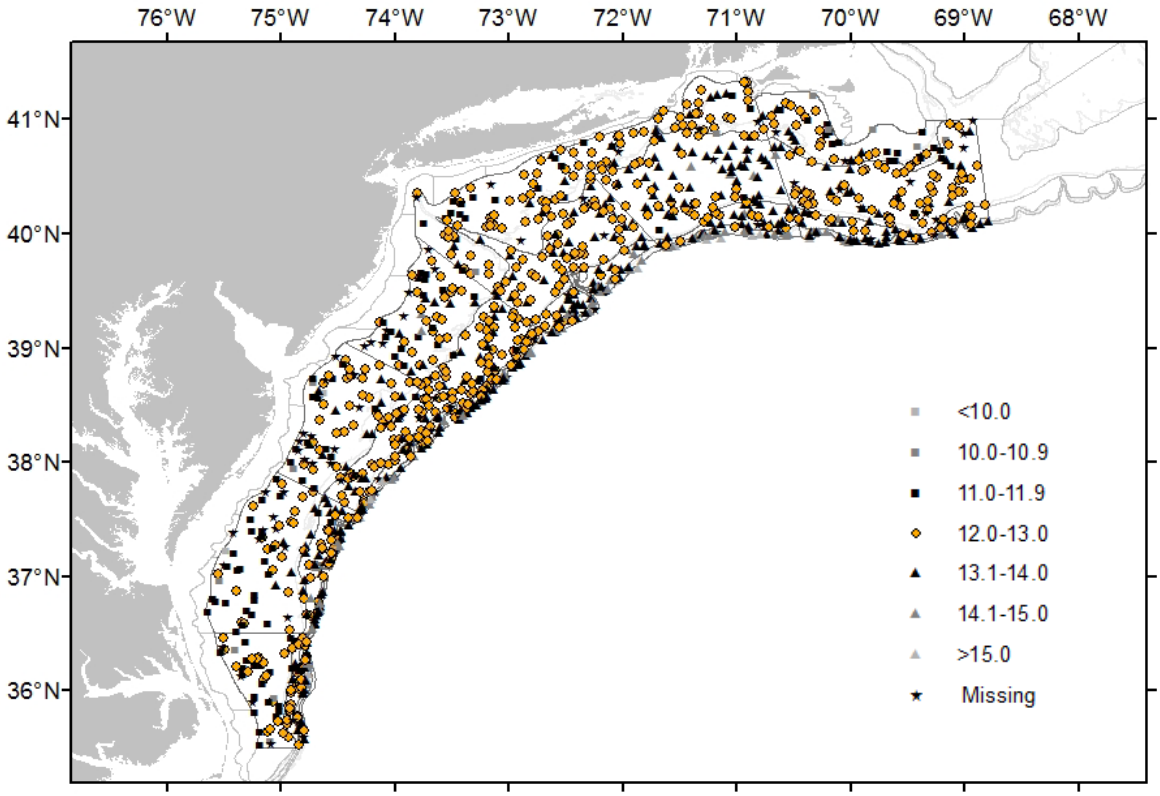


(a)



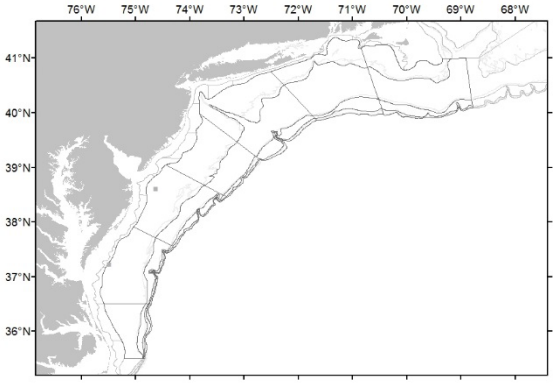
(b)

Figure 2. Hypothesized relative efficiency of the NEFSC survey vessel FSV Henry B. Bigelow *by wing spread for summer flounder (a) and yellowtail flounder (b). Note that these values area based on input from members of the industry; there are no available data to inform this relationship objectively. Spring 2009 to spring 2018 summer flounder data wing spread range is 8.6 – 16.0 m (dashed lines).*

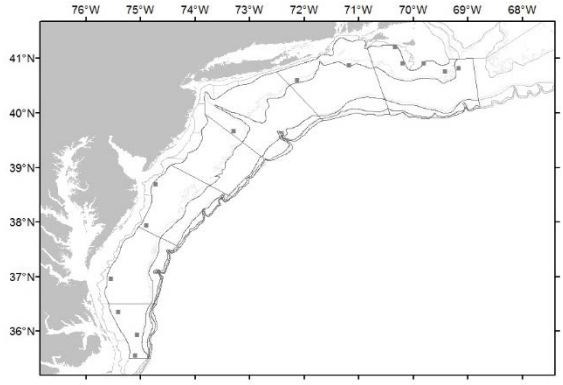


(a)

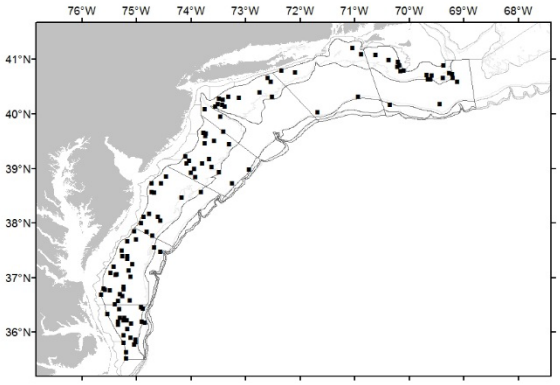
Figure 3. Station location for the 2009-2018 NEFSC spring survey for summer flounder (NEFSC offshore strata 1-12 and 61-76; thin black lines) for all stations combined (a) and stations by wing spread bin (b-i). The different symbols represent different wing spread bins (m), as indicated by the legend presented in (a). 'Missing' indicates wing spread data were not available. Figure letters are located in the bottom left corner of each plot. For reference, a map with stratum numbers is provided in Appendix figure 1.



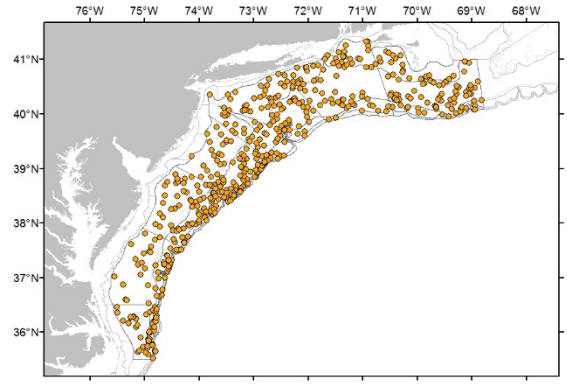
(b) < 10 m



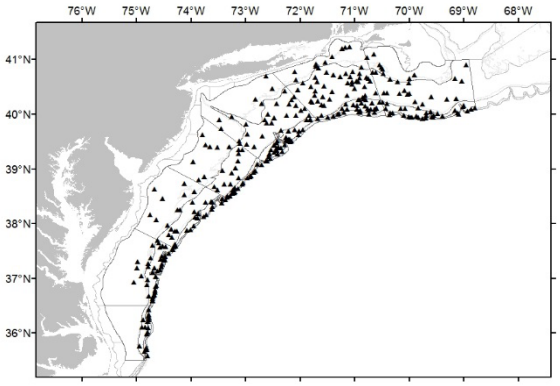
(c) 10.0 – 10.9 m



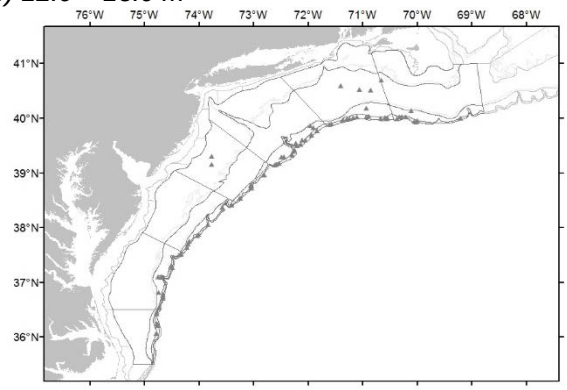
(d) 11.0 – 11.9 m



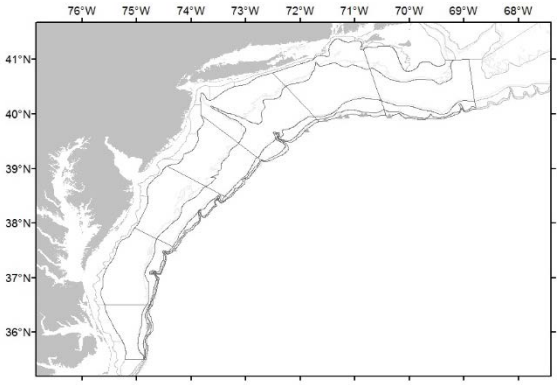
(e) 12.0 – 13.0 m



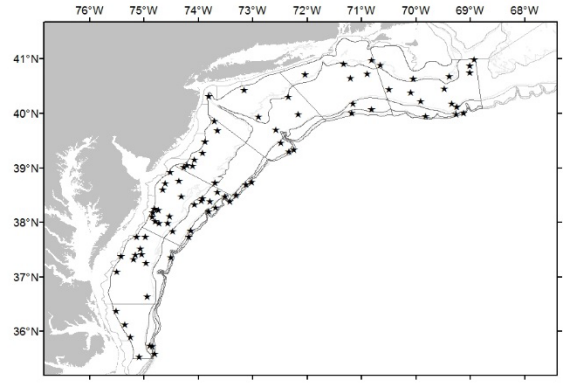
(f) 13.1 – 14.0 m



(g) 14.1 – 15.0 m

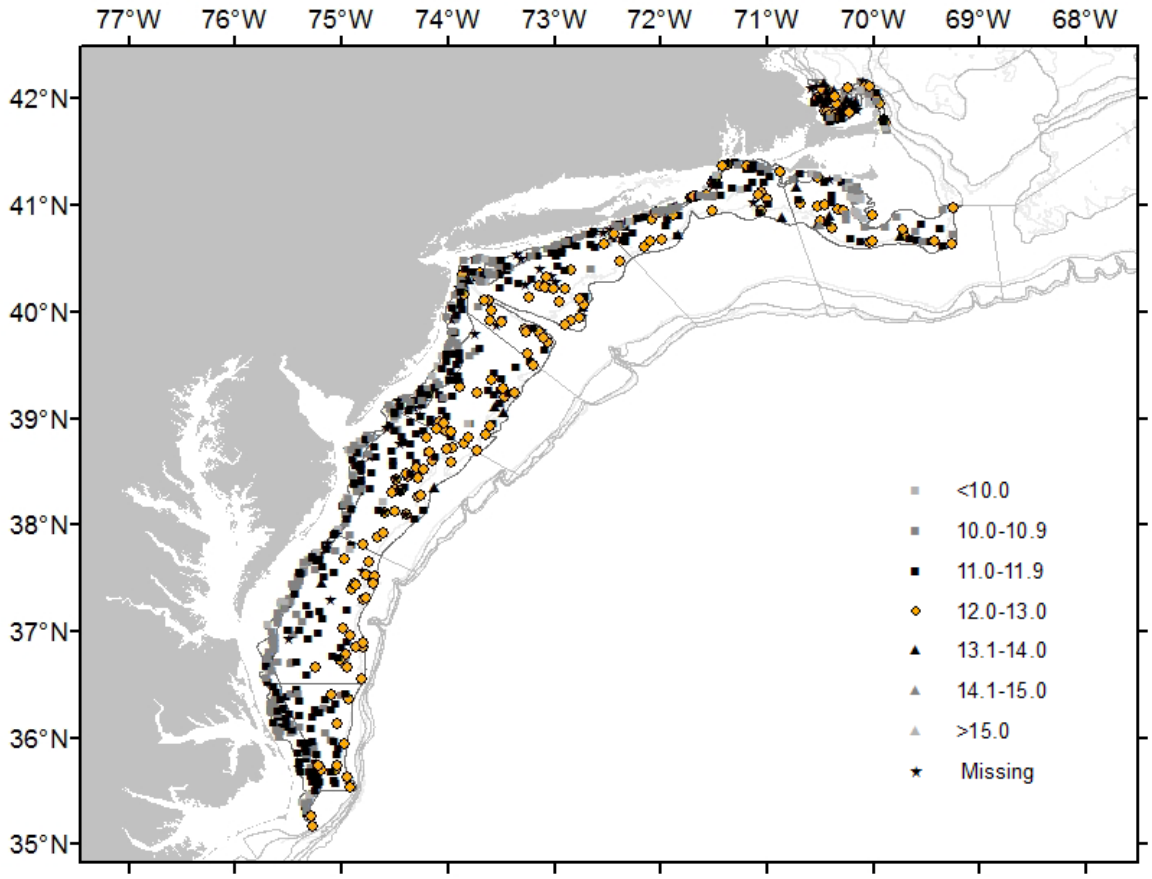


(h) > 15 m



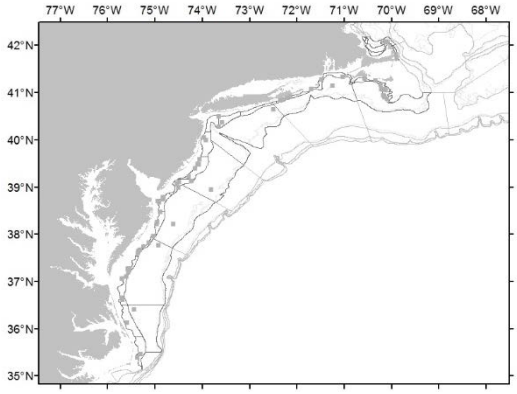
(i) Missing

Figure 3. Continued.

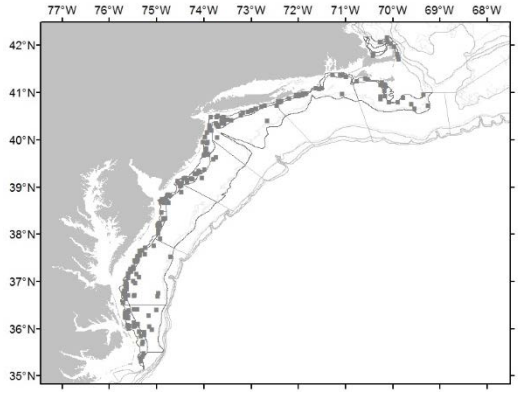


(a)

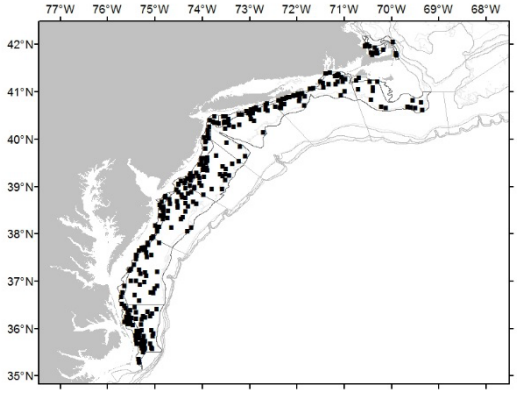
Figure 4. Station location for the 2009-2017 NEFSC fall survey for summer flounder (NEFSC offshore strata 1, 5, 9, 61, 65, 69, 73, and inshore strata 1-61; thin black lines) for all stations combined (a) and stations by wing spread bin (b-i). The different symbols represent different wing spread bins (m), as indicated by the legend presented in (a). 'Missing' indicates wing spread data were not available. Figure letters are located in the bottom left corner of each plot. For reference, a map with stratum numbers is provided in Appendix figure 1.



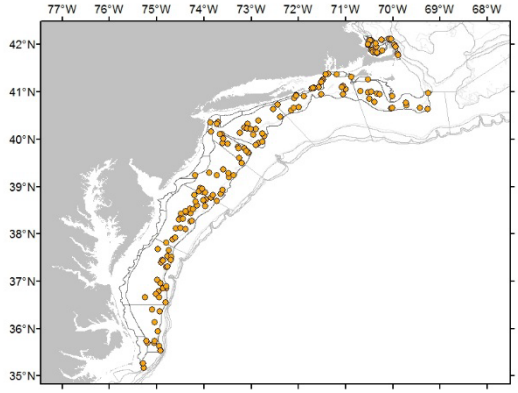
(b) < 10 m



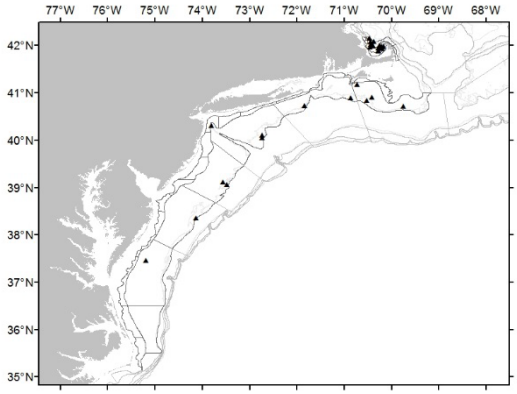
(c) 10.0 – 10.9 m



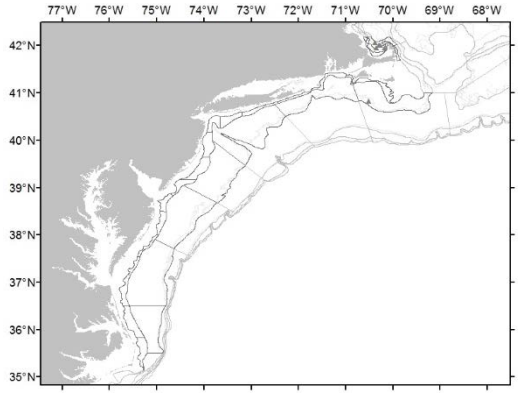
(d) 11.0 – 11.9 m



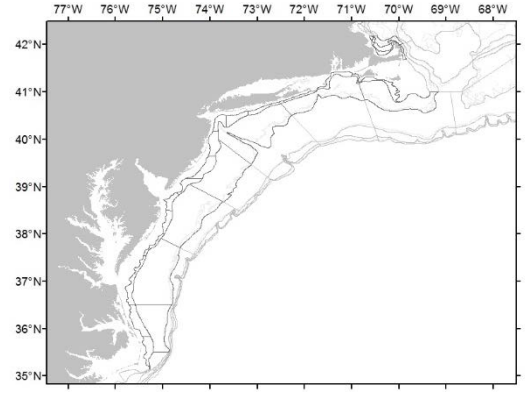
(e) 12.0 – 13.0 m



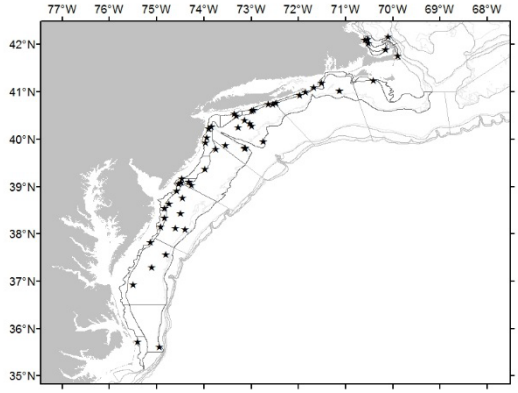
(f) 13.1 – 14.0 m



(g) 14.1 – 15.0 m



(h) > 15 m



(i) Missing

Figure 4. Continued.

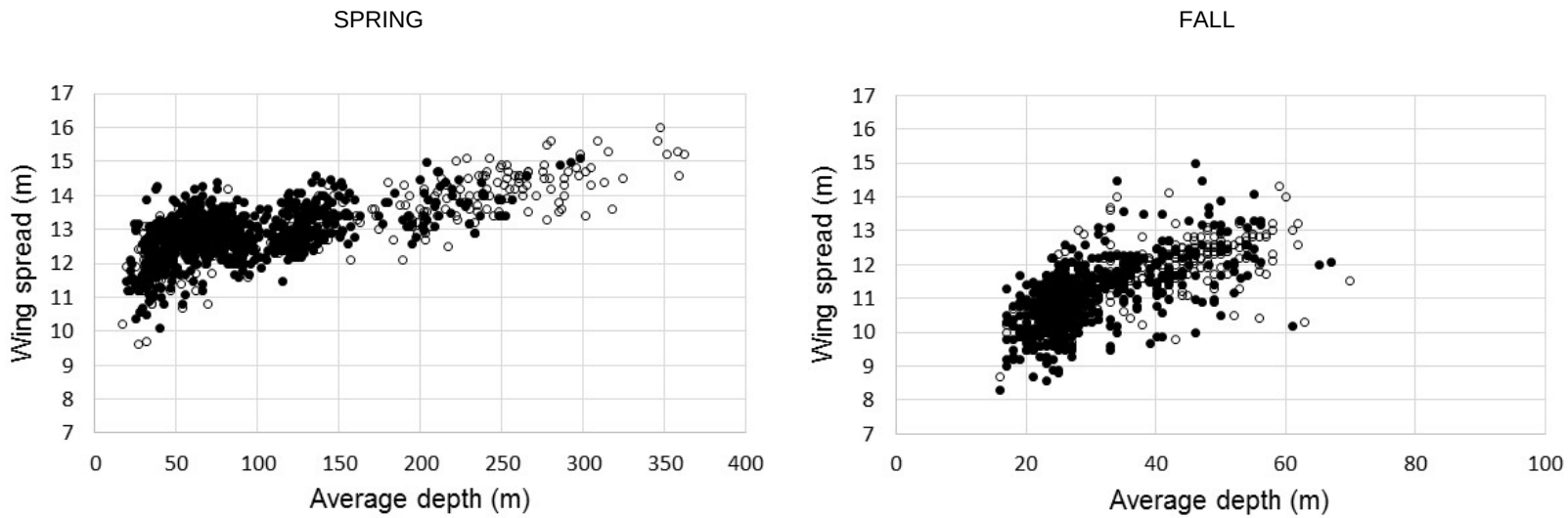


Figure 5. Wing spread by average depth of tow for the 2009-2018 spring and 2009-2017 fall NEFSC survey stations for summer flounder. Black dots represent tows with catch, and open circles represent tows with zero catch.

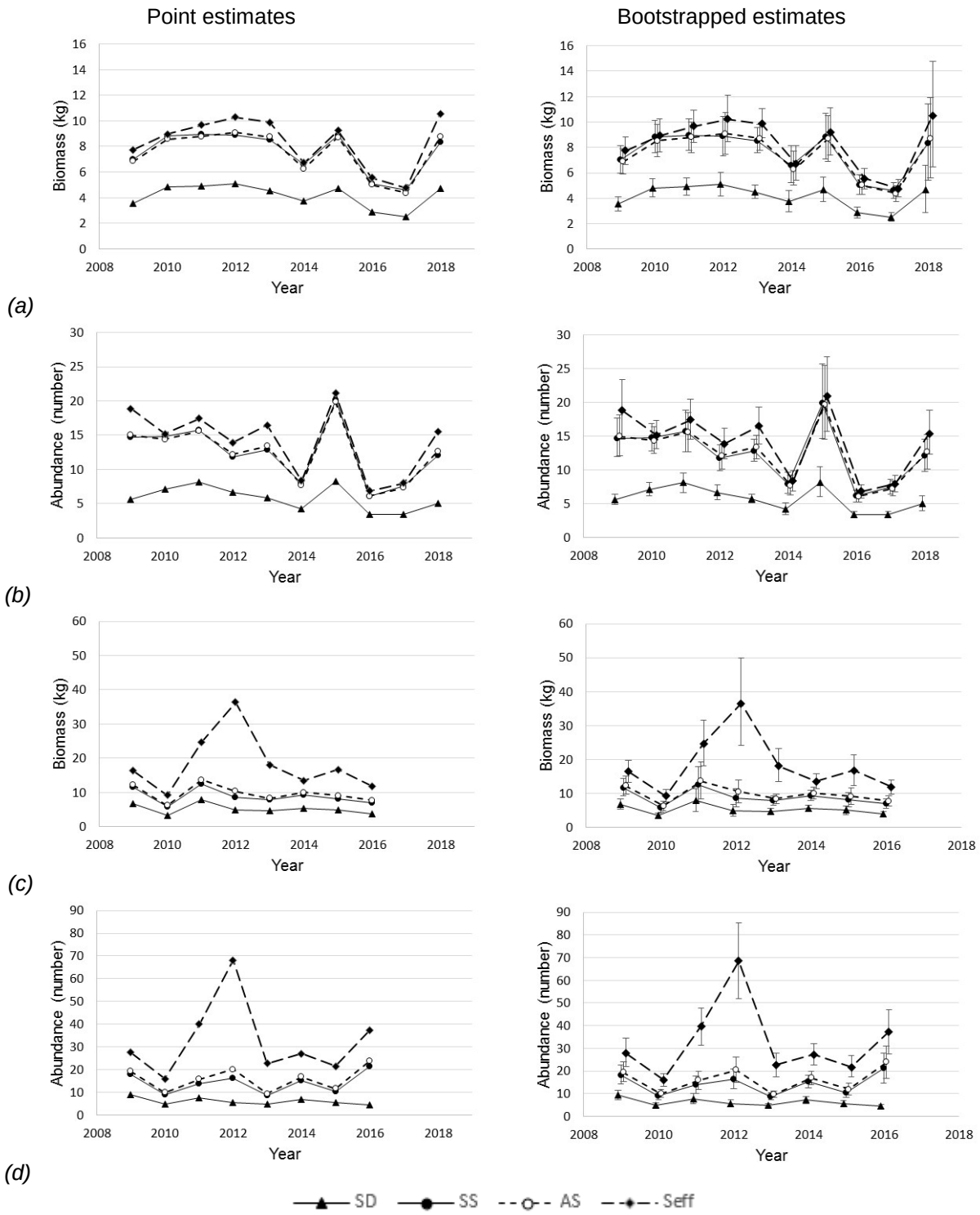


Figure 6. NEFSC survey aggregate stratified mean weight (i.e., biomass) per tow and mean number (i.e., abundance) per tow estimates for summer flounder for spring 2009-2018 (a) and (b), and fall 2009-2017 (c) and (d), for the standard data (SD), and sweep study (SS), area swept (AS), and summer flounder efficiency (Seff) adjusted data. Point estimates are presented in the left column, and bootstrapped estimates with 90% confidence intervals are in the right column. Bootstrapped estimates are offset a little from each other so confidence intervals are visible.

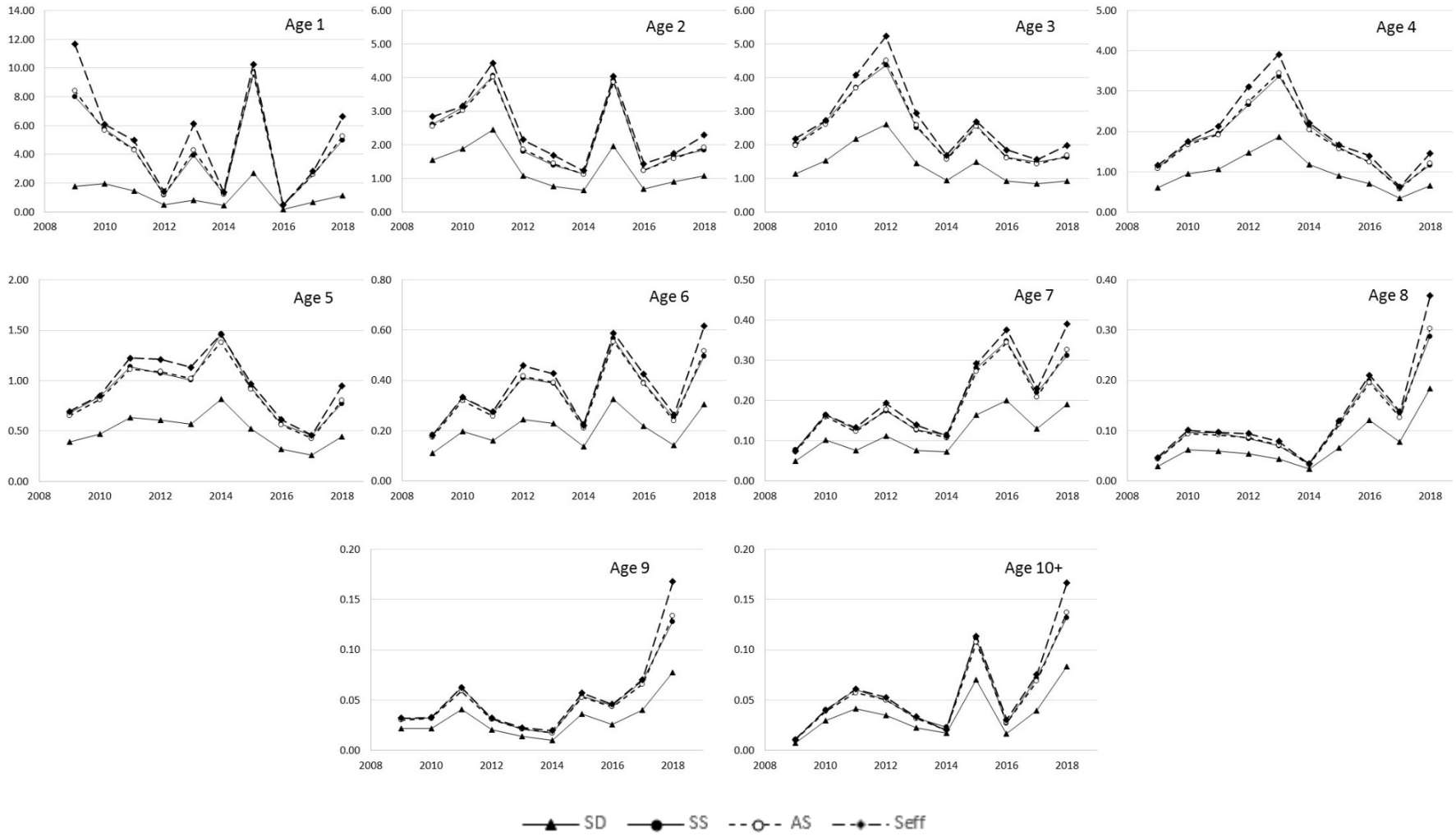


Figure 7. NEFSC survey stratified mean number per tow at age point estimates for summer flounder for spring 2009-2018, for the standard data (SD), and sweep study (SS), area swept (AS), and summer flounder efficiency (Seff) adjusted data.

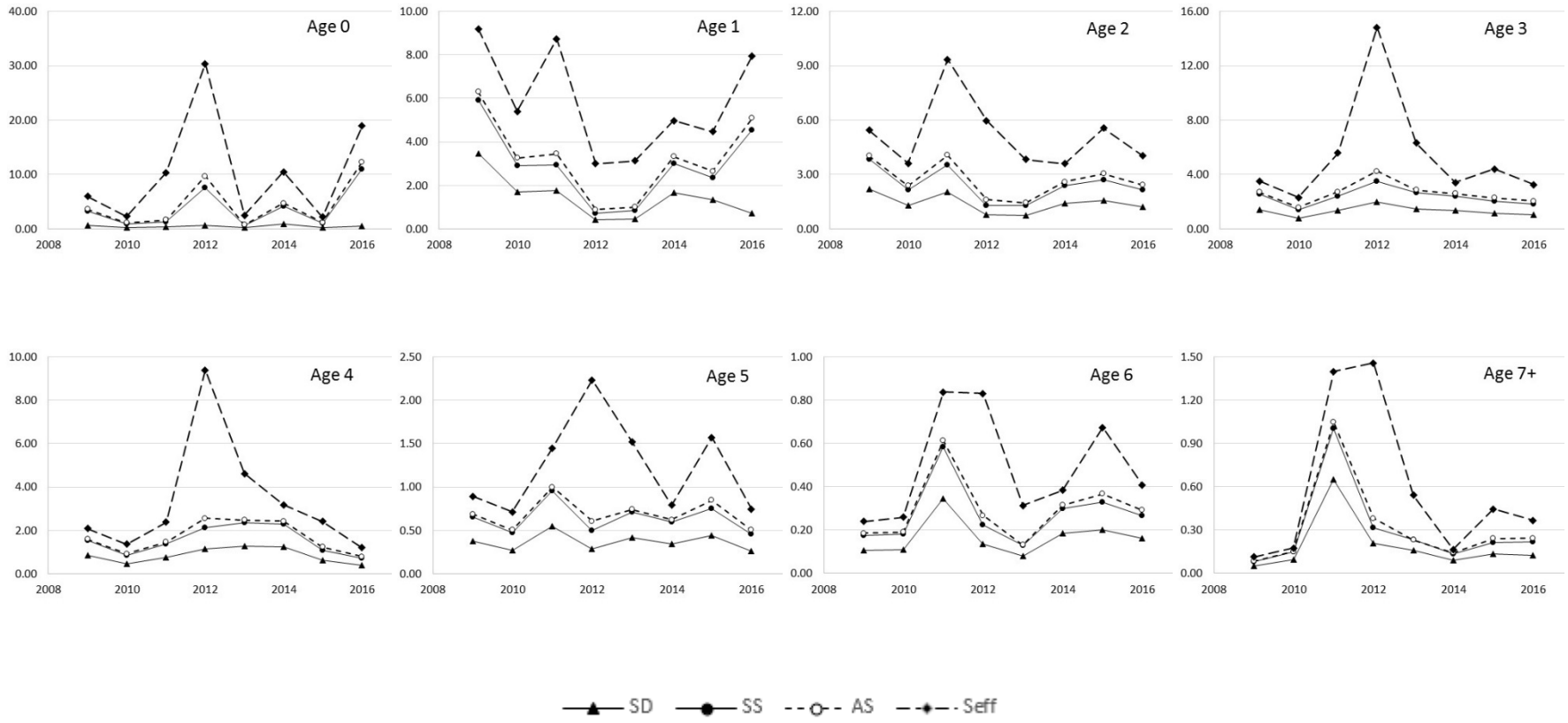


Figure 8. NEFSC survey stratified mean number per tow at age point estimates for summer flounder for fall 2009-2017, for the standard data (SD), and sweep study (SS), area swept (AS), and summer flounder efficiency (Seff) adjusted data.

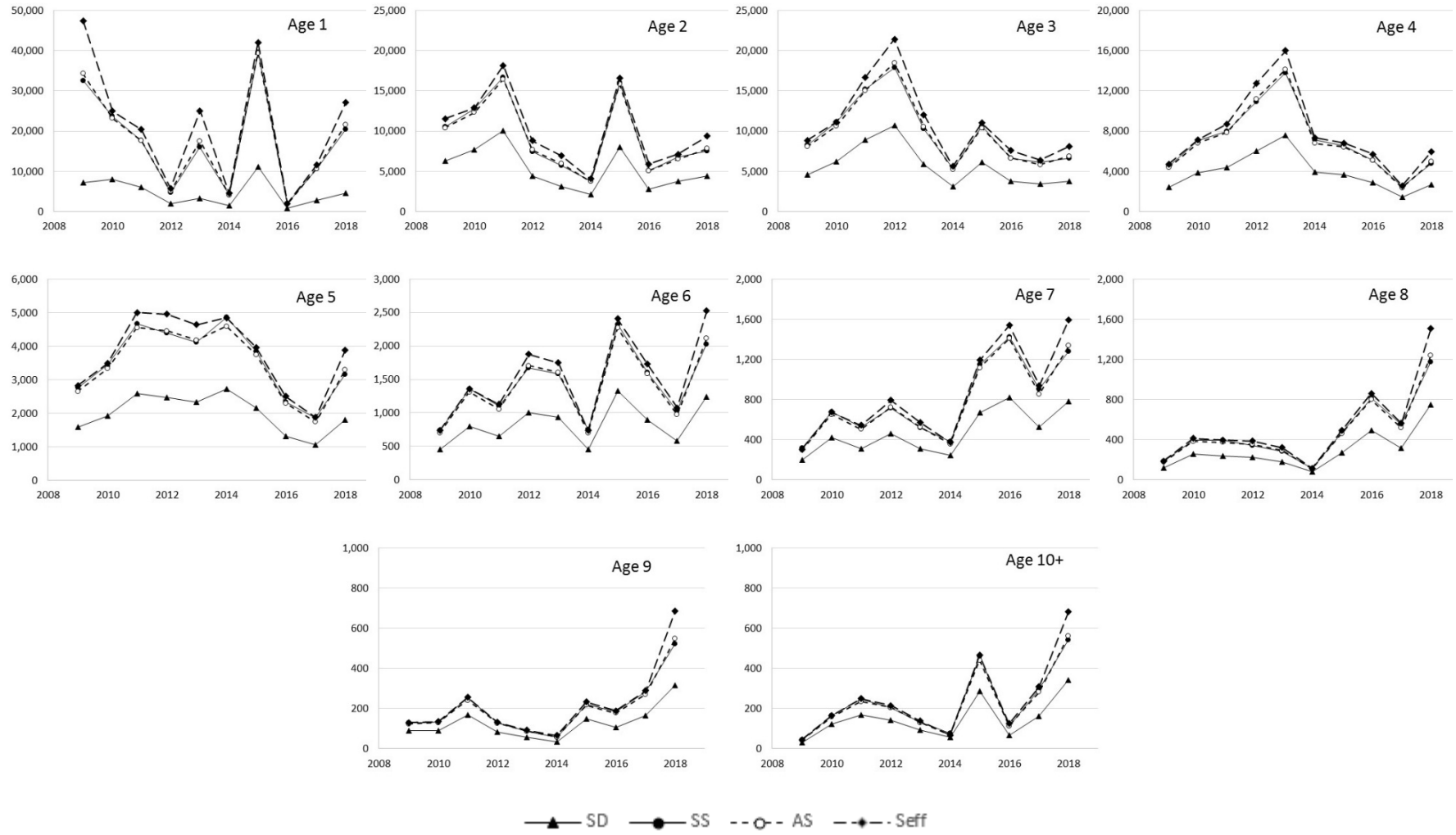


Figure 9. NEFSC survey absolute swept area numbers (SWAN) indices (000s) for summer flounder for spring 2009-2018, for the standard data (SD), and sweep study (SS), area swept (AS), and summer flounder efficiency (Seff) adjusted data.

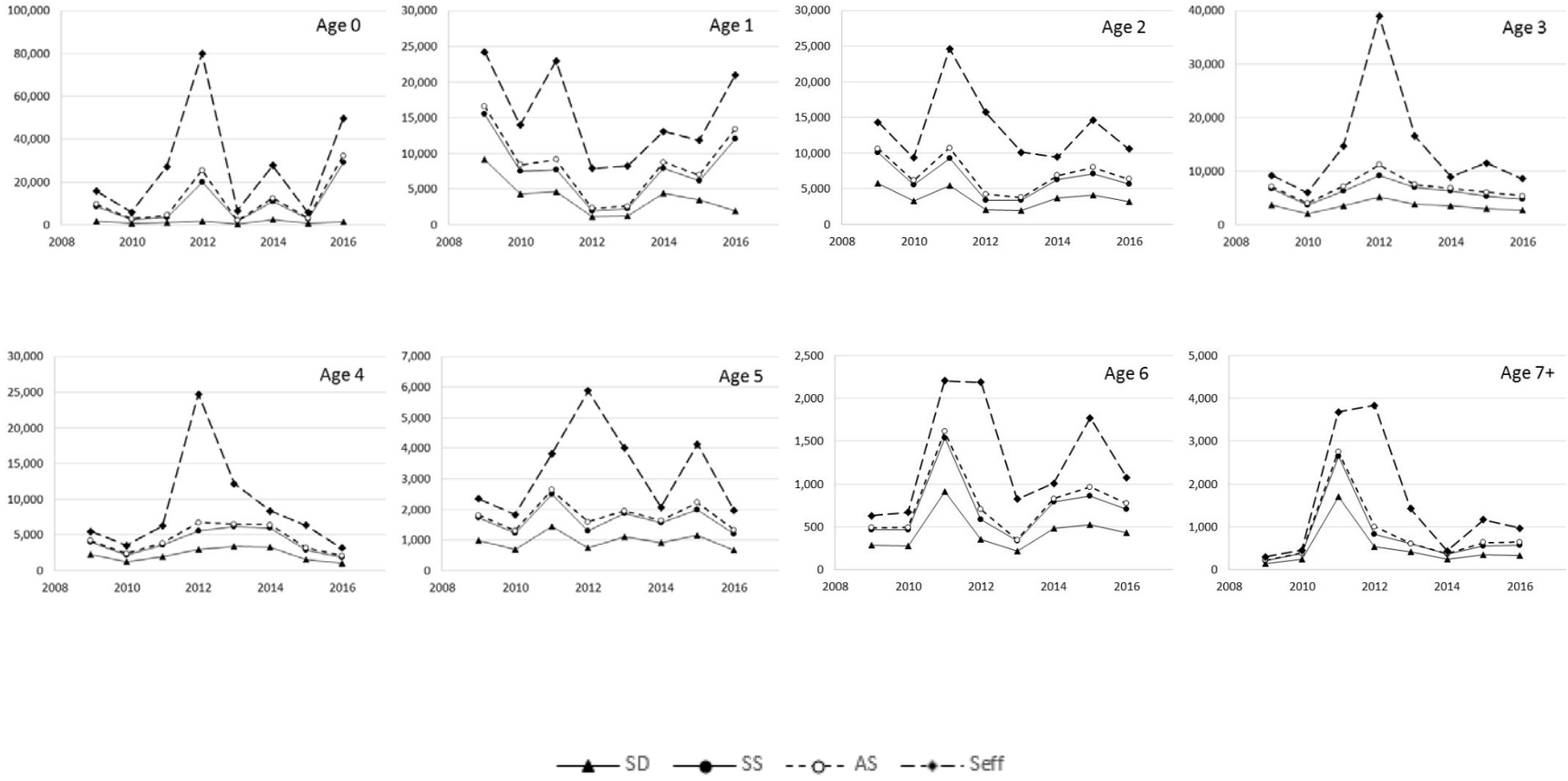


Figure 10. NEFSC survey absolute swept area numbers (SWAN) indices (000s) for summer flounder for fall 2009-2017, for the standard data (SD), and sweep study (SS), area swept (AS), and summer flounder efficiency (Seff) adjusted data.

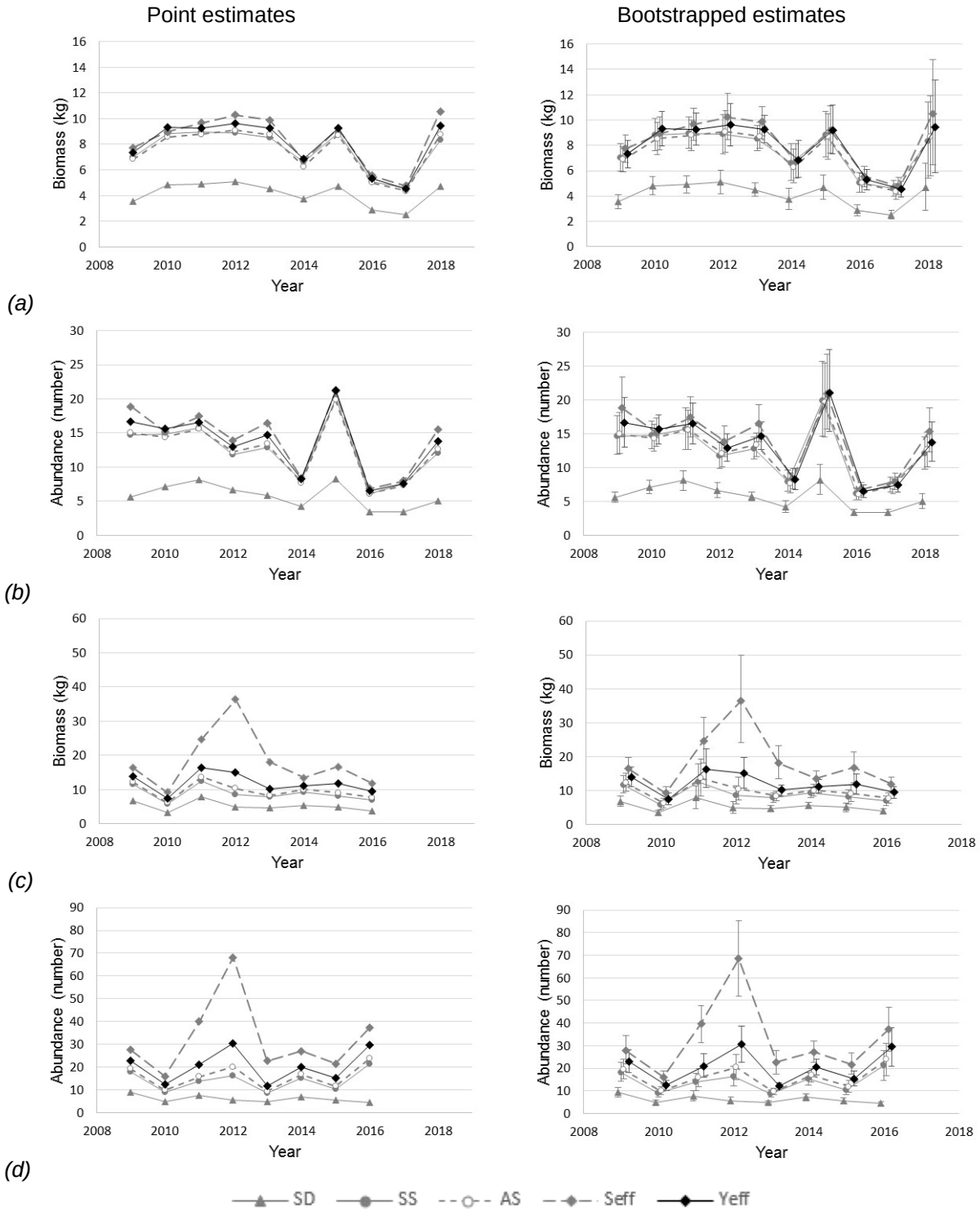


Figure 11. NEFSC survey aggregate stratified mean weight (i.e., biomass) per tow and mean number (i.e., abundance) per tow index estimates for summer flounder for spring 2009-2018 (a) and (b), and fall 2009-2017 (c) and (d), for the standard data (SD), and sweep study (SS), area swept (AS), summer flounder efficiency (Seff), and yellowtail flounder efficiency (Yeff) adjusted data. Point estimates are presented in the left column, and bootstrapped estimates with 90% confidence intervals are in the right column. Bootstrapped estimates are offset a little from each other so confidence intervals are visible.

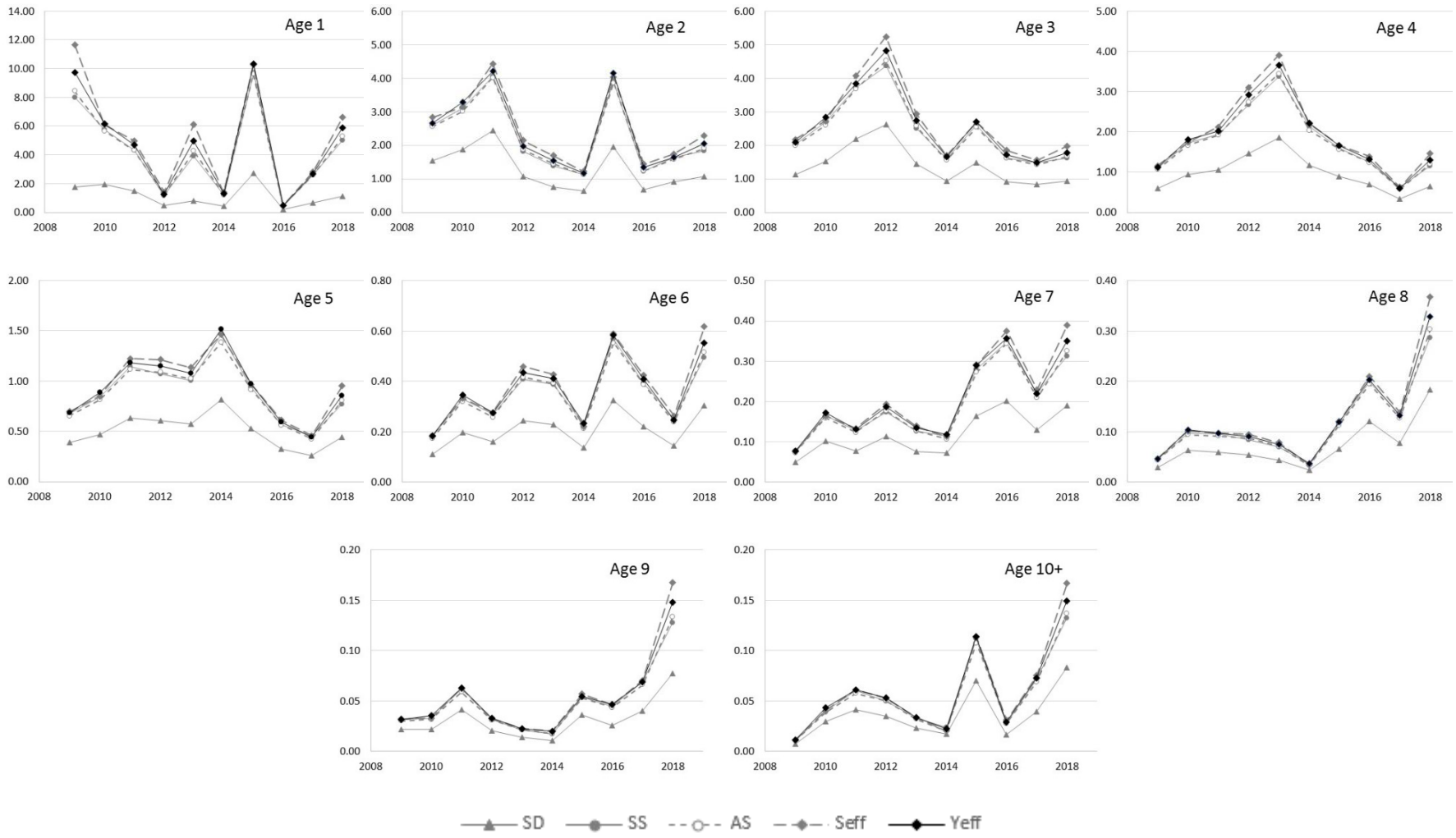


Figure 12. NEFSC survey stratified mean number per tow at age point estimates for summer flounder for spring 2009-2018, for the standard data (SD), and sweep study (SS), area swept (AS), summer flounder efficiency (Seff), and yellowtail flounder efficiency (Yeff) adjusted data.

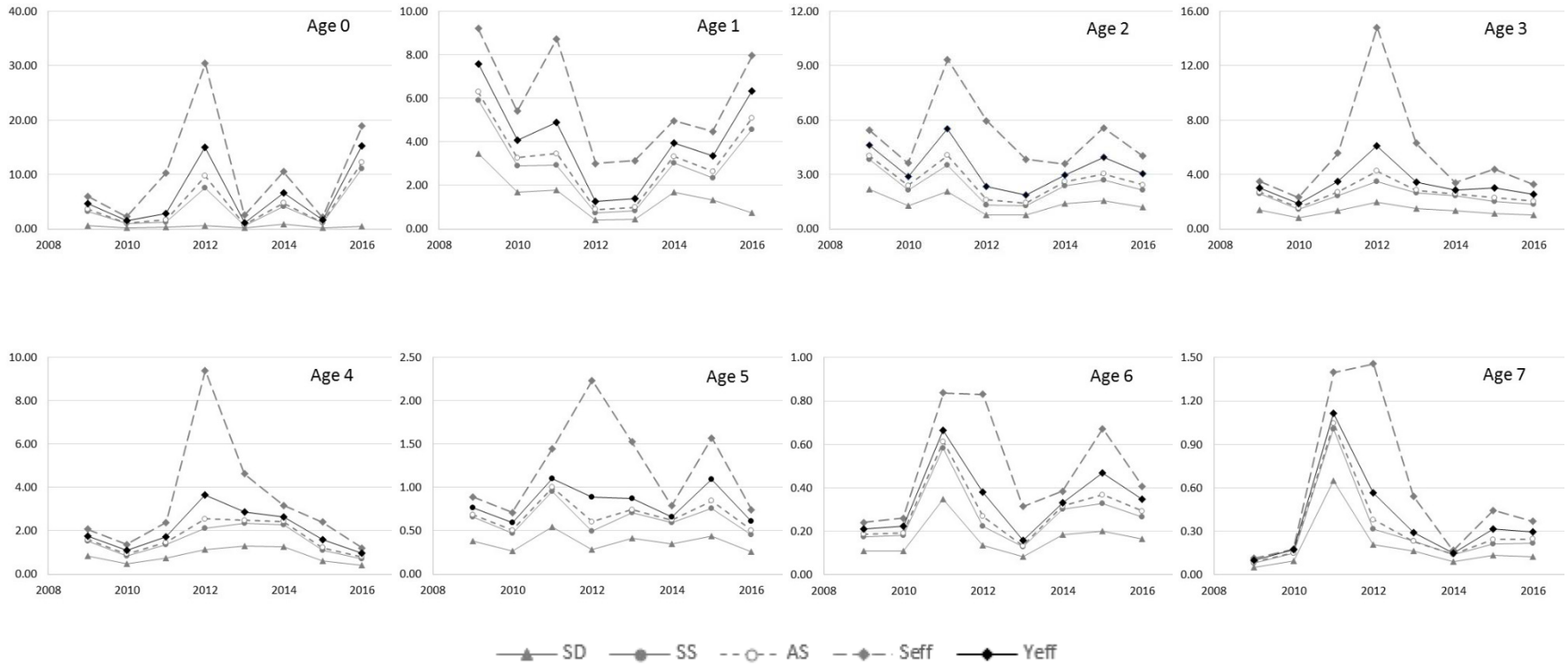


Figure 13. NEFSC survey stratified mean number per tow at age point estimates for summer flounder for fall 2009-2017, for the standard data (SD), and sweep study (SS), area swept (AS), summer flounder efficiency (Seff), and yellowtail flounder efficiency (Yeff) adjusted data.

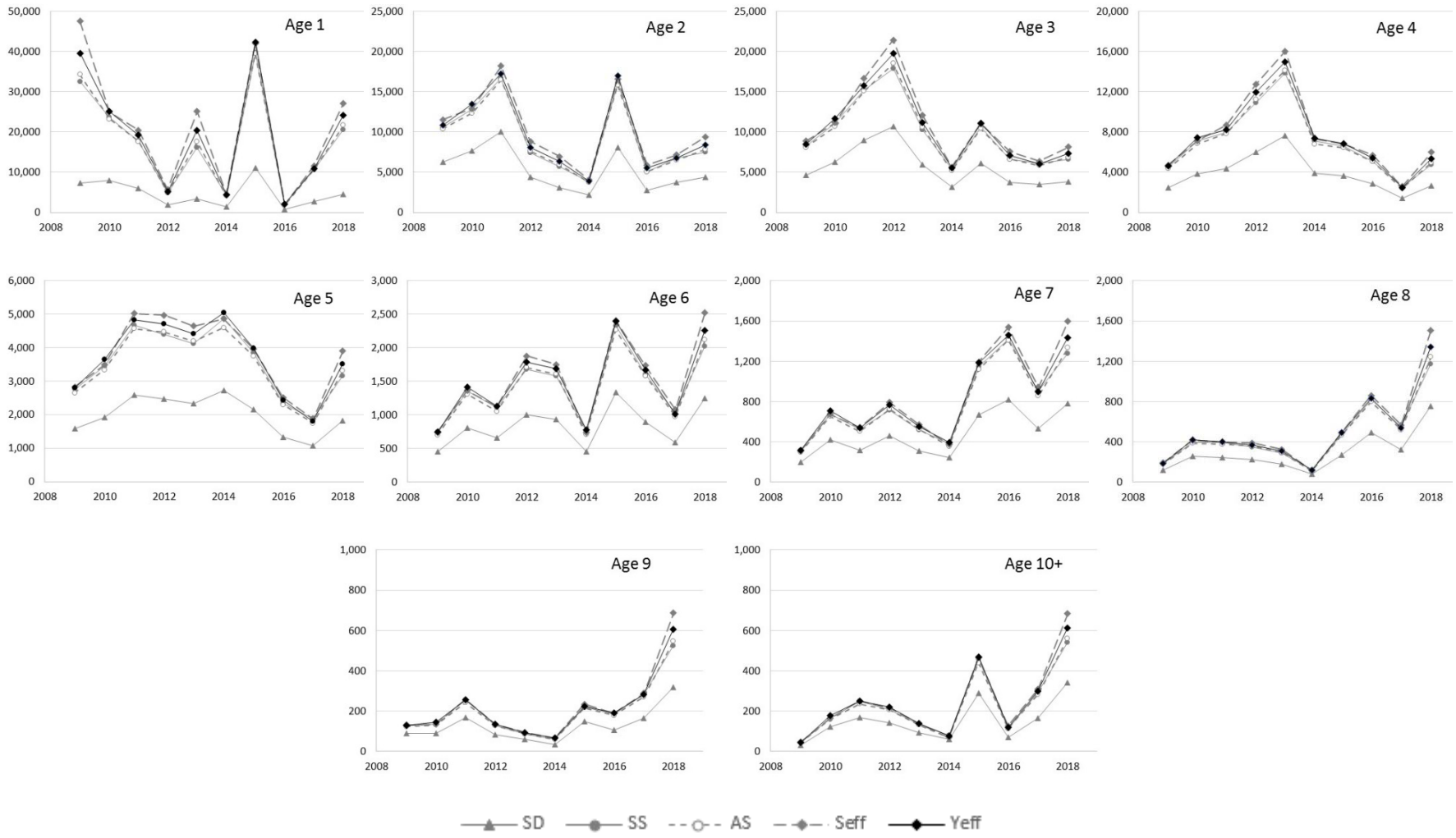


Figure 14. NEFSC survey absolute swept area numbers (SWAN) indices (000s) for summer flounder for spring 2009-2018, for the standard data (SD), and sweep study (SS), area swept (AS), summer flounder efficiency (Seff), and yellowtail flounder efficiency (Yeff) adjusted data.

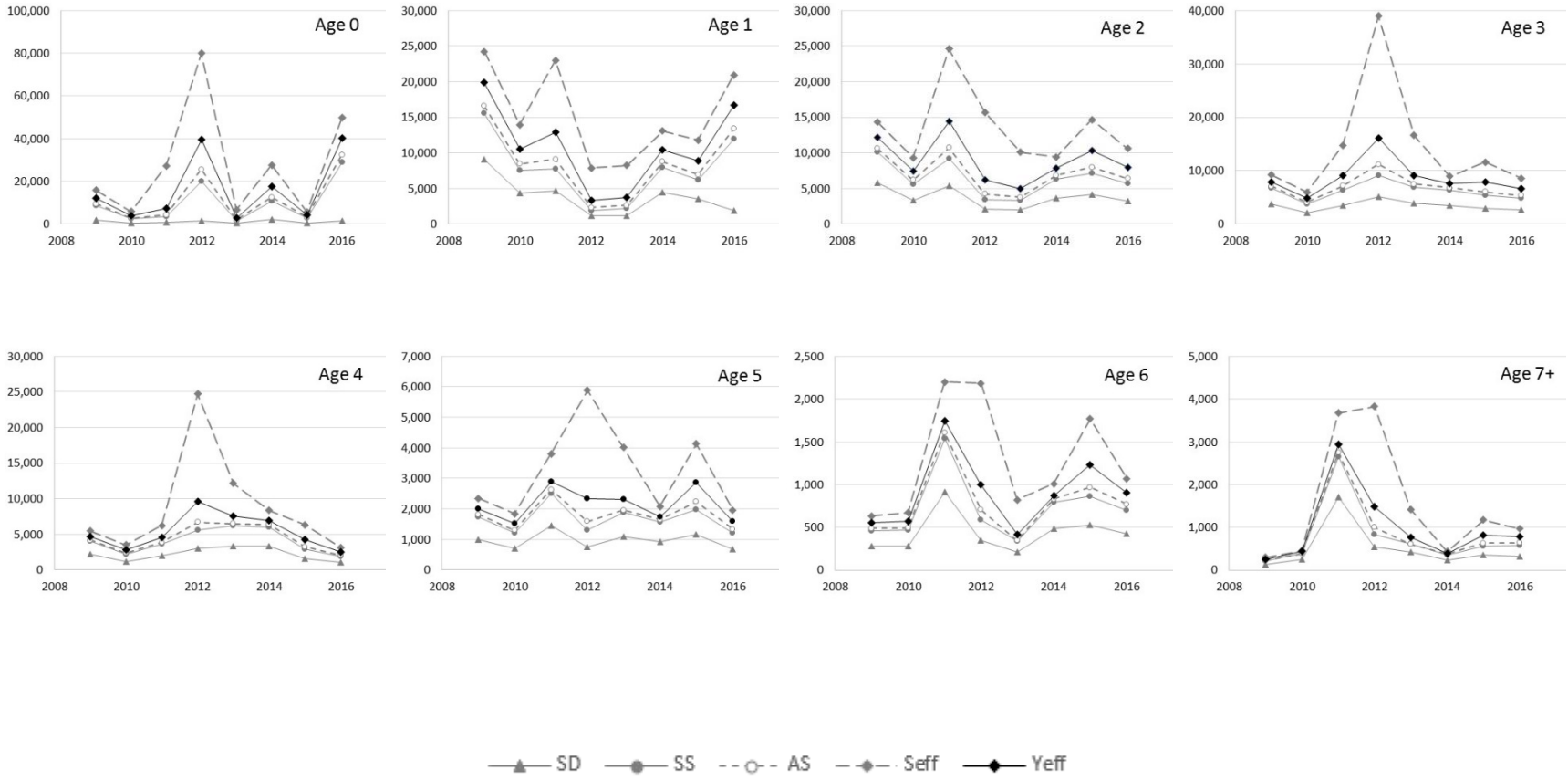
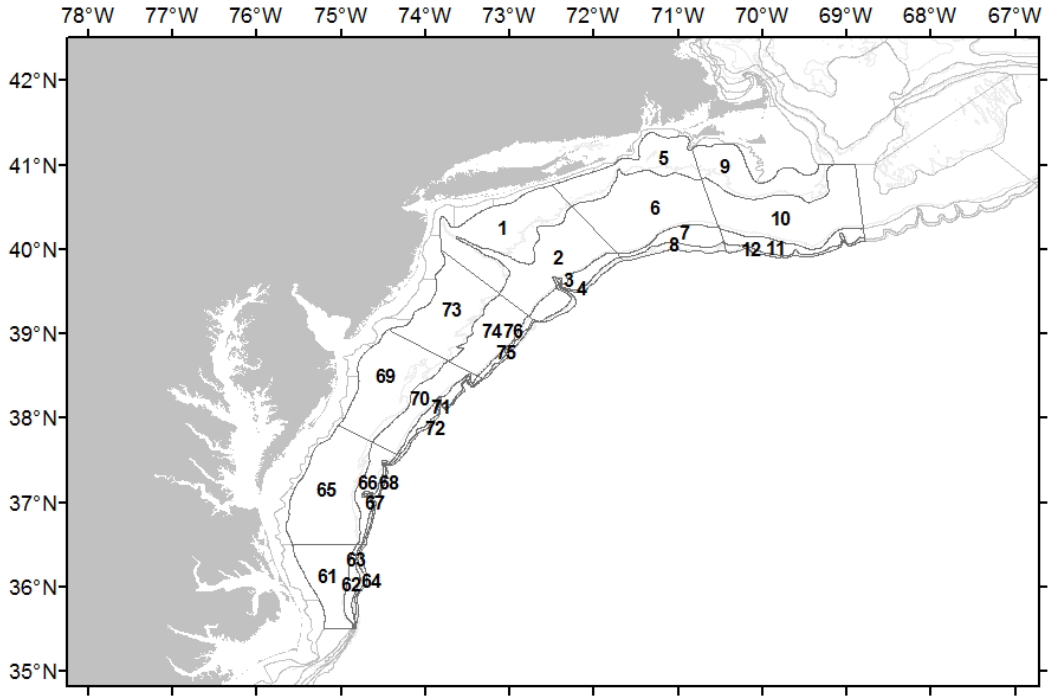
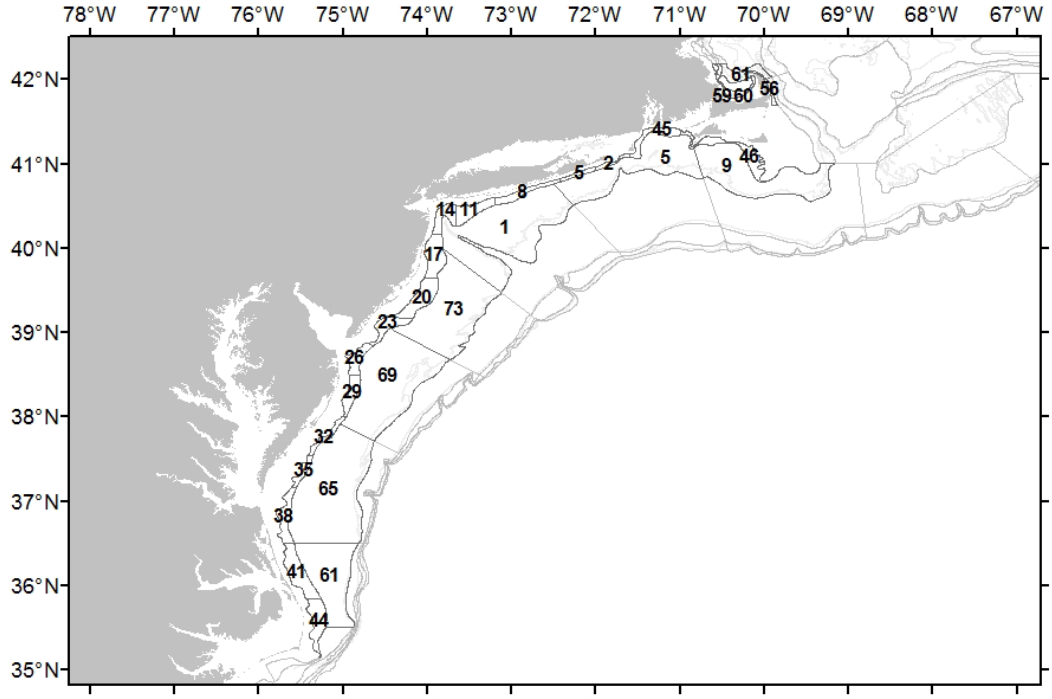


Figure 15. NEFSC survey absolute swept area numbers (SWAN) indices (000s) for summer flounder for fall 2009-2017, for the standard data (SD), and sweep study (SS), area swept (AS), summer flounder efficiency (Seff), and yellowtail flounder efficiency (Yeff) adjusted data.



(a)



(b)

Appendix figure 1. NEFSC strata sets for summer flounder for the spring (offshore strata 1-12 and 61-76; a) and fall (offshore strata 1, 5, 9, 61, 65, 69, 73, and inshore strata 1-61; b) sampled by the FSV Henry B. Bigelow*. Figure letters are located in the bottom left corner of each plot.*