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Transboundary Resources Assessment Committee

Working Paper 2018/05

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Effect of variable wing spread on USA bottom trawl survey index estimates for Eastern Georges Bank Atlantic cod, Eastern Georges Bank haddock, and Georges Bank yellowtail

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ABSTRACT

In response to concern about the performance of the fishing gear on the USA NMFS bottom trawl survey, we calculated alternative mean weight per tow and mean number per tow index estimates for Eastern Georges Bank Atlantic cod, Eastern Georges Bank haddock, and Georges Bank yellowtail flounder for spring 2009 to spring 2018. We evaluated the impact of two adjustments to the catch per tow data: 1) adjusting for tow-specific area swept, and 2) adjusting for 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 USA industry members; no experiments were conducted and no data were available to estimate the relationship. Our findings indicate that there are no significant differences between the standard survey index estimates and either of the alternative index estimates, across stocks and seasons.

RÉSUMÉ

INTRODUCTION

The TRAC assessments for Eastern Georges Bank Atlantic cod (*Gadus morhua*), Eastern Georges Bank haddock (*Melanogrammus aeglefinus*), and Georges Bank yellowtail flounder (*Limanda ferruginea*) use Canadian and USA fishery and research survey data to provide information on stock status (Barrett *et al*., 2017; Legault and McCurdy, 2017; Martin *et al*., 2017). The standard approach to calculating USA National Marine Fisheries Services (NMFS) spring and fall survey indices assumes that all tows are equal in terms of area swept and gear efficiency. In other words, 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 USA industry members that the gear used by the NMFS vessel since 2009, the FSV *Henry B. Bigelow*, does not perform equally across all tows. Specifically, 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 NMFS spring and fall survey indices for Eastern Georges Bank Atlantic cod, Eastern Georges Bank haddock, and Georges Bank yellowtail flounder that account for tow-specific area swept and hypothesized effects of wing spread on gear efficiency. Estimates of mean weight and mean number per tow are provided for spring 2009 to spring 2018 along with a comparison to standard NMFS indices to allow for the evaluation of the sensitivity of the indices to gear performance.

METHODS

This analysis uses NMFS 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). For Eastern Georges Bank Atlantic cod and haddock, stations were selected if they were located within the intersection of NMFS offshore survey strata 16-22 and USA Statistical Areas 551, 552, 561, and 562 (Fisheries and Oceans Canada (DFO) management unit area 5Zjm). For strata portions, we used the areas presented in the TRAC allocation document (Noble *et al*., 2017). For Georges Bank yellowtail flounder, the analysis used stations in NMFS offshore survey strata 13-21 (DFO management unit areas 5Zhjmn). All catch data were calibrated to the previous NMFS survey vessel (R/V *Albatross IV*) units (Brooks *et al.*, 2010; Miller *et al.*, 2010) to allow for comparison of results with values typically reported in TRAC documents.

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 on spring 2009 to spring 2018 NMFS 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 modified the calculation of mean weight and mean number per tow indices to account for tow-specific area swept and differing efficiency depending on wing spread. First, we adjusted the catch from each station by the ratio of the average area swept per tow to the area swept at the specific station (hereafter refered to as adjustement 1). We then applied a second, cumulative, modification to the area-adjusted catch to account for hypothesized variability in gear efficiencies at different wing spreads (hereafter refered to as adjustement 2). The hypothesized relative efficiency relationship (Table 1, Figure 1) was based on input from members of the USA industry and specifically intended for yellowtail flounder. No experiments were conducted and no data were available to estimate the relationship. In addition, no hypothesized gear efficiency relationships were available at the time of this analysis for either cod or haddock, so we used the yellowtail flounder values. We used recorded wing spread when available, or regression-derived wing spread if wing spread data were not available but door spread data were. Tows with wing spread 12.0-13.0 m were assigned an efficiency value of 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 12.0-13.0 m range. 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 area-adjusted catch per tow by the hypothesized relative efficiency of the tow.

Once the adjustments were made to the catch data, we derived the alternative index estimates (i.e., stratified mean weight and mean number per tow) for each of the two adjusted data sets using the standard calculation approach. We first calculated simple point estimates, and then bootstrapped the data to generate estimates with 90% confidence intervals. Note that for the two adjusted data sets, the uncertainty associated with filling missing wing spread and area swept information is not captured in these confidence bounds and thus the true uncertainty would be slightly greater.

RESULTS

In total, the analysis used data from 313 stations in the spring and 270 stations in the fall for the Eastern Georges Bank stocks (Table 2, Figures 2 and 3), and 523 stations in the spring and 481 stations in the fall for Georges Bank yellowtail flounder (Table 3, Figures 4 and 5). Data summaries are presented with the stations grouped in 1-meter wing spread bins.

For each region and season, more than a third of the stations had wing spread between 12.0 m and 13.0 m, and about 75% of the stations had wing spread between 11.0 m and 14.0 m (Tables 2 and 3). On average 14% of the 2009-2014 stations were missing wing spread data, with a higher proportion missing in 2011-2014; all 2015-2018 stations had wing spread data available. Mean depth averaged 92 m in the spring and 84 m in the fall for tows with wing spread between 12.0 m and 13.0 m, and 75-133 m in the spring and 82-149 m in the fall for tows with wing spread between 11.0 m and 14.0 m (Tables 2 and 3, Figure 6). Tows with narrow wing spread (<11.0 m) occurred at depths averaging 56 m in the spring and 65 m in the fall, and tows with wide wing spread (>14.0 m) occurred at depths averaging 230 m in the spring and 274 m in the fall.

Sampling of the Eastern Georges Bank and Georges Bank regions was well distributed across each region in each season (Figures 2a, 3a, 4a, and 5a). Tows with narrow wing spread (<11.0 m) were generally located on top of Georges Bank (i.e., NMFS strata 01130, 01160, 01190, and 01200; Figures 2bc, 3bc, 4bc, and 5bc) and tows with wide wing spread (>14.0 m) were mostly located along the edge of Georges Bank (i.e., NMFS strata 01140, 01150, 01170, 01180, 01210, and 01220; Figures 2gh, 3gh, 4gh, and 5gh). Tows with missing wing spread were distributed across each region (Figures 2i, 3i, 4i, and 5i).

Sampling for the Eastern Georges Bank stocks resulted in positive catch for stations across the range of wing spreads and depths for Atlantic cod in the spring (Figure 6a, left column) and haddock in the spring and fall (Figures 6b), but only for stations up to 244 m deep for Atlantic cod in the fall (Figure 6a, right column). Most of Georges Bank yellowtail flounder were caught at stations with depths less than 100 m in spring and fall (Figures 6c).

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 83% of the spring stations with missing wing spread data, and about 73% of the fall stations, for each region (Table 4). Wing spread for tows at these stations was estimated using the wing spread to door spread regression described above. Overall, less than 3% 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 NMFS survey stratified mean weight and stratified mean number per tow are presented in Tables 5-7 and Figures 7-9. Differences between the standard index estimates, estimates with adjustment 1 (i.e., using area swept adjusted data), and estimates with adjustment 2 (i.e., using area swept + efficiency adjusted data) were generally minimal across stocks and seasons. Point estimates (Tables 5-7, left 3 columns; Figures 7-9, left column) differed by a few percentage points only for most years, across stocks and seasons. Adjustment 1 could result in index estimates that were either larger or smaller than the standard estimate. In contrast, estimates with adjustment 2 were always larger than estimates with adjustment 1, since the additional efficiency adjustment could only rescale the catch per tow upward. Compared to the standard estimates, estimates with adjustment 2 varied more than those with adjustment 1 only. The largest percent differences between the standard point estimate and the adjusted point estimates occurred for Eastern Georges Bank haddock in spring 2015 (Tables 6ab, left 3 columns; Figures 8ab, left column). Here the difference between the standard estimate and the estimate with adjustment 1 was +12.2% for biomass and +14.1% for abundance, and the difference between the standard estimate and estimates with adjustment 2 was +43.0% for biomass and +49.4% for abundance. Bootstrapped estimates and confidence intervals show that the adjusted estimates are almost always well within the 90% confidence intervals of the standard estimates (Tables 5-7, right 9 columns; Figures 7-9, right column). There were only three cases where the mean estimate for adjustment 2 was outside the 90% confidence interval of the standard estimate [Eastern Georges Bank haddock spring 2015 and spring 2018 (Tables 6ab, right 9 columns; Figures 8ab, right column), and Georges Bank yellowtail flounder spring 2011 (Tables 7ab, right 9 columns; Figures 9ab, right column)]. However, there is considerable overlap in confidence intervals of these estimates so they are not significantly different.

DISCUSSION

We calculated alternative USA survey index estimates for Eastern Georges Bank Atlantic cod, Eastern Georges Bank haddock, and Georges Bank yellowtail flounder for spring 2009 to spring 2018. We evaluated the impact of two adjustments to the catch per tow data: 1) adjusting for tow-specific area swept, and 2) adjusting for tow-specific area swept and gear efficiency depending on wing spread. Results indicate that there are no significant differences in stratified mean weight per tow and stratified mean number per tow between the standard estimates and either of the adjusted estimates.

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.

The small differences between the standard estimates and the estimates with adjustment 1 (Tables 5-7, Figures 7-9) 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 = 1.01, std dev = 0.08 across all stations) indicating that actual area swept at each station is quite close to the theoretical average area swept (i.e., 0.0233352 km^2).

Applying the additional adjustement to account for differences in hypothesized relative efficiency depending on wing swept yielded index estimates that generally moved further away from the standard estimates (Tables 5-7, Figures 7-9). Here the mean efficiency across all stations was 0.93 (std dev = 0.09) which indicates that most stations had only a slight increase in catch per tow as the adjustment was applied. This could be expected since the majority (75%) of stations had wing spread within 11.0 m and 14.0 m, corresponding to hypothesized relative efficiencies of 0.85 (11.0 – 11.9 m), 1.00 (12.0 - 13.0 m), or 0.90 (13.1 - 14.0 m). Few stations had wing spreads associated with lower hypothesized efficiencies that would bump up the catch per tow significantly.

It is important to remember that the relative efficiency to wing spread relationship used for these analyses is not based on data, but rather on ‘best guess’ estimates of how efficiently the *Bigelow* gear performs with different wing spreads. The hypothesized efficiency relationship used here shows quite a dramatic drop in efficiency once the wing spread departs from the 12.0 m to 13.0 m range; this relationship cannot be confirmed at this time. Furthermore, this hypothesized relationship was intended to reflect impacts on yellowtail flounder, but we applied it to cod and haddock as well because no hypothesized relationships had been provided for these two round fish. The dramatic 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 adjustment 2 significantly. For example, for Eastern Georges Bank haddock in spring 2015, a single tow saw its catch adjusted from 18.9 kg to 29.1 kg because the wing spread was 10.7 m (so the efficiency was 0.65, and 18.9/0.65 = 29.1). Because of the subjective nature underlying the hypothesized efficiency relationship, results from the analysis with adjustment 2 should be considered as a theoretical exploration, not as reliable findings based on measured gear efficiency data.

CONCLUSION

Despite the caveats mentioned above, the analyses presented here are informative. While adjustments to catch per tow can be applied to the USA spring and fall bottom trawl data, our results show that accounting for tow-specific area swept and varying gear efficiency depending on wing spread does not alter the index estimates significantly for the TRAC stocks for spring 2009 to spring 2018.

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TABLES

Table 1. Hypothesized relative efficiency of the NMFS survey vessel FSV Henry B. Bigelow *by wing spread bin. Note that these values area based on input from members of the USA industry; there are no available data to inform this relationship objectively. Spring 2009 to spring 2018 TRAC data wing spread range is 9.4 – 15.9 m.*

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 2. Number of stations by wing spread bin from the 2009-2018 NMFS spring (a) and 2009-2017 NMFS fall (b) surveys for eastern Georges Bank Atlantic cod and Eastern Georges Bank haddock. '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)	*9.8 (.)*	*10.6 (0.3)*	*11.6 (0.3)*	*12.5 (0.3)*	*13.4 (0.3)*	*14.4 (0.3)*	*15.9 (.)*	*.*	***12.7 (0.9)***
Mean station depth (m)	*51 (.)*	*66 (30)*	*77 (20)*	*94 (41)*	*137 (68)*	*227 (39)*	*214 (.)*	*101 (50)*	***109 (59)***
2009	0	0	0	8	19	1	0	2	**30**
2010	0	0	2	10	17	2	0	0	**31**
2011	0	3	9	4	4	1	0	9	**30**
2012	0	2	7	6	4	1	0	12	**32**
2013	1	1	2	13	6	0	0	11	**34**
2014	0	0	2	6	1	0	0	20	**29**
2015	0	3	8	14	5	1	0	0	**31**
2016	0	1	0	18	11	4	1	0	**35**
2017	0	1	4	21	6	3	0	0	**35**
2018	0	1	7	11	7	0	0	0	**26**
Total	**1**	**12**	**41**	**111**	**80**	**13**	**1**	**54**	**313**

Table 2. 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)	*9.4 (.)*	*10.7 (0.2)*	*11.6 (0.3)*	*12.5 (0.3)*	*13.5 (0.3)*	*14.5 (0.3)*	*15.3 (0.3)*	*.*	***12.7 (1.0)***
Mean station depth (m)	*55 (.)*	*87 (10)*	*90 (46)*	*85 (33)*	*149 (75)*	*248 (69)*	*294 (76)*	*96 (48)*	***113 (70)***
2009	0	0	2	13	12	4	0	1	**32**
2010	0	0	0	16	9	4	1	1	**31**
2011	1	2	4	2	1	0	1	16	**27**
2012	0	1	5	13	2	0	1	6	**28**
2013	0	0	4	8	3	1	0	15	**31**
2014	0	1	10	10	8	0	0	0	**29**
2015	0	0	2	21	7	2	1	0	**33**
2016	0	1	7	17	6	2	0	0	**33**
2017	0	0	2	12	9	3	0	0	**26**
Total	**1**	**5**	**36**	**112**	**57**	**16**	**4**	**39**	**270**

Table 3. Number of stations by wing spread bin from the 2009-2018 NMFS spring (a) and 2009-2017 NMFS fall (b) surveys for Georges Bank yellowtail 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)	*9.6 (0.3)*	*10.6 (0.3)*	*11.6 (0.2)*	*12.5 (0.3)*	*13.4 (0.3)*	*14.4 (0.3)*	.	.	***12.5 (0.9)***
Mean station depth (m)	*43 (11)*	*63 (37)*	*73 (21)*	*90 (39)*	*128 (69)*	*240 (81)*	.	*89 (47)*	***99 (58)***
2009	0	0	2	15	27	2	0	2	**48**
2010	0	0	2	20	27	1	0	3	**53**
2011	0	7	20	9	5	1	0	11	**53**
2012	1	3	13	17	6	0	0	14	**54**
2013	1	3	6	29	6	1	0	14	**60**
2014	0	0	2	14	2	1	0	28	**47**
2015	0	4	15	28	7	2	0	0	**56**
2016	0	1	3	25	20	7	0	0	**56**
2017	0	1	9	36	9	2	0	0	**57**
2018	0	1	12	17	9	0	0	0	**39**
Total	**2**	**20**	**84**	**210**	**118**	**17**	**0**	**72**	**523**

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)	*9.4 (.)*	*10.7 (0.2)*	*11.6 (0.3)*	*12.5 (0.3)*	*13.4 (0.3)*	*14.4 (0.3)*	*15.4 (0.3)*	*.*	***12.5 (0.9)***
Mean station depth (m)	*55 (.)*	*64 (25)*	*74 (37)*	*83 (31)*	*148 (73)*	*255 (83)*	*299 (67)*	*83 (48)*	***101 (65)***
2009	0	1	4	24	15	4	0	1	**49**
2010	0	0	1	31	16	1	2	2	**53**
2011	1	4	7	7	4	1	1	24	**49**
2012	0	3	20	20	2	0	1	8	**54**
2013	0	0	11	18	7	2	0	18	**56**
2014	0	3	16	26	10	1	0	1	**57**
2015	0	0	7	38	9	3	1	0	**58**
2016	0	1	15	30	9	3	0	0	**58**
2017	0	1	5	28	10	3	0	0	**47**
Total	**1**	**13**	**86**	**222**	**82**	**18**	**5**	**54**	**481**

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 NMFS spring and 2009-2017 NMFS fall surveys for for Eastern Georges Bank Atlantic cod and Eastern Georges Bank haddock (a) and Georges Bank yellowtail flounder (b).

(a)

	Spring				Fall			
	Total	Wing	No wing		**Total**	Wing	No wing	
			Door	No door			Door	No door
2009	**30**	28	2	0	**32**	31	1	0
2010	**31**	31	0	0	**31**	30	1	0
2011	**30**	21	8	1	**27**	11	13	3
2012	**32**	20	9	3	**28**	22	5	1
2013	**34**	23	6	5	**31**	16	8	7
2014	**29**	9	20	0	**29**	29	0	0
2015	**31**	31	0	0	**33**	33	0	0
2016	**35**	35	0	0	**33**	33	0	0
2017	**35**	35	0	0	**26**	26	0	0
2018	**26**	26	0	0				
Total	**313**	**259**	**45**	**9**	**270**	**231**	**28**	**11**

(b)

	Spring				Fall			
	Total	Wing	No wing		**Total**	Wing	No wing	
			Door	No door			Door	No door
2009	**48**	46	2	0	**49**	48	1	0
2010	**53**	50	3	0	**53**	51	2	0
2011	**53**	42	8	3	**49**	25	19	5
2012	**54**	40	11	3	**54**	46	7	1
2013	**60**	46	8	6	**56**	38	10	8
2014	**47**	19	28	0	**57**	56	1	0
2015	**56**	56	0	0	**58**	58	0	0
2016	**56**	56	0	0	**58**	58	0	0
2017	**57**	57	0	0	**47**	47	0	0
2018	**39**	39	0	0				
Total	**523**	**451**	**60**	**12**	**481**	**427**	**40**	**14**

Table 5. NMFS survey stratified mean weight (i.e., biomass) per tow and mean number (i.e., abundance) per tow point estimates (left 3 columns) and bootstrapped estimates with 90% confidence intervals (CI; right 9 columns) for Eastern Georges Bank Atlantic cod for spring 2009-2018 (a) and (b), and fall 2009-2017 (c) and (d). 'Std' represents standard estimates, 'Adj 1' represents estimates including adjustment 1 (i.e., using area swept adjusted data), and 'Adj 2' represents estimates including adjustment 2 (i.e., using area swept + efficiency adjusted data).

(a)

	Biomass (kg) point estimates			**Biomass (kg) bootstrapped estimates with 90% CI**								
Year	**Std**	**Adj 1**	**Adj 2**	**Std**	*lower*	*upper*	**Adj 1**	*lower*	*upper*	**Adj 2**	*lower*	*upper*
2009	7.8	7.7	8.0	7.8	*5.7*	*9.9*	7.6	*5.5*	*9.8*	8.0	*5.9*	*10.1*
2010	6.5	6.2	6.8	6.4	*5.1*	*7.7*	6.2	*5.0*	*7.4*	6.8	*5.5*	*8.2*
2011	3.5	3.7	4.2	3.5	*2.2*	*4.9*	3.7	*2.3*	*5.2*	4.2	*2.8*	*5.8*
2012	8.8	9.1	10.0	8.7	*6.5*	*11.0*	9.0	*6.8*	*11.3*	9.9	*7.5*	*12.4*
2013	17.8	18.6	20.2	17.6	*7.1*	*28.5*	18.3	*7.8*	*29.2*	20.0	*9.3*	*30.9*
2014	5.9	5.8	5.9	5.9	*4.1*	*7.8*	5.8	*4.0*	*7.7*	5.9	*4.1*	*7.8*
2015	3.2	3.2	3.5	3.2	*2.5*	*3.9*	3.2	*2.5*	*3.9*	3.5	*2.7*	*4.2*
2016	6.5	6.5	6.5	6.6	*2.6*	*11.1*	6.6	*2.5*	*11.2*	6.7	*2.6*	*11.3*
2017	24.3	22.8	23.8	23.9	*12.0*	*38.6*	22.5	*11.4*	*36.0*	23.5	*12.3*	*37.2*
2018	6.0	5.7	6.4	6.0	*1.9*	*10.0*	5.8	*1.9*	*9.4*	6.4	*2.2*	*10.5*

(b)

	Abundance (number) point estimates			**Abundance (number) bootstrapped estimates with 90% CI**								
Year	**Std**	**Adj 1**	**Adj 2**	**Std**	*lower*	*upper*	**Adj 1**	*lower*	*upper*	**Adj 2**	*lower*	*upper*
2009	3.7	3.7	3.8	3.7	*2.4*	*5.0*	3.6	*2.4*	*4.9*	3.8	*2.5*	*5.1*
2010	2.8	2.7	3.0	2.8	*2.3*	*3.3*	2.7	*2.2*	*3.1*	3.0	*2.5*	*3.4*
2011	1.8	2.0	2.3	1.8	*1.2*	*2.5*	1.9	*1.3*	*2.6*	2.3	*1.6*	*3.0*
2012	4.3	4.4	4.9	4.3	*3.1*	*5.5*	4.4	*3.2*	*5.6*	4.8	*3.6*	*6.1*
2013	11.0	11.5	12.5	10.8	*4.2*	*17.7*	11.3	*4.7*	*18.2*	12.4	*5.6*	*19.3*
2014	3.2	3.2	3.2	3.2	*2.1*	*4.4*	3.2	*2.1*	*4.4*	3.2	*2.1*	*4.4*
2015	1.5	1.5	1.6	1.5	*1.2*	*1.8*	1.5	*1.2*	*1.8*	1.6	*1.3*	*2.0*
2016	3.7	3.8	3.8	3.8	*1.3*	*6.7*	3.9	*1.2*	*6.8*	3.9	*1.3*	*6.8*
2017	8.5	8.1	8.5	8.4	*4.8*	*12.6*	8.0	*4.6*	*11.9*	8.4	*4.9*	*12.5*
2018	3.4	3.3	3.7	3.4	*1.1*	*5.6*	3.3	*1.1*	*5.3*	3.7	*1.3*	*6.0*

Table 5. Continued.

(c)

	Biomass (kg) point estimates			Biomass (kg) bootstrapped estimates with 90% CI								
Year	**Std**	**Adj 1**	**Adj 2**	**Std**	*lower*	*upper*	**Adj 1**	*lower*	*upper*	**Adj 2**	*lower*	*upper*
2009	1.8	1.8	2.0	1.8	*1.0*	*2.6*	1.8	*1.0*	*2.7*	2.0	*1.1*	*3.0*
2010	1.0	1.0	1.0	1.0	*0.6*	*1.5*	1.0	*0.5*	*1.5*	1.0	*0.6*	*1.5*
2011	4.5	4.6	4.6	4.5	*1.2*	*7.9*	4.5	*1.2*	*8.0*	4.6	*1.3*	*8.1*
2012	1.0	1.1	1.3	1.0	*0.6*	*1.4*	1.1	*0.7*	*1.6*	1.3	*0.7*	*1.8*
2013	4.6	4.6	4.6	4.6	*1.3*	*8.1*	4.6	*1.3*	*8.1*	4.6	*1.3*	*8.1*
2014	2.5	2.7	3.0	2.5	*1.4*	*3.6*	2.7	*1.5*	*3.9*	3.0	*1.6*	*4.5*
2015	6.4	6.5	6.7	6.4	*3.5*	*9.5*	6.5	*3.5*	*9.7*	6.7	*3.7*	*10.0*
2016	9.8	10.5	11.6	9.9	*6.7*	*12.9*	10.6	*7.4*	*13.6*	11.6	*8.5*	*14.7*
2017	1.3	1.2	1.3	1.3	*0.3*	*2.4*	1.2	*0.3*	*2.2*	1.3	*0.3*	*2.4*

(d)

	Abundance (number) point estimates			Abundance (number) bootstrapped estimates with 90% CI								
Year	**Std**	**Adj 1**	**Adj 2**	**Std**	*lower*	*upper*	**Adj 1**	*lower*	*upper*	**Adj 2**	*lower*	*upper*
2009	1.0	1.0	1.1	1.0	*0.5*	*1.5*	1.0	*0.5*	*1.5*	1.1	*0.6*	*1.6*
2010	1.2	1.3	1.3	1.3	*0.3*	*2.2*	1.3	*0.3*	*2.2*	1.3	*0.3*	*2.2*
2011	2.5	2.6	2.6	2.5	*0.9*	*4.2*	2.6	*1.0*	*4.3*	2.6	*1.0*	*4.3*
2012	0.6	0.6	0.7	0.6	*0.3*	*0.8*	0.6	*0.3*	*0.9*	0.7	*0.4*	*1.1*
2013	2.8	2.8	2.9	2.8	*1.0*	*4.9*	2.8	*1.0*	*4.9*	2.8	*1.0*	*4.9*
2014	1.3	1.3	1.5	1.3	*0.8*	*1.7*	1.3	*0.8*	*1.8*	1.5	*0.8*	*2.1*
2015	3.4	3.4	3.5	3.3	*1.8*	*5.0*	3.4	*1.8*	*5.2*	3.5	*1.8*	*5.3*
2016	4.7	5.0	5.6	4.7	*3.3*	*6.1*	5.1	*3.7*	*6.4*	5.6	*4.2*	*7.0*
2017	0.7	0.6	0.7	0.7	*0.1*	*1.3*	0.6	*0.1*	*1.2*	0.7	*0.1*	*1.3*

Table 6. NMFS survey stratified mean weight (i.e., biomass) per tow and mean number (i.e., abundance) per tow point estimates (left 3 columns) and bootstrapped estimates with 90% confidence intervals (CI; right 9 columns) for Eastern Georges Bank haddock for spring 2009-2018 (a) and (b), and fall 2009-2017 (c) and (d). 'Std' represents standard estimates, 'Adj 1' represents estimates including adjustment 1 (i.e., using area swept adjusted data), and 'Adj 2' represents estimates including adjustment 2 (i.e., using area swept + efficiency adjusted data).

(a)

	Biomass (kg) point estimates			**Biomass (kg) bootstrapped estimates with 90% CI**								
Year	**Std**	**Adj 1**	**Adj 2**	**Std**	*lower*	*upper*	**Adj 1**	*lower*	*upper*	**Adj 2**	*lower*	*upper*
2009	105.6	101.6	109.2	106.3	*82.3*	*131.6*	102.3	*79.6*	*126.2*	109.9	*84.2*	*136.6*
2010	89.9	87.8	92.8	89.2	*72.8*	*106.3*	87.2	*71.2*	*103.8*	92.2	*75.7*	*108.9*
2011	39.0	41.3	48.2	38.7	*29.9*	*48.7*	41.0	*31.9*	*51.4*	47.9	*37.6*	*58.9*
2012	123.7	132.2	145.2	124.0	*80.3*	*170.1*	132.4	*85.1*	*182.8*	145.6	*92.8*	*202.8*
2013	148.2	153.6	165.3	148.5	*114.1*	*185.7*	154.1	*118.9*	*191.4*	166.0	*128.5*	*206.7*
2014	117.6	115.6	117.5	117.6	*99.2*	*136.5*	115.5	*100.1*	*131.0*	117.5	*101.8*	*133.1*
2015	207.9	233.3	297.4	208.6	*168.7*	*246.9*	234.3	*185.8*	*281.4*	299.1	*226.7*	*371.8*
2016	144.8	142.6	148.2	144.5	*113.0*	*175.0*	142.4	*111.5*	*172.3*	147.9	*115.7*	*179.1*
2017	168.7	161.6	173.3	169.8	*141.5*	*199.0*	162.8	*136.1*	*188.9*	174.5	*146.1*	*203.1*
2018	91.2	96.4	123.3	90.9	*76.9*	*105.8*	96.0	*75.3*	*117.4*	122.7	*83.7*	*162.4*

(b)

	Abundance (number) point estimates			**Abundance (number) bootstrapped estimates with 90% CI**								
Year	**Std**	**Adj 1**	**Adj 2**	**Std**	*lower*	*upper*	**Adj 1**	*lower*	*upper*	**Adj 2**	*lower*	*upper*
2009	71.2	68.8	73.6	71.7	*56.0*	*88.1*	69.3	*54.5*	*84.7*	74.1	*57.4*	*91.2*
2010	56.9	55.7	58.8	56.5	*46.1*	*67.1*	55.3	*45.2*	*65.8*	58.4	*48.1*	*69.0*
2011	58.1	62.6	77.0	57.6	*45.4*	*70.2*	62.2	*48.6*	*76.5*	76.4	*57.8*	*96.0*
2012	228.6	244.7	267.5	229.1	*133.7*	*335.9*	245.2	*141.5*	*362.9*	268.4	*149.9*	*399.9*
2013	170.7	176.5	188.5	171.0	*129.7*	*217.1*	176.9	*135.0*	*222.9*	189.1	*145.6*	*236.3*
2014	240.9	238.0	241.9	240.2	*203.4*	*277.6*	237.3	*203.1*	*271.7*	241.3	*207.4*	*275.0*
2015	412.9	471.1	617.0	414.7	*321.0*	*505.4*	473.5	*357.6*	*584.5*	621.2	*445.2*	*799.6*
2016	199.8	196.7	204.6	199.5	*153.2*	*245.5*	196.6	*151.4*	*241.7*	204.4	*157.2*	*252.0*
2017	197.7	187.9	200.8	198.5	*169.4*	*228.0*	188.7	*162.7*	*215.6*	201.8	*172.3*	*231.0*
2018	95.1	101.1	130.2	94.8	*75.7*	*114.8*	100.7	*73.4*	*128.4*	129.6	*81.3*	*178.7*

Table 6. Continued.

(c)

	Biomass (kg) point estimates			Biomass (kg) bootstrapped estimates with 90% CI								
Year	**Std**	**Adj 1**	**Adj 2**	**Std**	*lower*	*upper*	**Adj 1**	*lower*	*upper*	**Adj 2**	*lower*	*upper*
2009	55.8	55.9	60.6	55.9	*31.1*	*81.8*	55.9	*31.4*	*81.5*	60.6	*34.4*	*88.1*
2010	30.3	29.7	30.5	30.5	*19.2*	*42.4*	29.9	*18.8*	*41.6*	30.8	*19.7*	*42.5*
2011	62.0	64.3	70.8	62.1	*42.6*	*83.1*	64.5	*44.8*	*85.2*	71.2	*49.9*	*92.9*
2012	71.1	79.1	88.7	70.8	*35.9*	*110.1*	78.8	*38.0*	*122.9*	88.4	*40.9*	*139.5*
2013	169.1	173.8	178.0	166.7	*112.6*	*224.2*	171.1	*114.0*	*232.0*	175.4	*118.0*	*235.8*
2014	119.6	124.1	138.0	119.6	*90.2*	*149.6*	124.1	*93.6*	*155.8*	138.0	*104.0*	*173.7*
2015	380.5	399.0	446.7	385.2	*126.5*	*644.1*	403.9	*128.4*	*679.8*	452.4	*133.2*	*773.1*
2016	175.8	188.4	210.5	173.1	*81.2*	*279.9*	185.3	*84.9*	*300.9*	206.9	*92.4*	*338.9*
2017	66.3	67.4	76.6	66.4	*39.0*	*93.5*	67.5	*38.6*	*96.3*	76.7	*43.3*	*110.4*

(d)

	Abundance (number) point estimates			Abundance (number) bootstrapped estimates with 90% CI								
Year	**Std**	**Adj 1**	**Adj 2**	**Std**	*lower*	*upper*	**Adj 1**	*lower*	*upper*	**Adj 2**	*lower*	*upper*
2009	52.7	*52.8*	*57.5*	52.5	*31.8*	*74.2*	52.7	*32.1*	*74.7*	57.3	*35.2*	*80.8*
2010	140.0	*137.5*	*143.2*	139.2	*99.0*	*182.8*	136.7	*97.1*	*179.8*	142.3	*99.6*	*188.5*
2011	237.1	*247.8*	*279.8*	238.4	*163.8*	*318.5*	249.4	*171.8*	*332.3*	282.5	*197.4*	*367.8*
2012	158.0	*176.4*	*198.7*	157.5	*80.3*	*244.8*	175.8	*86.0*	*273.4*	198.2	*94.2*	*310.8*
2013	1,756.2	*1,852.5*	*1,881.6*	1,709.4	*842.2*	*2,657.1*	1,801.3	*867.1*	*2,831.0*	1,830.3	*895.3*	*2,857.9*
2014	488.3	*513.4*	*579.9*	488.4	*375.6*	*611.3*	513.5	*390.9*	*646.5*	580.3	*439.3*	*737.5*
2015	815.6	*848.0*	*938.5*	825.0	*343.0*	*1,320.1*	857.7	*347.7*	*1,381.6*	949.7	*357.7*	*1,554.5*
2016	481.5	*514.9*	*575.0*	477.6	*260.3*	*730.0*	510.5	*274.9*	*787.1*	570.0	*296.8*	*891.2*
2017	139.3	*143.5*	*162.9*	139.7	*82.0*	*202.5*	143.9	*83.3*	*210.1*	163.3	*92.5*	*241.4*

Table 7. NMFS survey stratified mean weight (i.e., biomass) per tow and mean number (i.e., abundance) per tow point estimates (left 3 columns) and bootstrapped estimates with 90% confidence intervals (CI; right 9 columns) for Georges Bank yellowtail flounder for spring 2009-2018 (a) and (b), and fall 2009-2017 (c) and (d). 'Std' represents standard estimates, 'Adj 1' represents estimates including adjustment 1 (i.e., using area swept adjusted data), and 'Adj 2' represents estimates including adjustment 2 (i.e., using area swept + efficiency adjusted data).

(a)

	Biomass (kg) point estimates			**Biomass (kg) bootstrapped estimates with 90% CI**								
Year	**Std**	**Adj 1**	**Adj 2**	**Std**	*lower*	*upper*	**Adj 1**	*lower*	*upper*	**Adj 2**	*lower*	*upper*
2009	4.9	4.9	5.2	4.9	*3.5*	*6.3*	5.0	*3.5*	*6.4*	5.2	*3.7*	*6.8*
2010	5.9	5.8	6.1	5.9	*4.1*	*8.0*	5.8	*4.0*	*7.7*	6.1	*4.2*	*8.2*
2011	2.6	2.8	3.6	2.6	*1.9*	*3.3*	2.8	*2.0*	*3.7*	3.6	*2.5*	*4.8*
2012	4.0	4.2	4.6	4.0	*1.9*	*6.4*	4.2	*2.0*	*6.6*	4.6	*2.3*	*7.2*
2013	1.1	1.1	1.2	1.1	*0.8*	*1.4*	1.1	*0.8*	*1.4*	1.2	*0.9*	*1.5*
2014	0.7	0.8	0.8	0.7	*0.6*	*0.9*	0.8	*0.6*	*0.9*	0.8	*0.6*	*1.0*
2015	0.5	0.5	0.6	0.5	*0.4*	*0.6*	0.5	*0.4*	*0.7*	0.6	*0.4*	*0.7*
2016	0.3	0.3	0.3	0.3	*0.2*	*0.4*	0.3	*0.2*	*0.4*	0.3	*0.2*	*0.4*
2017	0.2	0.2	0.2	0.2	*0.2*	*0.3*	0.2	*0.2*	*0.3*	0.2	*0.2*	*0.3*
2018	0.0	0.0	0.0	0.0	*0.0*	*0.0*	0.0	*0.0*	*0.0*	0.0	*0.0*	*0.0*

(b)

	Abundance (number) point estimates			**Abundance (number) bootstrapped estimates with 90% CI**								
Year	**Std**	**Adj 1**	**Adj 2**	**Std**	*lower*	*upper*	**Adj 1**	*lower*	*upper*	**Adj 2**	*lower*	*upper*
2009	14.1	14.4	15.2	14.2	*9.9*	*18.3*	14.5	*10.0*	*19.0*	15.3	*10.5*	*20.2*
2010	17.9	17.4	18.3	17.9	*12.2*	*24.3*	17.4	*12.0*	*23.4*	18.3	*12.4*	*24.9*
2011	8.4	9.3	11.8	8.4	*6.1*	*10.9*	9.3	*6.6*	*12.1*	11.8	*8.3*	*15.6*
2012	12.3	13.0	14.3	12.4	*5.9*	*19.5*	13.1	*6.5*	*20.4*	14.3	*7.5*	*21.8*
2013	3.6	3.7	3.9	3.6	*2.6*	*4.7*	3.7	*2.7*	*4.8*	3.8	*2.8*	*4.9*
2014	2.2	2.2	2.3	2.2	*1.7*	*2.7*	2.2	*1.8*	*2.7*	2.3	*1.8*	*2.8*
2015	1.5	1.6	1.8	1.5	*1.1*	*2.0*	1.6	*1.2*	*2.1*	1.8	*1.3*	*2.3*
2016	0.7	0.7	0.8	0.7	*0.5*	*1.0*	0.7	*0.5*	*0.9*	0.8	*0.5*	*1.0*
2017	0.6	0.6	0.6	0.6	*0.5*	*0.8*	0.6	*0.4*	*0.8*	0.6	*0.5*	*0.8*
2018	0.0	0.0	0.0	0.0	*0.0*	*0.1*	0.0	*0.0*	*0.1*	0.0	*0.0*	*0.1*

Table 7. Continued.

(c)

	Biomass (kg) point estimates			Biomass (kg) bootstrapped estimates with 90% CI								
Year	**Std**	**Adj 1**	**Adj 2**	**Std**	*lower*	*upper*	**Adj 1**	*lower*	*upper*	**Adj 2**	*lower*	*upper*
2009	6.7	6.7	6.8	6.7	*4.5*	*9.3*	6.7	*4.5*	*9.2*	6.8	*4.5*	*9.2*
2010	2.2	2.2	2.2	2.3	*1.4*	*3.1*	2.3	*1.4*	*3.1*	2.3	*1.5*	*3.1*
2011	2.5	2.6	3.0	2.5	*1.7*	*3.3*	2.6	*1.8*	*3.5*	3.0	*2.1*	*3.9*
2012	2.5	2.8	3.1	2.5	*1.2*	*4.0*	2.8	*1.3*	*4.5*	3.1	*1.4*	*5.1*
2013	0.9	0.9	0.9	0.9	*0.5*	*1.4*	0.9	*0.5*	*1.4*	0.9	*0.5*	*1.4*
2014	1.0	1.1	1.2	1.0	*0.6*	*1.4*	1.1	*0.7*	*1.5*	1.2	*0.7*	*1.7*
2015	0.5	0.5	0.5	0.5	*0.1*	*0.8*	0.5	*0.1*	*0.8*	0.5	*0.1*	*0.8*
2016	0.4	0.5	0.5	0.4	*0.2*	*0.6*	0.5	*0.3*	*0.7*	0.5	*0.3*	*0.8*
2017	0.2	0.2	0.2	0.2	*0.1*	*0.3*	0.2	*0.1*	*0.3*	0.2	*0.1*	*0.3*

(d)

	Abundance (number) point estimates			Abundance (number) bootstrapped estimates with 90% CI								
Year	**Std**	**Adj 1**	**Adj 2**	**Std**	*lower*	*upper*	**Adj 1**	*lower*	*upper*	**Adj 2**	*lower*	*upper*
2009	20.0	19.8	20.0	20.0	*13.1*	*27.7*	19.8	*13.1*	*27.3*	20.0	*13.3*	*27.4*
2010	8.5	8.5	8.5	8.7	*5.6*	*11.8*	8.6	*5.6*	*11.7*	8.7	*5.6*	*11.7*
2011	8.3	8.9	9.9	8.3	*5.8*	*11.0*	8.9	*6.2*	*11.7*	9.9	*7.0*	*13.0*
2012	7.4	8.1	9.1	7.4	*3.7*	*11.7*	8.2	*3.9*	*13.2*	9.1	*4.2*	*14.8*
2013	3.0	3.1	3.1	3.0	*1.7*	*4.6*	3.1	*1.7*	*4.7*	3.1	*1.8*	*4.7*
2014	3.3	3.4	3.8	3.3	*2.3*	*4.5*	3.4	*2.3*	*4.7*	3.7	*2.5*	*5.1*
2015	1.4	1.4	1.4	1.4	*0.5*	*2.4*	1.5	*0.5*	*2.4*	1.5	*0.5*	*2.4*
2016	1.5	1.6	1.8	1.5	*0.8*	*2.2*	1.6	*0.8*	*2.3*	1.8	*1.0*	*2.6*
2017	0.6	0.6	0.6	0.6	*0.4*	*0.9*	0.6	*0.4*	*0.9*	0.6	*0.4*	*0.9*

FIGURES

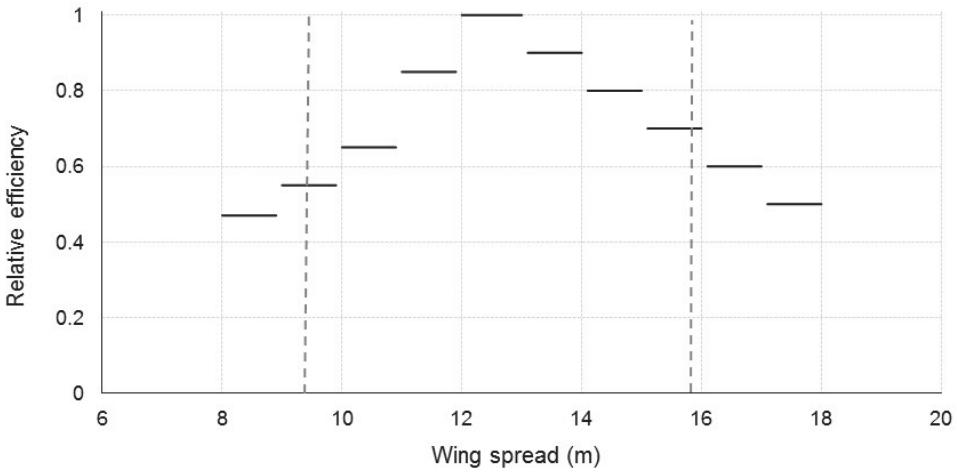
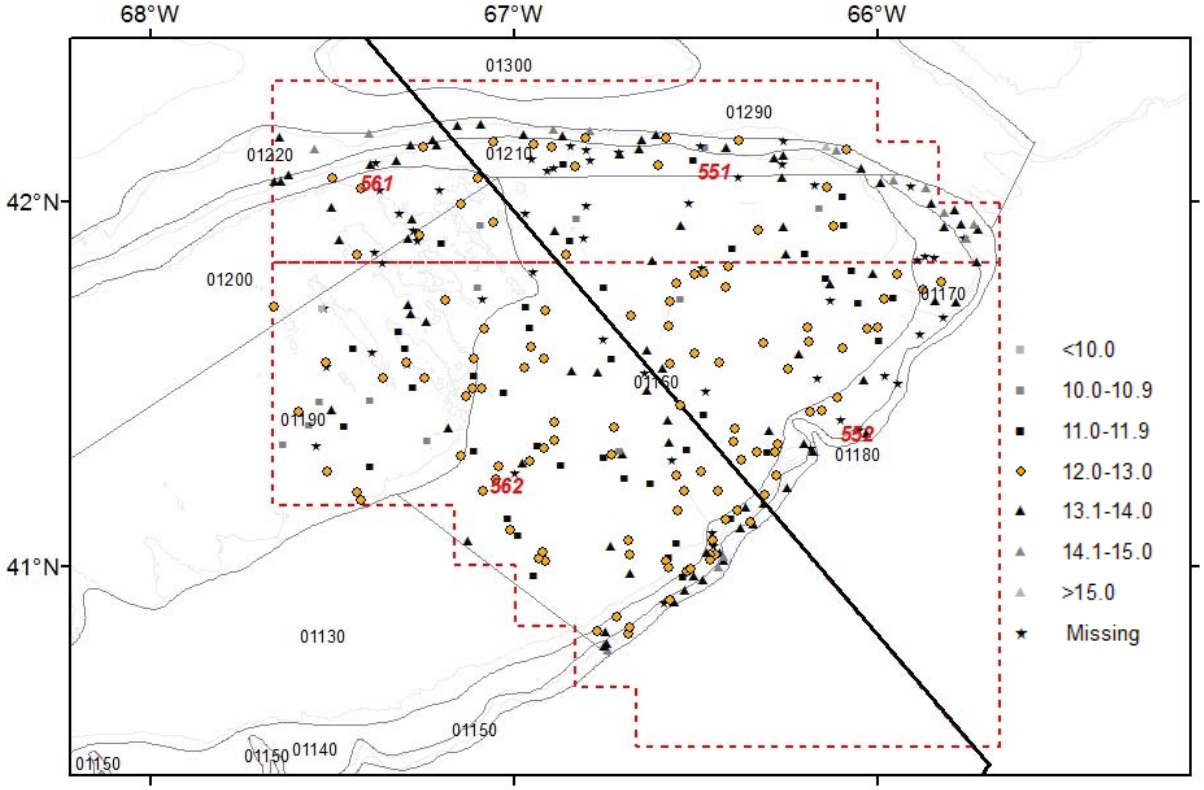
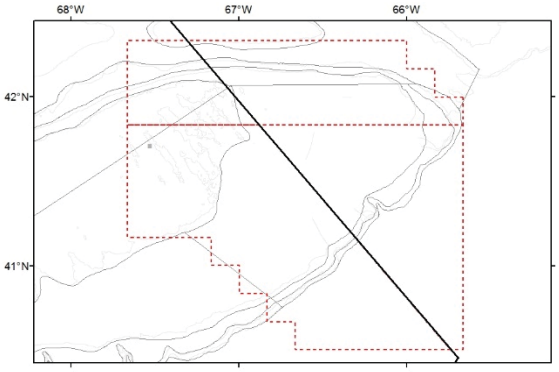


Figure 1. Hypothesized relative efficiency of the NMFS survey vessel FSV Henry B. Bigelow *by wing spread. Note that these values area based on input from members of the USA industry; there are no available data to inform this relationship objectively. Spring 2009 to spring 2018 TRAC data wing spread range is 9.4 – 15.9 m (dashed lines).*

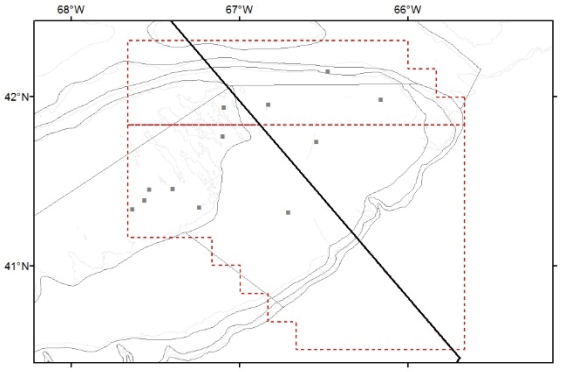


(a)

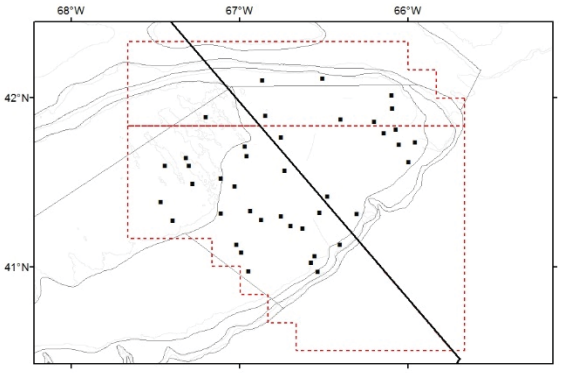
Figure 2. Station location for the 2009-2018 NMFS spring survey for Eastern Georges Bank Atlantic cod and Eastern Georges Bank haddock [intersection of NMFS survey strata 01160-01220 (thin black lines) and USA statistical areas 551, 552, 561, and 562 (red dashed lines)] for all stations combined (a) 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. The thick black line represents the Hague line. Figure letters are located in the bottom left corner of each plot.



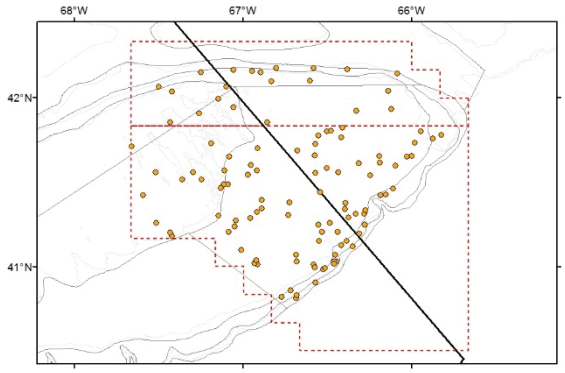
(b) < 10 m



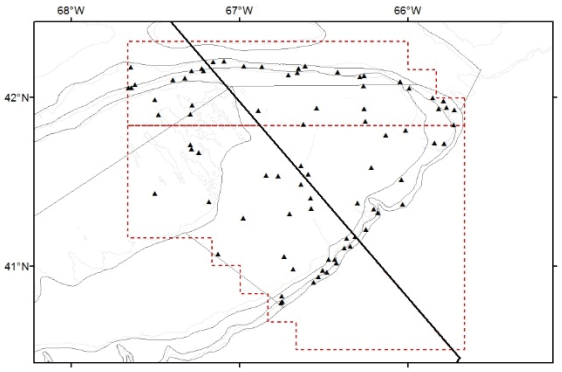
(c) 10.0 – 10.9 m



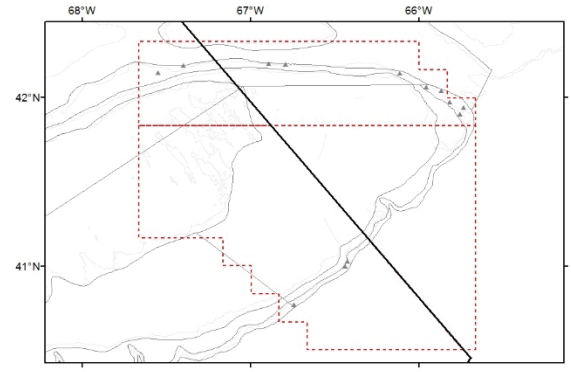
(d) 11.0 – 11.9 m



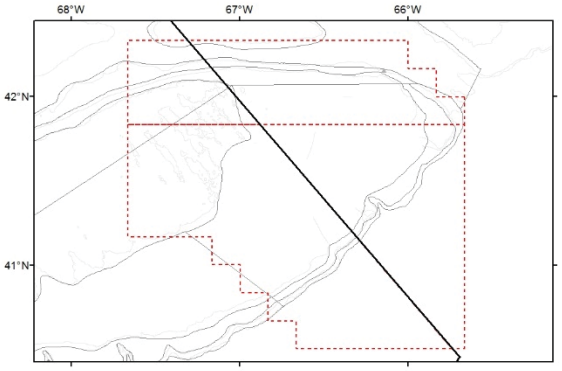
(e) 12.0 – 13.0 m



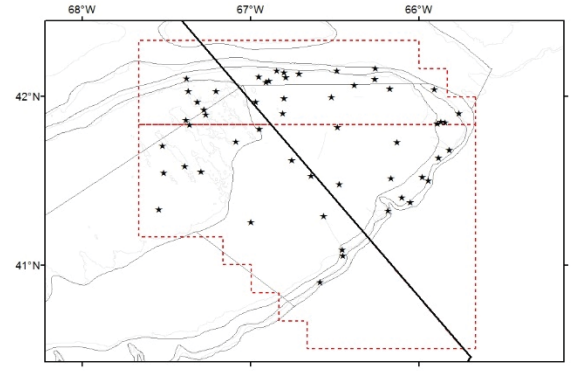
(f) 13.1 – 14.0 m



(g) 14.1 – 15.0 m

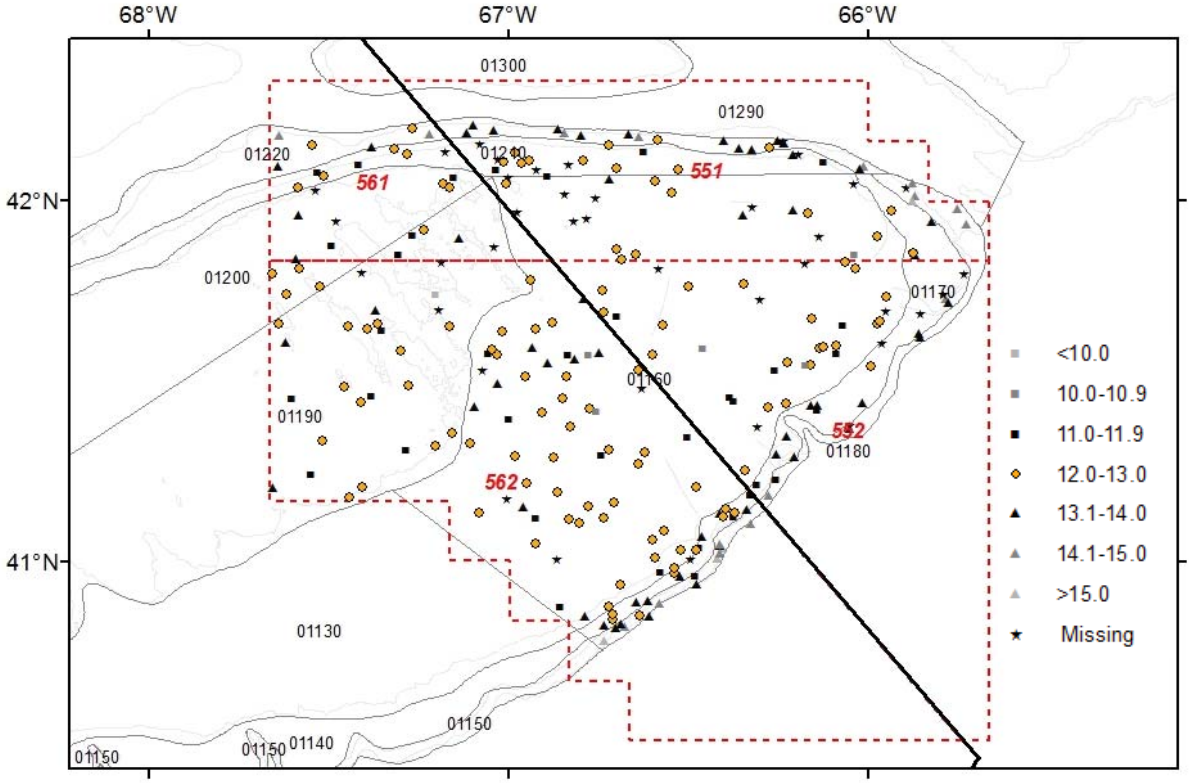


(h) > 15 m



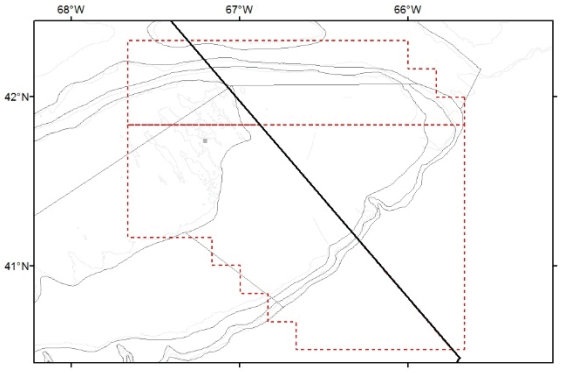
(i) Missing

Figure 2. Continued.

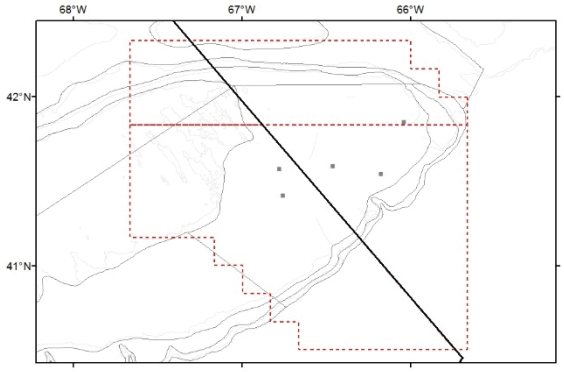


(a)

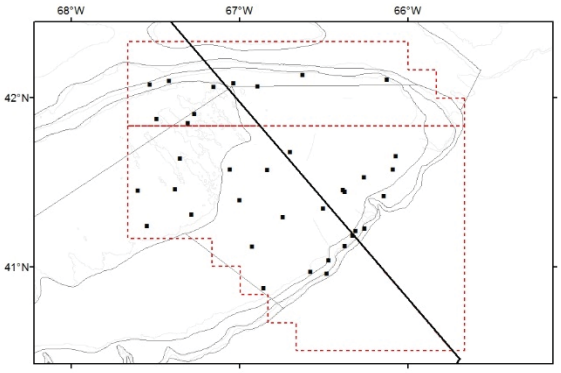
Figure 3. Station location for the 2009-2017 NMFS fall survey for Eastern Georges Bank Atlantic cod and Eastern Georges Bank haddock [intersection of NMFS survey strata 01160-01220 (thin black lines) and USA statistical areas 551, 552, 561, and 562 (red dashed lines)] for all stations combined (a) and 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. The thick black line represents the Hague line. Figure letters are located in the bottom left corner of each plot.



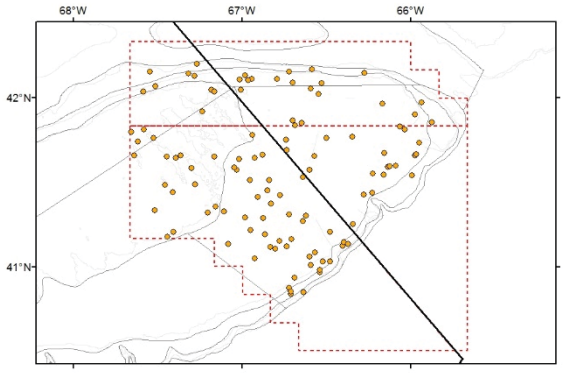
(b) < 10 m



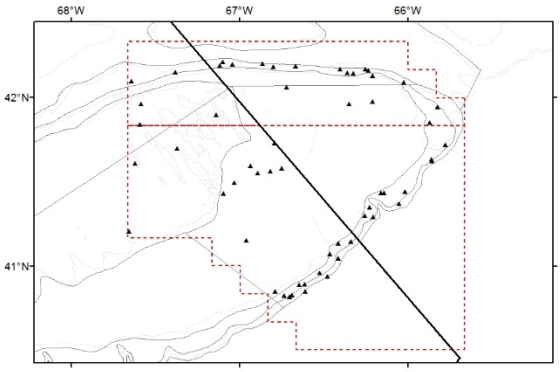
(c) 10.0 – 10.9 m



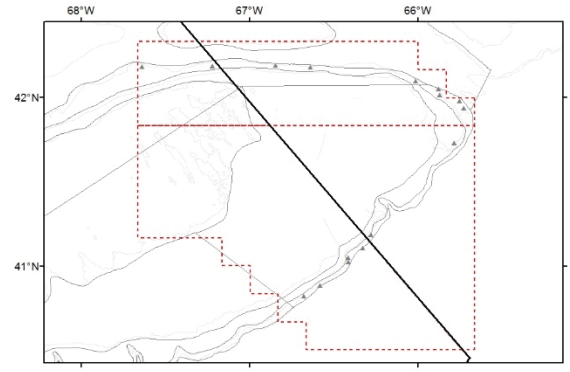
(d) 11.0 – 11.9 m



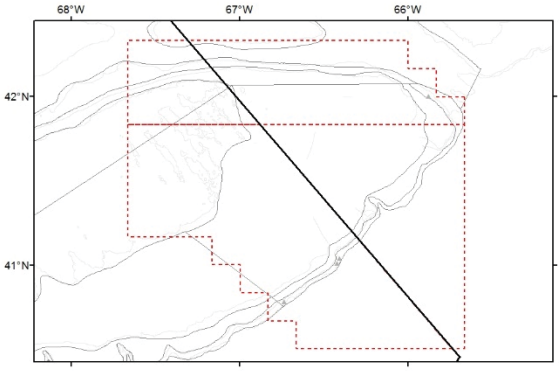
(e) 12.0 – 13.0 m



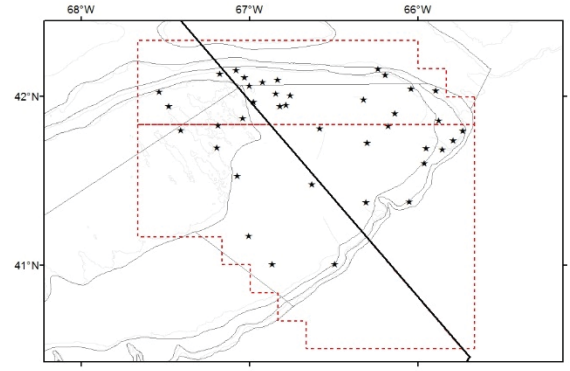
(f) 13.1 – 14.0 m



(g) 14.1 – 15.0 m

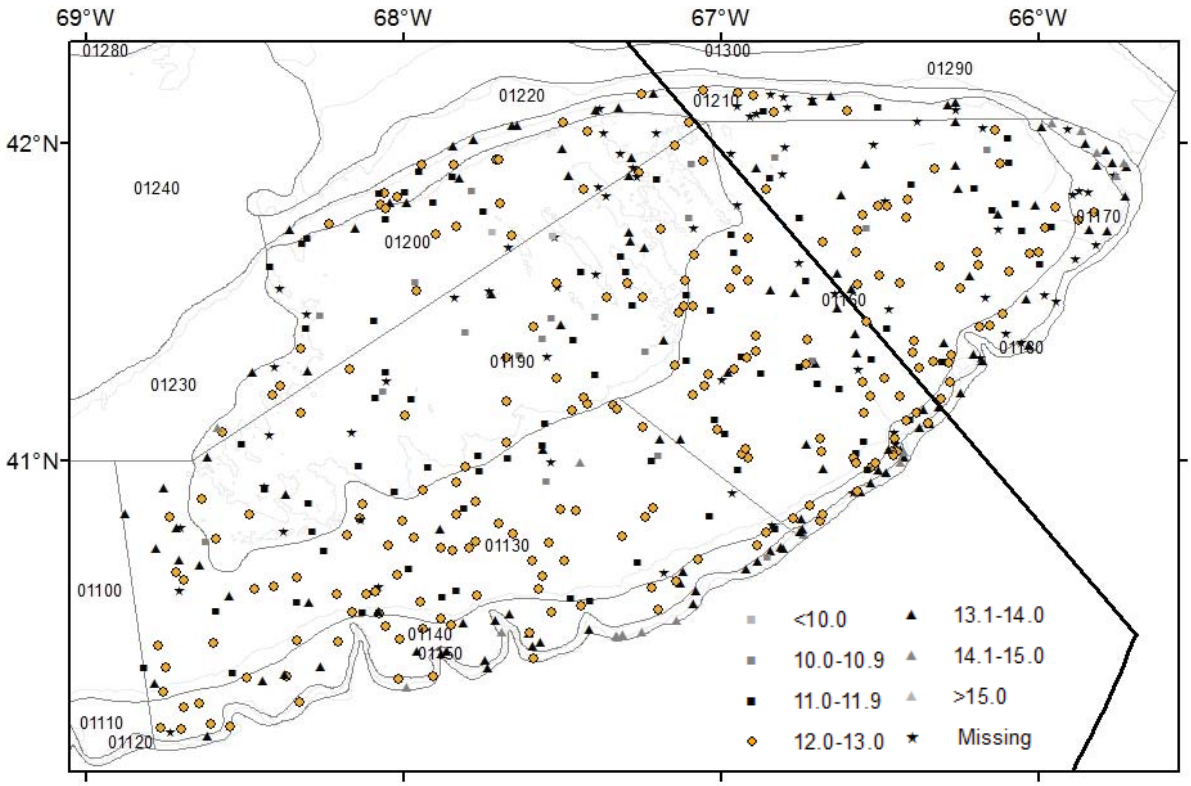


(h) > 15 m



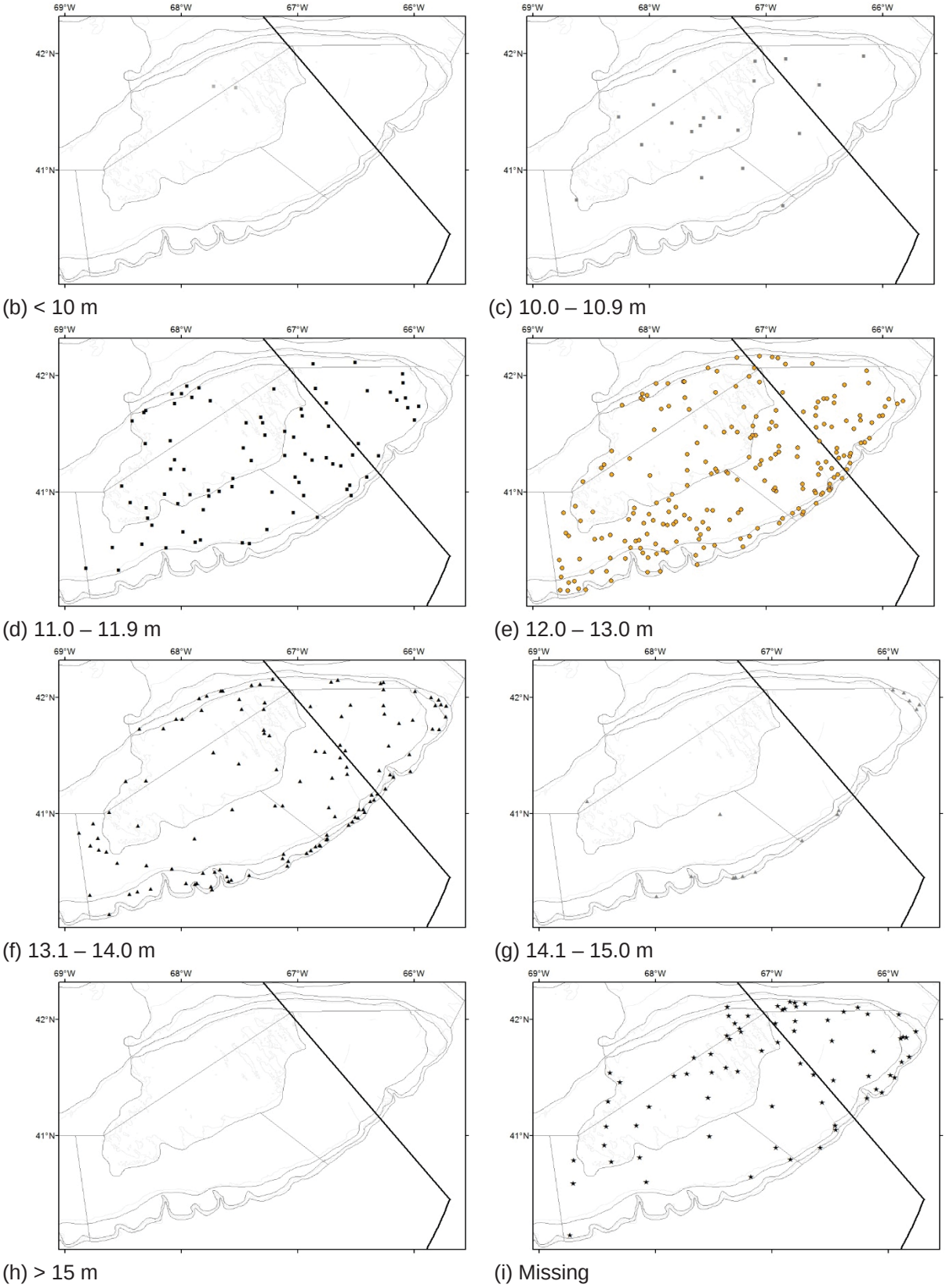
(i) Missing

Figure 3. Continued.



(a)

Figure 4. Station location for the 2009-2018 NMFS spring survey for Georges Bank yellowtail flounder [NMFS survey strata 01130-01210 (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. The thick black line represents the Hague line. Figure letters are located in the bottom left corner of each plot.



(b) < 10 m

(c) 10.0 – 10.9 m

(d) 11.0 – 11.9 m

(e) 12.0 – 13.0 m

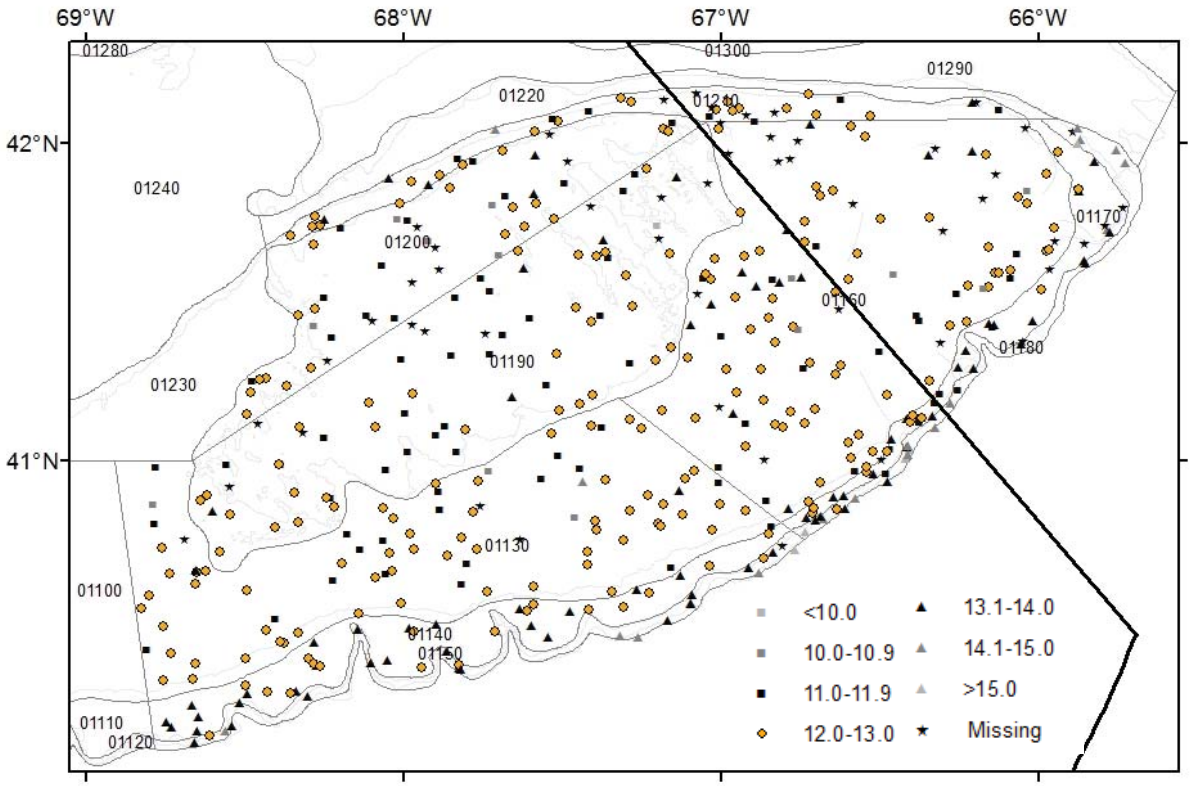
(f) 13.1 – 14.0 m

(g) 14.1 – 15.0 m

(h) > 15 m

(i) Missing

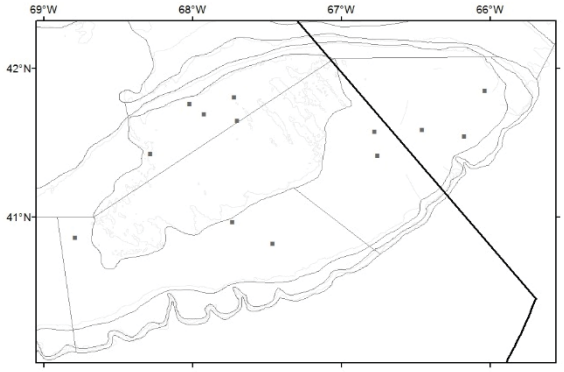
Figure 4. Continued.



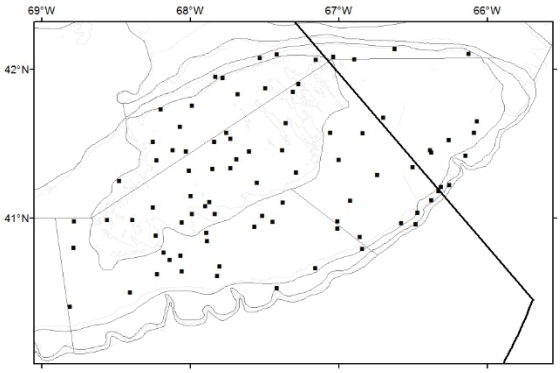
(a)

Figure 5. Station location for the 2009-2017 NMFS fall survey for Georges Bank yellowtail flounder [NMFS survey strata 01130-01210 (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. The thick black line represents the Hague line. Figure letters are located in the bottom left corner of each plot.

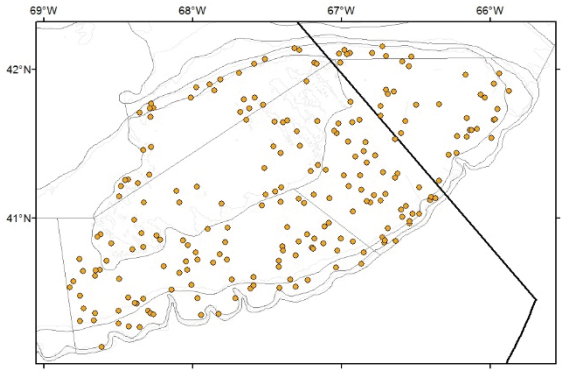
(b) < 10 m



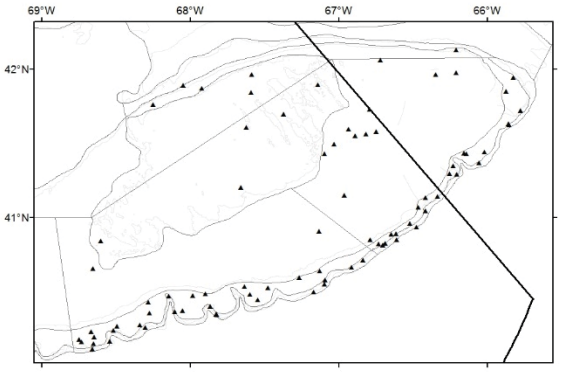
(c) 10.0 – 10.9 m



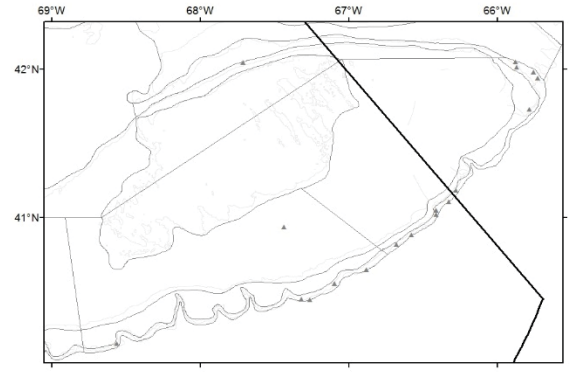
(d) 11.0 – 11.9 m



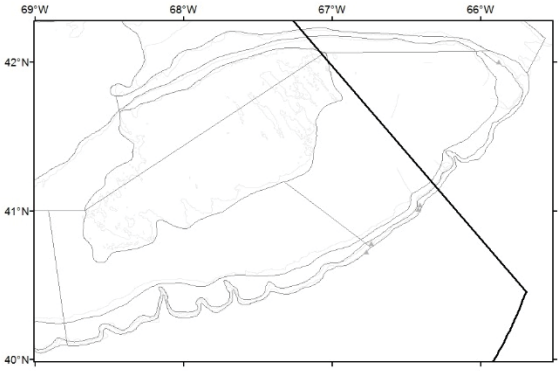
(e) 12.0 – 13.0 m



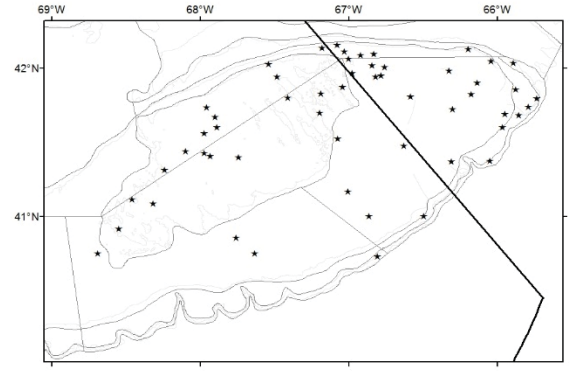
(f) 13.1 – 14.0 m



(g) 14.1 – 15.0 m



(h) > 15 m



(i) Missing

Figure 5. Continued.

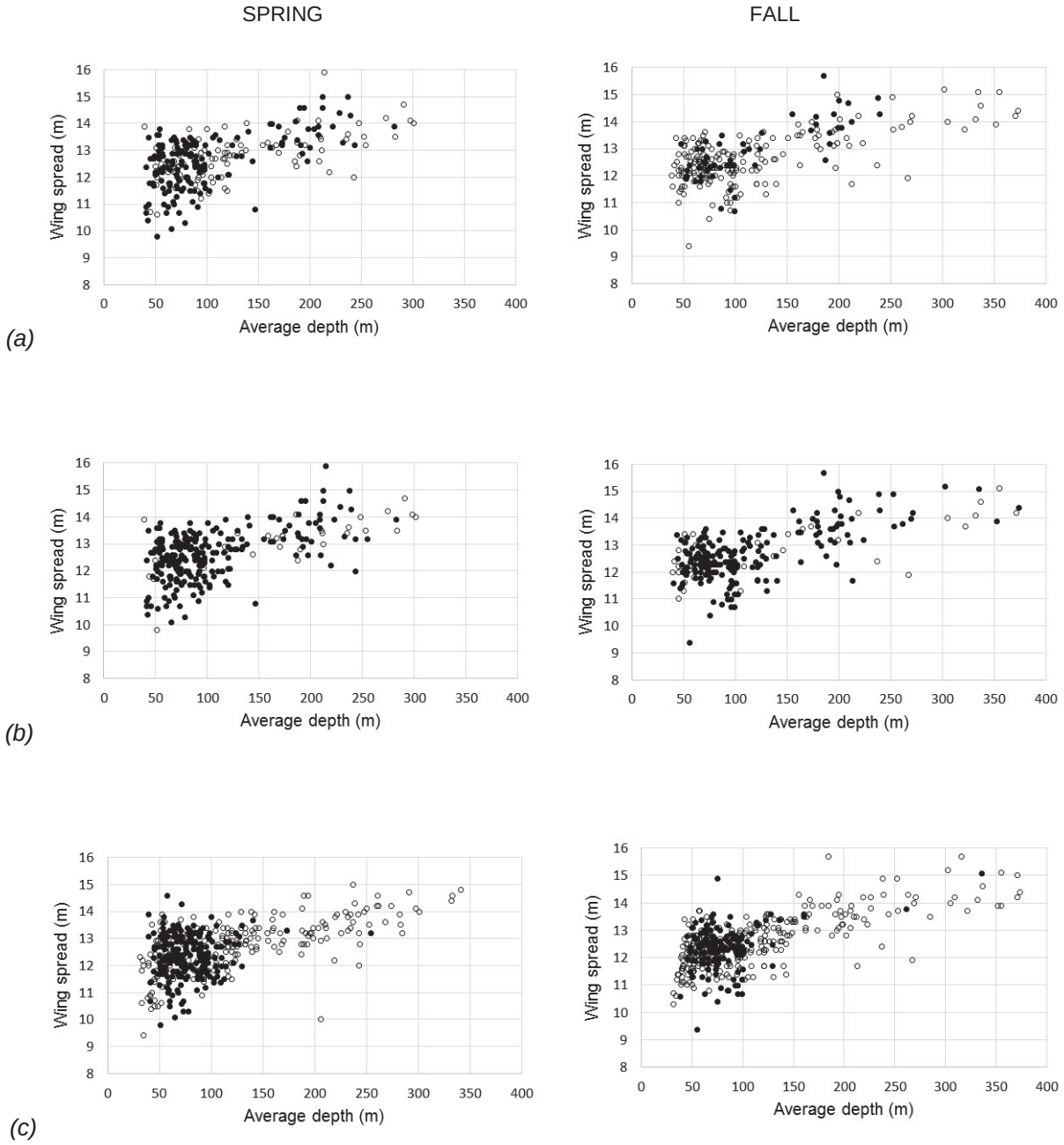


Figure 6. Wing spread by average depth of tow for the 2009-2018 spring and 2009-2017 fall NMFS survey stations for Eastern Georges Bank Atlantic cod (a), Eastern Georges Bank haddock (b), and Georges Bank yellowtail flounder (c). Black dots represent tows with catch, and open circles represent tows with zero catch.

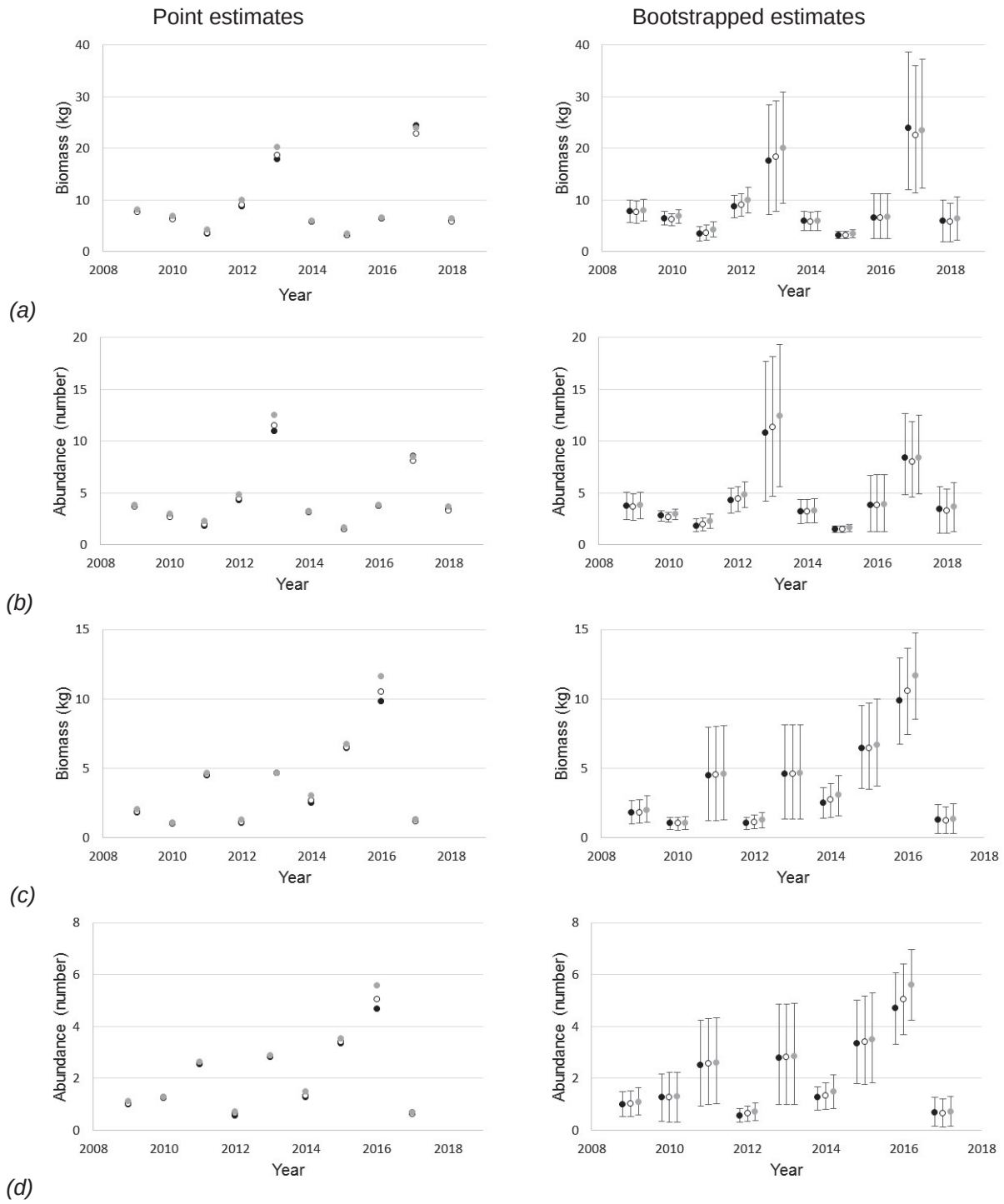


Figure 7. NMFS survey stratified mean weight (i.e., biomass) per tow and mean number (i.e., abundance) per tow index estimates for Eastern Georges Bank Atlantic cod for spring 2009-2018 (a) and (b), and fall 2009-2017 (c) and (d). Point estimates are presented in the left column, and bootstrapped estimates with 90% confidence intervals are in the right column. Black dots represent standard estimates, open circles represent estimates including adjustment 1 (i.e., using area swept adjusted data), and grey dots represent estimates including adjustment 2 (i.e., using area swept + efficiency adjusted data).

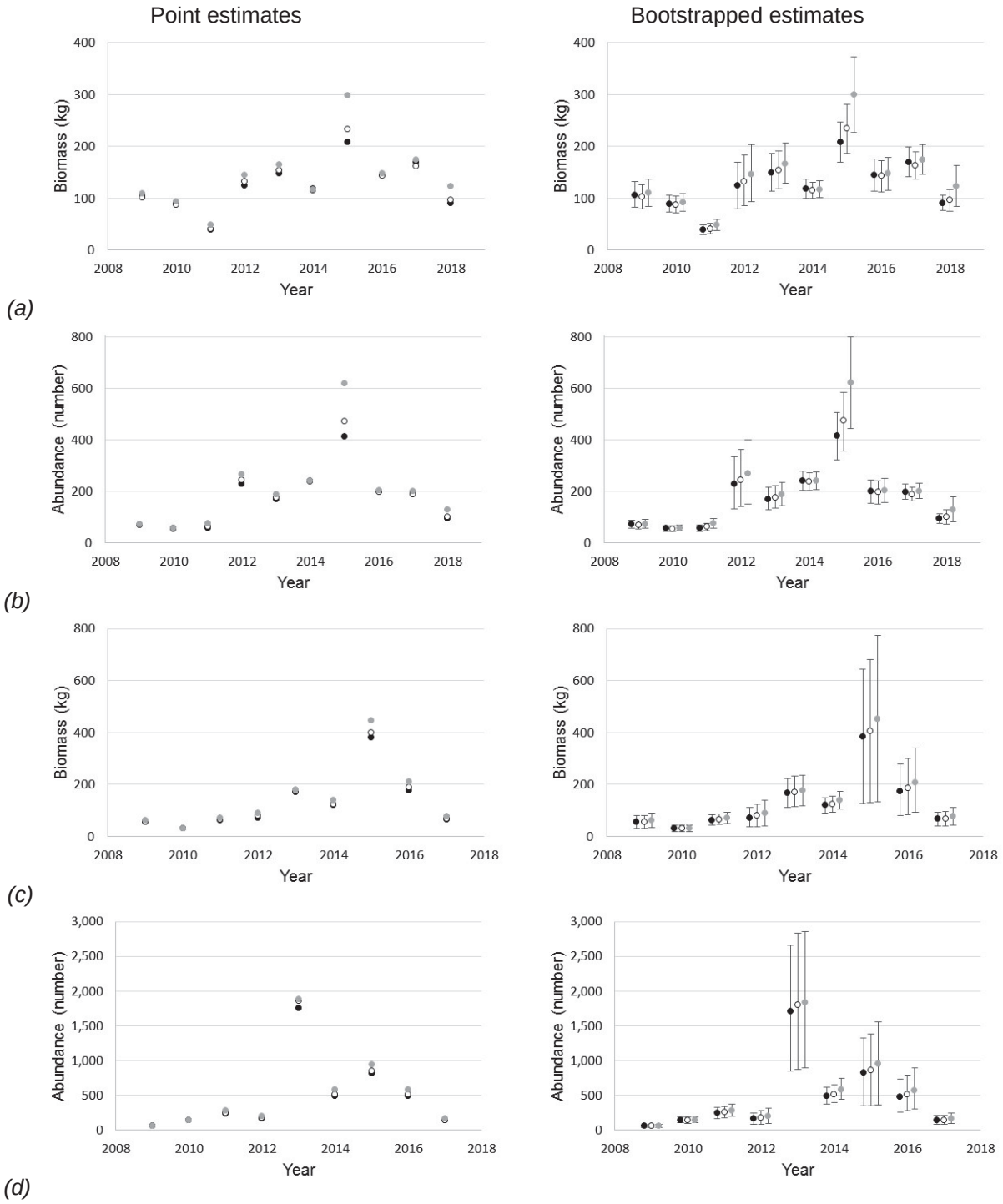


Figure 8. NMFS survey stratified mean weight (i.e., biomass) per tow and mean number (i.e., abundance) per tow index estimates for Eastern Georges Bank haddock for spring 2009-2018 (a) and (b), and fall 2009-2017 (c) and (d). Point estimates are presented in the left column, and bootstrapped estimates with 90% confidence intervals are in the right column. Black dots represent standard estimates, open circles represent estimates including adjustment 1 (i.e., using area swept adjusted data), and grey dots represent estimates including adjustment 2 (i.e., using area swept + efficiency adjusted data).

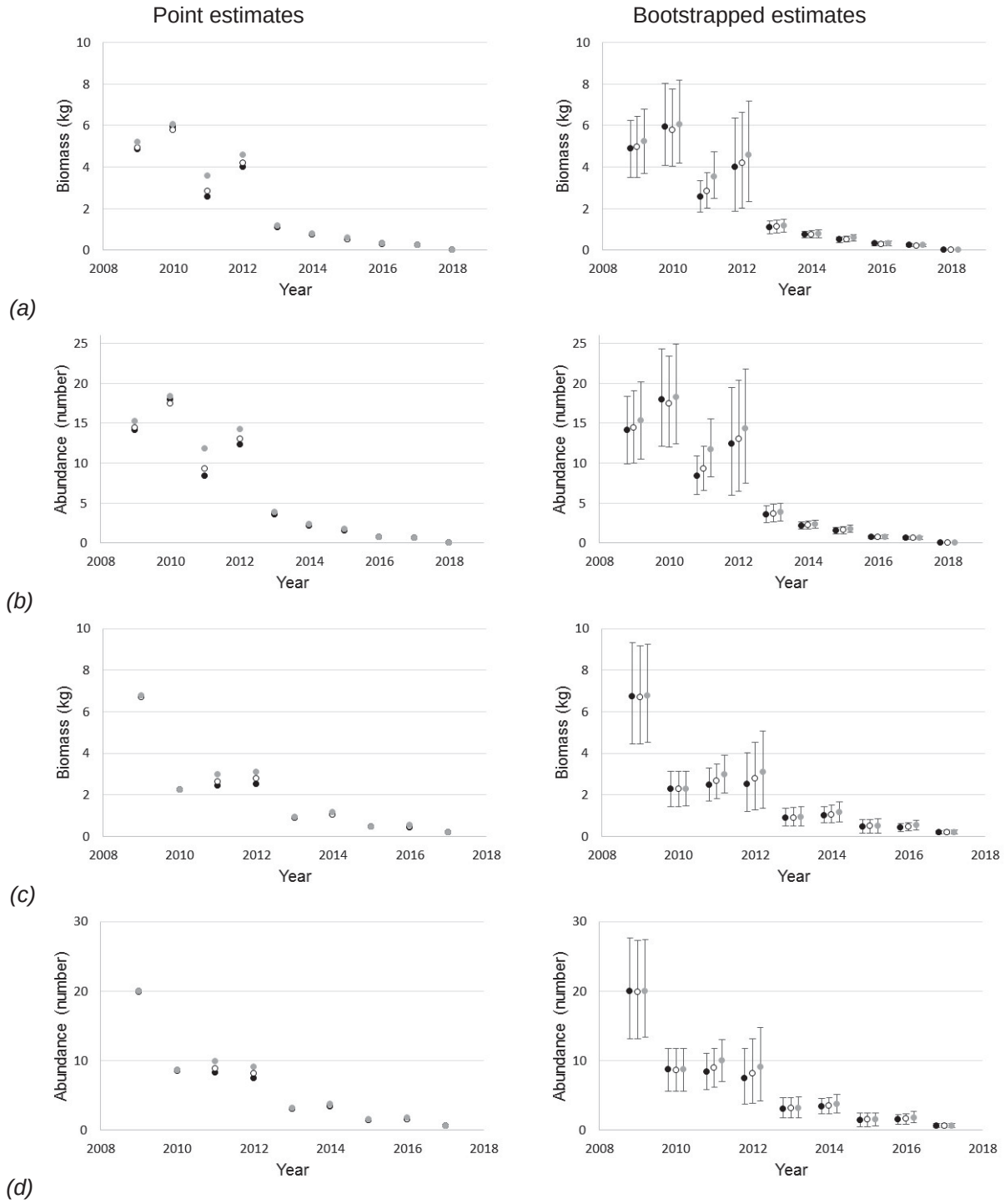


Figure 9. NMFS survey stratified mean weight (i.e., biomass) per tow and mean number (i.e., abundance) per tow index estimates for Georges Bank yellowtail flounder for spring 2009-2018 (a) and (b), and fall 2009-2017 (c) and (d). Point estimates are presented in the left column, and bootstrapped estimates with 90% confidence intervals are in the right column. Black dots represent standard estimates, open circles represent estimates including adjustment 1 (i.e., using area swept adjusted data), and grey dots represent estimates including adjustment 2 (i.e., using area swept + efficiency adjusted data).