Summary of Sea Education Association Long-term Sargasso Sea Surface Net Data

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The Sargasso Sea Alliance is led by the Bermuda Government and aims to promote international awareness of the importance of the Sargasso Sea and to mobilise support from a wide variety of national and international organisations, governments, donors and users for protection measures for the Sargasso Sea.

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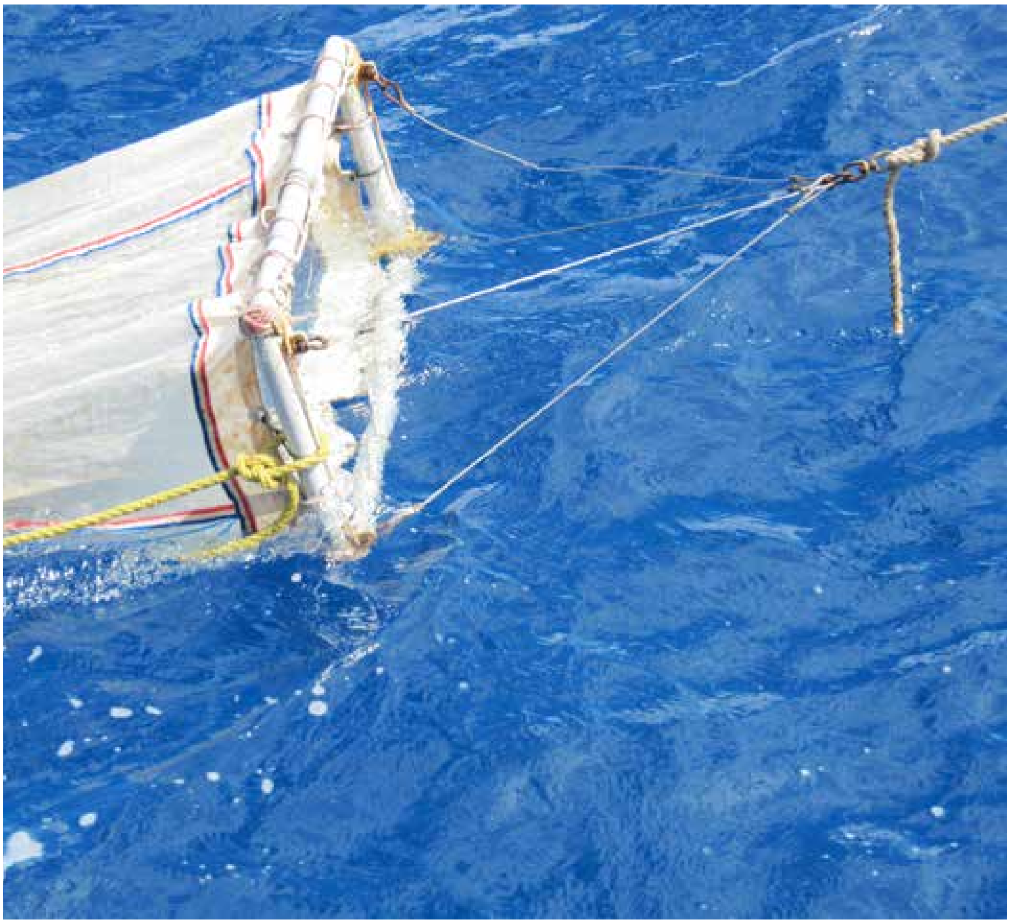

Summary of Sea Education Association Long-Term Sargasso Sea Surface Net Data

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Foreword

BETWEEN 2010 AND 2012 a large number of authors from seven different countries and 26 separate organisations developed a scientific case to establish the global importance of the Sargasso Sea. A summary of this international study was published in 2012 as the "Summary science and Supporting Evidence Case." Nine reasons why the Sargasso Sea is important are identified in the summary. Compiling the science and evidence for this case was a significant undertaking and during that process a number of reports were specially commissioned by the Sargasso Sea Alliance to summarise our knowledge of various aspects of the Sargasso Sea.

This report is one of these commissioned reports. These are now being made available in the Sargasso Sea Alliance Science Series to provide further details of the research and evidence used in the compilation of the summary case. A full list of the reports in this series can be found in the inside back cover of this report. All of them can be downloaded from **www.sargassoalliance.org.**

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Summary of Sea Education Association Long-Term Sargasso Sea Surface Net Data

Dataset Summary

SEA Neuston Tow records from 1973 to 2010 were digitized. Many of the quantitative record keeping began in 1977. *Sargassum* sp. densities (g/m^2) were recorded for 1999 individual tows, whereas tar densities (g/m^2) were recorded least regularly, resulting in 1254 records from individual tows (**TABLE 1**). Plastic pieces and *Sargassum* sp. were encountered in all sampling years, and frequency of presence was high (**TABLE 1**). In contrast, eel larvae were less frequently observed (**TABLE 1**). Moreover, the frequency of tar balls decreased dramatically to nearly zero from the mid-1990s onward (**TABLE 1**).

Methods

Samples were collected with a surface skimming neuston net (1 m wide x 0.5 m high, 333 µm mesh) towed half in and half out of the water (**FIGURE 1**) for approximately 1 nautical mile at 2 knots. Because sampling was conducted from the deck of a sailing vessel, speed varies, but most tows measured close to 1 nautical mile. While current (2008-present) sampling protocols call for 1200 and 0000 neuston net sampling each day the vessel is underway, earlier cruises may not have followed the same regular sampling schedule. Note: Sampling through 1986 was conducted using a 500 µm mesh net. The larger mesh should result in lower zooplankton densities than tows conducted with a 333 µm mesh net, but should not impact the densities of eel larvae, plastic and tar.

For the current analysis, the Sargasso Sea region was designated as: less than 38°N, greater than 20°N, east of 78°W, and west of 55°W. Some spring cruises skirted the east coast of the US and the Gulf Stream. As a result, stations above 33°N and west of 72°W were excluded from the analysis. Based on analysis by Ullman et al., (2006), 29°N was chosen as the boundary (STCZ) between north and south regions of the Sargasso Sea. Surface plots of *Sargassum* sp. density (**FIGURE 2**) and eel larvae density (**FIGURE 3**) reveal the station distribution in fall and spring, as well as regional (north and south) variability.

Annual mean densities in each season and region (North or South Sargasso Sea) were calculated directly from individual tow densities. With inherent patchiness associated with many of the parameters examined, a weighted mean calculated as the sum of all individuals or mass in a given year (cruise) divided by the total distance towed might be more accurate. Although weighted means for *Sargassum* density were slightly different than the gross means presented here, the temporal patterns persisted.

FIGURE 1. Surface skimming neuston net (1 m x 0.5 m) equipped with 333 µm mesh. All tows approximately 1 nm in length while the vessel was sailing at 2 kts.

Results of Preliminary Analyses

1977 to 2010 fall and spring means for temperature, wind speed, zooplankton density, eel larvae density, plastic density, and tar density are presented in **FIGURES 4-10.** Initial analysis identified some temporal trends. During fall, a decreasing trend in zooplankton, eel larvae, and tar was observed in the North Sargasso Sea. Similarly, zooplankton and tar have been decreasing during fall in the South Sargasso Sea. During spring, a decreasing trend in eel larvae, *Sargassum* sp. and tar, and a slight increase in plastic were observed in the North Sargasso Sea. Also in the spring, tar and *Sargassum* sp. decreased, while eel larvae and plastic slightly increased in the South Sargasso Sea region. Moreover, significant differences in overall means between fall and spring in the North Sargasso Sea, fall and spring in the South Sargasso Sea, North and South during fall, and North and South during spring were detected for temperature (**FIGURE 4**), wind speed (**FIGURE 5**), *Sargassum* sp. density (**FIGURE 7**), and tar mass (**FIGURE 10**). While similar seasonal and regional differences proved significant for the other parameters examined, some exceptions were observed: no significant difference in zooplankton densities between North and South during spring (**FIGURE 6**), no seasonal difference in the South Sargasso Sea for eel larvae (**FIGURE 8**) or plastic (**FIGURE 9**), and no significant difference in plastic densities between North and South during fall (**FIGURE 9**). Clearly, transect locations vary between fall and spring, especially in the South Sargasso Sea. 1999, 2001, 2005 and 2007 are examples of years with similar fall and spring transects through the South Sargasso Sea, and clear seasonal differences in *Sargassum* sp. density are observed during these years (**FIGURE 7**). Unfortunately, further explanation of seasonal and regional patterns cannot be resolved without data from the Caribbean, Florida Straits and Gulf Stream during other times of the year.

Mean wind speeds in the North Sargasso Sea do correspond with the Annual NAO Index (**FIGURE 11**; i.e., positive NAO Index is associated with stronger winds). A similar correspondence is not found, nor is it expected in the South Sargasso Sea, since NAO predominantly impacts the westerly winds. In 2003 and 2005, maximum observed wind speed coincident with a net tow was 37 kts. More commonly (during 10 years of the dataset), maximum observed winds were between 25 and 30 kts. Furthermore, maximum wind speed (kts) during fall (**FIGURE 5**) is hypothesized to push *Sargassum* below the surface, thus making it less likely to be caught in a surface skimming net. While it does appear that *Sargassum* sp. catch is inversely related to wind speed (**FIGURE 12**), greatest concentrations of *Sargassum* sp. were measured in the North Sargasso Sea during the windy fall (**FIGURE 7**).

It does appear that *Sargassum* sp. is either a filter for passively drifting particles or attractive habitat/protection for plankton. To assess coincidence of *Sargassum* sp. and the other parameters, the question was asked: when zooplankton, eel larvae, plastic and tar are present, are increased concentrations found in the presence of *Sargassum*? The results are presented in **FIGURE 13**. For zooplankton, greater densities were found associated with *Sargassum* in the South Sargasso Sea during both fall and spring. No significant differences were observed in the North Sargasso Sea. For eel larvae, greater densities were observed in the presence of *Sargassum* only during fall in the North Sargasso Sea. For plastic, densities were greater in the presence of *Sargassum* during fall throughout the Sargasso Sea, and during the spring only in the South Sargasso Sea. For tar, greater densities were observed in the presence of *Sargassum* only during spring in the North Sargasso Sea. Many of these seasonal and regional differences can be explained by the general distribution of each parameter.

Qualitative comments related to community composition of organisms greater than 2 cm were recorded for 1192 tows in the Sargasso Sea. A lack of qualitative record may either indicate that no organisms greater than 2 cm were collected *OR* that the data were not recorded on the data sheet. It should also be noted that even when qualitative comments were recorded on a data sheet, the list of organisms may not be comprehensive. In some cases numbers of individuals were recorded, but this practice was not consistent throughout the dataset. Juvenile and larval fish were most frequently listed in the qualitative comments and were more common in the presence of *Sargassum* sp. (**FIGURES 14** and **15**). In addition to the generic record of unidentified juvenile or larval fish, identification suggests collection of a number of different pelagic species viz mahi mahi, jack, tuna, bluefish. At times, *Sargassum* sp. may be caught on the net frame, towed for a distance, then released to the outside of the mouth. As a result, some *Sargassum* community organisms could also be found in tows that did not collect *Sargassum* sp.

Acknowledgments

The author gratefully acknowledges the funding from SSA which supported the preparation of this report.

YEAR	SEASON	SARGASSUM (G/M²)		ZOOPLANKTON (ML/M²)		LEPTOCEPHALI (#/M²)		PLASTIC (#/M²)		TAR (G/M²)	
		N TOWS	% PRESENT	N TOWS	% PRESENT	N TOWS	% PRESENT	N TOWS	% PRESENT	N TOWS	% PRESENT
1977	F	11	91	0		0		0		11	100
	S	12	83	0		0		0		12	100
1978	F	13	77	0		0		0		13	92
	S	0		0		0		0		0	
1979	F	9	100	0		2	100	0		8	100
	S	0		0		0		0		0	
1980	F	0		0		0		0		0	
	S	0		0		0		0		0	
1981	F	9	78	0		4	75	0		9	89
	S	0		0		0		0		0	
1982	F	7	100	0		0		0		3	100
	S	0		0		0		0		0	
1983	F	6	100	4	100	0		0		1	100
	S	5	100	0		1	100	0		0	
1984	F	32	91	30	100	32	22	0		27	89
	S	0		0		0		0		0	
1985	F	37	100	29	100	35	29	35	100	33	88
	S	14	79	0		0		0		17	82
1986	F	0		11	100	0		8	100	7	100
	S	38	89	38	100	39	28	39	77	0	
1987	F	19	95	32	100	28	0	0		0	
	S	0		0		15	0	19	100	21	95
1988	F	90	90	63	100	86	15	49	94	27	89
	S	3	100	29	100	0		0		0	
1989	F	13	92	13	100	0		13	92	13	92
	S	67	96	0		19	42	81	94	73	95
1990	F	18	89	18	100	4	0	18	94	12	100
	S	104	81	103	83	57	2	102	75	98	79
1991	F	81	93	82	99	81	14	78	81	48	92
	S	65	88	59	100	41	2	67	85	49	69
1992	F	74	99	65	100	74	18	74	88	41	85
	S	109	71	102	100	108	11	109	93	4	0
1993	F	43	79	44	100	44	20	44	91	42	33
	S	48	67	48	96	48	4	48	92	21	0
1994	F	43	49	45	100	46	30	47	87	10	0
	S	21	52	21	95	21	19	21	76	21	0
1995	F	61	57	61	98	61	18	61	89	59	86

TABLE 1. **Number of Neuston Net tows (N Tows) and encounter rate (% Present) for *Sargassum* sp., zooplankton, eel larvae, plastic pieces and tar mass along each SEA Sargasso Sea transect (e.g., fall or spring of each year). Differences in total tow counts result from differences in quality of original records. Cruises for which a parameter was collected in greater than 75% of the tow are highlighted in orange.**

Table 1 continues

YEAR	SEASON	SARGASSUM (G/M²)		ZOOPLANKTON (ML/M²)		LEPTOCEPHALI (#/M²)		PLASTIC (#/M²)		TAR (G/M²)	
		N TOWS	% PRESENT	N TOWS	% PRESENT	N TOWS	% PRESENT	N TOWS	% PRESENT	N TOWS	% PRESENT
	S	38	26	37	100	39	8	39	85	25	0
1996	F	58	60	60	100	60	33	60	88	41	34
	S	44	50	44	100	43	14	44	95	14	0
1997	F	46	83	46	100	46	48	45	93	40	0
	S	30	60	30	100	30	3	30	80	18	44
1998	F	59	76	59	100	59	25	59	83	22	0
	S	23	61	22	100	22	14	23	78	23	87
1999	F	55	53	56	100	56	21	56	86	0	
	S	29	62	29	100	29	14	29	97	0	
2000	F	55	33	55	100	55	24	55	78	13	46
	S	40	60	37	100	40	25	40	88	40	65
2001	F	28	75	27	96	28	32	28	93	8	0
	S	40	50	38	97	40	33	40	90	16	0
2002	F	30	77	30	100	30	30	30	87	12	0
	S	41	15	43	100	44	9	44	84	14	0
2003	F	23	83	23	100	23	22	22	77	23	70
	S	19	74	19	100	19	11	19	95	9	0
2004	F	30	90	30	100	30	20	30	53	27	0
	S	14	43	14	100	14	14	14	93	13	0
2005	F	44	84	44	100	44	18	44	89	41	0
	S	19	42	20	100	20	15	20	100	14	0
2006	F	17	82	20	100	20	15	20	80	17	0
	S	0		0		0		0		0	
2007	F	38	76	38	100	38	39	38	79	36	6
	S	31	42	29	97	31	23	31	90	29	3
2008	F	10	50	10	90	10	10	10	70	9	0
	S	0		0		0		0		0	
2009	F	17	82	17	100	17	29	17	94	14	0
	S	16	88	17	100	17	12	17	100	11	0
2010	F	33	73	33	100	33	36	33	91	29	0
	S	20	65	20	100	20	5	20	95	16	0
Total		**1999**		**1844**		**1803**		**1870**		**1254**	
Min (>0)		**5**		**4**		**1**		**10**		**1**	
Max		**109**		**103**		**108**		**109**		**98**	
Mean		**29**		**27**		**27**		**28**		**18**	

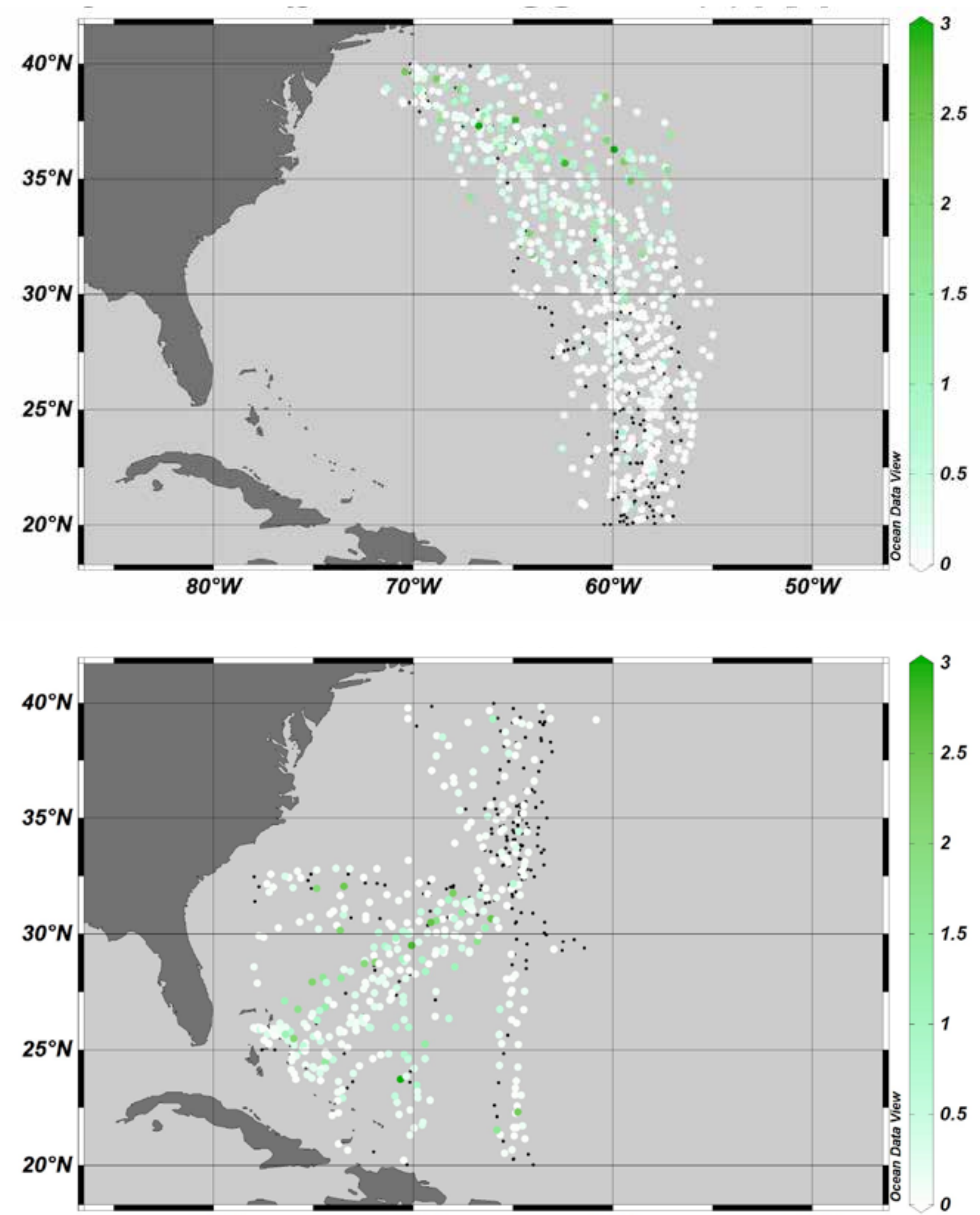


FIGURE 2. Distribution of *Sargassum* sp. during fall (top panel) and spring (bottom panel) cruises (1977 – 2010). Color bar indicates density (g/m^2). Black points indicate tows with a *Sargassum* sp. density of 0 g/m^2.

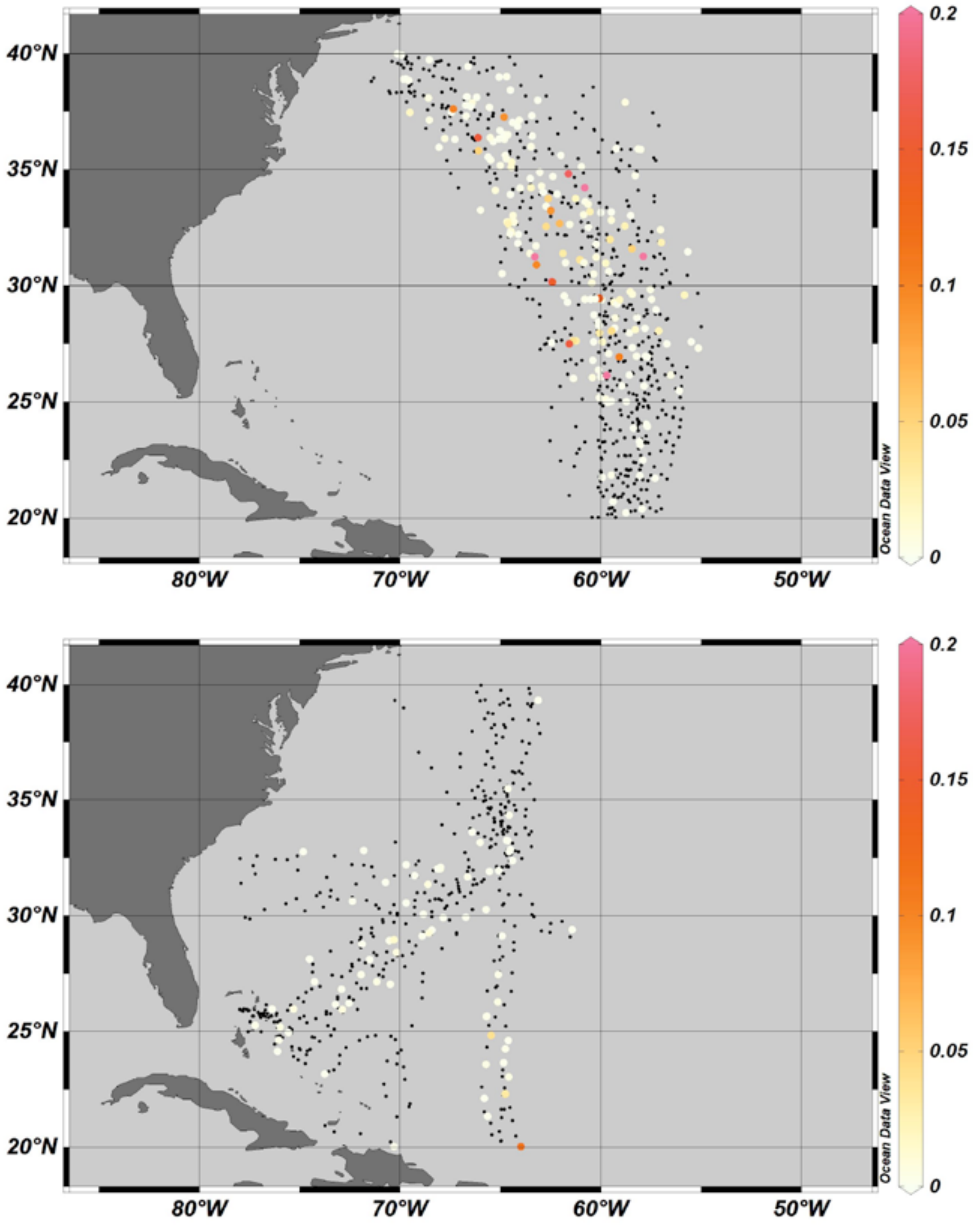
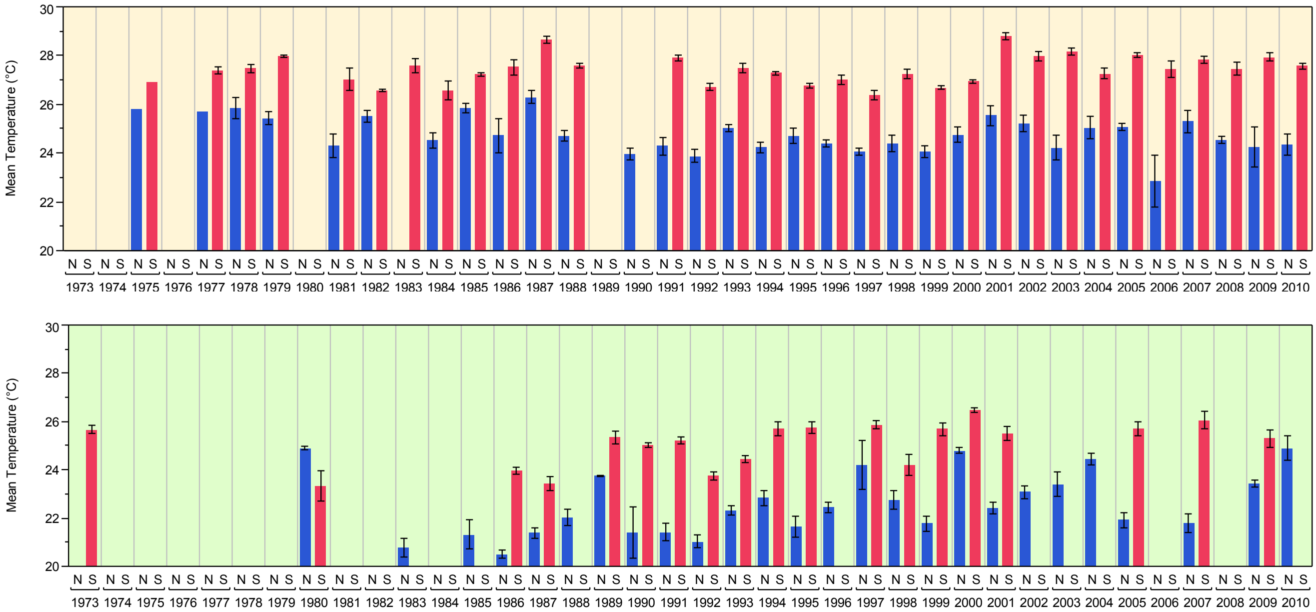


FIGURE 3. Distribution of eel larvae during fall (top panel) and spring (bottom panel) cruises (1977 – 2010). Color bar indicates density (g/m^2). Black points indicate tows with an eel larvae density of 0 g/m^2.



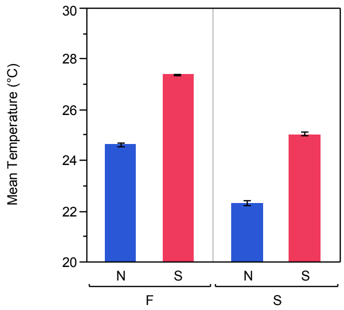
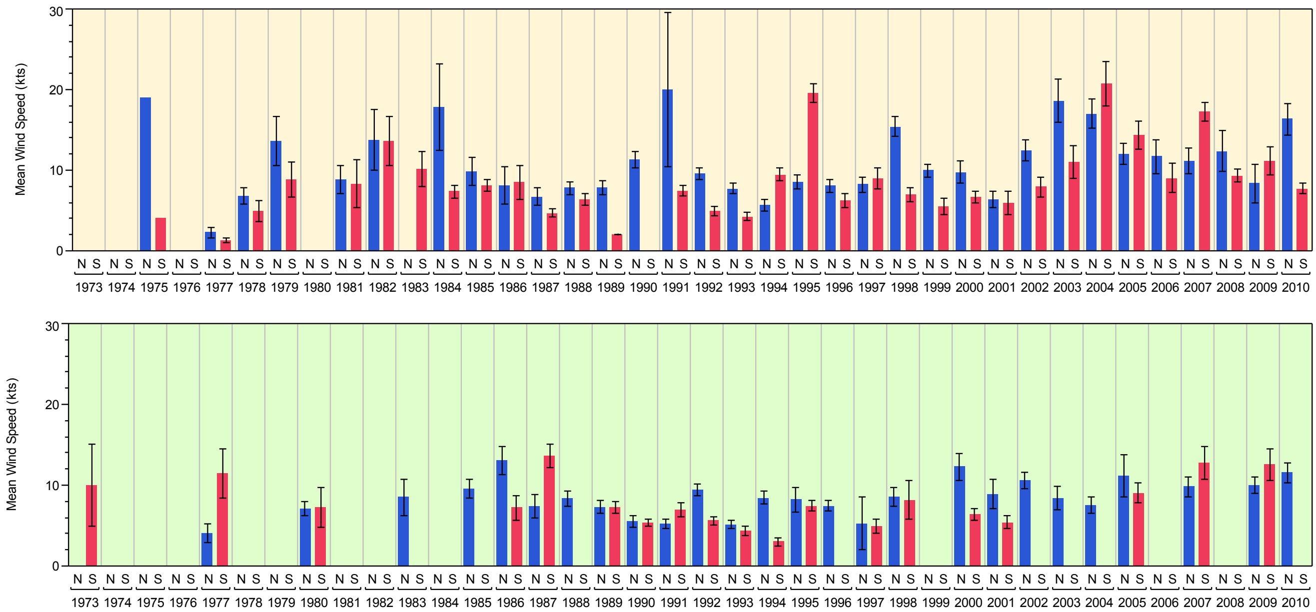


FIGURE 4. Mean temperature in fall (top, orange panel) and spring (middle, green panel) for each sampling year. Overall mean temperatures (bottom panel) for North (N) and South (S) Sargasso Sea during fall (F) and spring (S). Error bars represent standard errors.



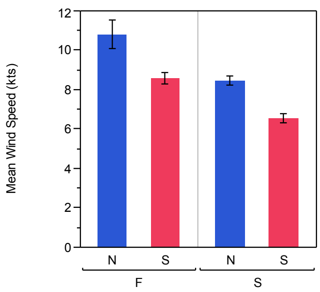
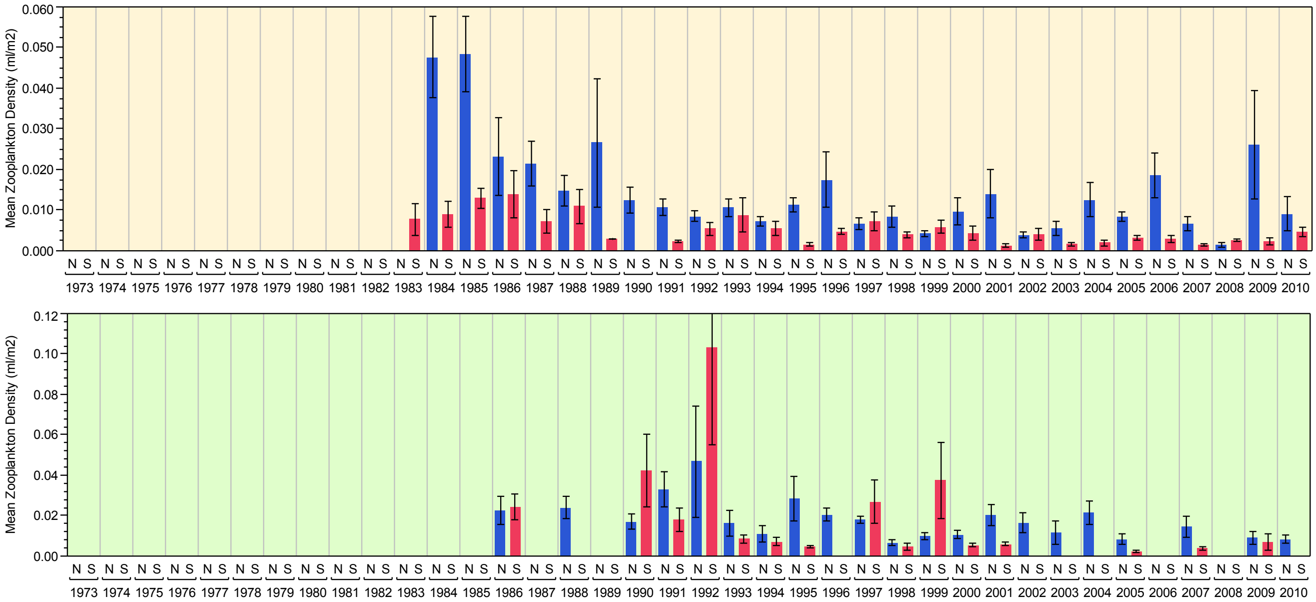


FIGURE 5. Mean wind speed in fall (top, orange panel) and spring (middle, green panel) for each sampling year. Overall mean wind speeds (bottom panel) for North (N) and South (S) Sargasso Sea during fall (F) and spring (S). Error bars represent standard errors.



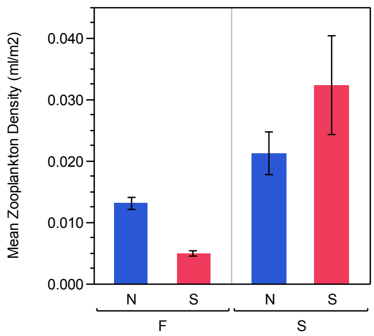
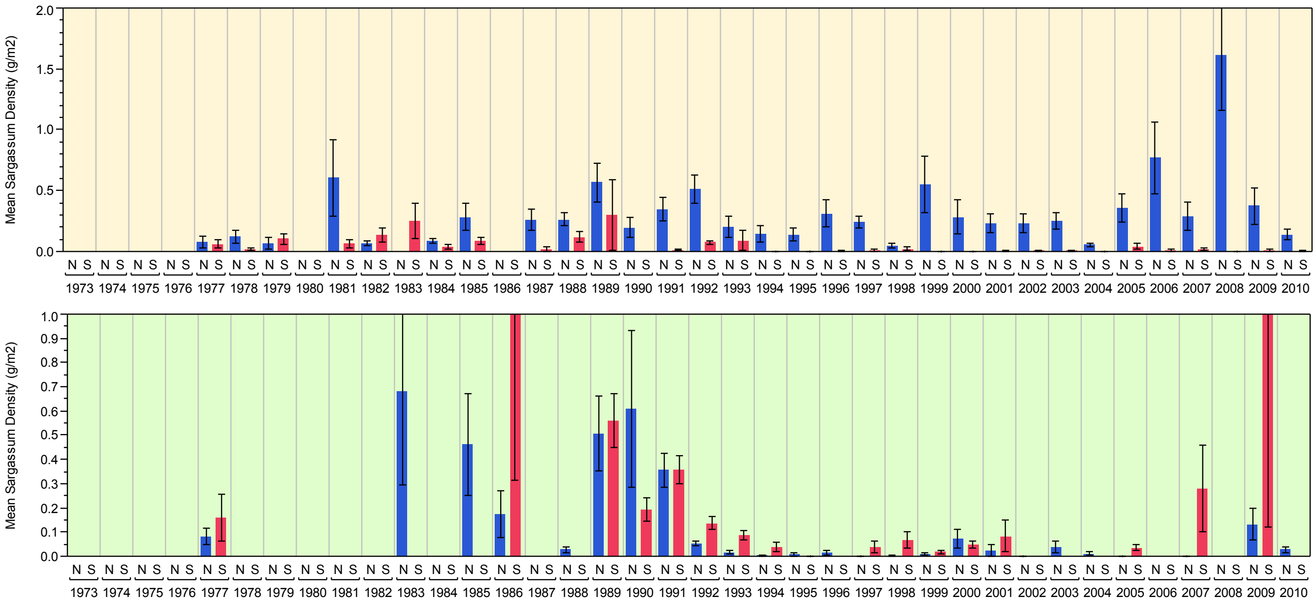


FIGURE 6. Mean zooplankton density in fall (top, orange panel) and spring (middle, green panel) for each sampling year. Overall mean zooplankton densities (bottom panel) for North (N) and South (S) Sargasso Sea during fall (F) and spring (S). Error bars represent standard errors.



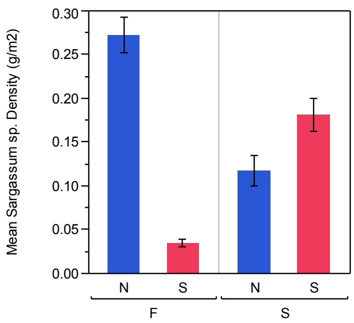
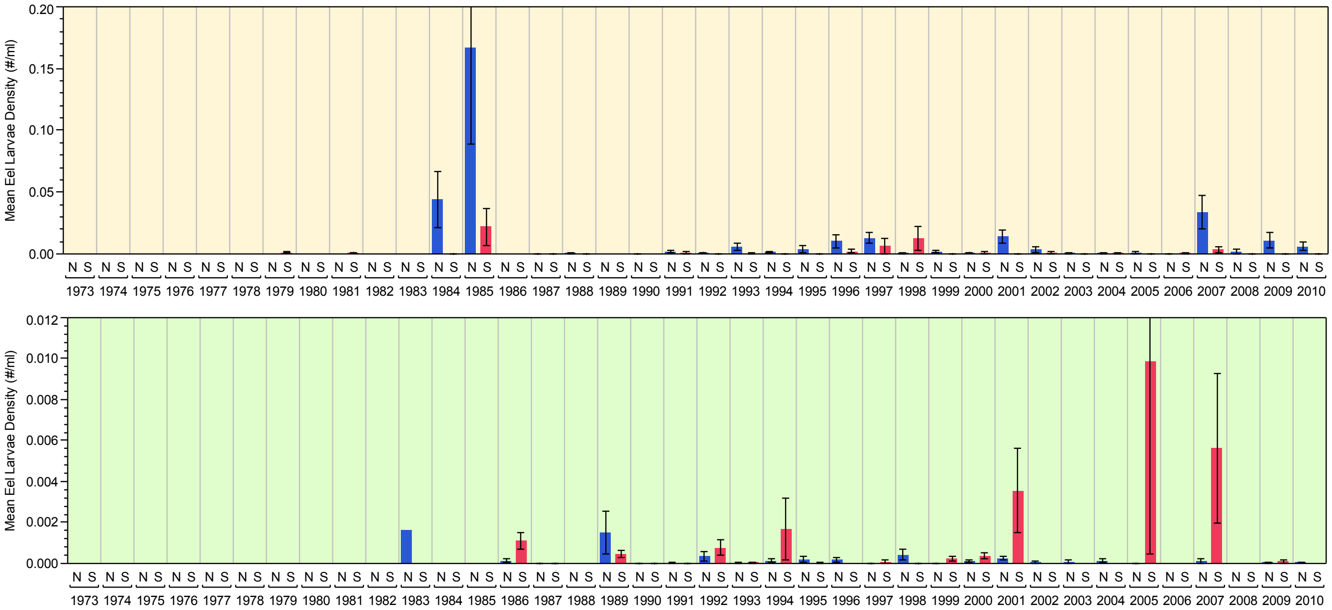


FIGURE 7. Mean Sargassum sp. density in fall (top, orange panel) and spring (middle, green panel) for each sampling year. Overall mean *Sargassum* sp. densities (bottom panel) for North (N) and South (S) Sargasso Sea during fall (F) and spring (S). Error bars represent standard errors. Note: Four outliers were removed prior to determining overall means.



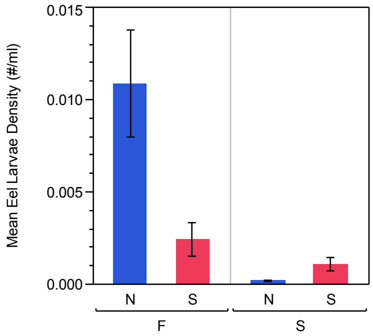
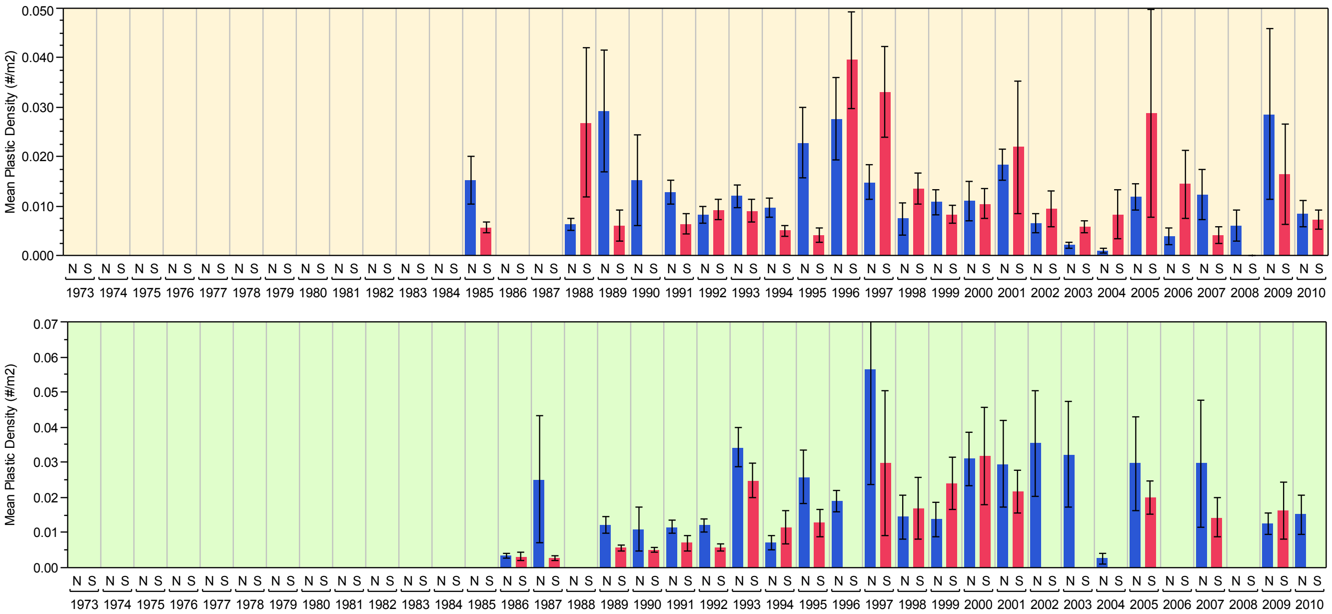


FIGURE 8. Mean eel larvae density in fall (top, orange panel) and spring (middle, green panel) for each sampling year. Overall mean eel larvae densities (bottom panel) for North (N) and South (S) Sargasso Sea during fall (F) and spring (S). Error bars represent standard errors.



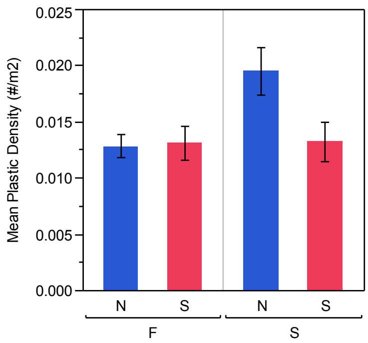


FIGURE 9. Mean plastic density in fall (top, orange panel) and spring (middle, green panel) for each sampling year. Overall mean plastic densities (bottom panel) for North (N) and South (S) Sargasso Sea during fall (F) and spring (S). Error bars represent standard errors.

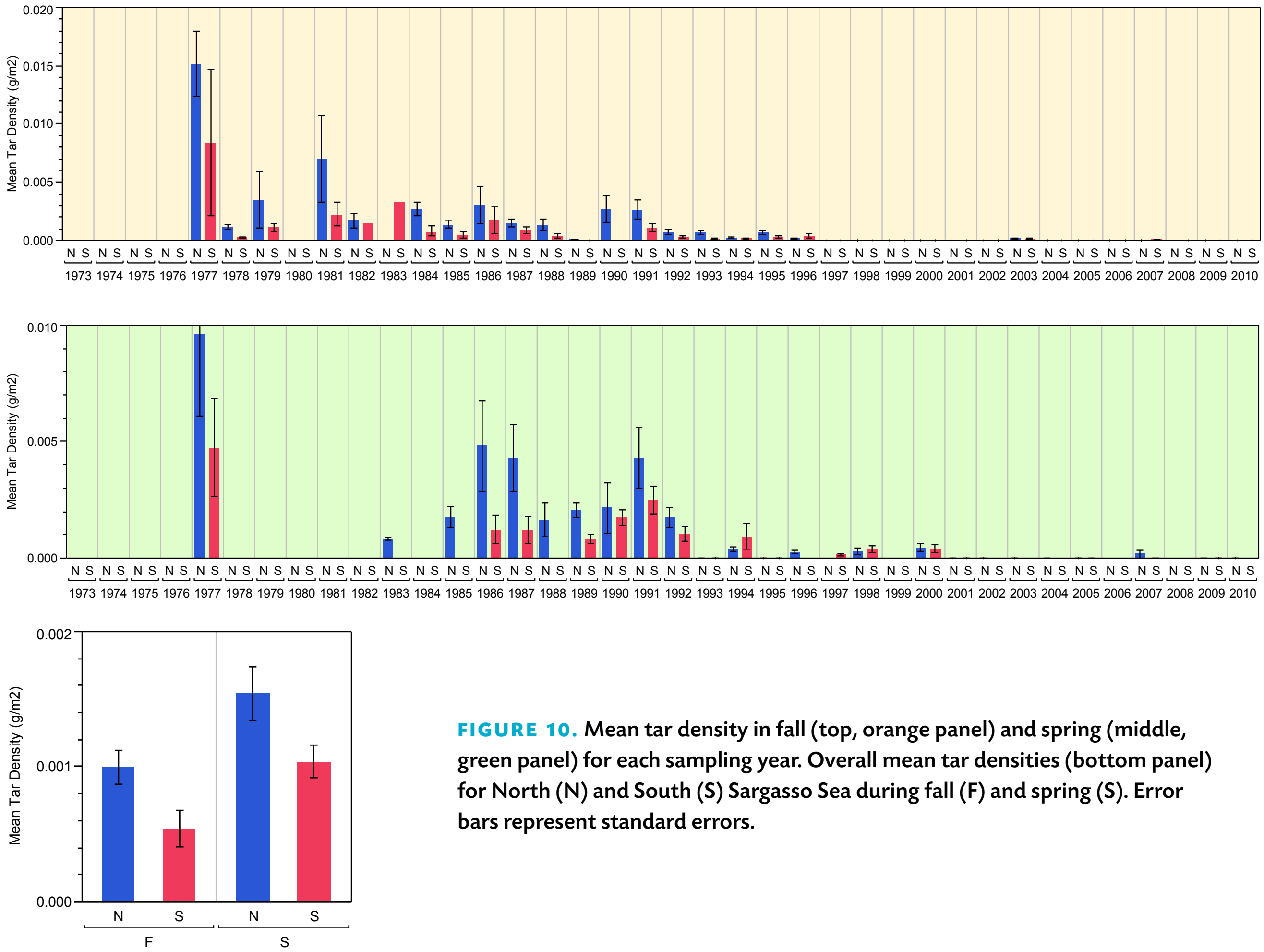


FIGURE 10. Mean tar density in fall (top, orange panel) and spring (middle, green panel) for each sampling year. Overall mean tar densities (bottom panel) for North (N) and South (S) Sargasso Sea during fall (F) and spring (S). Error bars represent standard errors.

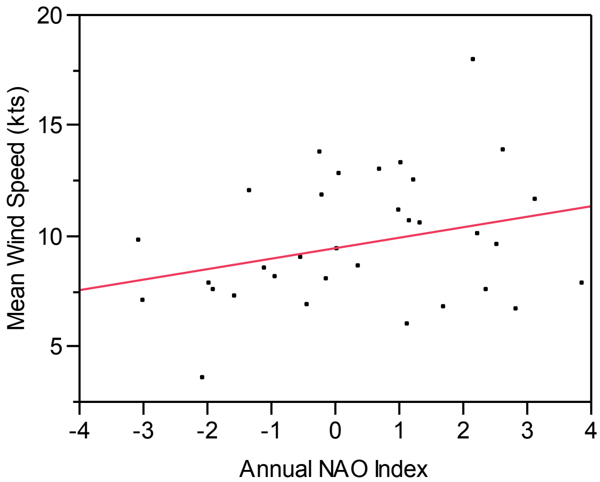


FIGURE 11. Mean wind speed in N Sargasso does seem to increase as the Annual NAO Index increases (p = 0.097).

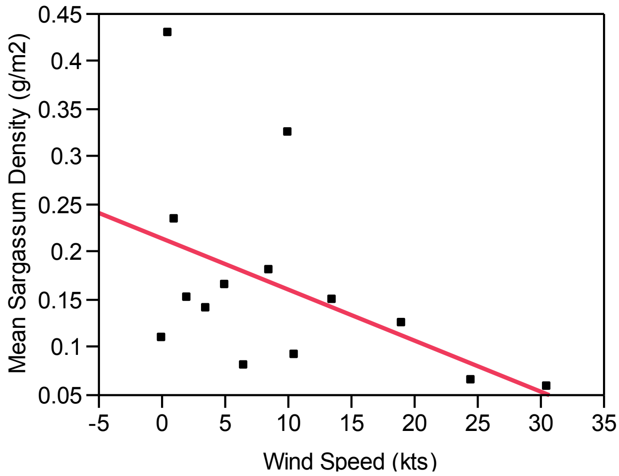


FIGURE 12. Inverse relationship between mean *Sargassum* sp. density and wind speed (p = 0.079). Note: Mean densities for each wind speed were calculated from entire Sargasso Sea dataset, but regression includes only those means resulting from greater than 10 measurements.

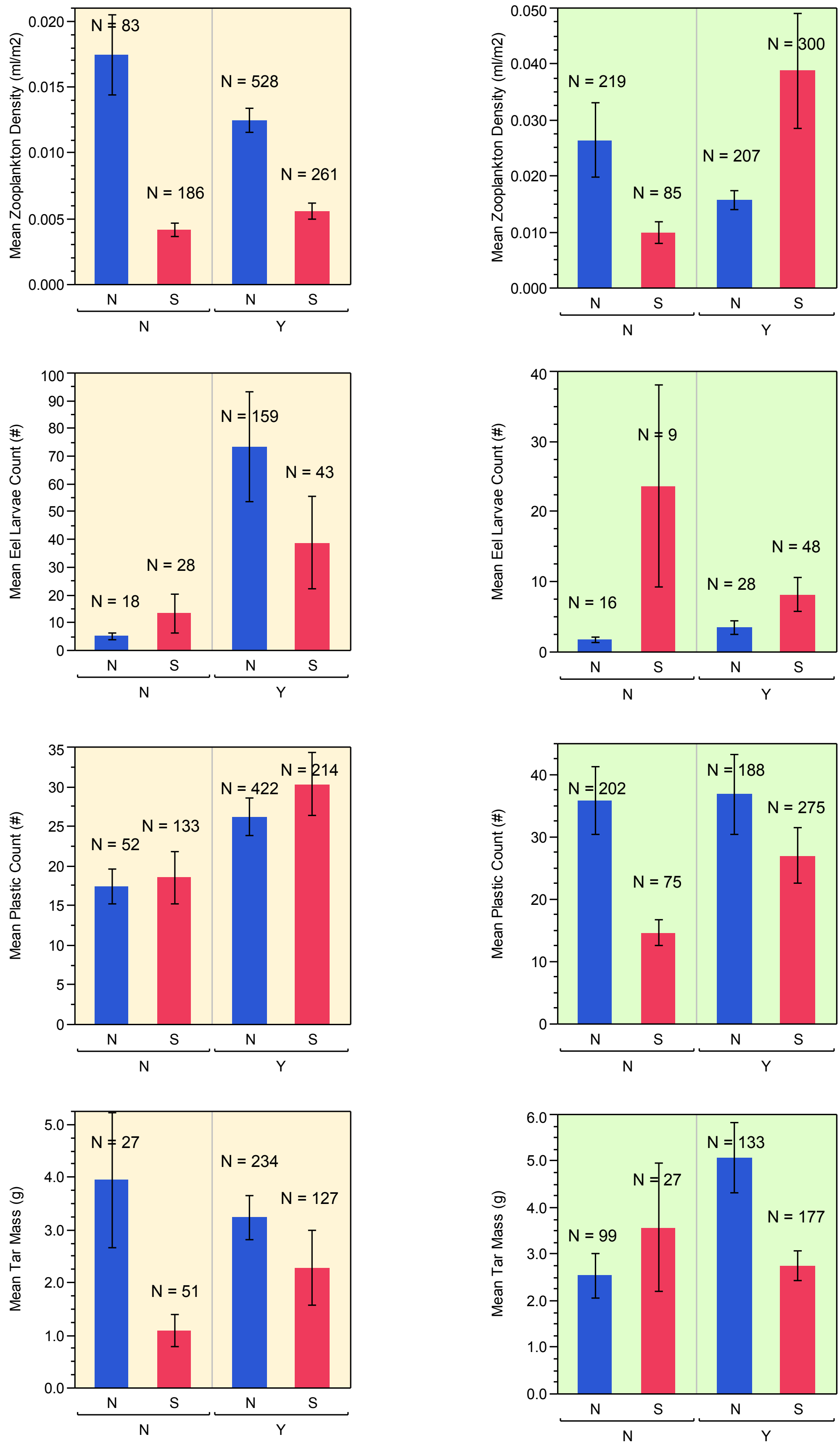


FIGURE 13. Means for zooplankton density, eel larvae counts, plastic counts, and tar mass recorded during fall (orange panels) and spring (green panels) tows in the North (N) and South (S) Sargasso Sea in the absence (N) or presence (Y) of *Sargassum* sp. Error bars represent standard errors. Note: Tows with zero values were excluded when determining means.

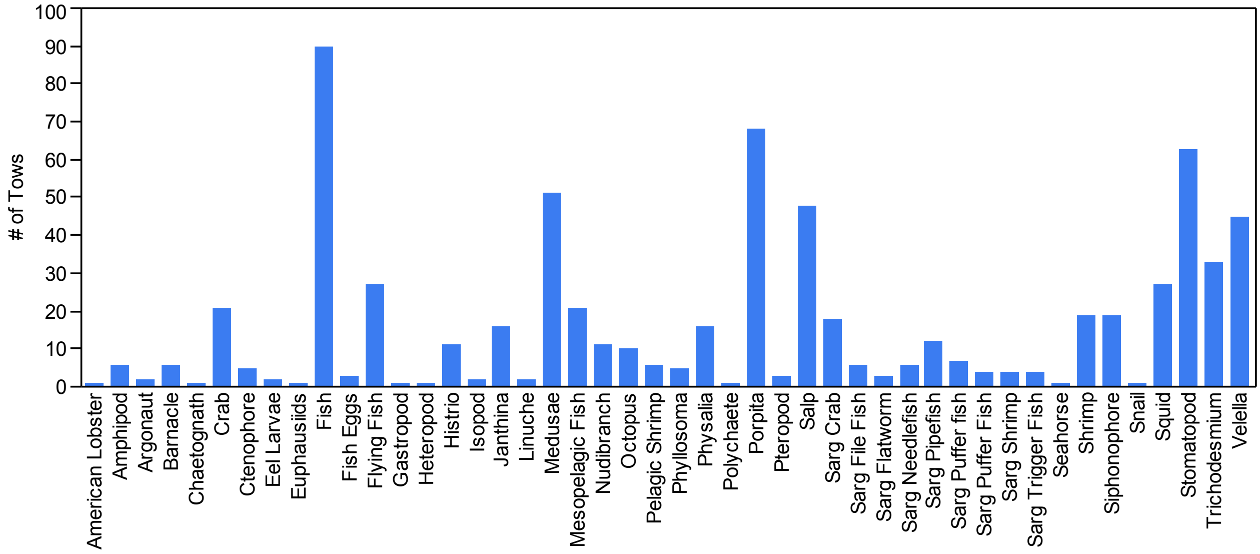


FIGURE 14. **Frequency of collection of large net plankton (> 2 cm) in tows without *Sargassum* sp.**

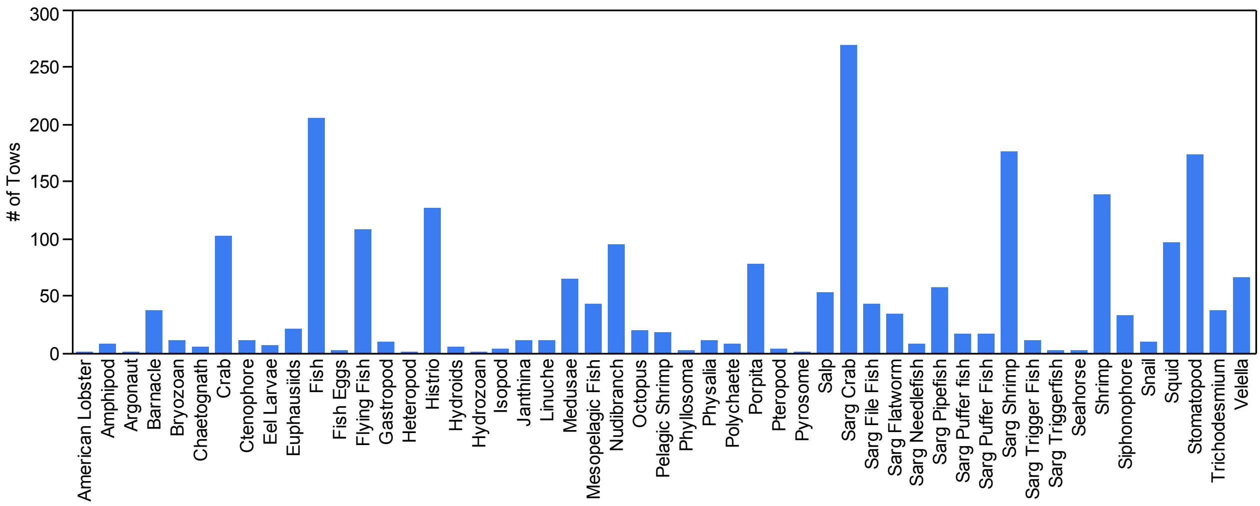


FIGURE 15. **Frequency of collection of large net plankton (> 2 cm) in tows with *Sargassum* sp.**

References

Ullman, D. S., P. C. Cornillon, and Z. Shan (2007), On the characteristics of subtropical fronts in the North Atlantic, *J. Geophys. Res.*, 112, C01010, doi:10.1029/2006JC003601.

Sargasso Sea Alliance Science Series

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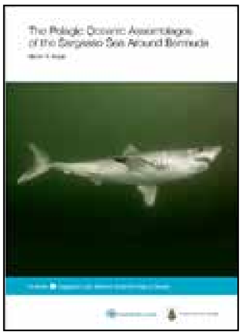
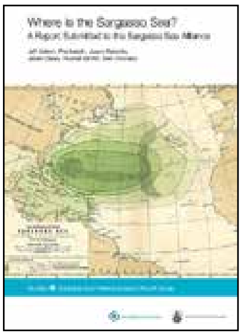


1

Angel, M.V. 2011. *The pelagic ocean assemblages of the Sargasso Sea around Bermuda.* Sargasso Sea Alliance Science Report Series, No 1, 25 pp.



2

Ardron, J., Halpin, P., Roberts, J., Cleary, J., Moffitt, M. and J. Donnelly 2011. *Where is the Sargasso Sea?* Sargasso Sea Alliance Science Report Series, No 2, 24 pp.

3

Gollock, M. 2011. *European eel briefing note for Sargasso Sea Alliance.* Sargasso Sea Alliance Science Report Series, No 3, 11 pp.

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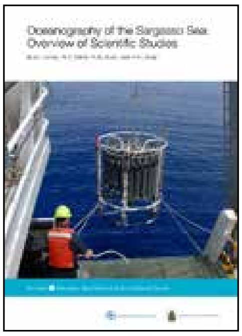

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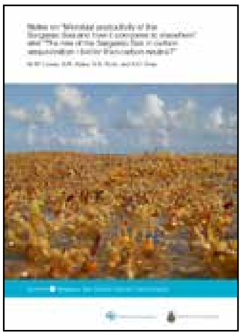

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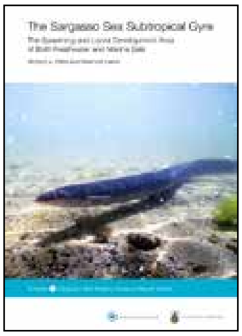

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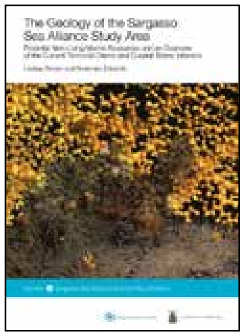

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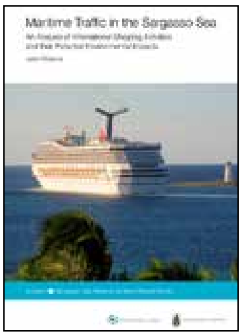

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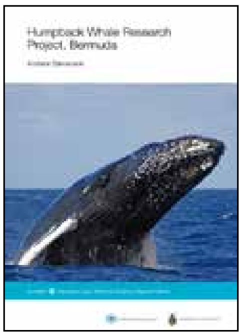

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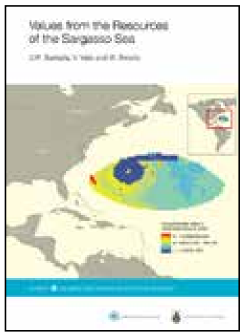

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SARGASSO SEA ALLIANCE

Since the initial meetings the partnership around the Sargasso Sea Alliance has expanded. Led by the Government of Bermuda, the Alliance now includes the following organisations.

PARTNER	TYPE OF ORGANISATION
Department of Environmental Protection	Government of Bermuda
Department of Conservation Services	Government of Bermuda
Mission Blue / Sylvia Earle Alliance	Non-Governmental Organisation
International Union for the Conservation of Nature (IUCN) and its World Commission on Protected Areas	Multi-lateral Conservation Organisation
Marine Conservation Institute	Non-Governmental Organisation
Woods Hole Oceanographic Institution	Academic
Bermuda Institute for Ocean Sciences	Academic
Bermuda Underwater Exploration Institute	Non-Governmental Organisation
World Wildlife Fund International	Non-Governmental Organisation
Atlantic Conservation Partnership	Non-Governmental Organisation