CRUISE RESULTS
NOAA Research Vessel HENRY BIGELOW
Cruise No. HB 19-02
Spring Northeast Ecosystem Monitoring Survey

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CRUISE PERIOD AND AREA

The NOAA research vessel *HENRY BIGELOW* sampled a total of 139 stations on the Spring Ecosystem Monitoring Survey (EcoMon). The vessel sailed from Pier 2 at the Naval Station in Newport RI on 22 May and returned on 6 June 2019, having sampled as far south as a line of stations south of Delaware Bay, so that the southernmost part of the Mid-Atlantic Bight was not covered. However this strategy enabled the survey to reach almost every station in the Southern New England, Georges Bank and the Gulf of Maine areas during the 16 sea days allotted for this trip. Being the last area to be sampled, the Gulf of Maine had not received complete coverage during the past several Ecosystem Monitoring cruises due to time running out at the end of the allotted cruise period.

OBJECTIVES

The principal objective of this survey was to assess the pelagic components of the Northeast U.S. Continental Shelf Ecosystem from water currents to plankton, pelagic fishes, marine mammals, sea turtles, and seabirds. The spatial distribution of the following parameters was quantified: water properties, phytoplankton, microzooplankton, mesozooplankton, pelagic fish and invertebrates. Both traditional and novel techniques and instruments were used.
Other operational objectives of this cruise were to:

(1) collect underway data using TSG, SCS, and ADCP.

2) complete CTD and bongo operations at stations throughout area.

(3) collect acoustic data using the ES60 and EK60.

(4) collect samples for the Census of Marine Zooplankton (CMarZ) genetics studies.

(5) collect samples for aging and genetic analyses of fish larvae and eggs.

(6) collect near-surface underway data and imagery from the entire cruise track using a TSG, fluorometer, SCS, ES-60 and EK-60 Scientific Sounders, ADCP and an Imaging FlowCytoBot

unit.

(7) gather data on trends in ocean acidification and nutrient levels by collecting seawater samples at three depths (surface, midwater and bottom) with a rosette water sampler at predetermined fixed locations for the NOAA Ocean Acidification Program.

(8) measure the optical properties of seawater at various depths using optical sensors to better identify sizes and types of phytoplankton using color measurements derived from satellite images.

(9) compare plankton catches taken by a vertical ring net tow protocol from Canada's Department of Fisheries and Oceans Atlantic Zone Monitoring Program with Ecomon bongo tows from the same area. This work is part of an effort to find ways of combining data collected by the US and Canada in the Gulf of Maine and Georges Bank.

(10) have an outreach component with elementary school students in Westerly RI where Styrofoam cups they decorated are shrunk at depth with our sampling gear to illustrate the effects of water pressure.

METHODS

The survey originally consisted of **155** stations at which the vessel planned to stop and lower instruments over the port side of the vessel from an A-frame and two conductive-wire winches. Due to time constraints imposed by a previously scheduled calibration of the Dynamic Positioning System on the first day of the survey, a decision was made to not visit the southern-most part of the Middle Atlantic Bight area, so only a total of **139** stations were sampled from Delaware Bay north. (Figure 1).

Plankton and hydrographic sampling was conducted with double oblique tows using the 61-cm bongo sampler and a Seabird CTD. The tows extended to approximately 5 meters above the bottom, or to a maximum depth of 200 meters. All plankton tows were conducted at a ship speed of 1.5 – 2.0 knots. Plankton sampling gear consisted of a 61-centimeter diameter aluminum bongo frame with two 335-micron nylon mesh nets equipped with analog flowmeters that recorded the number of revolutions during the tow. At **22** randomly designated Census of Marine Zooplankton (CMarZ) stations, a 20-cm diameter PVC bongo frame fitted with paired 165-micron nylon mesh nets was added to the towing wire one half meter above the Seabird CTD and towed together with the large aluminum bongo frame (Figure 2). No flowmeters were deployed with the 20-cm bongos. At all other plankton stations, 20 cm 335 micron mesh nets were deployed above the standard CTD/61-cm Bongo sampler in order to collect larval fish and egg samples for NOAA researcher David Richardson. These samples were preserved for genetics and otolith analysis to be carried out at the Narragansett NEFSC Lab. A 45-kilogram lead weight was attached by a 20-centimeter length of 3/8-inch diameter chain below the aluminum bongo frame to depress the sampler. The plankton sampling gear was deployed off the starboard side of the vessel at the side-sampling station using an A-frame and the forward conducting cable winch. Tow depth was monitored in

real time with a Seabird CTD profiler. The Seabird CTD profiler provided simultaneous depth, temperature, and salinity during each plankton tow. A Power Data Interface Module (PDIM) signal booster was used to facilitate data transfer at high baud rates over more than 1600 meters of conducting wire spooled onto the oceanic winch. After retrieval, both the large and small bongo nets were washed down with seawater on a table set up on the deck of the sampling area to obtain the plankton samples.

The 61-centimeter bongo plankton samples were preserved in a 5% solution of formalin in seawater. The CMarZ genetics samples and the genetics and otolith larval fish and egg samples from the 20-centimeter bongo nets were preserved in 95% ethanol, which was changed once, 24 hours after the initial preservation. At a subset of **23** plankton stations (**14** in the Gulf of Maine and **9** on Georges Bank) a vertical tow was made after the bongo net tow using a 75 cm diameter ring net with 200-micron mesh. The tow extended from 5 meters off the bottom to the surface (Figure 3). This was done to compare plankton catches made by Canada's Atlantic Zone Monitoring Program sampling protocols with samples collected by NEFSC EcoMon protocols in an effort to find ways of combining data collected by each country in the Gulf of Maine and Georges Bank.

A Seabird 911+ CTD was deployed on a rosette frame with a carousel water sampling system (SBE32) and 12 10-liter Niskin bottles at all fixed stations (Figure 4). The package was deployed from the starboard side-sampling station, using the A-frame and aft conducting cable winch. This SBE9/11+ CTD and rosette package was deployed on vertical casts, collecting profiles of water temperature, salinity, chlorophyll-a and oxygen levels. Water samples were collected by the Niskin sampling bottles at multiple depths along the upcast to be processed ashore for nutrients and carbonate chemistry. Analysis for chlorophyll-a levels from these water samples was conducted onboard the vessel in the chemistry lab, using a Turner Designs 10-AU fluorometer and a filtration setup. Water samples for the chlorophyll-a analysis were drawn from the surface, chlorophyll-max layer and from one depth below the chlorophyll-max layer. These were taken as a check for the submersible fluorometer mounted on the rosette. Water was also filtered from 2 to 3 depths for URI GSO researchers to capture phytoplankton from the surface, the chlorophyll max layer and sometimes below the chlorophyll max. This provided them with water column optical data in addition to the surface water optical data they were obtaining from the surface seawater flow through system. Care was taken to draw a nutrient sample from the same bottle that each Dissolved Inorganic Carbon (DIC) sample had been drawn from, (surface, mid-water and bottom) to ensure the best possible correlation between the DIC and nutrient parameters.

During the daytime rosette casts, the URI researchers made a simultaneous cast from the starboard stern quarter of the vessel with a hand-deployed submersible radiometer to measure incident light coming down from the surface with an upward-facing sensor and backscatter incident light from a downward-facing sensor (Figure 5). This unit provided valuable optical data to correlate with phytoplankton captured at various depths by the rosette but the unit stopped functioning two thirds of the way through the cruise.

One other objective of the water casts made with the carousel water sampling system was to carry 68 styrofoam cups in a mesh bag strapped to the rosette frame. These cups, hand decorated by fourth graders from the Westbrook Elementary School, were part of an outreach project to involve

elementary school students in our oceanography fieldwork (Figure 6). The cups were returned to them after the cruise in a much reduced size, demonstrating the effects of water pressure at depth.

Near-surface (~3 meters depth) salinity, temperature and pCO2 levels were monitored continuously along the entire cruise track using a thermosalinograph, and a partial pressure of carbon dioxide (pCO2) system hooked up to the ship's scientific flow-through seawater system. In addition to the pCO2 system, UNH scientists added a sensor to the flow-through scientific seawater plumbing to measure Total Alkalinity (TA). The Scientific Computer System (SCS) recorded the output from the thermosalinograph at 10-second intervals. Records were given a time-date stamp by the GPS unit. Data from the pCO2 and TA systems were logged independently on dedicated computers hooked up to those sensors. These dedicated, independent computers for pCO2 and TA did receive correlated data from the SCS system onboard. In addition, an ImagingFlowCytobot unit was plumbed into the flow-through seawater system in the CTD lab**.** This device captured images of diatoms, dinoflagellates and marine ciliates on an independent computer provided by the Woods Hole Oceanographic Institution (WHOI) (Figure 7). This system was monitored daily by Kyle Turner, a graduate student and researcher from the Graduate School of Oceanography at URI.

Marine mammal and seabird observations and photography were conducted from the bridge and flying bridge of the *HENRY BIGELOW* by seabird and marine mammal observers John Loch and Nick Metheny (Figure 8).

RESULTS

A summary of routine survey activities is presented in Table 1. Areal coverage for the cruise is shown in Figure 1. The NOAA vessel *HENRY BIGELOW* sailed from Newport, RI on Wednesday, 22 May at 1400 hours EDT. Sampling started just south of Narragansett Bay as the vessel headed 6 stations south of Narragansett Bay, sampling them and then returning to Narragansett Bay on the morning of 23 May to pick up a contractor by small boat off the coast of Newport. The contractor worked on the Dynamic Positioning System all day before being taken off, again by small boat that evening and returned to Newport. After his departure the *BIGELOW* started working its way south and west along a line of inshore stations south of Long Island. The vessel sampled all the inshore stations on its way south to a transect of fixed stations just south of the entrance to Delaware Bay. This marked the southernmost part of the cruise following a decision made to start heading back north to better ensure more complete coverage of the northern survey areas. Good weather allowed rapid progress along a long line of offshore stations on the Middle Atlantic Bight, and Southern New England. At this point a favorable forecast led to our continuing onto Georges Bank, which was sampled in its entirety prior to our heading to the last remaining survey area, the Gulf of Maine. With continued good weather the *HENRY BIGELOW* transitioned from Georges Bank to the Northeast Channel and continued north, sampling at all stations in the Gulf of Maine, with the exception of 4 stations farther east along the Scotian Shelf. The northernmost station visited was in the Bay of Fundy off Grand Manan Island which marked a turning point for returning to the western Gulf of Maine. Five supplementary stations in the western Gulf of Maine were surveyed to improve our chances of finding mackerel larvae, and preliminary microscopic examination of the zooplankton side of the large bongo sampler (6B3 Z net) by Quentin Nichols while at sea did reveal numbers of fish larvae being captured for later identification ashore, (Figure 9).

The Henry Bigelow returned to Narragansett Bay via the Cape Cod Canal and docked at Pier 2 Naval Station Newport on 6 June 2019, marking the end of a very productive Spring Ecosystem Monitoring Survey.

DISPOSITION OF SAMPLES AND DATA

All samples and data, except for the CMarZ zooplankton genetics samples, the University of Maine nutrient samples, and the Seabird CTD data, were delivered to the NEFSC Ecosystem Monitoring Group in Narragansett, RI for quality control processing and further analysis. The CMarZ samples and associated data were delivered to Nancy Copley at the Woods Hole Oceanographic Institution. The nutrient samples were sent by overnight UPS to Maura Thomas at the University of Maine, School of Marine Sciences, 5706 Aubert Hall, Orono, ME. The Total Alkalinity Sensor on the Scientific Seawater system remained in place for the next cruise aboard the Henry Bigelow, but Shawn Shellito took all data collected during the Ecomon cruise to the University of New Hampshire. The ImagingFlowCytoBot unit and the images and data it collected were delivered to Emily Peacock at WHOI. The CTD data were delivered to NEFSC Oceans and Climate Branch staff in Woods Hole, MA. Marine mammal observation data and the seabird observation data went to Tim White at the Bureau of Ocean Energy Management (BOEM) in Reedsville, MD and Beth Josephson, NEFSC Protected Species Branch, Woods Hole, MA.

SCIENTIFIC PERSONNEL

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Table 1. Summary of sample activities conducted at 139 stations at which the *HENRY BIGELOW* stopped to lower instruments over the side during Cruise No. HB 1902. Latitude and Longitude are shown in degrees and minutes. BON/CTD = 61 cm bongo Standard Protocol, CTD 911+WATER= water cast at a fixed station, SAL=salinity sample, 2B3 D = 333 mesh 20 cm bongo Dave R. samples, NUT = Nutrients, CHL = Chlorophyll 2B1 C = 165 mesh 20 cm bongo CMARZ samples, DIC = Dissolved Inorganic Carbon, Net Vertical = Vertical Ring Net Tow, CTD 19/19+ WATER = Seabird 19+ Profiler+water sample, URI = URI water sample
LTER = Long Term Eco Research Station

CTD Cast	Site ID/ STA#	Date GMT	Latitude (deg min)	Longitude (deg min)	Bottom Depth(m)	Operation
1	1	5/22/2019	4105.1	7129.9	22	BON/CTD, 2B3 D
2	2	5/22/2019	4100.1	7135.1	43	BON/CTD, 2B3 D
3	3	5/23/2019	4040.1	7120.0	60	BON/CTD, 2B1 C
4	4	5/23/2019	4049.2	7120.0	61	BON/CTD, 2B3 D
5	5	5/23/2019	4054.6	7105.1	53	BON/CTD, 2B3 D
6	6	5/23/2019	4104.8	7115.1	38	BON/CTD, 2B1 C
7	7	5/24/2019	4025.3	7209.7	61	BON/CTD, 2B1 C
8	8	5/24/2019	4024.8	7239.4	47	BON/CTD, 2B3 D
9	9	5/24/2019	4019.9	7259.5	40	BON/CTD, 2B3 D
10	10	5/24/2019	4029.8	7309.7	32	BON/CTD, 2B3 D
11	11	5/24/2019	4020.0	7339.6	25	BON/CTD, 2B3 D
12	12	5/24/2019	4004.9	7301.0	48	BON/CTD, 2B1 C
13	13	5/24/2019	3945.1	7300.4	57	BON/CTD, 2B3 D
14	14	5/24/2019	3945.1	7300.4	57	BON/CTD, 2B3 D
15	15	5/24/2019	3935.0	7325.0	35	BON/CTD, 2B3 D
16	16	5/25/2019	3950.2	7350.1	25	BON/CTD, 2B3 D
1	17	5/25/2019	3942.4	7359.7	22	CTD 911+ WATER NUT, CHL, DIC, URI, SAL

17	18	5/25/2019	3920.0	7400.6	29	BON/CTD, 2B1 C
CTD Cast	**Site ID/ STA#**	**Date GMT**	**Latitude (deg min)**	**Longitude (deg min)**	**Bottom Depth(m)**	**Operation**
2	19	5/25/2019	3921.7	7323.9	50	CTD 911+ WATER DIC, NUT, CHL
18	20	5/25/2019	3905.3	7320.0	60	BON/CTD, 2B3 D
19	21	5/25/2019	3859.9	7340.5	48	BON/CTD, 2B3 D
20	22	5/25/2019	3850.4	7345.3	48	BON/CTD, 2B1 C
21	23	5/25/2019	3854.9	7400.0	39	BON/CTD, 2B3 D
22	24	5/25/2019	3850.1	7404.9	46	BON/CTD, 2B3 D
23	25	5/25/2019	3850.0	7425.1	28	BON/CTD, 2B3 D
24	26	5/25/2019	3844.9	7459.8	23	BON/CTD, 2B3 D
25	27	5/25/2019	3807.9	7507.1	17	BON/CTD, 2B1 C
26	28	5/25/2019	3800.7	7457.5	23	BON/CTD, 2B3 D
3	28	5/25/2019	3800.7	7457.0	24	CTD 911+ WATER NUT, DIC, CHL
27	29	5/26/20190	3804.5	7435.5	36	BON/CTD, 2B3 D
28	30	5/26/2019	3751.1	7434.5	54	BON/CTD, 2B3 D
4	30	5/26/2019	3750.9	7434.4	54	CTD911+ WATER NUT,SAL,DIC,URI,CHL
29	31	5/26/2019	3740.0	7420.1	97	BON/CTD, 2B1 C
5	32	5/26/2019	3741.8	7415.5	113	CTD 911+ WATER NUT,DIC,CHL,URI,SAL
30	33	5/26/2019	3824.6	7414.9	47	BON/CTD, 2B1 C
31	34	5/26/2019	3814.9	7345.1	118	BON/CTD, 2B3 D
32	35	5/26/2019	3834.5	7330.2	80	BON/CTD, 2B3 D
33	36	5/26/2019	3839.7	7315.1	104	BON/CTD, 2B3 D
6	37	5/26/2019	3902.6	7244.7	267	CTD 911+ WATER NUT,SAL,CHL,URI,DIC
7	38	5/26/2019	3900.9	7235.1	1035	CTD 911+ WATER NUT,SAL,CHL,URI,DIC

CTD Cast	Site ID/ STA#	Date GMT	Latitude (deg min)	Longitude (deg min)	Bottom Depth(m)	Operation
34	39	5/27/2019	3939.8	7220.1	115	BON/CTD, 2B3 D
35	40	5/27/2019	3954.8	7225.1	77,	BON/CTD, 2B1 C
36	41	5/27/2019	3940.3	7200.9	180	BON/CTD, 2B3 D
37	42	5/27/2019	4004.8	7105.6	186	BON/CTD, 2B3 D
38	43	5/27/2019	3950.0	7037.4	883	BON/CTD, **LTER,** 2B3 D
8	43	5/27/2019	3949.9	7037.5	890	CTD 911+ WATER, **LTER** NUT,SAL,CHL,URI,DIC
39	44	5/27/2019	4001.3	7036.2	190	BON/CTD, **LTER,** 2B3 D
9	44	5/27/2019	4002.7	7036.5	150	CTD 911+ WATER, **LTER** NUT,SAL,CHL,,URI,DIC
40	45	5/27/2019	3954.7	6950.3	330	BON/CTD, 2B3 D
41	45	5/27/2019	3955.7	6950.6	261	CTD19+WATERCAST, SAL
42	46	5/27/2019	4004.6	6941.1	107	BON/CTD, 2B3 D
43	47	5/28/2019	4024.6	7014.8	77	BON/CTD, 2B3 D
44	48	5/28/2019	4015.8	7029.5	108	BON/CTD, 2B3 D
45	49	5/28/2019	4030.0	7055.3	79	BON/CTD, 2B3 D
46	50	5/28/2019	4030.0	7050.6	78	BON/CTD, 2B3 D
47	51	5/28/2019	4039.9	7037.8	62	BON/CTD, **LTER**, 2B3 D
10	51	5/28/2019	4040.1	7037.7	62	CTD 911+ WATER, **LTER** NUT, SAL, CHL, DIC
48	52	5/28/2019	4039.9	7025.6	56	BON/CTD, 2B3 D
49	53	5/28/2019	4044.7	7010.8	42	BON/CTD, 2B3 D
50	54	5/28/2019	4100.0	7035.1	49	BON/CTD, 2B3 D
51	55	5/28/2019	4106.3	7037.2	43	BON/CTD, **LTER,** 2B3 D
11	55	5/28/2019	4106.0	7037.1	44	CTD 911+ WATER, **LTER** NUT,DIC,URI,SAL,CHL
52	56	5/28/2019	4104.4	7006.0	24	BON/CTD, 2B3 D

CTD Cast	Site ID/ STA#	Date GMT	Latitude (deg min)	Longitude (deg min)	Bottom Depth(m)	Operation
53	57	5/29/2019	4039.7	6925.8	55	BON/CTD, 2B3 D
54	58	5/29/2019	4025.3	6910.3	82	BON/CTD, 2B3 D
55	59	5/29/2019	4029.8	6845.6	74	BON/CTD, NO 2B
12	60	5/29/2019	4054.1	6909.5	68	CTD 911+ WATER SAL, DIC, CHL, NUT
56	61	5/29/2019	4059.8	6835.3	45	BON/CTD, 2B1 C
57	62	5/29/2019	4104.8	6830.1	43	BON/CTD, 2B3 D
58	63	5/29/2019	4124.5	6825.4	66	BON/CTD, 2B1 C
59	64	5/29/2019	4134.3	6825.6	54	BON/CTD, 2B3 D
60	65	5/29/2019	4154.5	6815.5	223	BON/CTD, 2B3 D
61	65	5/29/2019	4155.1	6816.0	223	CTD 19+ WATER , SAL
62	66	5/29/2019	4224.2	6810.4	179	BON/CTD, 2B3 D
63	67	5/30/2019	4215.5	6805.2	184	BON/CTD, 2B1 C
64	68	5/30/2019	4205.4	6745.5	189	BON/CTD, 2B3 D
13	69	5/30/2019	4200.4	6741.4	63	CTD 911+ WATER SAL, DIC, CHL, URI, NUT
65	70	5/30/2019	4204.8	6715.7	48	BON/CTD, 2B1 C
66	71	5/30/2019	4156.2	6720.0	49	BON/CTD, 2B3 D
67	72	5/30/2019	4140.0	6729.9	48	BON/CTD, 2B1 C
14	73	5/30/2019	4128.5	6741.1	38	CTD 911 +WATER SAL, DIC, URI, CHL, NUT
68	74	5/30/2019	4109.8	6735.2	49	BON/CTD, 2B1 C
69	75	5/30/2019	4110.1	6725.3	54	BON/CTD, 2B3 D
70	76	5/30/2019	4054.9	6730.1	75	BON/CTD, 2B3 D
71	76	5/30/2019	4054.7	6730.1	75	CTD/NET VERTICAL
15	77	5/30/2019	4055.8	6742.4	38	CTD 911+ WATER,

SAL,DIC, URI, CHL, NUT

CTD Cast	Site ID/ STA#	Date GMT	Latitude (deg min)	Longitude (deg min)	Bottom Depth(m)	Operation
72	78	5/30/2019	4049.8	6755.6	68	BON/CTD, 2B3 D
73	78	5/30/2019	4050.0	6755.4	68	CTD/NET VERTICAL
74	79	5/30/2019	4031.8	6809.7	105	BON/CTD, 2B3 D
75	79	5/30/2019	4032.1	6809.3	103	CTD/NET VERTICAL
76	80	5/31/2019	4010.7	6750.6	1939	BON/CTD, 2B3 D
77	80	5/31/2019	4010.7	6749.7	1628	CTD 19+ WATER, SAL
78	81	5/31/2019	4014.9	6740.8	1192	CTD PROFILE 19+
79	82	5/31/2019	4023.0	6742.7	148	CTD 19+ WATER, SAL
80	83	5/31/2019	4029.8	6750.1	116	BON/CTD, 2B1 C
81	84	5/31/2019	4034.5	6735.7	104	BON/CTD, 2B3 D
82	85	5/31/2019	4044.8	6720.5	96	BON/CTD, 2B3 D
83	85	5/31/2019	4044.6	6720.8	96	CTS/NET VERTICAL
84	86	5/31/2019	4054.7	6710.4	85	BON/CTD, 2B3 D
85	87	5/31/2019	4044.9	6650.4	172	BON/CTD, 2B3 D
86	88	5/31/2019	4109.6	6625.8	96	BON/CTD, 2B3 D
87	88	5/31/2019	4109.3	6626.6	93	CTS/NET VERTICAL
88	89	5/31/2019	4134.6	6620.9	89	BON/CTD, 2B3 D
89	90	5/31/2019	4135.0	6629.7	83	BON/CTD, 2B3 D
90	91	5/31/2019	4130.2	6635.1	84	BON/CTD, 2B3 D

CTD Cast	Site ID/ STA#	Date GMT	Latitude (deg min)	Longitude (deg min)	Bottom Depth(m)	Operation
91	92	6/1/2019	4134.9	6640.4	77	BON/CTD, 2B3 D
92	92	6/1/2019	4135.3	6640.8	77	CTD/NET VERTICAL
93	93	6/1/2019	4139.6	6654.4	63	BON/CTD, 2B3 D
94	93	6/1/2019	4139.7	6654.4	64	CTD/NET VERTICAL
95	94	6/1/2019	4159.5	6655.3	58	BON/CTD, 2B3 D
96	95	6/1/2019	4159.4	6644.7	72	BON/CTD, 2B3 D
97	95	6/1/2019	4158.8	6645.0	73	CTD/NET VERTICAL
98	96	6/1/2019	4204.6	6605.6	95	BON/CTD, 2B1 C
99	97	6/1/2019	4200.0	6555.5	135	BON/CTD, 2B3 D
100	98	6/1/2019	4200.1	6546.0	249	BON/CTD, 2B3 D
101	98	6/1/2019	4200.0	6545.6	251	CTD/NET VERTICAL
16	99	6/1/2019	4145.6	6527.0	1945	CTD 911+ WATER, SAL,DIC, URI, CHL, NUT
102	100	6/1/2019	4213.4	6546.2	223	BON/CTD, 2B3 D
103	100	6/1/2019	4213.5	6546.5	221	CTD/NET VERTICAL
17	100	6/1/2019	4213.3	6547.3	222	CTD 911+ WATER, SAL,DIC, URI, CHL, NUT

CTD Cast	Site ID/ STA#	Date GMT	Latitude (deg min)	Longitude (deg min)	Bottom Depth(m)	Operation
104	101	6/1/2019	4234.6	6559.8	108	BON/CTD, 2B3 D
105	101	6/1/2019	4234.9	6559.9	104	CTD/NET VERTICAL
18	102	6/2/2019	4301.9	6620.6	144	
106	103	6/2/2019	4239.9	6635.1	170	BON/CTD, 2B1 C
107	104	6/2/2019	4244.7	6649.7	183	BON/CTD, 2B3 D
108	105	6/2/2019	4230	6650.2	282	BON/CTD, 2B3 D
109	105	6/2/2019	4230.7	6649.7	265	CTD 19/19+ WATER CAST, SAL
110	106	6/2/2019	4221.8	6703.2	331	BON/CTD, 2B3 D
111	106	6/2/2019	4222.2	6703.2	332	CTD/NET VERTICAL
19	106	6/2/2019	4222.2	6703.5	332	CTD 911 SAL, DIC, URI, NUT, CHL
20	107	6/2/2019	4241.9	6742.2	191	CTD 911 SAL, DIC, URI, CHL, NUT
112	108	6/2/2019	4249.5	6750.1	186	BON/CTD, 2B3 D
113	108	6/2/2019	4249.9	6749.9	195	CTD/NET VERTICAL
114	109	6/2/2019	4323.9	6742.2	250	BON/CTD, 2B3 D
115	109	6/2/2019	4324.7	6742.6	249	CTD/NET VERTICAL
21	109	6/2/2019	4324.8	6742.7	250	CTD 911 SAL, DIC, URI, CHL, NUT
116	110	6/2/2019	4334.4	6749.8	233	BON/CTD, 2B3 D
117	110	6/2/2019	4335.1	6749.6	243	CTD/NET VERTICAL
118	111	6/3/2019	4350.2	6730.4	220	BON/CTD, 2B1 C
119	111	6/3/2019	4351.1	6730	218	CTD 19/19+ WATER CAST SAL
120	112	6/3/2019	4410	6714.9	135	BON/CTD, 2B3 D
21	112	6/3/2019	4410.2	6714.3	138	CTD/NET VERTICAL
22	113	6/3/2019	4428.6	6713.4	96	CTD 911 SAL, DIC, URI, CHL, NUT
23	114	6/3/2019	4411.8	6742	150	CTD 911 SAL, DIC, URI, CHL, NUT
122	115	6/3/2019	4355.6	6819.8	126	BON/CTD, 2B1 C
123	115	6/3/2019	4355.3	6820.2	121	CTD/NET VERTICAL
124	116	6/3/2019	4359.5	6824.9	90	BON/CTD, 2B3 D
125	117	6/3/2019	4346.6	6839.6	114	BON/CTD, 2B3 D
24	117	6/3/2019	4346.1	6840.1	117	CTD 911 SAL, DIC, URI, CHL, NUT
126	118	6/3/2019	4337.2	6917.9	102	BON/CTD, 2B3 D
127	119	6/3/2019	4314.9	6935	166	BON/CTD, 2B3 D

CTD Cast	Site ID STA#	Date GMT	Latitude (deg min)	Longitude (deg min)	Bottom Depth(m)	Operation
128	119	6/3/2019	4314.5	6935.3	157	CTD/NET VERTICAL
129	120	6/3/2019	4324.4	6939.9	151	BON/CTD, 2B3 D
130	121	6/4/2019	4319.4	7009.3	117	BON/CTD, 2B3 D
131	122	6/4/2019	4309.5	7015.7	125	BON/CTD, 2B3 D
132	123	6/4/2019	4259.9	7025.2	105	BON/CTD, 2B3 D
25	123	6/4/2019	4259.6	7025.8	105	CTD 911 SAL, DIC, URI, CHL, NUT
133	124	6/4/2019	4250.7	7005.7	117	BON/CTD, 2B1 C
134	125	6/4/2019	4259.5	6948.1	187	BON/CTD, 2B3 D
135	126	6/4/2019	4250	6915.4	139	BON/CTD, 2B3 D
136	126	6/4/2019	4250	6915.4	138	CTD/NET VERTICAL
137	127	6/4/2019	4230	6905.1	212	BON/CTD, 2B3 D
138	127	6/4/2019	4229.7	6905.9	222	CTD/NET VERTICAL
139	128	6/4/2019	4210	6900.2	162	BON/CTD, 2B3 D
140	129	6/4/2019	4140.6	6900.1	163	BON/CTD, 2B3 D
141	130	6/4/2019	4144.7	6924.9	163	BON/CTD, 2B3 D
142	131	6/5/2019	4210.4	6948.7	180	BON/CTD, 2B3 D
143	132	6/5/2019	4230.1	6940.1	256	BON/CTD, 2B3 D
144	132	6/5/2019	4229.5	6940.3	261	CTD/NET VERTICAL
26	132	6/5/2019	4229.3	6940.2	261	CTD 911 SAL, DIC, URI, CHL, NUT
145	133	6/5/2019	4230.2	6945	272	BON/CTD, 2B3 D
146	133	6/5/2019	4229.5	6944.6	272	CTD 19/19+ WATER CAST SAL
147	134	6/5/2019	4230.3	7029.8	76	BON/CTD, 2B3 D
148	134	6/5/2019	4229.9	7029.8	82	CTD/NET VERTICAL
149	135	6/5/2019	4225.7	7035.8	86	BON/CTD, 2B3 D
27	135	6/5/2019	4225.3	7035.6	87	CTD 911 SAL, DIC, URI, CHL, NUT
150	136	6/5/2019	4220.7	7049.7	29	BON/CTD, 2B3 D
151	137	6/5/2019	4221.5	7027.5	71	BON/CTD, 2B3 D
152	137	6/5/2019	4221	7027.4	86	CTD/NET VERTICAL
28	137	6/5/2019	4220.9	7027.3	88	CTD 911 SAL, DIC, URI, CHL, NUT
153	138	6/5/2019	4218.8	7016.8	35	BON/CTD, 2B3 D
154	138	6/5/2019	4218.6	7016.3	34	CTD/NET VERTICAL
29	138	6/5/2019	4218.7	7015.9	35	CTD 911 SAL, DIC, URI, CHL, NUT
155	139	6/5/2019	4203.8	7026.3	54	BON/CTD, 2B3 D

TOTALS:	Std BON/CTD Casts	=	105
	2B3 D Bongo Casts	=	99
	2B1 C (CMarZ) Bongo Casts	=	22
	CTD PROFILE 911 Casts	=	29
	Nutrient Casts	=	29
	Chlorophyll Casts	=	29
	Dissolved Inorganic Carbon casts (DIC)	=	29
	Salinity Sample Casts	=	36
	Vertical Net Casts	=	21

Note: CTD Cast 18 STA 102 was on 6/2/2019, 4301.9 N 6620.6 W, 139 m depth. It was a CTD 911 with SAL, DIC, URI, CHL, and NUT samples.

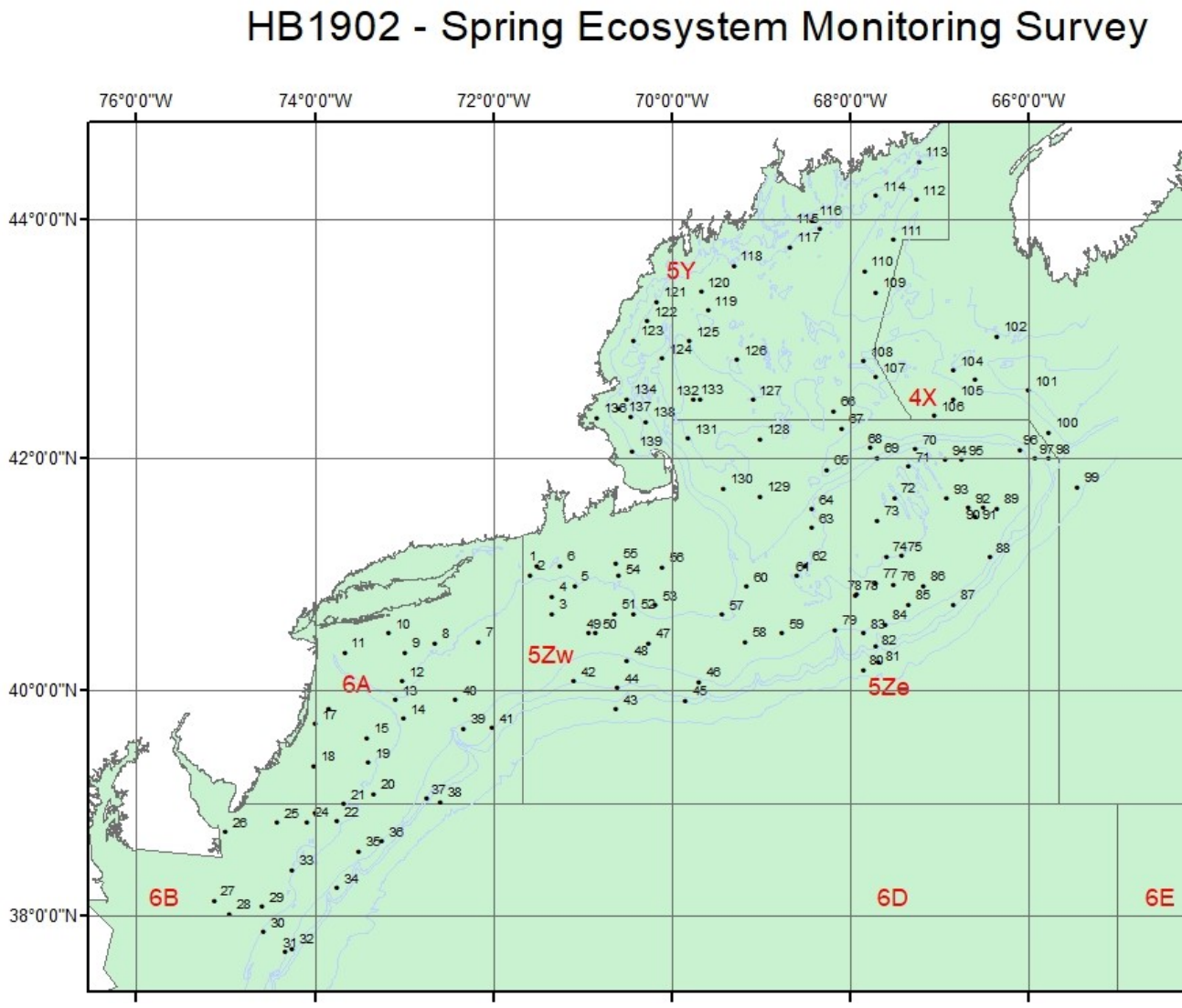

Figure 1. Station locations numbered consecutively for Spring Ecosystem Monitoring Survey HB 1902, 22 May – 6 June 2019.

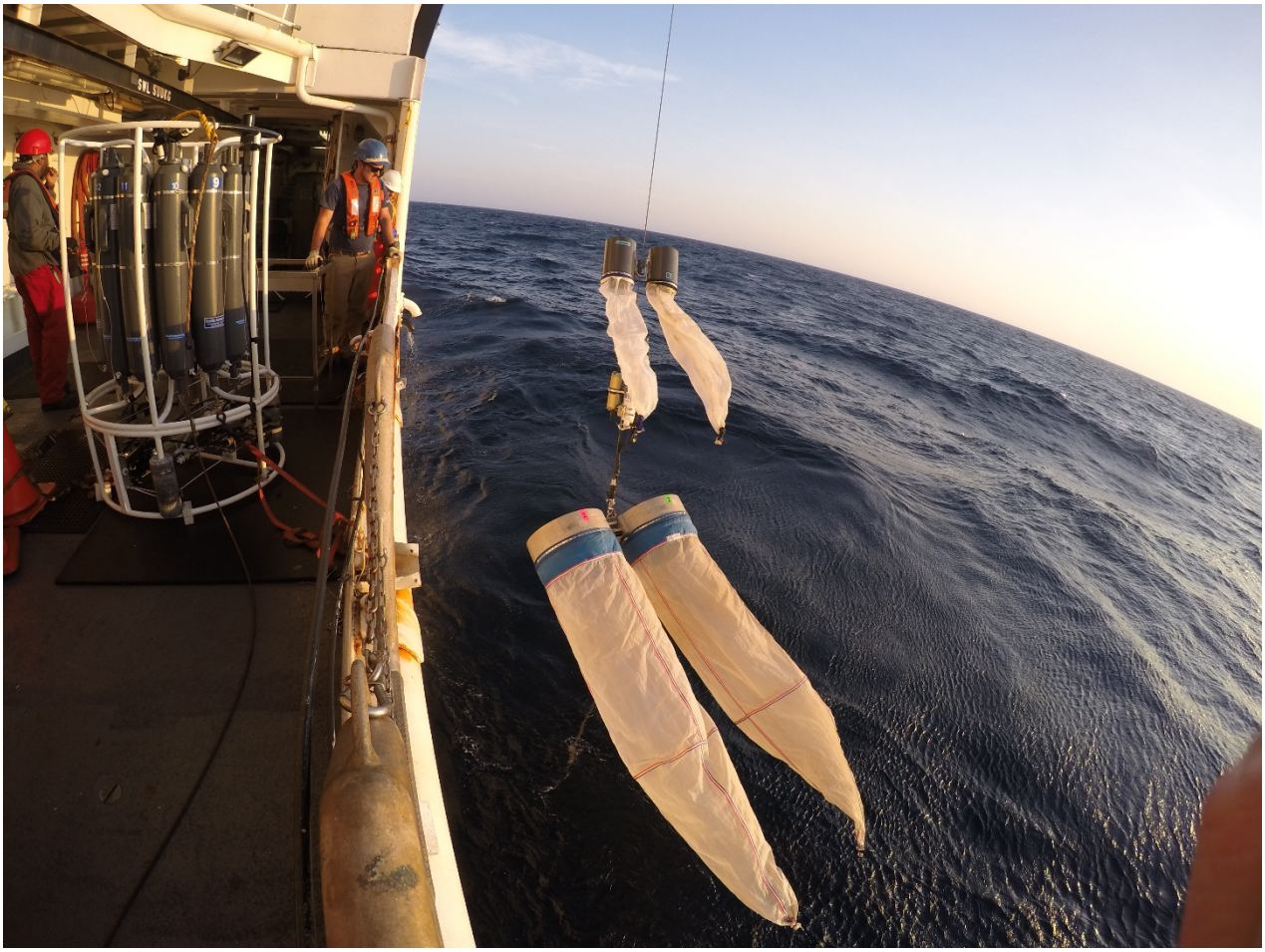

Figure 2. Bongo net array showing 61 and 20 cm bongo nets being deployed from the side sampling station on the Henry Bigelow.

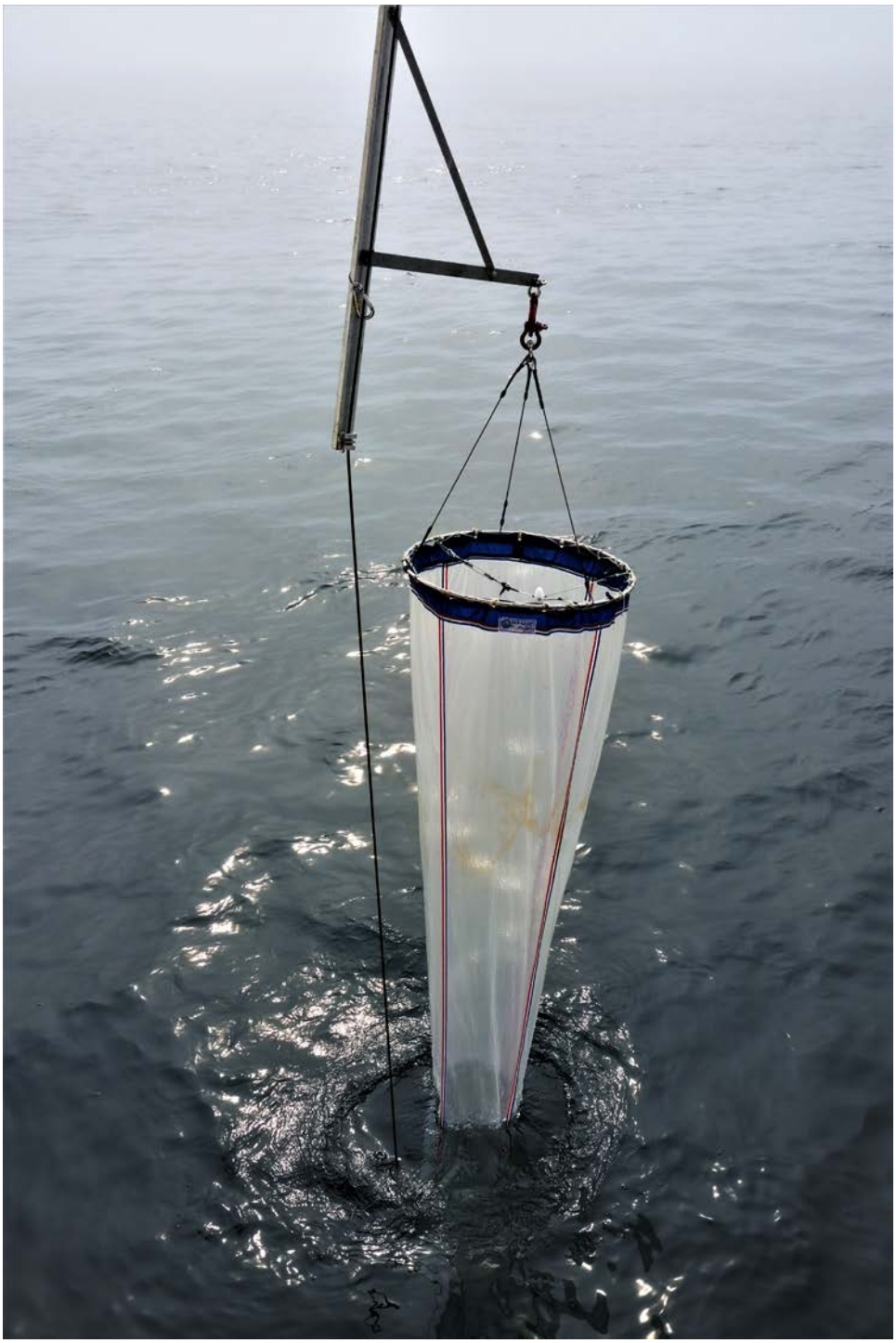

Figure 3. A 75 cm diameter ring net with 200 micron mesh being deployed from the Side-sampling station on the Henry Bigelow.

Figure 4. Niskin bottle and CTD 911 rosette being deployed aboard the FSV *Henry Bigelow*.

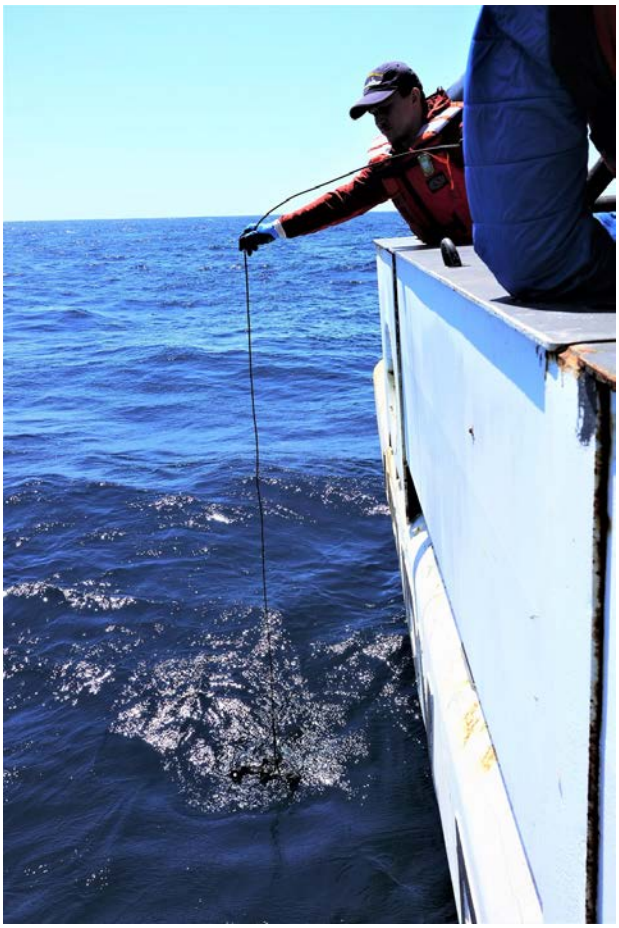

Figure 5. Kyle Turner deploying radiometer from the starboard stern quarter of the Henry Bigelow.

Figure 6. Before and after photos showing student-decorated styrofoam cups in mesh bag prior to and after repeated submersions on the Niskin bottle rosette during the HB 1902 Survey.

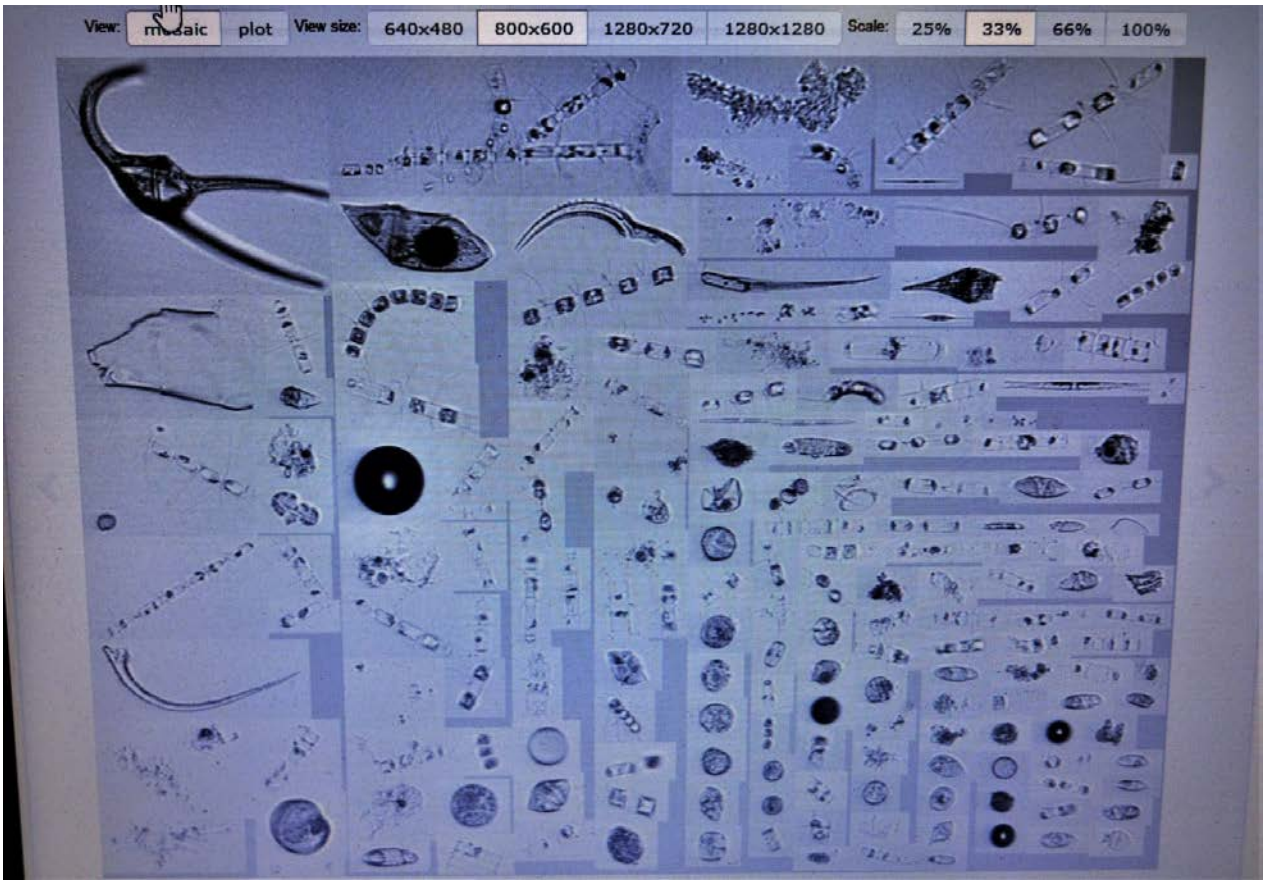

Figure 7. Imagery from the Imaging FlowCytoBot unit in the CTD lab aboard the Henry Bigelow.

Figure 8. Seabird and marine mammal observers Nick Metheny (in foreground) and John Loch at their observation posts on the flying bridge of the Henry Bigelow.

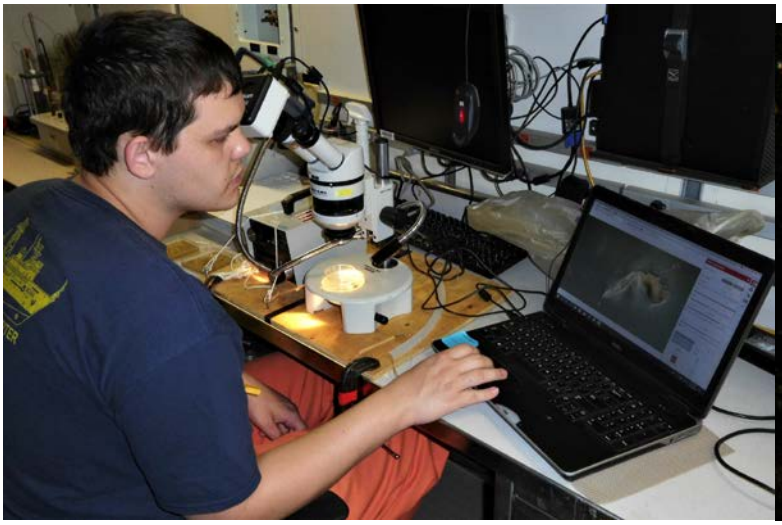


Figure 9. Quentin Nichols photographing fish larvae from the bongo net while on board the Henry Bigelow.

Appendix A

Seabird Survey Report
22 May-6 June 2019
Integrated Statistics, Northeast Fisheries Science Center Contractor
16 Sumner St, Woods Hole, MA, 02543
Nicholas Metheny: procellateryx@gmail.com
Marine Species Observers: Nicholas Metheny and John Loch

Objective:

The primary goal of conducting seabird surveys aboard the Henry Bigelow in May/June 2019 was to gather data on the abundance and distribution of seabirds as a part of longer term monitoring efforts for these far-ranging apex predators. Our secondary objective in conducting theses surveys was to also collect data, when possible, on the abundance and distribution of other marine megafauna including, marine mammals, sea turtles, sharks, and other large pelagic fishes.

Collecting this data in conjunction with other biological data and abiotic factors will help better complete our “picture” of possible changes occurring in the marine ecosystem in the Northwest Atlantic from the Outer Banks to the Bay of Fundy.

Methods:

The protocol used for this survey is based on a standardized 300 meter strip transect survey, one that is used by various agencies in North America and Europe (e.g., Anon 2011, Ballance 2011; Tasker 2004).

The survey strip is 300 meters wide, with observers collecting data on all seabirds within that strip, from the bow to 90 degrees to either the port or the starboard side (depending on viewing conditions). Observations can be made in seas up to a Beaufort 7, in light rain, fog, and ship speeds between 8-12 knots (below 8 knots, the data becomes questionable to use for abundance estimates).

Surveys were conducted on the flying bridge (15.3 m) of the Henry Bigelow whenever possible, even during thick fog, as long as proper hearing protection was observed.

Beta testing of the new SeaScribe program (version 1.2.1) was attempted, but issues with the location services/GPS positioning of the tablet device running the program was not continuously updating sighting positions, and therefore the beta testing was concluded after the first afternoon, and data collection reverted back to SeeBird version 4.3.7. The SeeBird program draws GPS coordinates, as well as time from the ship's navigation through a NMEA data feed, so each observation received a Lat/Long, time stamp, and ship's course. The standard data collected for observations included, species, distance, number of individuals, association, behavior, flight direction, flight height, and if possible or applicable, age, sex, and plumage status. For the purposes of this cruise a flock was deemed an aggregation of seven birds or more and were recorded even if seen outside the standard survey area. For flocks, Lat/Long, time, bearing, distance (estimated distances were made in the comment section), species composition and number, association, behavior, age, and sex were recorded. While SeeBird was not specifically designed to collect data on other marine megafauna, other such observations were recorded anytime an animal was seen, both in, and outside of the survey zone.

During surveys, individual observers took two-hour shifts, to prevent

observer fatigue. Observers utilized binoculars (10x42) for general scanning purposes within the survey strip, however, if an animal proved elusive a pair of 20x60 Zeiss imaged-stabilized binoculars were used to attain positive identifications. To aide in approximating distance observers used custom made range finders based on height above water and the observers' personal body measurement (Heinemann 1981).

Results:

Seabird Sightings

Over the course of the cruise approximately 1,487 nautical miles were surveyed, from the Delamarva Peninsula, to Georges Bank, and to the western Gulf of Maine (see Figure 1). A total of 2,589 birds were observed in the survey zone, within an additional 1,686 birds observed outside the zone (on and off effort). As is usual at this time of year, migration is under way with high arctic breeders nearly absent, and denizens from further South, and elsewhere coming to feed during the summer months and/or rear young. At the species level, Sooty Shearwaters, *Ardenna grisea*, Unidentified Scoters, *Melanitta sp,* and Wilson's Storm Petrel, *Oceanites oceanicus*, were the most abundant birds seen, making up 18%, 14.7% , and 13.6% relatively of the total count of birds recorded. It should be noted Wilson's Storm Petrels were the most abundant bird seen inside the survey zone, where as Sooty Shearwaters were the greatest overall due to greater visibility at a distance. The abundance of Unidentified Scoters was a single sighting event at a significant distance while the vessel was surveying by Nantucket Shoals. Further seabirds showing up in significant numbers were Red Phalaropes, *Phalaropus fulicarius*, Northern Fulmars, *Fulmarus glacialis*, Great Shearwaters, *Puffinus gravis*, and Northern Gannets, *Morus bassanus,* making up 8%, 7.5%, 7.4%, and 6.7% relatively, of the total birds seen.

Of special note, some birds we perhaps did not expect to see so late in the season were Dovekie, *Alle alle*, and Red Throated Loon, *Gavia stellata*, all adults in breeding plumage. Of further note six identified passerine species were seen on their migration North.

Table 1. Total Number of Birds Observed and Distance Distribution on Survey Strip

		Distance				
Common Bird Name	**Scientific Name**	1	2	3	4	**Grand Total**
Atlantic Puffin	*Fratercula arctica*	2	6	18	18	44
Dovekie	*Alle alle*	4	1	3	1	9
Razorbill	*Alca torda*		2			2
Unidentified Alcid				1	5	6
Common Loon	*Gavia immer*		3	9	2	14
Red-throated Loon	*Gavia stellata*		1			1
Common Eider	*Somateria mollissima*			1		1
Cory's Shearwater	*Calonectris borealis*			11	5	16
Great Shearwater	*Puffinus gravis*	21	97	140	57	315
Sooty Shearwater	*Ardenna grisea*	17	103	285	366	771
Manx Shearwater	*Puffinus puffinus*		3	3		6
Wilson's Storm Petrel	*Oceanites oceanicus*	19	332	114	117	582
Leach's Storm Petrel	*Oceanodrama leucorhoa*	7	140	54	7	208
Unidentified Storm Petrel			2	5	4	11
Northern Fulmar	*Fulmarus glacialis*	55	58	65	142	320
Arctic Tern	*Sterna paradisaea*		1	7	5	13
Common Tern	*Sterna hirundo*	11	14	66	53	144
Royal Tern	*Thalasseus maximus*	1				1
Unidentified Tern			2	9	29	40
Great Black-backed Gull	*Larus marinus*	29	12	41	38	120
Herring Gull	*Larus argentatus*	40	37	74	25	176
Laughing Gull	*Leucophaeus atricilla*	17	6	21	14	58
Ring-billed Gull	*Larus delawarensis*			1		1
Black-legged Kittiwake	*Rissa tridactyla*	1	1			2
Great Blue Heron	*Ardea herodias*			1		1
Green Heron	*Butorides virescens*	1				1
Long-tailed Jaeger	*Stercorarius longicaudus*		1		1	2
Unidentified Jaeger					2	2
South Polar Skua	*Stercorarius maccormicki*		3	4	5	12
Double Crested Comorant	*Phalacrocorax auritus*		24	9	4	37
Northern Gannet	*Morus bassanus*	7	35	146	100	288
Red Phalarope	*Phalaropus fulicarius*	33	75	187	50	345
Red-necked Phalarope	*Phalaropus lobatus*		2			2
Unidentified Phalarope			1	11		12
Ruddy Turnstone	*Arenaria interpres*	18				18
Geater Yellowlegs	*Tringa melanoleuca*	1				1
Unidentified Sandpiper			2			2
Unidentified Shorebird					4	4
White-winged Scoter	*Melanitta fusca*			2		2
Unidentified Scoter					630	630
Barn Swallow	*Hirundo rustica*	2		1		3
Chimney Swift	*Chaetura pelagica*	1				1
Cedar Waxwing	*Bombycilla cedrorum*	1		1		2
Common Yellowthroat	*Geothlypis trichas*	1				1
Magnolia Warbler	*Setopaga magnolia*	1			1	2
Blackpoll Warbler	*Setopaga striata*	1				1
Unidentified Warbler				1		1
Passerine		4	2	37		43
Osprey	*Pandion haliaetus*				1	1

Marine Mammal, Sea Turtle, and Large Fishes Sightings

The most commonly seen marine mammal, was of course, the Common Dolphin, *Delphinus delphis*, accounting for approximately 66.4% of all mammal sightings, followed by Bottlenose Dolphins, *Tursiops truncates,* at approximately 12.8%. Of the large whales, Humpback Whales, *Megaptera novaengliae*, made up almost half of identified whales, followed by Unidentified Whales, making up about a quarter of all whales seen. There were a fair number of Sei Whales seen on this survey compared to past EcoMon Cruises, with a total of eight being seen in the Wilkinson Basin area of the Gulf of Maine.

There were only two confirmed Loggerhead sea turtle, *Caretta caretta,* sighted in the warmer waters off the Mid-Atlantic. Basking Sharks, *Cetorhinus maximus,* were mostly seen in Mid-Atlantic waters as well. It should be noted that a large concentration of Basking Sharks continued to be sighted after the end of the survey day on May 26th, 2019, with over forty more Basking Sharks sighted until around 20:00 as light conditions limited the ability to detect more Basking Sharks.

Table 2. Other Sighted Marine Megafauna

Common Name	Scienctific Name	Number Observed
Fin Whale	*Balaenoptera physalus*	1
Sei Whale	*Balaenoptera borealis*	8
Fin/Sei Whale		8
Humpback Whale	*Megaptera novaeangliae*	40
Minke Whale	*Balaenoptera acutorostrata*	4
Unidentified Baleen Whale	*Balaenoptera sp*	4
Unidentified Whale		22
Risso's Dolphin	*Grampus griseus*	26
Pilot Whale Species	*Globicephala sp*	7
Atlantic White Sided Dolphin	*Lagenorhynchus acutus*	38
Common Dolphin	*Delphinus delphis*	535
Bottlenose Dolphin	*Tursiops truncatus*	103
White Beaked Dolphin	*Lagenorhynchus albirostris*	3
Grey Seal	*Halichoerus grypus*	5
Harbor seal	*Phoca vitulina*	2
Loggerhead Sea Turtle	*Caretta caretta*	2
Unidentified Sea Turtle		2
Ocean Sunfish	*Mola mola*	22
Basking Shark	*Cetorhinus maximus*	18
Unidentified Shark		2

Figure 1. Transect Lines Visually Surveyed on the 2019 Spring EcoMon (HB1902)

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