CRUISE RESULTS
NOAA Research Vessel HENRY BIGELOW
Cruise No. HB 15-02
Spring Northeast Pelagic-Ecosystem Monitoring Survey

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CRUISE PERIOD AND AREA

The NOAA research vessel *HENRY BIGELOW* sampled at a total of 153 stations from 19 May to 3 June 2015. With good weather for most of the cruise period, and with the vessel steaming at 11-12 knots much of the time, the cruise attained excellent coverage of all the survey areas, with the exception of a few far-flung stations in the Gulf of Maine. Some supplemental stations were sampled in the Southern New England and western Gulf of Maine areas to increase sampling density for mackerel larvae.

OBJECTIVES

The principal objective of the 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 currents, 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) conduct acoustic surveys using the 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 underway data using a TSG, fluorometer, SCS, EK-60 Scientific Sounder, ADCP and an Imaging FlowCytoBot unit.
- (7) Gather data on trends in ocean acidification and nutrient levels by collecting seawater samples at various depths with a rosette water sampler at predetermined fixed locations.
- (8) Collect stable isotope data from phytoplankton and some zooplankton size fractions.

- (9) Recover an Autonomous Multichannel Acoustic Recorder (AMAR) buoy from its mooring near the Lydonia Canyon on the southern flank of Georges Bank.

- (10) Deploy 2 Drifter Buoys as part of the NOAA Adopt a Drifter and Teacher at Sea Programs.

METHODS

The survey consisted of 153 stations at which the vessel stopped to lower instruments over the port side of the vessel from an A-frame and two conductive-wire winches. Of these, 37 were on Georges Bank, 36 were in the Gulf of Maine, 39 were in Southern New England and the remaining 41 stations were in the Middle Atlantic Bight (Figure 1).

Plankton and hydrographic sampling was conducted by making double oblique tows using the 61-cm bongo sampler and a Seabird CTD. The tows were made 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 and equipped with digital flowmeters that recorded number of revolutions during the tow, both visually and electronically. At the 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 put on the towing wire one half meter above the Seabird CTD with a wire stop and towed together with the large aluminum bongo frame (Figure 2). This same bongo frame and net array was also used on 18 stations by Princeton researcher Jessica Lueders-Dumont, who fractionated the zooplankton samples obtained and froze them on board for stable isotope analysis ashore to correlate with phytoplankton samples from rosette casts made in the same vicinity. A similar PVC bongo frame fitted with two 335 micron mesh nets was towed in a similar fashion at 75 of the remaining plankton stations to collect larval fish and egg samples for genetics and otolith analysis at the Narragansett NEFSC lab. A 45-kilogram bell-shaped 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 flat bottomed configuration of the depressor weight made for safer deployment and retrieval of the sampling gear when the boat was rolling in rough seas. No flowmeters were used in the 20-cm bongos. The plankton sampling gear was deployed off the port side of the vessel using an A-frame and a conducting cable winch. After retrieval the large bongo nets were washed down on a table set up on the deck of the side sampling station to obtain the plankton samples, while the small bongos were hung from a hook on a bulkhead in the same area. Both the large and small bongos were washed down with seawater. 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 were preserved in 95% ethanol, which was changed once 24 hours after the initial preservation. Tow depth was monitored in real time with a Seabird CTD profiler. The Seabird CTD profiler was hard-wired to the conductive towing cable, providing simultaneous depth, temperature, and salinity for each plankton tow. A Power Data Interface Module (PDIM) signal booster was also used to allow the data transfer at a high baud rate from the Seabird 19+ CTD profiler over the great length of wire (>1600 meters) on the *HENRY BIGELOW* oceanographic winch. Flowmeter revolutions were also monitored in real time through the tow cable.

A CTD 9/11 Niskin bottle rosette sampler cast was made at all the fixed stations to obtain water samples for nutrient analysis, as well as profiles of water temperatures, salinities, and chlorophyll-a

and oxygen levels. The Niskin bottle rosette sampler was also equipped with a fluorometer and transmissometer for simultaneous measurements of chlorophyll levels and turbidity, and to document the thickness and turbidity of the Benthic Nepheloid Layer (BNL) for U. Maine graduate student Megan Switzer, one of the guest researchers on board. The data from this instrument was logged to a Seabird 19 Profiler CTD set to archival mode and was downloaded periodically throughout the cruise (Figure 3). Princeton researcher Jessica Lueders-Dumont also took water samples from several depths to filter for her stable isotope analyses of phytoplankton.

Continuous monitoring of the seawater salinity, temperature and chlorophyll-*a* level, from a depth of 3.7 meters along the entire cruise track was done by means of a thermosalinograph, and a flow-through fluorometer hooked up to the ship's scientific flow-through seawater system. The Scientific Computer System (SCS) recorded the output from both the thermosalinograph, and the fluorometer at 10-second intervals. The data records were given a time-date stamp by the GPS unit. In addition to these sensors, an ImagingFlowCytobot unit was plumbed into the flow-through seawater system in the CTD lab to collect images of diatoms, dinoflagellates and marine ciliates on an independent computer from the Woods Hole Oceanographic Institute (WHOI) (Figure 4). This system was monitored daily by WHOI researcher Emily Peacock.

Marine mammal and seabird observations were conducted from the flying bridge of the *HENRY BIGELOW* by mammal observers Marjorie Foster and Brigid McKenna from NOAA and seabird observer Tom Bradley from Canada (Figure 5). A Seabird Survey Report by Carina Gjerdrum of the Canadian Wildlife Service, Environment Canada summarizes Tom's seabird observations in Appendix A..

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 at 1230 PM on Tuesday, May 19 from its berth on Pier 2 of the Newport Naval Station. Sampling was started right outside of Narragansett Bay as the vessel proceeded south on an offshore track towards the Middle Atlantic Bight as far south as Cape Hatteras North Carolina. From there sampling was done on all the inshore stations of the Mid-Atlantic Bight and Southern New England.

While transiting past the entrance to New York Harbor a stop was made to pass some supplies to an oar-powered vessel that was anchored and waiting to cross the Atlantic to Gallipoli, Turkey the next day (Figure 6). The inshore Southern New England stations were marked by large numbers of very small copepods, and large masses of diatoms in the water, as seen from coatings on the plankton nets, and images taken by the imaging flowcytobot unit. There were also unusually large numbers of sand lance in the 4 to 10 cm range, in the Southern New England waters. These were not only caught by the plankton nets, but also by the seawater intake strainers for the ship's engines.

Georges Bank was the next area sampled. In addition to the routine sampling activities an Autonomous Multichannel Acoustic Recorder (AMAR) buoy which had been deployed in the summer of 2014 was located and retrieved from the Lydonia Canyon area on the southern flank of Georges Bank. The mooring was located by pinging it from the vessel to determine its exact location and distance from the ship, followed by a release command which sent the buoyant recorder portion of the unit to the surface (Figure 7). While off the northeast peak of Georges Bank Two NOAA drifter buoys were deployed by NOAA Teacher-at-Sea Dieuwertje Jasmijn Kast (DJ) as part of her

on-board experience. These buoys, equipped with radio transmitters, ARGOS satellite position location systems and thermistors, are carried along by surface currents pulling on their subsurface drogues. Students ashore can monitor the positions of "their buoys" and the surface water temperatures they are traveling through for over 400 days until the batteries expire. Upon monitoring the buoys post-launch it was discovered that only one of the two buoys was functioning properly, Buoy # 39708 (Figure 8).

Upon completion of Georges Bank sampling, the vessel proceeded on into the Gulf of Maine which was sampled in a counterclockwise loop from east to west until sampling was completed on June 2. The *HENRY BIGELOW* then proceeded through the Cape Cod Canal, and returned to Pier 2 at the Newport Naval Station on 3 June at 0800, marking the end of the 2015 Spring Ecosystem Monitoring Survey, HB1502.

DISPOSITION OF SAMPLES AND DATA

All samples and data, except for the zooplankton genetics samples, the University of Maine nutrient samples, and the Seabird CTD data, were delivered to the Ecosystem Monitoring Group of the NEFSC, Narragansett, RI, for quality control processing and further analysis. The zooplankton genetics samples were delivered to Nancy Copley of the Woods Hole Oceanographic Institute. The nutrient samples were taken by Megan Switzer to the University of Maine. Jessica Lueders-Dumont took her frozen stable isotope samples back with her to Princeton University. The CTD data were delivered to the Oceanography Branch of the NEFSC, Woods Hole, MA. Marine mammal observation data was retained by the Protected Species Branch in Woods Hole, MA, and the seabird observation data went to the Canadian Wildlife Service in Dartmouth, Nova Scotia.

SCIENTIFIC PERSONNEL

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Table 1. Summary of sample activities conducted at 153 stations at which the *HENRY BIGELOW* stopped to lower instruments over the side during Cruise No. HB 1502. Latitude and Longitude are shown in decimal degrees.
Std BON/CTD = 61 cm bongo Standard Protocol, CTD PROFILE 911 = fixed station, 2B3 = 333 mesh 20 cm bongo 2B1 C = 165 mesh 20 cm bongo CMARZ 2B1 P = 165 mesh 20 cm bongo PRINCETON, ISO=isotope NUT=nutrients

CTD Cast#	SiteID/ STA#	Date GMT	Latitude (dd)	Longitude (dd)	Bottom Depth(m)	Operation
1	1	5/19/2015	41.4083	-71.2533	26	BON/CTD, 2B1 C
2	2	5/19/2015	41.34	-71.25	31	BON/CTD, 2B3
3	3	5/19/2015	41.1733	-71.1717	41	BON/CTD, 2B3
4	4	5/19/2015	40.76	-71.09	60	BON/CTD, 2B3
5	5	5/20/2015	40.2633	-71.0017	118	BON/CTD, 2B1 P
1	6	5/20/2015	40.0317	-70.5933	183	**CTD PROFILE911, NUT, DIC**
2	7	5/20/2015	39.8417	-70.6183	790	**CTD PROFILE911, NUT, DIC**
6	8	5/20/2015	40.24	-71.4033	88	BON/CTD, 2B1 C
7	9	5/20/2015	40.1667	-71.73	83	BON/CTD, 2B3
8	10	5/20/2015	39.5867	-72.0817	188	BON/CTD, 2B3
9	11	5/20/2015	39.4967	-72.7367	72	BON/CTD, 2B1 C
10	12	5/20/2015	39.2617	-72.995	74	BON/CTD, 2B1 C
3	13	5/21/2015	39.0567	-72.7517	142	CTD PROFILE911, NUT
4	14	5/21/2015	39.015	-72.5917	1125	**CTD PROFILE911, NUT, DIC**
11	15	5/21/2015	38.835	-73.0733	92	BON/CTD, 2B3
12	16	5/21/2015	38.9067	-73.5767	51	BON/CTD, 2B3
13	17	5/21/2015	38.7517	-73.5867	64	BON/CTD, 2B1 C
14	18	5/21/2015	38.5867	-73.75	60	BON/CTD, 2B3
15	19	5/21/2015	37.9267	-74.0017	174	BON/CTD, 2B1 P
5	20	5/21/2015	37.7033	-74.255	108	**CTD PROFILE911, NUT, ISO, DIC**
16	21	5/21/2015	37.5	-74.7433	51	BON/CTD, 2B1 C
17	22	5/21/2015	37.4217	-74.75	49	BON/CTD, 2B3
18	23	5/21/2015	37.1717	-75.0783	37	BON/CTD, 2B3
19	24	5/22/2015	36.7533	-74.75	80	BON/CTD, 2B1 C
6	25	5/22/2015	36.005	-74.675	1211	**CTD PROFILE911, NUT, DIC**
7	26	5/22/2015	36.0033	-74.7667	476	**CTD PROFILE911, NUT, ISO, DIC**
20	27	5/22/2015	36.0033	-74.755	580	BON/CTD, 2B1 P
21	28	5/22/2015	35.59	-74.9067	51	BON/CTD, 2B3
22	29	5/22/2015	35.4983	-75.2467	31	BON/CTD, 2B3
23	30	5/22/2015	35.9133	-75.415	22	BON/CTD, 2B1 P
8	31	5/22/2015	35.99	-75.4683	27	**CTD PROFILE911, NUT, ISO**

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20 cm bongo 2B1 C = 165 mesh 20 cm bongo CMARZ 2B1 P = 165 mesh 20 cm bongo PRINCETON, NUT=nutrients

CTD Cast#	SiteID/ STA#	Date GMT	Latitude (dd)	Longitude (dd)	Bottom Depth(m)	Operation
9	32	5/22/2015	36.0017	-75.185	35	**CTD PROFILE911, NUT, DIC**
24	33	5/22/2015	36.4167	-75.4183	27	BON/CTD, 2B1 C
25	34	5/23/2015	36.985	-75.4167	33	BON/CTD, 2B3
26	35	5/23/2015	37.3267	-75.4933	21	BON/CTD, 2B3
27	36	5/23/2015	37.4117	-75.4183	28	BON/CTD, 2B1 C
28	37	5/23/2015	37.495	-75.3333	30	BON/CTD, 2B3
10	38	5/23/2015	37.8383	-74.5867	55	**CTD PROFILE911, NUT, DIC**
11	39	5/23/2015	37.9967	-74.9483	23	**CTD PROFILE911, NUT, ISO, DIC**
29	40	5/23/2015	38.165	-74.5133	45	BON/CTD, 2B3
30	41	5/23/2015	38.3283	-74.7433	28	BON/CTD, 2B1 P
31	42	5/23/2015	38.41	-74.8267	22	BON/CTD, 2B3
32	43	5/23/2015	38.7483	-74.7383	16	BON/CTD, 2B3
33	43	5/23/2015	38.7533	-74.7417	18	CTD 19/19+ WATER CAST PROFILE
34	45	5/23/2015	38.8317	-74.2583	46	BON/CTD, 2B3
35	46	5/23/2015	38.835	-74.1017	46	BON/CTD, 2B3
36	47	5/24/2015	39.2417	-73.3433	54	BON/CTD, 2B1 P
12	48	5/24/2015	39.355	-73.3867	49	**CTD PROFILE911, NUT, ISO, DIC**
37	49	5/24/2015	39.4917	-73.5717	36	BON/CTD, 2B3
38	50	5/24/2015	39.495	-74.18	19	BON/CTD, 2B1 P
13	51	5/24/2015	39.6983	-74.005	22	**CTD PROFILE911, NUT, ISO, DIC**
39	52	5/24/2015	39.665	-73.595	36	BON/CTD, 2B3
40	53	5/24/2015	39.6667	-73.26	42	BON/CTD, 2B3
41	54	5/24/2015	39.6633	-73.0167	60	BON/CTD, 2B1 C
42	55	5/24/2015	39.825	-73.0733	66	BON/CTD, 2B3
43	56	5/24/2015	39.905	-73.1633	58	BON/CTD, 2B3
44	57	5/24/2015	40.0767	-73.8167	30	BON/CTD, 2B1 C
45	58	5/24/2015	40.165	-73.99	19	BON/CTD, 2B3
46	59	5/24/2015	40.3383	-73.9067	20	BON/CTD, 2B3
47	59	5/24/2015	40.3383	-73.905	20	CTD 19/19+ WATER CAST PROFILE
48	60	5/25/2015	40.6617	-72.755	33	BON/CTD, 2B3
49	61	5/25/2015	40.745	-72.5017	33	BON/CTD, 2B3, sand lance
50	62	5/25/2015	40.7433	-72.24	46	BON/CTD, 2B3, sand lance
51	63	5/25/2015	40.83	-71.845	44	BON/CTD, 2B3
52	64	5/25/2015	40.83	-71.595	63	BON/CTD, 2B3
53	65	5/25/2015	40.9867	-71.59	43	BON/CTD, 2B3

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CTD Cast#	SiteID/ STA#	Date GMT	Latitude (dd)	Longitude (dd)	Bottom Depth(m)	Operation
54	66	5/25/2015	41	-71.26	47	BON/CTD, 2B3
14	67	5/25/2015	41.1033	-70.6283	44	**CTD PROFILE911, NUT, DIC**
55	68	5/25/2015	41.0833	-70.0983	24	BON/CTD, 2B3
56	68	5/25/2015	41.0783	-70.09	23	CTD 19/19+ WATER CAST PROFILE
57	69	5/25/2015	40.7533	-70.3283	50	BON/CTD, 2B3
15	70	5/25/2015	40.6733	-70.605	62	**CTD PROFILE911, NUT, DIC**
58	71	5/25/2015	40.5833	-70.4367	63	BON/CTD, 2B3
59	72	5/26/2015	40.6583	-69.9283	52	BON/CTD, 2B3
60	73	5/26/2015	40.5067	-69.995	68	BON/CTD, 2B3, salps
61	74	5/26/2015	40.2583	-70.2383	97	BON/CTD, 2B3
62	75	5/26/2015	40.0833	-69.5917	104	BON/CTD, 2B3
63	76	5/26/2015	40.0017	-69.095	339	BON/CTD, 2B3
64	76	5/26/2015	39.9983	-69.085	480	CTD 19/19+ WATER CAST PROFILE
65	77	5/26/2015	40.155	-69.25	100	BON/CTD, 2B3
66	78	5/26/2015	40.405	-69.3267	77	BON/CTD, 2B3
67	79	5/26/2015	40.74	-69.2533	65	BON/CTD, 2B1 P
16	80	5/26/2015	40.895	-69.1583	68	**CTD PROFILE911, NUT, ISO, DIC**
68	81	5/26/2015	40.4183	-68.6717	87	BON/CTD, 2B1 C
69	82	5/26/2015	40.33	-68.2617	150	BON/CTD, 2B1 C
70	83	5/27/2015	40.6583	-67.835	82	BON/CTD, 2B3
71	84	5/27/2015	40.6617	-67.755	78	BON/CTD, 2B3
17	85	5/27/2015	40.9183	-67.7067	67	**CTD PROFILE911, NUT, DIC**
72	86	5/27/2015	40.99	-67.7533	58	BON/CTD, 2B3
73	87	5/27/2015	41.2433	-67.6767	37	BON/CTD, 2B3
74	88	5/27/2015	41.1717	-67.595	51	BON/CTD, 2B1 C
75	89	5/27/2015	41.0867	-67.2617	65	BON/CTD, 2B3
76	90	5/27/2015	40.75	-67.4917	88	BON/CTD, 2B3
18	91	5/27/2015	40.3867	-67.7033	152	CTD PROFILE911, NUT
19	92	5/27/2015	40.2533	-67.6883	1179	**CTD PROFILE911, NUT, ISO, DIC**
77	93	5/27/2015	40.4933	-67.3467	158	BON/CTD, 2B1 P
78	94	5/27/2015	40.915	-67.08	85	BON/CTD, 2B1 C
79	95	5/28/2015	40.9983	-66.8333	77	BON/CTD, 2B3
80	96	5/28/2015	41.0783	-66.8367	74	BON/CTD, 2B3
81	97	5/28/2015	41.16	-66.7517	70	BON/CTD, 2B3
82	98	5/28/2015	40.995	-66.5117	120	BON/CTD, 2B3
83	99	5/28/2015	41.1583	-66.34	159	BON/CTD, 2B1 P
84	99	5/28/2015	41.1433	-66.3367	285	CTD 19/19+ WATER CAST PROFILE
85	100	5/28/2015	41.5833	-66.255	91	BON/CTD, 2B3

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CTD Cast#	SiteID/ STA#	Date GMT	Latitude (dd)	Longitude (dd)	Bottom Depth(m)	Operation
86	101	5/28/2015	41.58	-66.1817	97	BON/CTD, 2B1 C
20	102	5/28/2015	41.7467	-65.4567	1776	**CTD PROFILE911, NUT, DIC**
21	103	5/28/2015	42.22	-65.7683	225	**CTD PROFILE911, NUT, ISO, DIC**
87	103	5/28/2015	42.215	-65.7717	223	BON/CTD, 2B1 P
88	104	5/28/2015	41.92	-66.0817	96	BON/CTD, 2B1 C
89	105	5/28/2015	41.9183	-66.2433	83	BON/CTD, 2B1 C
90	106	5/29/2015	41.9117	-66.83	63	BON/CTD 2B3
91	107	5/29/2015	42.0717	-66.9983	63	BON/CTD, 2B3
92	107	5/29/2015	42.0667	-66.9867	63	CTD 19/19+ WATER CAST PROFILE
93	108	5/29/2015	41.76	-67.16	52	BON/CTD, 2B3
94	109	5/29/2015	41.5833	-66.9333	64	BON/CTD, 2B3
95	110	5/29/2015	41.3433	-67.245	51	BON/CTD, 2B3
96	111	5/29/2015	41.4933	-67.5833	32	BON/CTD, 2B1 P
22	112	5/29/2015	41.475	-67.6817	40	**CTD PROFILE911, NUT, ISO, DIC**
97	113	5/29/2015	41.25	-68.23	42	BON/CTD, 2B3
98	114	5/29/2015	41.4083	-68.8217	138	BON/CTD, 2B3
99	115	5/29/2015	41.8133	-68.0433	58	BON/CTD, 2B3
100	115	5/29/2015	41.815	-68.04	58	CTD 19/19+ WATER CAST PROFILE
101	116	5/29/2015	41.8783	-67.6467	38	BON/CTD, 2B1 P
23	117	5/29/2015	42.0017	-67.6817	58	**CTD PROFILE911, NUT, ISO, DIC**
102	118	5/30/2015	42.1533	-67.6783	191	BON/CTD, 2B3
103	119	5/30/2015	42.235	-67.7467	230	BON/CTD, 2B1 C
104	119	5/30/2015	42.2417	-67.745	229	CTD PROFILE 19/19+
105	120	5/30/2015	42.575	-68.155	183	BON/CTD, 2B1 C
24	121	5/30/2015	42.7	-67.7083	190	CTD PROFILE911, NUT
106	122	5/30/2015	42.5833	-67.2617	286	BON/CTD, 2B3
107	122	5/30/2015	42.5783	-67.2583	289	CTD 19/19+ WATER CAST PROFILE
25	123	5/30/2015	42.385	-67.0567	345	**CTD PROFILE911, NUT, ISO**
108	123	5/30/2015	42.3833	-67.0583	344	BON/CTD, 2B1 P
109	124	5/30/2015	42.4867	-66.5117	265	BON/CTD, 2B3
110	124	5/30/2015	42.48	-66.5	264	CTD 19/19+ WATER CAST PROFILE
111	125	5/30/2015	42.6617	-65.93	86	BON/CTD, 2B1 C
112	126	5/30/2015	42.8233	-66.57	161	BON/CTD, 2B3

Table 1. Summary of sample activities conducted at 153 stations at which the *HENRY BIGELOW* stopped to lower instruments over the side during Cruise No. HB 1502. Latitude and Longitude are shown in decimal degrees.
Std BON/CTD = 61 cm bongo Standard Protocol, CTD PROFILE 911 = fixed station, 2B3 = 333 mesh
20 cm bongo 2B1 C = 165 mesh 20 cm bongo CMARZ 2B1 P = 165 mesh 20 cm bongo PRINCETON, NUT=nutrients

CTD Cast#	SiteID/ STA#	Date GMT	Latitude (dd)	Longitude (dd)	Bottom Depth(m)	Operation
26	127	5/30/2015	43.0367	-66.3467	132	**CTD PROFILE911, NUT, DIC**
113	128	5/31/2015	43.1617	-67.0783	189	BON/CTD, 2B3
114	129	5/31/2015	43.1633	-67.3217	184	BON/CTD, 2B1 C
115	130	5/31/2015	43.17	-67.65	192	BON/CTD, 2B3
27	131	5/31/2015	43.395	-67.7	248	**CTD PROFILE911, NUT, ISO, DIC**
116	131	5/31/2015	43.39	-67.69	247	BON/CTD, 2B1 P
28	132	5/31/2015	43.4917	-67.8717	284	CTD PROFILE911. NUT
117	133	5/31/2015	43.9733	-67.0133	170	BON/CTD, 2B3
29	134	5/31/2015	44.1983	-67.7133	176	**CTD PROFILE911, NUT, ISO, DIC**
118	135	5/31/2015	44.1633	-67.83	124	BON/CTD, 2B1 P
30	136	5/31/2015	43.7783	-68.665	111	**CTD PROFILE911, NUT, DIC**
119	137	6/1/2015	43.2533	-68.2533	198	BON/CTD, 2B3
120	138	6/1/2015	42.8333	-68.6717	195	BON/CTD, 2B3
121	139	6/1/2015	42.3383	-68.6633	188	BON/CTD, 2B1
122	140	6/1/2015	41.9983	-69.69	189	BON/CTD, 2B3
123	141	6/1/2015	41.8317	-69.83	78	BON/CTD, 2B3
124	142	6/1/2015	42.085	-70.0717	36	BON/CTD, 2B3
125	143	6/1/2015	42.4067	-69.9233	201	BON/CTD, 2B3
31	144	6/1/2015	42.5	-69.6817	263	**CTD PROFILE911, NUT, ISO, DIC**
126	144	6/1/2015	42.5067	-69.6667	250	BON/CTD, 2B1 P
127	145	6/2/2015	42.7467	-69.5217	206	BON/CTD, NO 2B
128	146	6/2/2015	43.2383	-69.5117	150	BON/CTD, NO 2B
129	147	6/2/2015	42.995	-70.1717	190	BON/CTD, 2B1 P
130	147	6/2/2015	42.9933	-70.175	189	BON/CTD, NO 2B
32	148	6/2/2015	43.0017	-70.4183	104	CTD PROFILE911, NUT
131	149	6/2/2015	42.425	-70.6183	88	BON/CTD, NO 2B
33	149	6/2/2015	42.4283	-70.6183	90	**CTD PROFILE911, NUT, DIC**
34	150	6/2/2015	42.3733	-70.4667	88	**CTD PROFILE911, NUT, DIC**
132	151	6/2/2015	42.335	-70.4183	94	BON/CTD, 2B3
35	152	6/2/2015	42.315	-70.29	33	CTD PROFILE911, DIC
133	153	6/2/2015	41.8317	-70.42	26	BON/CTD, 2B3

TOTALS:

Std BON/CTD Casts	**=**	**123**
CTD 19/19+ Water Casts	**=**	**9**
2B3 Bongo Casts	**=**	**75**
2B1 C Bongo Casts	**=**	**22**
2B1 P Bongo Casts	**=**	**18**
CTD PROFILE 911 Casts	**=**	**35**
Nutrient Casts	**=**	**35**
DIC Casts	**=**	**35**

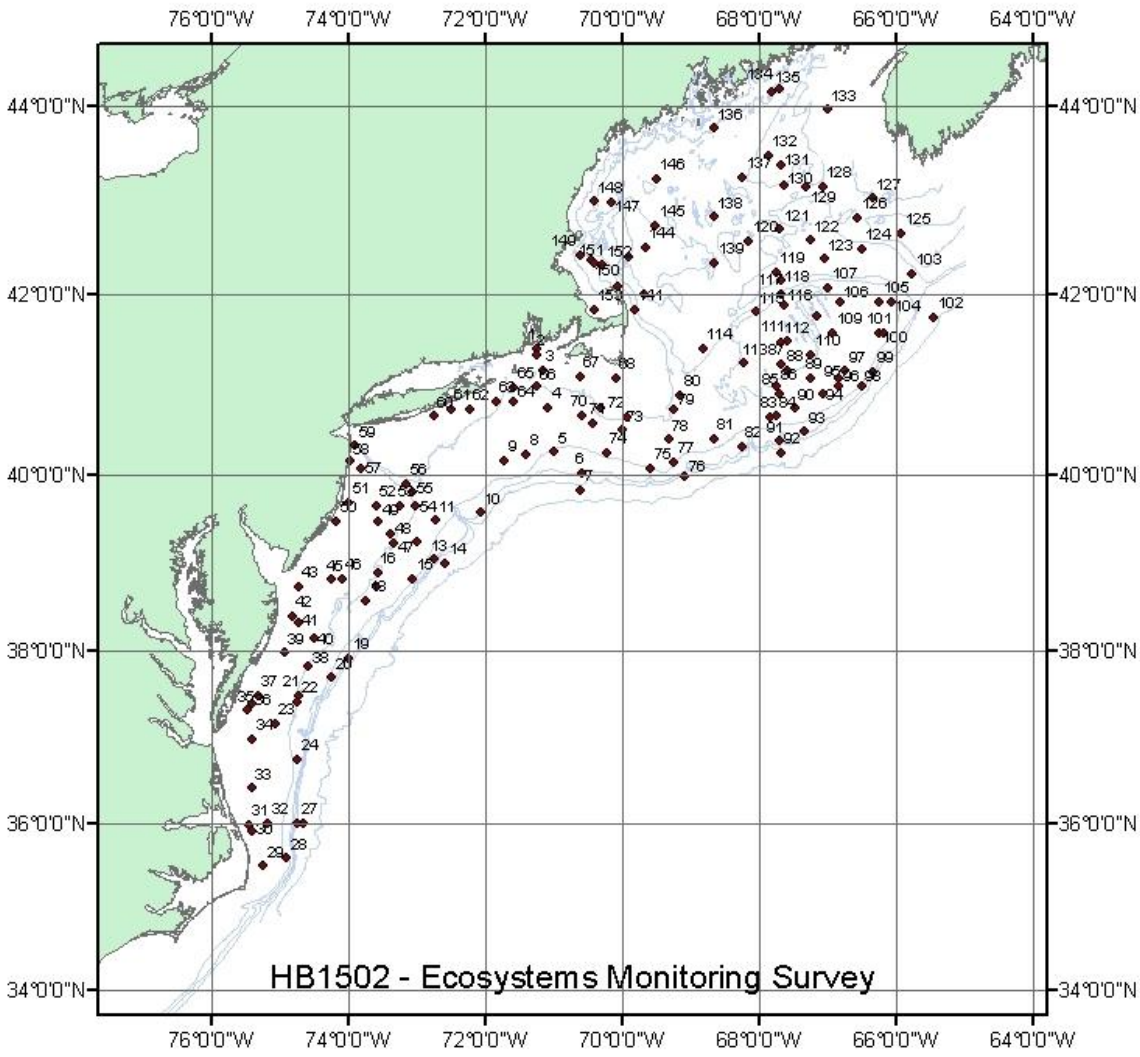


Figure 1. Station locations numbered consecutively for Spring Ecosystem Monitoring Survey HB 1502.

Figure 2. Bongo net array, showing 61 and 20 cm bongo nets being deployed from the *HENRY BIGELOW* Side Sampling Station. (DJ Kast photo).

Figure 3. Wetlabs Fluorometer mounted next to a Seabird 19 Profiler CTD on a Niskin Bottle Rosette.

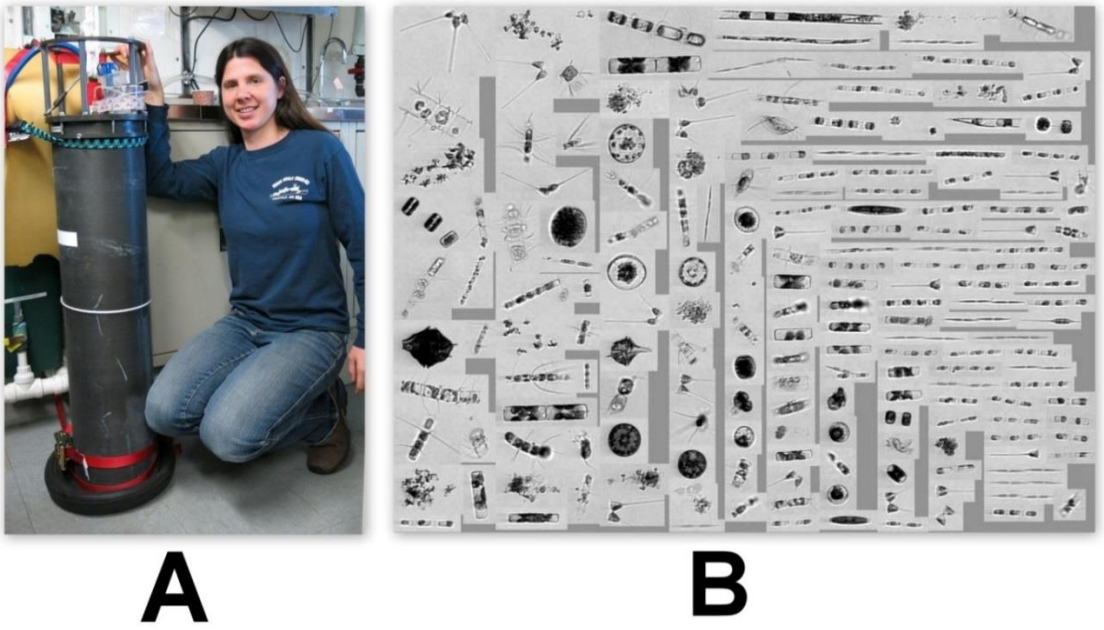


Figure 4. A. WHOI researcher Emily Peacock and Imaging FlowCytobot Unit. B. Images of Diatoms from the Imaging FlowCytobot Unit.

Figure 5. Seabird observer Tom Bradley and marine mammal observers Marjorie Foster and Brigid McKenna documenting their day's observations on the flying bridge of the *HENRY BIGELOW*.

Figure 6. A 23 foot Trans-Atlantic Rowboat anchored outside of New York Harbor, awaiting more favorable winds before heading to Gallipoli, Turkey was the recipient of a "care package" from the *HENRY BIGELOW*.

Figure 7. A. Sonar unit to communicate with AMAR buoy. B. Retrieval of AMAR buoy on the port stern quarter of the *HENRY BIGELOW*.

A B

Figure 8. A. NOAA Drifter Buoy #39708 being deployed from the starboard stern quarter of the *HENRY BIGELOW* by NOAA Teacher-at-Sea DJ Kast.

B. Track of Drifter Buoy #39708 during 7-27 July 2015.

Appendix A.

Seabird Survey Report
19 May - 2 June, 2015
Canadian Wildlife Service, Environment Canada
45 Alderney Drive, Dartmouth, Nova Scotia, Canada
Carina Gjerdrum carina.gjerdrum@ec.gc.ca
Seabird Observer: Brad Toms

Background

The east coast of Canada supports millions of breeding marine birds as well as migrants from the

southern hemisphere and northeastern Atlantic. In 1969, PIROP (*Programme intégré de recherches sur les oiseaux pélagiques*) was initiated based on a systematic survey technique and computer database (Brown *et al.* 1975; Brown 1986) to document the abundance and distribution of marine birds in Atlantic Canada and elsewhere. The program was operated by the Canadian Wildlife Service (CWS) of Environment Canada and supported by the large DFO (Department of Fisheries and Oceans) oceanographic fleet based in eastern Canada. Much of the data collected under PIROP are limited beyond the mid-1980s, therefore, CWS reinvigorated the pelagic seabird monitoring program in 2005 with the goal of identifying and minimizing the impacts of human activities on birds in the marine environment. Since 2005, a protocol for collecting data at sea (Gjerdrum *et al.* 2012) and a sophisticated geodatabase have been developed, relationships with industry and others to support offshore seabird observers have been established, and over 200,000 km of ocean track have been surveyed by CWS-trained observers. These data are now being used to identify and address threats to birds in their marine environment (Gjerdrum *et al.* 2008; Fifield *et al.* 2009; Lieske *et al.* 2014; Wong *et al.* 2014).

Objective

The objective of our seabird survey on board the Henry Bigelow in May-June, 2015 was to collect data on the distribution and abundance of seabirds as part of our long term monitoring program for seabirds at sea in eastern Canada.

Methods

Seabird surveys were conducted from the port side of the bridge of the Henry Bigelow during oceanographic surveys from 19 May to 2 June, 2015. Surveys were conducted while the ship was moving at speeds greater than 4 knots, looking forward and scanning a 90° arc to one side of the ship. All birds observed on the water within a 300m-wide transect were recorded, and we used the snapshot approach for flying birds (intermittent sampling based on the speed of the ship) to avoid overestimating abundance of birds flying in and out of transect. Distance sampling methods were incorporated to address the variation in bird detectability (Buckland *et al.* 2001). Marine mammal, large fish, and turtle observations were also recorded, although surveys were not specifically designed to detect marine organisms other than birds. Details of the methods used can be found in the CWS standardized protocol for pelagic seabird surveys from moving platforms (Gjerdrum *et al.* 2012).

Results and discussion

Seabird sightings

We surveyed 1506 km of ocean track from 19 May to 2 June, 2015 (Figure 1). A total of 4203 waterbirds from 9 families were observed during the surveys; 2867 of the birds sighted were counted in transect (Table 1). Overall, bird densities averaged 5.3 birds/km^2 (ranging from 0 - 550.0 birds/km^2). The highest densities of birds (>100 birds/km^2; Figure 1) were observed on George's

Bank, offshore Rhode Island (southwest of Cape Cod), and to the southeast of New York City.

Great shearwater was the most commonly observed species, accounting for 21% of the observations, followed by the sooty shearwater (15% of the observations; Table 1). Both species breed in the southern hemisphere and spend their non-breeding season in the North Atlantic. Most were observed on George's Bank (Figure 2a). Other members of the family Procellariidae were sighted in far fewer numbers, and included northern fulmar (Figure 2b), Cory's shearwater, Audubon's shearwater and Manx shearwater, all breeders from the northern hemisphere.

Storm-petrels made up a total of 20% of the observations. The largest flocks were observed on George's Bank and off Rhode Island, particularly at the shelf edges (Figure 2c). The Leach's storm-petrel breeds in the millions in Newfoundland and Labrador and Nova Scotia. They begin arriving in Atlantic breeding colonies in April and May, and are known to wander widely prior to egg-laying, which typically begins in late May. Wilson's storm-petrels breed in the southern hemisphere and winter in the North Atlantic. They are at times difficult to tell apart from the Leach's storm-petrels, and as a result, most of what were observed were unidentified to species.

Phalaropes accounted for 18% of the observations and were observed primarily on George's Bank and off southwest Nova Scotia (Figure 2d). These birds are moving towards their Arctic breeding grounds, using the Bay of Fundy and Gulf of Maine as a stopover site.

Sightings of the family Laridae (skua, jaegers, gulls and terns) made up a total of 12% of the observations, the majority of which were herring and black-backed gulls (Figure 3a) as well as common terns (Figure 3b). Most of these birds were observed at points closer to shore, likely associated with local breeding sites.

Marine Mammal, turtle and fish sightings

Although the survey protocol (Gjerdrum et al. 2012) used for the seabird surveys was not designed for marine mammals, turtles or large fish, these observations were also recorded. A total of 331 marine organisms in addition to the birds were sighted and recorded (Table 2). These included 258 dolphin, 34 whales, 22 unidentified cetaceans, 1 seal, 14 fish and 2 turtles (Table 2; Figure 4).

Data Storage

All data collected on marine bird, mammal, fish and turtles from the Henry Bigelow have been imported into our main pelagic seabird survey database (MS Access), which is managed by Canadian Wildlife Service, Environment Canada in Dartmouth, Nova Scotia. The data are made publically available on OBIS (Ocean Biogeographic Information System), which is updated on a semi-annual basin.

Acknowledgements

The CWS monitoring program for seabirds at sea relies on the generous support of ships' crew and personnel; the surveys conducted from the Henry Bigelow would not have been possible without the kind support of Jerry Prezioso, NOAA, and we thank Jerry, the science staff, and ship's crew for giving us this valuable opportunity to accompany their mission.

Table 1: List of bird species sighted during seabird surveys on board the Henry Bigelow from 19 May to 2 June, 2015.

Family	English	Latin	Number observed in transect	Total number observed
Gaviidae	Common Loon	*Gavia immer*	16	16
Procellariidae	Great Shearwater	*Puffinus gravis*	616	729
	Northern Fulmar	*Fulmarus glacialis*	232	578
	Sooty Shearwater	*Puffinus griseus*	429	542
	Cory's Shearwater	*Calonectris diomedea*	29	41
	Audubon's Shearwater	*Puffinus lherminieri*	3	3
	Manx Shearwater	*Puffinus puffinus*	1	1
	Unidentified Shearwaters	*Puffinus* or *Calonectris*	19	116
Hydrobatidae	Leach's Storm-Petrel	*Oceanodroma leucorhoa*	108	139
	Wilson's Storm Petrel	*Oceanites oceanicus*	21	80
	White-faced Storm-Petrel	*Pelagodroma marina*	1	1
	Unidentified Storm-Petrels	Hydrobatidae	428	828
Sulidae	Northern Gannet	*Morus bassanus*	57	67
	Masked Booby	*Sula dactylatra*	1	1
Phalacrocoracidae	Double-crested Cormorant	*Phalacrocorax auritus*	6	9
	Great Cormorant	*Phalacrocorax carbo*	0	2
Anatidae	White-winged Scoter	*Melanitta fusca*	18	30
	Unidentified Ducks	Anatidae	0	4
Scolopacidae	Red Phalarope	*Phalaropus fulicaria*	136	136
	Red-necked Phalarope	*Phalaropus lobatus*	33	33
	Unidentified Phalaropes	*Phalaropus*	339	342
Laridae	Great Skua	*Stercorarius skua*	6	6
	Unidentified Skuas	*Stercorarius*	0	1
	Parasitic Jaeger	*Stercorarius parasiticus*	2	3
	Pomarine Jaeger	*Stercorarius pomarinus*	2	2
	Long-tailed Jaeger	*Stercorarius longicaudus*	1	1
	Unidentified Jaegers	*Stercorarius*	0	1
	Herring Gull	*Larus argentatus*	80	113
	Great Black-backed Gull	*Larus marinus*	26	56
	Black-headed Gull	*Larus ridibundus*	3	3
	Laughing Gull	*Larus atricilla*	2	2
	Lesser Black-backed Gull	*Larus fuscus*	2	2
	Unidentified Gulls	Laridae	0	4
	Common Tern	*Sterna hirundo*	161	176
	Least Tern	*Sterna albifrons*	0	17
	Unidentified Terns	Sternidae	73	102
Alcidae	Razorbill	*Alca torda*	15	15
	Unidentified Murres	*Uria*	1	1
TOTALS			**2867**	**4203**

Table 2: List of other marine organisms sighted during seabird surveys on board the Henry Bigelow from 19 May to 2 June, 2015.

English	Latin	Total number observed
Common Dolphin	*Delphinus delphis*	219
Long-snouted Spinner Dolphin	*Stenella longirostris*	6
Unidentified Dolphins	Delphinidae	33
Long-finned Pilot Whale	*Globicephala melas*	23
Fin Whale	*Balaenoptera physalus*	9
Genus: Pilot whales	*Globicephala*	2
Unidentified cetacean	Cetacea	22
Gray Seal	*Halichoerus grypus*	1
Ocean Sunfish	*Mola mola*	8
Sharks	Elasmobranchii	6
Loggerhead Sea Turtle	*Caretta caretta*	1
Leatherback Turtle	*Dermochelys coriacea*	1

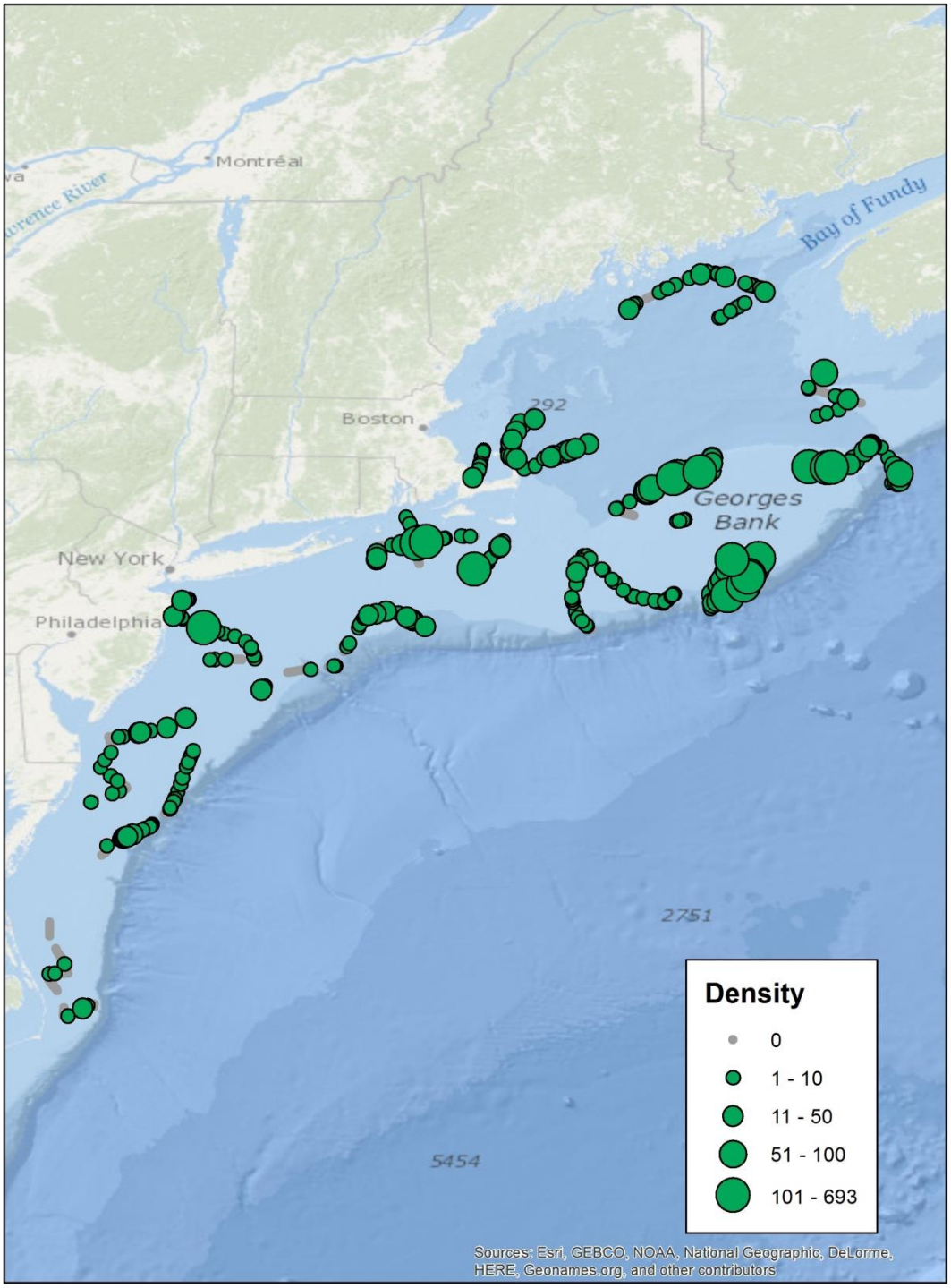


Figure 1. Density (count/km^2) of birds (all species combined) sighted during seabird surveys on board the Henry Bigelow from 19 May to 2 June, 2015.

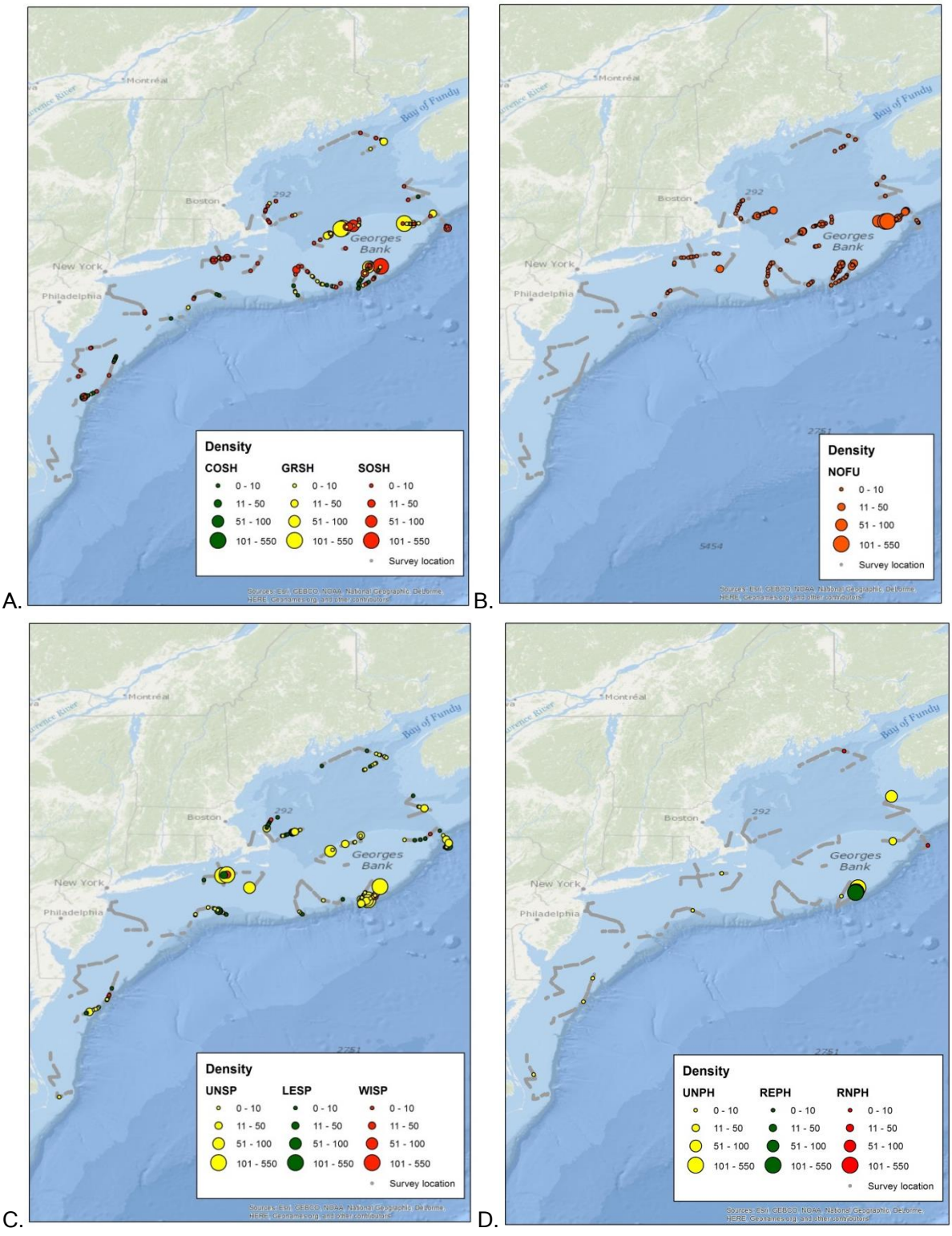
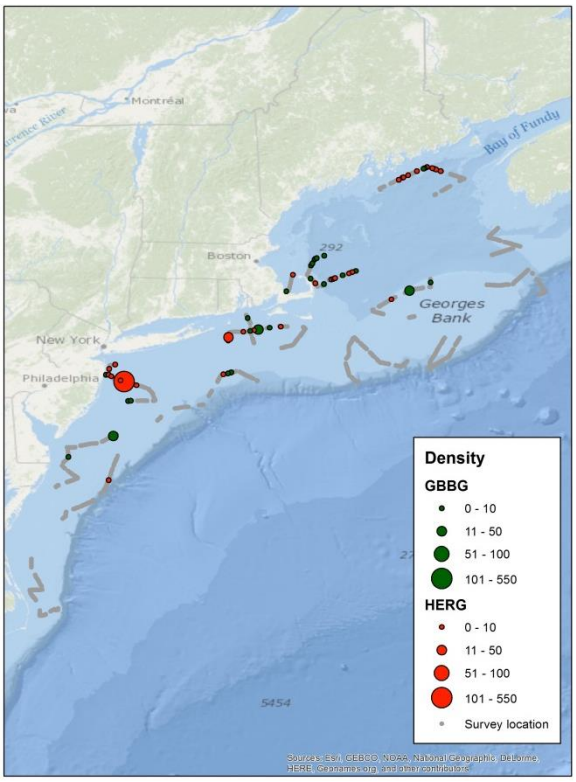


Figure 2. Density (count/km^2) of (A) shearwaters (GRSH = great shearwater; SOSH = sooty shearwater; COSH = Cory's shearwater; (B) northern fulmar (NOFU); (C) Hydrobatidae (LESP = Leach's storm-petrel; WISP = Wilson's storm-petrel; UNSP = unidentified storm-petrel); and (D) phalaropes (UNPH = unidentified phalarope; REPH = red phalarope; RNPH = red-necked phalarope) sighted during seabird surveys on board the Henry Bigelow from 19 May to 2 June, 2015.

A. 

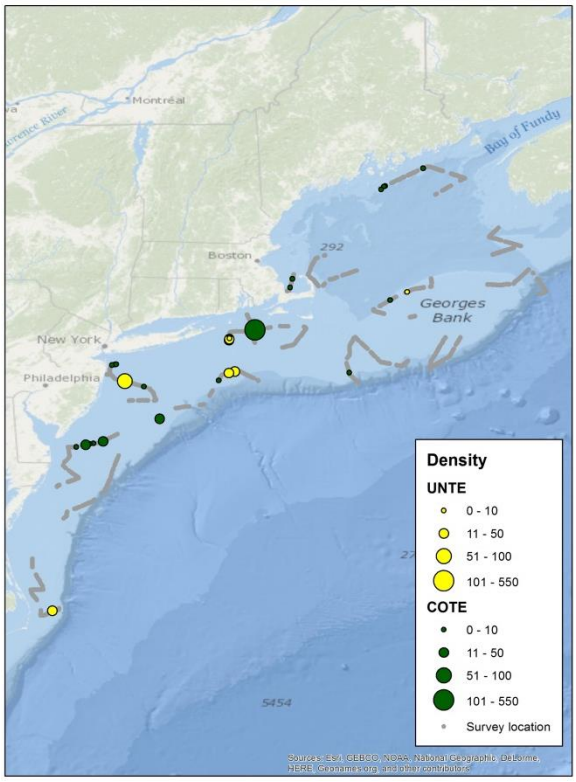
B. 

Figure 3. Density of (A) gulls (HERG = herring gull; GBBG = great black-backed gull); and (B) terns (UNTE = unidentified tern; COTE = common tern) sighted during seabird surveys on board the Henry Bigelow from 19 May to 2 June, 2015.

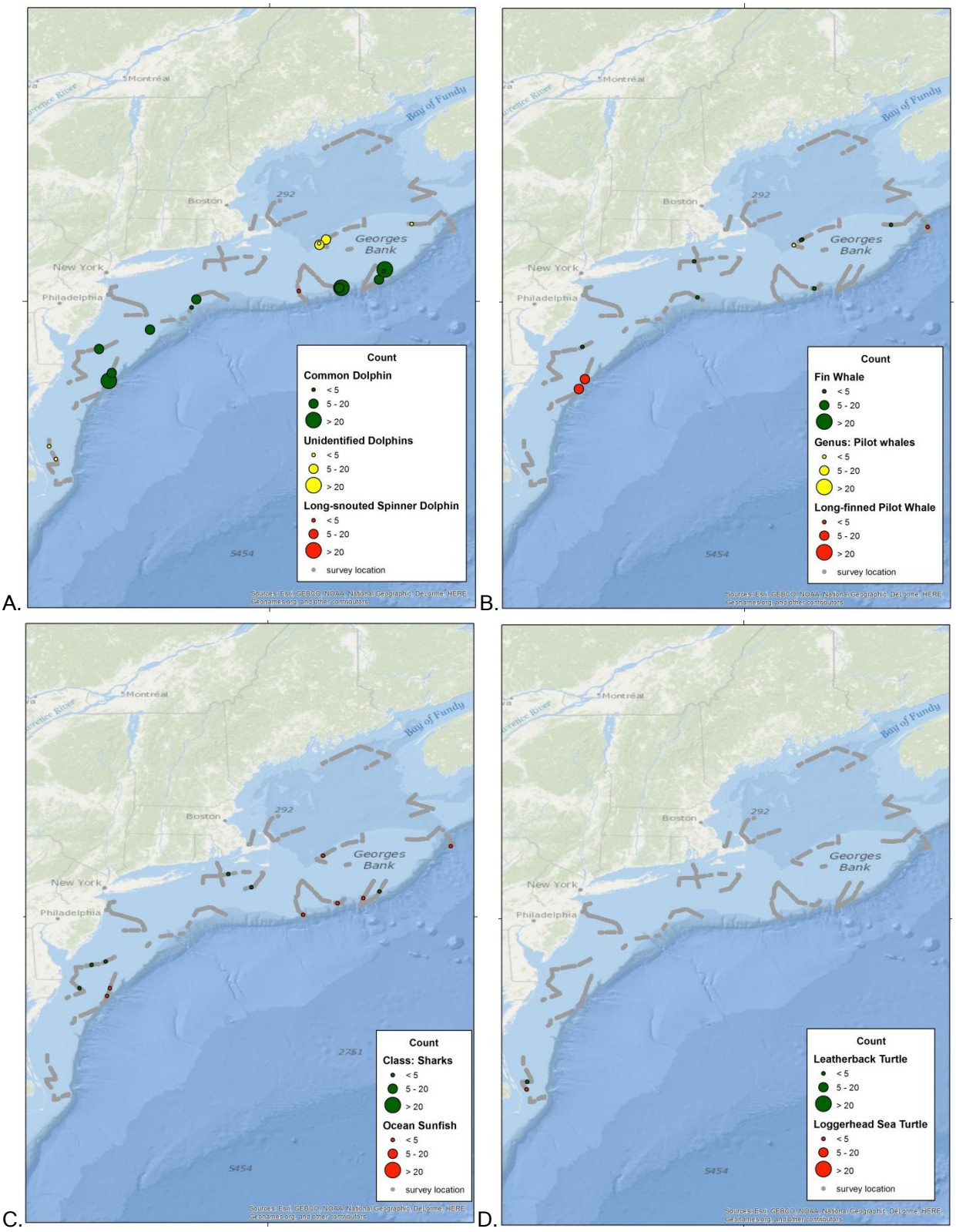


Figure 4. Counts of (A) dolphins; (B) whales; (C) fish; and (D) turtles sighted during seabird surveys on board the Henry Bigelow from 19 May to 2 June, 2015.

References cited

Brown, R. G. B. 1986. Revised Atlas of Eastern Canadian Seabirds. Canadian Wildlife Service, Ottawa.

Brown, R. G. B., D. N. Nettleship, P. Germain, C. E. Tull, and T. Davis. 1975. Atlas of eastern Canadian seabirds. Canadian Wildlife Service, Ottawa.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to Distance Sampling: Estimating Abundance of Biological Populations. Oxford University Press, Oxford.

Fifield, D. A., K. P. Lewis, C. Gjerdrum, G. J. Robertson, and R. Wells. 2009. Offshore seabird montiroing program. Environmental Studies Research Funds Report No. 183, St. John's.

Gjerdrum, C., D. A. Fifield, and S. I. Wilhelm. 2012. Eastern Canada Seabirds at Sea (ECSAS) standardized protocol for pelagic seabird surveys from moving and stationary platforms. Technical Report Series 515. Canadian Wildlife Service Atlantic Region.

Gjerdrum, C., E. J. H. Head, and D. A. Fifield. 2008. Monitoring seabirds at sea in eastern Canada. AZMP Bulletin PMZA 7:52-58.

Lieske, D. J., D. A. Fifield, and C. Gjerdrum. 2014. Maps, models, and marine vulnerability: Assessing the community distribution of seabirds at-sea. Biological Conservation 172:15-28.

Wong, S., C. Gjerdrum, K. H. Morgan, and M. L. Mallory. 2014. Hotspots in cold seas: the composition, distribution and abundance of marine birds in the North American Arctic. Journal of Geophysical Research - Oceans 119:1691-1705.