



Supplement of

Unusual *Hemiaulus* bloom influences ocean productivity in Northeastern US Shelf waters

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Table S1. Cruise details for NES-LTER broadscale IFCB sampling conducted in partnership with NOAA programs in the period 2013 – 2023; *Hemiaulus* biomass concentrations derived from these observations are summarized in Fig. S1. Program abbreviations: Ecosystem Monitoring Program (EcoMon), Harmful Algal Bloom Cyst Surveys (HAB Cyst), Atlantic Marine Assessment Program for Protected Species (AMAPPS).

Cruise ID	IFCB sample dates	Program name	Ship
EX1305	24 Aug 2013 – 04 Sep 2013	EcoMon	NOAA Ship Okeanos Explorer
EX1306	06 Nov 2013 – 11 Nov 2013	HAB Cyst	NOAA Ship Okeanos Explorer
HB1502	19 May 2015 – 02 Jun 2015	EcoMon	NOAA Ship Henry B Bigelow
GU1506	13 Oct 2015 – 25 Oct 2015	EcoMon	NOAA Ship Gordon Gunter
HB1507	12 Nov 2015 – 17 Nov 2015	HAB Cyst	NOAA Ship Henry B Bigelow
GU1608	21 May 2016 – 16 Jun 2016	EcoMon	NOAA Ship Gordon Gunter
HB1603	28 Jun 2016 – 14 Jul 2016	AMAPPS	NOAA Ship Henry B Bigelow
PC1607	08 Aug 2016 – 19 Aug 2016	EcoMon	NOAA Ship Pisces
PC1609	19 Oct 2016 – 20 Oct 2016	EcoMon	NOAA Ship Pisces
PC1610	12 Nov 2016 – 18 Nov 2016	HAB Cyst	NOAA Ship Pisces
HB1701	11 Feb 2017 – 23 Feb 2017	EcoMon	NOAA Ship Henry B Bigelow
GU1701	17 May 2017 – 07 Jun 2017	EcoMon	NOAA Ship Gordon Gunter
GU1706	31 Oct 2017 – 09 Nov 2017	EcoMon	NOAA Ship Gordon Gunter
HB1803	23 May 2018 – 05 Jun 2018	EcoMon	NOAA Ship Henry B Bigelow
GU1804	22 Aug 2018 – 31 Aug 2018	EcoMon	NOAA Ship Gordon Gunter
S11802	02 Nov 2018 – 13 Nov 2018	EcoMon	R/V Hugh R Sharp
HB1902	23 May 2019 – 04 Jun 2019	EcoMon	NOAA Ship Henry B Bigelow
GU1902	15 Aug 2019 – 30 Aug 2019	EcoMon	NOAA Ship Gordon Gunter
GU1905	15 Oct 2019 – 01 Nov 2019	EcoMon	NOAA Ship Gordon Gunter
GU2102	14 May 2021 – 26 May 2021	EcoMon	NOAA Ship Gordon Gunter
HB2102	16 Jun 2021 – 7 Jul 2021 28 Jul 2021-23 Aug 2021	AMAPPS	NOAA Ship Henry B Bigelow
PC2104	05 Aug 2021 – 18 Aug 2021	EcoMon	NOAA Ship Pisces
PC2106	16 Oct 2021 – 25 Oct 2021	EcoMon	NOAA Ship Pisces
HB2204	31 May 2022 – 04 Jun 2022	EcoMon	NOAA Ship Henry B Bigelow
PC2205	01 Nov 2022 – 10 Nov 2022	EcoMon	NOAA Ship Pisces
HB2302	09 Jun 2023 – 28 Jun 2023	EcoMon	NOAA Ship Henry B Bigelow

Table S2. Locations of the mid-shelf stations on the NES-LTER cruises and the date and time when each CTD cast occurred. Water from the casts was used to quantify the various productivity metrics. GOP and NCP data were collected at all these stations as well as at points between stations. NPP and microzooplankton data were collected at times noted by *. Only microzooplankton grazing data were collected at times marked by +.

Station	Latitude	Longitude	2018	2019	2020	2021	2022
L3	40.863°N	70.883°W	7/21 06:39 ⁺	8/21 07:38	7/25 21:37	7/21 02:12	8/2 21:14
L4	40.697°N	70.883°W	7/21 14:51 ⁺	8/24 05:17*	7/26 11:06*	7/17 13:18*	7/30 11:42*
L5	40.530°N	70.883°W	7/21 17:23	8/24 02:50	7/26 19:03	7/17 15:41	7/13 14:06
L6	40.197°N	70.883°W	7/22 02:08	8/21 20:27*	7/28 01:54	7/20 09:21*	8/2 03:22*

Table S3. Mixed layer depths, in m, for each NES-LTER station (listed in the top row) for all the summer NES-LTER cruises used in this paper. The starting month and year of the cruise are listed next to the cruise name.

Cruise ID	Cruise starting date	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10
EN617	7/2018	6	6	8	6	10	9	16	15	14	13
EN644	8/2019	5	6	6	10	9	6	7	16	6	15
EN655	7/2020	6	8	6	9	7	7	7	—	6	10
EN668	7/2021	6	6	9	6	9	13	13	10	10	9
EN687	7/2022	7	7	9	6	10	11	15	11	7	9

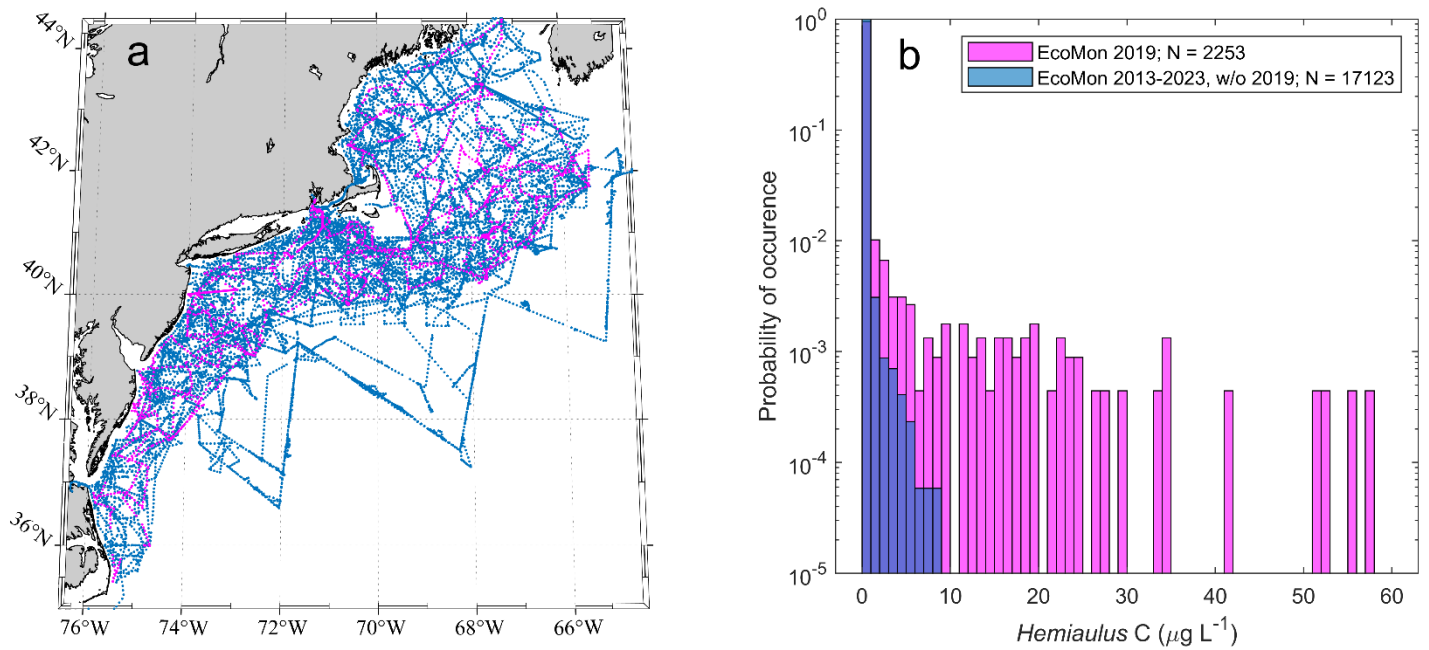


Fig. S1. IFCB-based observations of carbon concentration associated with *Hemiaulus* collected across the NES broadscale cruise over the last decade emphasize the extreme nature of the high concentrations observed in 2019. (a) Map of automated IFCB measurement locations on 26 broadscale survey cruises conducted in the period 2013-2023 in partnership with NOAA's National Marine Fisheries Service, through their EcoMon program plus a couple of other ship-based observational programs (AMAPPS, HAB cyst surveys). IFCB sample locations ($N = 19376$) extend across the continental shelf from North Carolina to Maine, with the sampling distribution over the three 2019 cruises ($N = 2253$) highlighted by magenta coloring. (b) Normalized histograms of *Hemiaulus* carbon concentration in 2019 (magenta bars) and for all years except 2019 (blue bars). While most observations had undetectable *Hemiaulus* (0 mgC L^{-1}) in both periods (94.9% in 2019; 99.4% in all other years), the high concentration tail in 2019 is extraordinary compared to the rest of the decade.

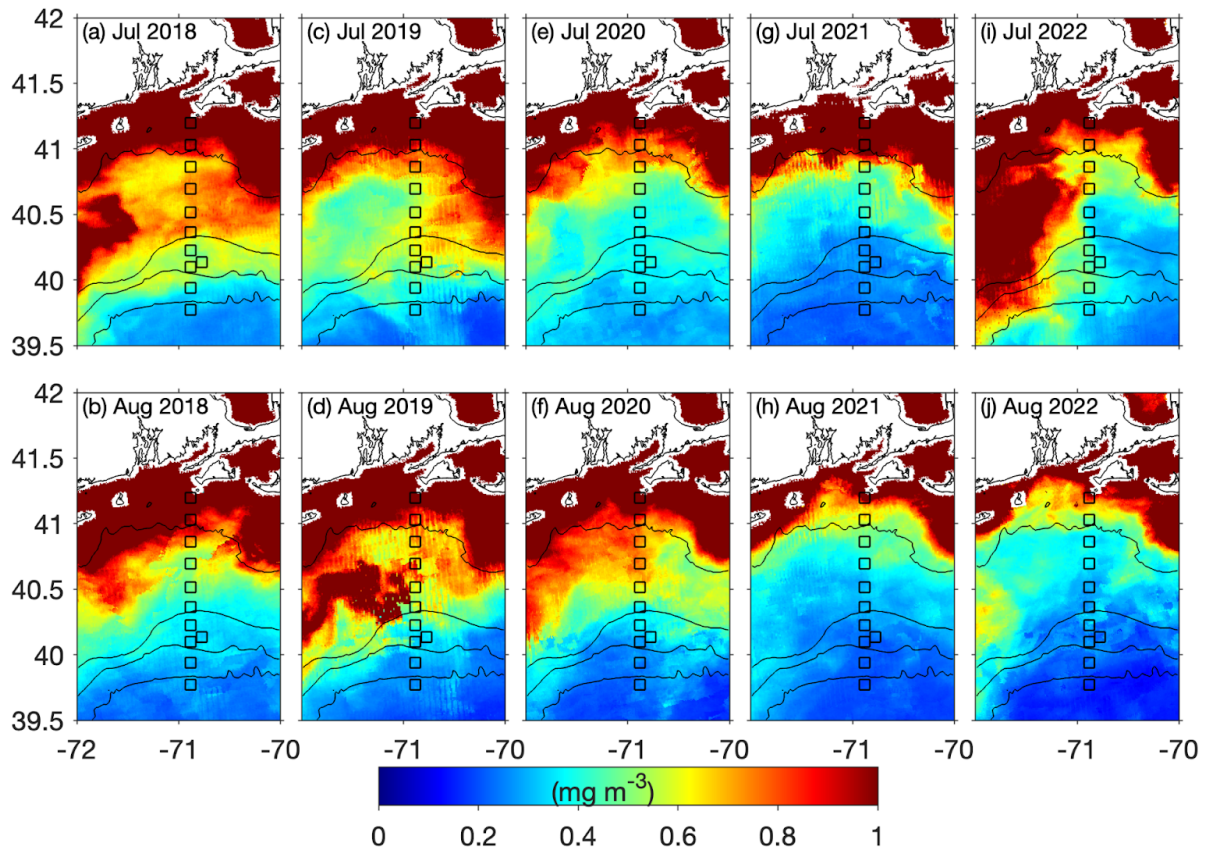


Fig S2. Monthly mean sea surface chlorophyll concentration on the New England shelf in July and August of 2018-2022. The squares mark NES-LTER stations (Table S2) and the black lines are bathymetric contours corresponding to 50, 100, 200, 1000 m.

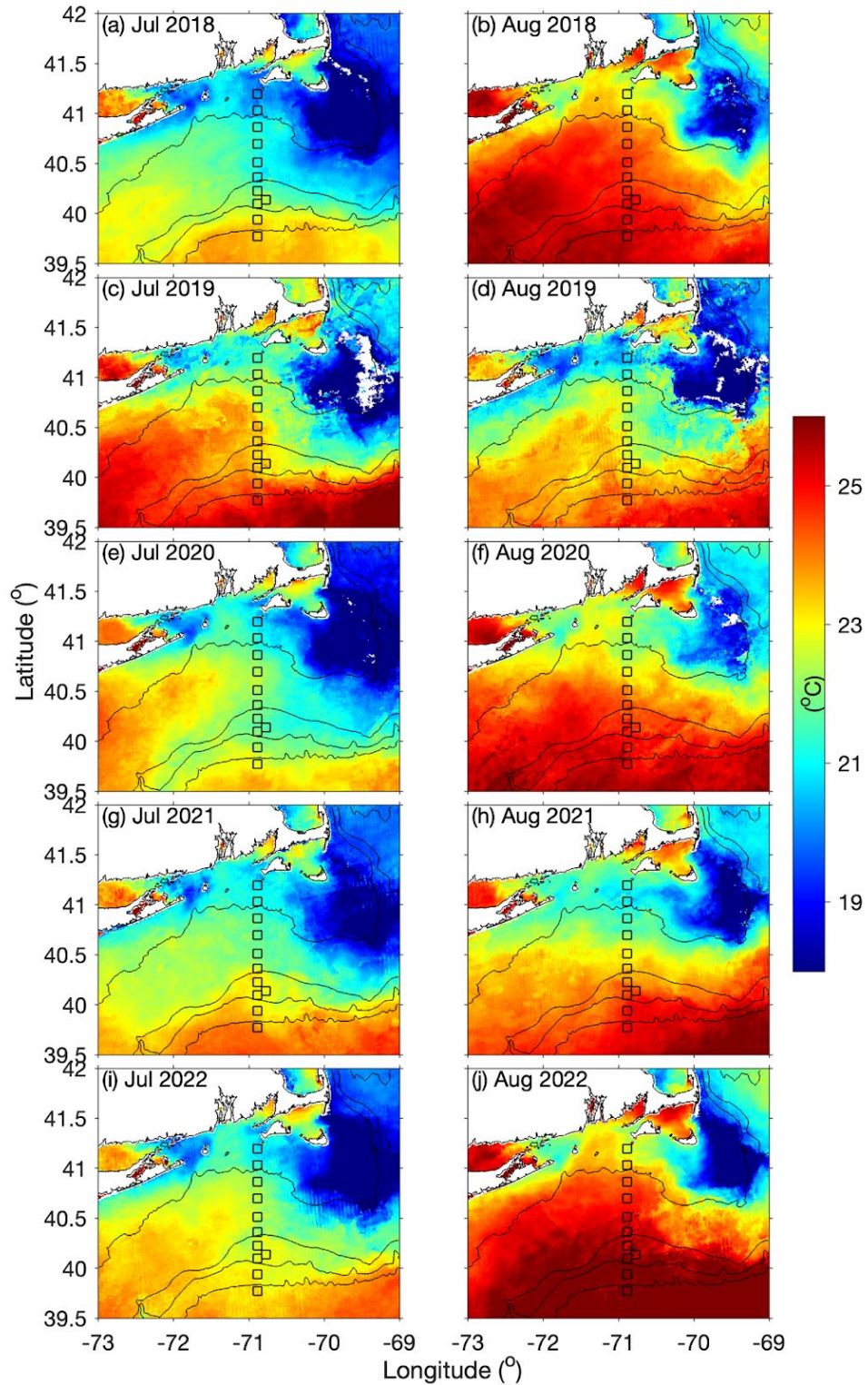


Fig S3. Monthly mean sea surface temperature on the New England shelf in July and August, 2018-2022. The square symbols are NES-LTER stations (Table S2); the black lines are bathymetric contours of 50, 100, 200, 1000 m.

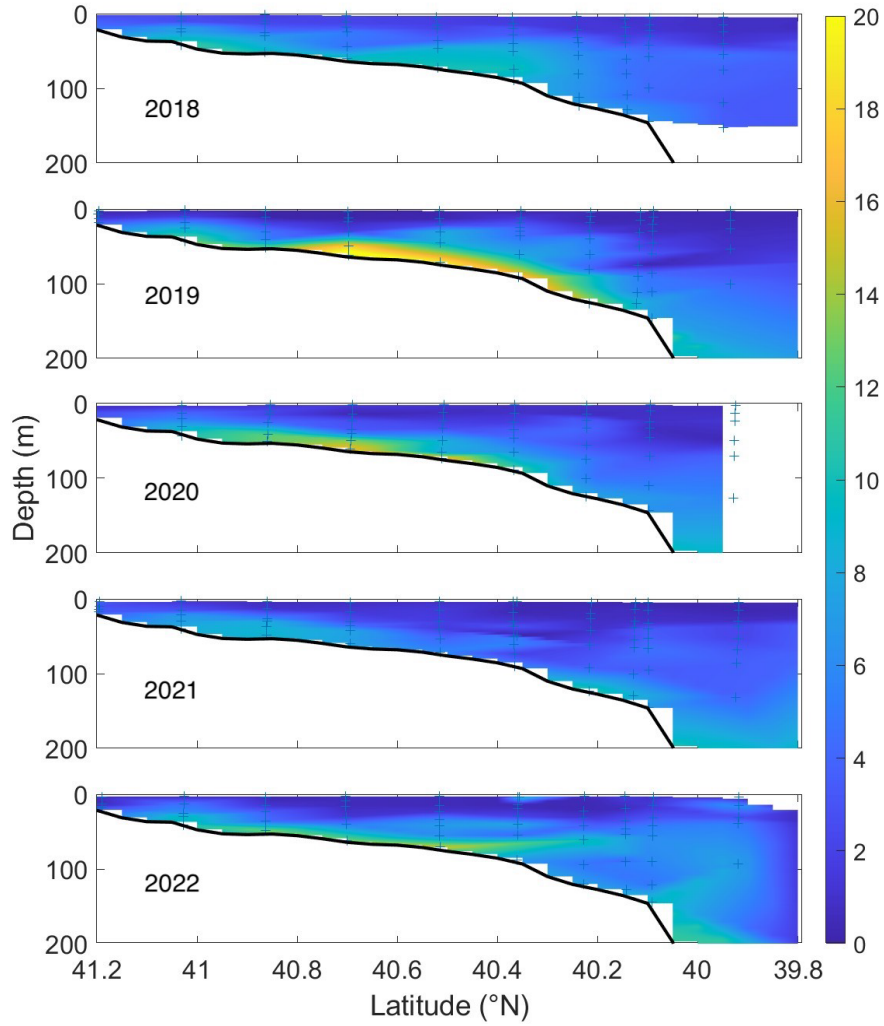


Fig S4. Silicate concentration as a function of depth and latitude for the NES-LTER summer cruises 2018-2022 (from top to bottom). Niskin sample locations (+) are indicated on each section.

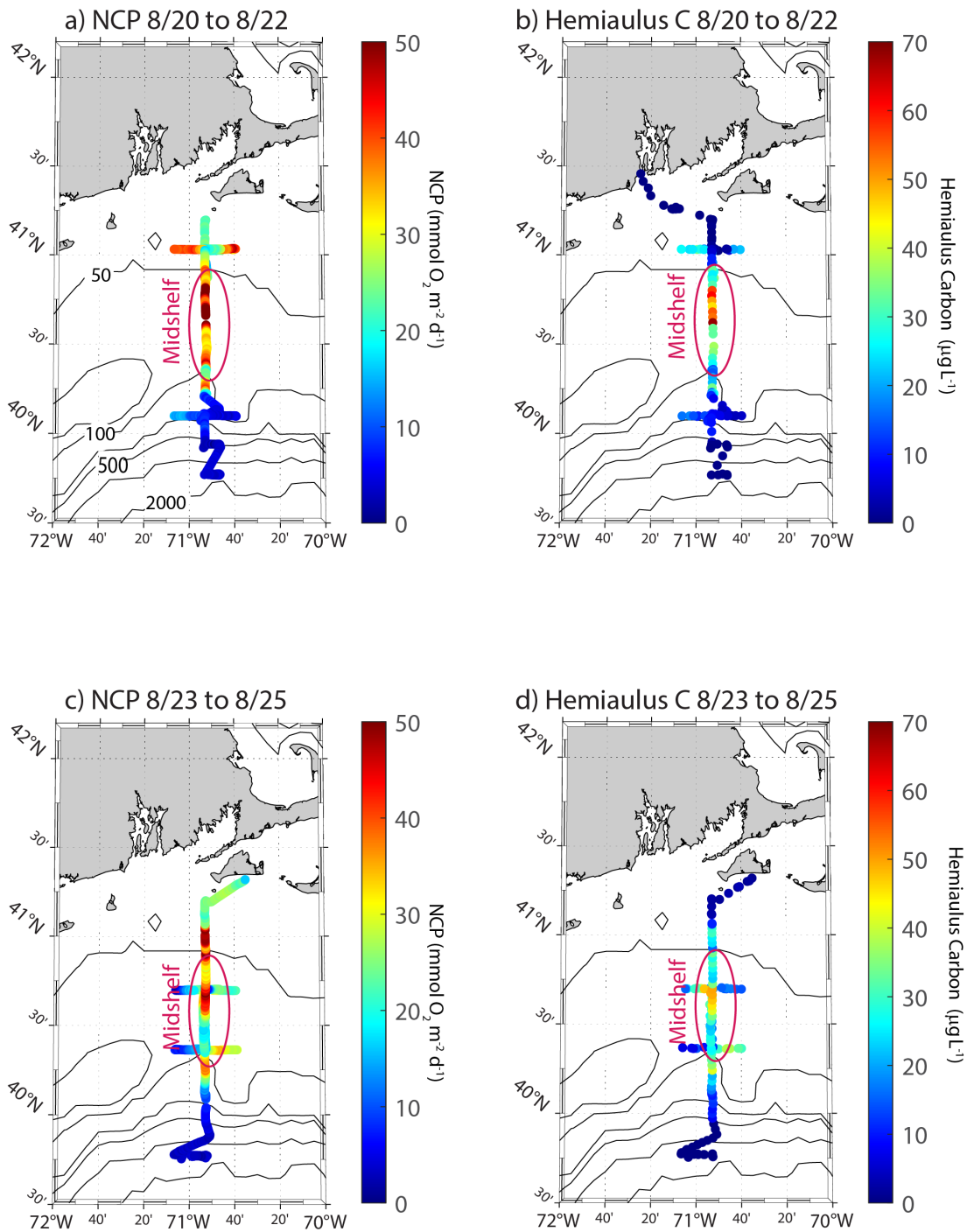


Fig. S5. Rates of net community production and *Hemiaulus* carbon in the first half of the cruise (panels a and b) and the second half of the cruise (panels c and d). The mid-shelf region is highlighted with the red ellipse for each panel and bathymetry contours are labelled in the first panel. Note that the later time period has smaller NCP and lower amounts of *Hemiaulus* carbon, suggesting the bloom may have been in decline.

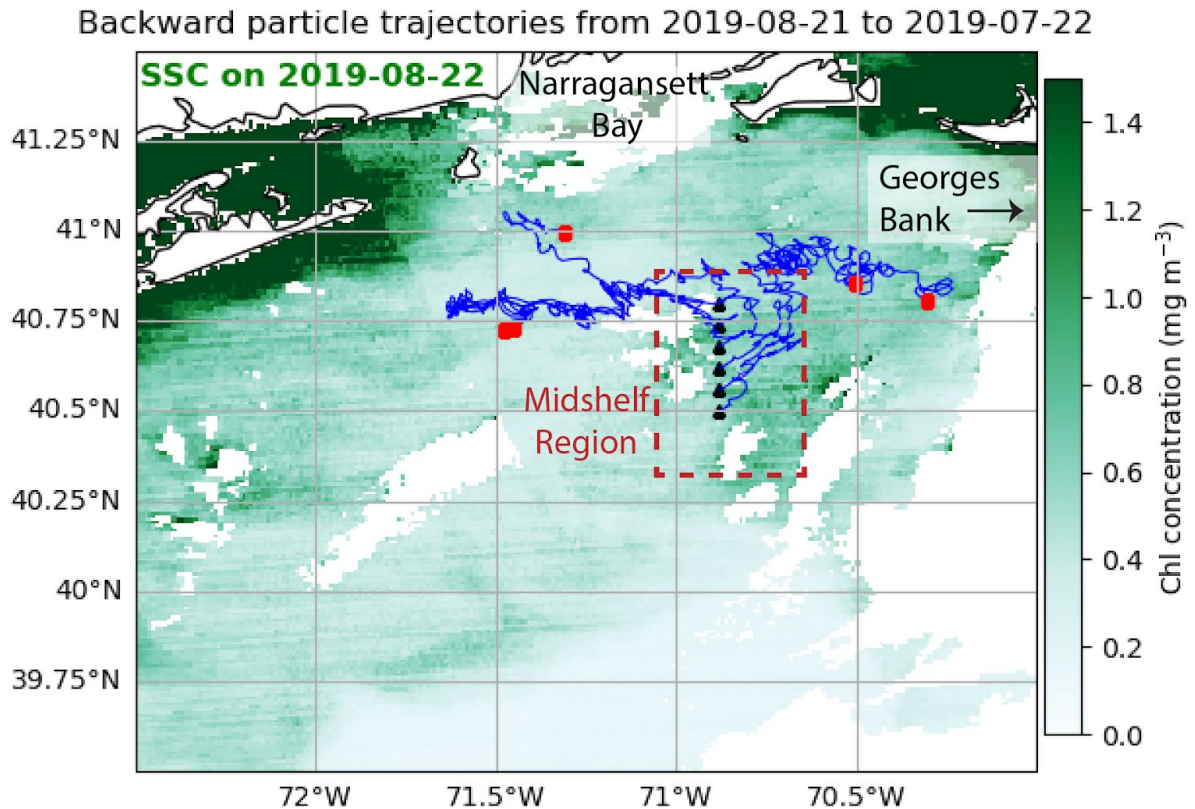


Fig S6. Backward particle trajectories beginning along the mid-shelf stations from the NES-LTER transect line (shown in black triangles) on 21 Aug , 2019 suggest that the *Hemiaulus* bloom water came from the inner shelf region near Narragansett Bay and Georges Bank rather than mid-shelf region further south. The red squares indicate the positions of the particles on 22 Jul, 2019. The background color shows the satellite-measured surface chlorophyll concentration on 22 Aug, 2019.