CRUISE RESULTS
NOAA Research Vessel GORDON GUNTER
Cruise No. GU 15-06
Fall Northeast Ecosystem Monitoring Survey

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CRUISE PERIOD AND AREA

The NOAA research vessel *GORDON GUNTER* sampled a total of 117 stations from 12 to 26 October 2015. With the loss of several days at the start of the cruise due to Hurricane Joaquin, and periods of marginal weather during much of the remaining cruise period, the southernmost portion of the Mid-Atlantic Bight (MAB) and most of the Gulf of Maine (GOM) were not surveyed. Good coverage was achieved in the Mid-Atlantic Bight north of the Chesapeake Bay, in southern New England (SNE) waters and on Georges Bank (GB).

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 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 taken at various depths with a rosette water sampler at six fixed locations.

METHODS

The survey consisted of 117 stations at which the vessel stopped to lower instruments over the port side of the vessel from a J-frame and two conductive-wire winches. Of these, 28 were in the Middle Atlantic Bight (MAB), 34 were in Southern New England (SNE), 39 were on Georges Bank (GB), and 16 were in the Gulf of Maine (GOM) (Figure 1).

Plankton and hydrographic sampling was conducted with double oblique tows using the 61-cm bongo sampler and a Seabird CTD. The tows were 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 number of revolutions during the tow. At the 20 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). No flowmeters were used in the 20-cm bongos. A similar array, with 20 cm 335 micron mesh nets deployed above the 61 cm 335 micron mesh nets, was fished for larval fish and egg samples for NOAA researcher David Richardson at all the other plankton stations. These samples were saved for genetics and otolith analysis to be carried out 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. The plankton sampling gear was deployed off the port side of the vessel using a J-frame and a conducting cable winch. 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 high baud rate from the Seabird 19+ CTD profiler over the great length of wire (>1600 meters) on the *GORDON* GUNTER 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 were preserved in 95% ethanol, which was changed once 24 hours after the initial preservation.

A Seabird 911+ CTD was deployed on a rosette frame with a carousel water sampling system (SBE32) and 11 10-liter Niskin bottles at all fixed stations. The 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, carbonate chemistry and stable isotope analysis of phytoplankton (Figure 3).

Salinity, temperature and chlorophyll-*a* levels were monitored continuously from a depth of about 3 meters along the entire cruise track using a thermosalinograph, and a 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 fluorometer at 10-second intervals. Records were given a time-date stamp by the GPS unit. In addition, an ImagingFlowCytobot unit was plumbed into the flow-through seawater system in the CTD lab (Figure 4**).** The device captured images of diatoms, dinoflagellates and marine ciliates on an independent computer provided by the Woods Hole Oceanographic Institution (WHOI) (Figure 5). This system was monitored daily by University of Maine researcher Maura Thomas.

Marine mammal and seabird observations and photography were conducted from the bridge of the *GORDON GUNTER* by Canadian Wildlife Observer Jeannine Winkel (Figure 6). A Seabird Survey Report by Carina Gjerdrum of the Canadian Wildlife Service, Environment Canada summarizes Jeannine'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 *GORDON GUNTER* sailed from the Marine Operations Center in Norfolk Virginia at 1500 on Columbus Day, Monday October 12, 2015. Sampling was started right outside of Chesapeake Bay as the vessel proceeded north on a track through the Middle Atlantic Bight towards Southern New England waters. From the Southern New England area the track was set to sample stations in the western Gulf of Maine while a weather system moved across and away from Georges Bank. The *GORDON GUNTER* followed behind the front, moving onto Georges Bank where this high priority area was sampled in its entirety as weather conditions improved. Upon completion of the Georges Bank sampling there was just enough time left for sampling some of the remaining plankton stations in the eastern part of the Southern New England area before docking at the Newport Naval Station Pier 2 in Narragansett Bay Rhode Island, where the cruise ended at 0900 on October 26, 2015.

The survey coverage for this cruise was truncated owing to the loss of several days at the start of the survey from Hurricane Joaquin. Twelve of the southernmost stations down to Cape Hatteras in the Middle Atlantic Bight were skipped to save time. The remainder of the Mid-Atlantic Bight was sampled thoroughly, as was all of Southern New England and Georges Bank. Most of the Gulf of Maine was not surveyed at all, due to lack of time. Only 13 stations in the southwest portion of the Gulf of Maine, and 2 stations in the eastern Gulf of Maine were sampled. A CTD 911 Niskin Bottle Rosette array was made next to NERACOOS Gulf of Maine Northeast Channel Buoy N 0118 to provide hydrographic data for the NEFSC Fisheries Oceanography Branch and nutrient data for researchers at the University of Maine. The Fisheries Oceanography Branch Fixed Station Northeast Channel GOM Acid 2 was sampled with both the CTD 911 Rosette for hydrographic data and bongo nets for plankton samples.

Although we did not have any teachers from the NOAA Teacher-at-Sea program on this cruise we did bring a student project from Prout High School in Narragansett, RI with us. A Styrofoam manikin head decorated by Oceanography Class students was submerged on 25 casts down to as deep as 500 meters in a mesh bag on the Niskin Bottle rosette array. The water pressure from these casts shrunk the head down to a fraction of its original size, dramatically demonstrating the pressure effects of Boyle's Law on the gas bubbles that make up the bulk of Styrofoam material (Figure 7).

Water samples from 6 stations were collected to provide stable isotope samples for Princeton researcher Jessica Lueders-Dumont, to continue her sample collections from the previous Ecosystem Monitoring cruise in May-June 2015. We had originally planned to collect 8 samples but did not reach the northern and southernmost sites due to the cruise truncation.

Dissolved Inorganic Carbon (DIC) samples were collected at 21 of the fixed stations from various depths sampled with the CTD 911 Rosette array.

A turtle tracking tag was tested for the Protected Species Branch by submerging it during our CTD 911 Niskin Bottle Rosette casts on the first days of the cruise.

Census of Marine Zooplankton (CMarZ) were collected using the 20 cm bongos with 165 micron mesh nets from all 4 areas sampled; MAB, SNE, GB and GOM. Five stations from each of these areas were sampled, for a total of 20 CMarZ samples. A total of 74 plankton samples from across the entire survey area were obtained for Dave Richardson using 20 cm bongos with 335 micron mesh nets.

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 Ecosystem Monitoring Group of the NEFSC, Narragansett, RI, for quality control processing and further analysis. The CMarZ samples were delivered to Nancy Copley at the Woods Hole Oceanographic Institution. The nutrient samples were taken by Maura Thomas to the University of Maine. The frozen stable isotope samples were sent to Jessica Lueders-Dumont at Princeton University. The CTD data were delivered to the Oceanography Branch of the NEFSC, Woods Hole, MA. Marine mammal observation data 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 117 stations at which the *GORDON GUNTER* stopped to lower instruments over the side during Cruise No. GU 1506. Latitude and Longitude are shown in decimal degrees.
Std BON/CTD = 61 cm bongo Standard Protocol, CTD PROFILE 911 = fixed station, P = Princeton isotope samples
2B3 D = 333 mesh 20 cm bongo Dave R. samples, 2B1 C = 165 mesh 20 cm bongo CMARZ samples
NUT=nutrients, DIC=Dissolved Inorganic Carbon, ISO=stable isotope samples, CHL=chlorophyll samples

CTD Cast	SiteID/ STA#	Date GMT	Latitude (dd)	Longitude (dd)	Bottom Depth(m)	Operation
1	1	10/12/2015	37.0833	-75.665	16.5	BON/CTD, 2B1 C
2	2	10/13/2015	37.1667	-75.4133	30.2	BON/CTD, 2B3 D
3	3	10/13/2015	37.1683	-74.915	49.2	BON/CTD, 2B3 D
4	4	10/13/2015	37.4167	-74.9967	35	BON/CTD, 2B3 D
5	5	10/13/2015	37.5817	-74.7567	48	BON/CTD, 2B3 D
1	6	10/13/2015	37.7067	-74.26	109	**CTD PROFILE 911+, NUT, DIC**
6	7	10/13/2015	38.0817	-74.09	82	BON/CTD, 2B3 D
7	8	10/13/2015	37.9967	-74.5783	37.9	BON/CTD, 2B1 C
2	9	10/13/2015	37.8467	-74.5767	53.4	**CTD PROFILE 911+, NUT, DIC, ISO**
8	10	10/13/2015	37.915	-74.9183	23.5	BON/CTD, 2B3 D
3	11	10/13/2015	38.0017	-74.9583	22	**CTD PROFILE 911+, NUT, DIC**
9	12	10/13/2015	38.505	-74.9617	16	BON/CTD, 2B3 D
10	13	10/14/2015	38.505	-74.8217	26.1	BON/CTD, 2B1 C
11	14	10/14/2015	38.8317	-74.8	17	BON/CTD, 2B1 C
12	15	10/14/2015	38.725	-74.5833	27	BON/CTD, 2B3 D
13	16	10/14/2015	39.2433	-74.4883	16	BON/CTD, 2B3 D
14	17	10/14/2015	39.5017	-73.92	26	BON/CTD, 2B3 D
4	18	10/14/2015	39.7083	-74.0033	23	**CTD PROFILE 911+, NUT, DIC**
15	19	10/14/2015	39.6633	-73.8367	32	BON/CTD, 2B3 D
5	20	10/14/2015	39.3617	-73.3933	49	**CTD PROFILE 911+, NUT, DIC**
16	21	10/14/2015	39.33	-73.3333	50.6	BON/CTD, 2B3 D
17	22	10/14/2015	39.2467	-73.5917	47	BON/CTD, 2B1 C
18	23	10/14/2015	38.9967	-73.5017	53.6	BON/CTD, 2B3 D
19	24	10/14/2015	38.835	-73.5167	58	BON/CTD, 2B3 D
20	25	10/15/2015	38.9933	-73.2467	72.3	BON/CTD, 2B3 D
21	26	10/15/2015	38.995	-72.9133	96	BON/CTD, 2B3 D
6	27	10/15/2015	39.055	-72.7417	199	**CTD PROFILE 911+, NUT, DIC**
7	28	10/15/2015	39.0133	-72.5833	1000	**CTD PROFILE 911+, NUT, DIC**
22	29	10/15/2015	39.5	-72.5	112	BON/CTD, 2B3 D
23	30	10/15/2015	39.5	-72.9167	60	BON/CTD, 2B3 D
24	31	10/15/2015	39.5817	-72.9183	62	BON/CTD, 2B3 D
25	32	10/15/2015	39.915	-73.3317	52	BON/CTD, 2B3 D
26	33	10/15/2015	40.3317	-73.395	32.1	BON/CTD, 2B1 C
27	34	10/15/2015	40.0833	-73.0017	49	BON/CTD, 2B1 C
28	35	10/15/2015	40.165	-72.9217	48.3	BON/CTD, 2B3 D

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Std BON/CTD = 61 cm bongo Standard Protocol, CTD PROFILE 911+ = fixed station, P = Princeton isotope samples
2B3 D = 333 mesh 20 cm bongo Dave R. samples, 2B1 C = 165 mesh 20 cm bongo CMARZ samples
NUT=nutrients, DIC=Dissolved Inorganic Carbon, ISO=stable isotope samples, CHL=chlorophyll samples

CTD Cast#	SiteID/ STA#	Date GMT	Latitude (dd)	Longitude (dd)	Bottom Depth(m)	Operation
29	36	10/15/2015	40.4417	-72.625	46	BON/CTD, 2B3 D
30	37	10/16/2015	39.9967	-72.5817	63.5	BON/CTD, 2B3 D
31	38	10/16/2015	39.915	-71.9983	96	BON/CTD, 2B3 D
32	39	10/16/2015	40.0817	-71.8367	84	BON/CTD, 2B1 C
33	40	10/16/2015	40.25	-71.5033	88	BON/CTD, 2B3 D
34	41	10/16/2015	40.4217	-71.4183	75	BON/CTD, 2B3 D
35	42	10/16/2015	40.3317	-71.2567	89	BON/CTD, 2B1 C
36	43	10/16/2015	40.58	-70.92	73	BON/CTD, 2B3 D
37	44	10/16/2015	40.6133	-71.5	67	BON/CTD, 2B1 C
38	45	10/16/2015	40.9983	-71.17	53.3	BON/CTD, 2B3 D
39	46	10/17/2015	40.9983	-71.5867	43	BON/CTD, 2B3 D
40	47	10/17/2015	41.085	-71.5017	22.5	BON/CTD, 2B3 D
41	48	10/17/2015	41.25	-71.3367	38	BON/CTD, 2B3 D
8	49	10/17/2015	41.1067	-70.6233	44	**CTD PROFILE 911+, NUT, DIC**
42	50	10/17/2015	41.165	-70.505	38	BON/CTD, 2B3 D
43	51	10/17/2015	40.665	-70.0883	47	BON/CTD, 2B3 D
9	52	10/17/2015	40.67	-70.62	62.2	**CTD PROFILE 911+, NUT, DIC**
10	53	10/17/2015	40.0383	-70.6017	169	**CTD PROFILE 911+, NUT, DIC**
11	54	10/17/2015	39.8333	-70.6233	900	**CTD PROFILE 911+, NUT, DIC**
44	55	10/18/2015	39.9133	-69.7533	255	BON/CTD, 2B3 D
45	55	10/18/2015	39.9233	-69.7533	233	CTD PROFILE 19/19+
46	56	10/18/2015	40.3333	-69.505	74	BON/CTD, 2B3 D
47	57	10/18/2015	40.4983	-69.7483	71	BON/CTD, 2B3 D
48	58	10/18/2015	40.58	-69.5	57	BON/CTD, 2B3 D
49	59	10/18/2015	40.6633	-69.0017	68	BON/CTD, 2B3 D
12	60	10/19/2015	40.8983	-69.1617	68.9	**CTD PROFILE 911+, NUT, DIC, ISO, CHL**
50	61	10/19/2015	40.9983	-69.0867	78	BON/CTD, 2B3 D
51	62	10/19/2015	41.165	-68.835	89	BON/CTD, 2B3 D
52	63	10/19/2015	41.33	-68.92	143	BON/CTD, 2B3 D
53	64	10/19/2015	41.9133	-69	188	BON/CTD, 2B1 C
54	65	10/19/2015	42.25	-69.6783	250	BON/CTD, 2B1 C

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2B3 D = 333 mesh 20 cm bongo Dave R. samples, 2B1 C = 165 mesh 20 cm bongo CMARZ samples
NUT=nutrients, DIC=Dissolved Inorganic Carbon, ISO=stable isotope samples, CHL=chlorophyll samples

CTD Cast#	SiteID/ STA#	Date GMT	Latitude (dd)	Longitude (dd)	Bottom Depth(m)	Operation
55	65	10/19/2015	42.25	-69.6783	245	CTD 19/19+ WATER CAST PROFILE
58	66	10/19/2015	42.3267	-69.9383	210	BON/CTD, 2B3 D
13	67	10/20/2015	42.3167	-70.28	31	**CTD PROFILE 911+, NUT, DIC, CHL**
14	68	10/20/2015	42.36	-70.4683	68	**CTD PROFILE 911+, NUT, CHL**
59	69	10/20/2015	42.4167	-70.615	86	BON/CTD, 2B1 C
15	69	10/20/2015	42.4217	-70.6217	86	**CTD PROFILE 911+, NUT, DIC, CHL**
60	70	10/20/2015	42.4133	-70.2517	63	BON/CTD, 2B3 D
16	71	10/20/2015	42.9983	-70.4217	105	**CTD PROFILE 911+, NUT, DIC, CHL**
61	72	10/20/2015	42.9983	-70.085	125	BON/CTD, 2B1 C
62	72	10/20/2015	42.995	-70.1017	143	BON/CTD, 2B3 D
63	73	10/20/2015	42.5	-69.6683	255	BON/CTD, 2B3 D
17	73	10/20/2015	42.5067	-69.68	261	**CTD PROFILE 911+, NUT, DIC, CHL, ISO**
64	74	10/21/2015	42.3167	-68.5583	169	BON/CTD, 2B1 C
65	75	10/21/2015	41.7483	-68.17	53	BON/CTD, 2B3 D
66	76	10/21/2015	41.5133	-67.9967	34	BON/CTD, 2B3 D
18	77	10/21/2015	41.465	-67.6867	37	**CTD PROFILE 911+, NUT, DIC, CHL**
67	78	10/21/2015	41.58	-67.4217	32	BON/CTD, 2B1 C
19	79	10/21/2015	42.0083	-67.6933	64	**CTD PROFILE 911+, NUT, DIC, ISO, CHL**
68	80	10/21/2015	41.9133	-67.505	52	BON/CTD, 2B1 C
69	81	10/21/2015	41.8317	-66.9983	64	BON/CTD, 2B3 D
70	82	10/21/2015	42.08	-66.7467	77	BON/CTD, 2B3 D
71	83	10/21/2015	42.085	-66.6033	82	BON/CTD, 2B1 C
20	84	10/22/2015	42.3067	-65.91	228	**CTD PROFILE 911+, NUT, CHL**
72	85	10/22/2015	42.225	-65.7683	227	BON/CTD, 2B3 D
21	85	10/22/2015	42.2233	-65.765	226	**CTD PROFILE 911+, NUT, DIC, ISO, CHL**
22	86	10/22/2015	41.7517	-65.4417	1800	**CTD PROFILE 911+, NUT, DIC, CHL**
73	87	10/22/2015	41.915	-65.9233	110	BON/CTD, 2B3 D
74	88	10/22/2015	41.8317	-66.085	94	BON/CTD, 2B3 D
75	89	10/22/2015	41.7467	-66.335	80	BON/CTD, 2B3 D
76	90	10/22/2015	41.9083	-66.4267	88	BON/CTD, 2B1 C
77	91	10/22/2015	41.665	-67.085	58	BON/CTD, 2B3 D
78	92	10/22/2015	41.5817	-67.005	62	BON/CTD, 2B3 D
79	93	10/22/2015	41.4133	-67.17	52	BON/CTD, 2B1 C
80	94	10/23/2015	41.165	-67.0883	64	BON/CTD, 2B3 D
81	95	10/23/2015	41.08	-66.6717	80	BON/CTD, 2B3 D
82	96	10/23/2015	40.9133	-66.755	94	BON/CTD, 2B3 D
83	97	10/23/2015	40.8333	-66.7517	114	BON/CTD, 2B3 D

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2B3 D = 333 mesh 20 cm bongo Dave R. samples, 2B1 C = 165 mesh 20 cm bongo CMARZ samples
NUT=nutrients, DIC=Dissolved Inorganic Carbon, ISO=stable isotope samples, CHL=chlorophyll samples

CTD Cast#	**SiteID/** STA#	**Date** GMT	**Latitude** (dd)	**Longitude** (dd)	**Bottom** Depth(m)	**Operation**
84	98	10/23/2015	40.8333	-67.255	93	BON/CTD, 2B3 D
85	99	10/23/2015	40.8317	-67.3367	90	BON/CTD, 2B3 D
86	100	10/23/2015	40.605	-67.2633	111	BON/CTD, 2B3 D
87	101	10/23/2015	40.5883	-67.33	107	BON/CTD, 2B3 D
88	102	10/23/2015	40.5167	-67.16	215	BON/CTD, 2B3 D
89	103	10/23/2015	40.4967	-67.755	127	BON/CTD, 2B3 D
23	104	10/23/2015	40.38	-67.6867	310	**CTD PROFILE 911+, NUT, DIC, CHL**
24	105	10/23/2015	40.2467	-67.6867	1118	**CTD PROFILE 911+, NUT, DIC, ISO, CHL**
90	106	10/24/2015	40.13	-68.6833	174	BON/CTD, no 2B too rough
91	107	10/24/2015	40.495	-68.59	83	BON/CTD, 2B3 D
92	108	10/24/2015	40.6633	-68.255	78	BON/CTD, 2B3 D
93	109	10/24/2015	40.8267	-68.2517	51	BON/CTD, 2B3 D
94	110	10/24/2015	40.8283	-67.9233	68	BON/CTD, 2B3 D
25	111	10/24/2015	40.9233	-67.7133	63	**CTD PROFILE 911+, NUT, DIC**
95	112	10/24/2015	41.0783	-67.59	58	BON/CTD, 2B3 D
96	113	10/24/2015	41.31	-68.0867	36	BON/CTD, 2B3 D
97	114	10/24/2015	41.255	-68.1683	40	BON/CTD, 2B3 D
98	115	10/25/2015	41.165	-68.17	38	BON/CTD, 2B3 D
99	116	10/25/2015	40.9117	-69.0883	74	BON/CTD, 2B3 D
100	117	10/25/2015	41.345	-69.4317	31	BON/CTD, 2B3 D

TOTALS:

Std BON/CTD Casts	**= 99**
2B3 D Bongo Casts	**= 74**
2B1 C Bongo Casts	**= 20**
CTD PROFILE 911 Casts	**= 25**
Nutrient Casts	**= 25**
Stable Isotope samples	**= 6**
Chlorophyll Casts	**= 13**
Dissolved Inorganic Carbon Samples (DIC)	**= 23**

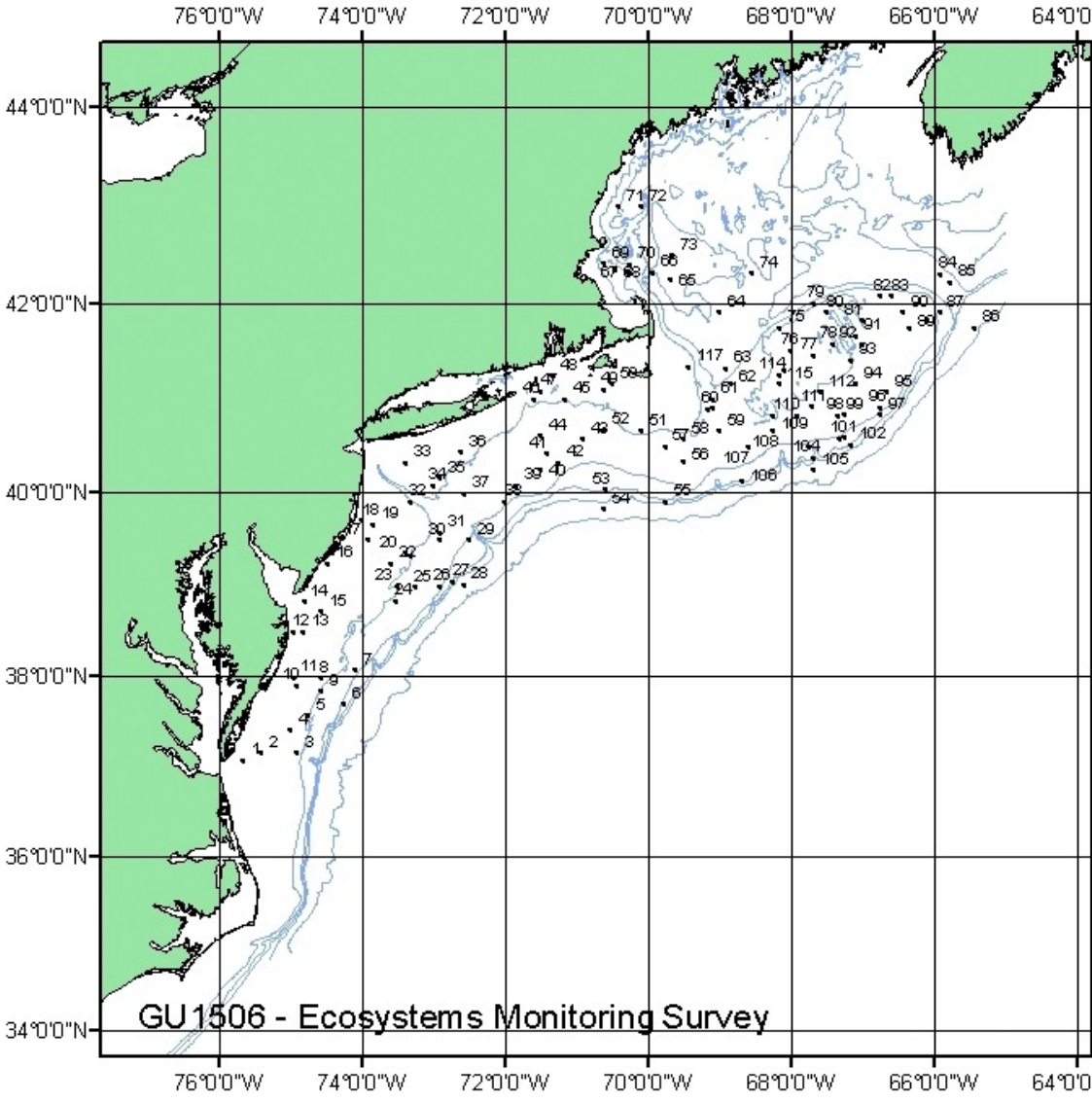

Figure 1. Station locations numbered consecutively for Fall Ecosystem Monitoring Survey GU 1506.

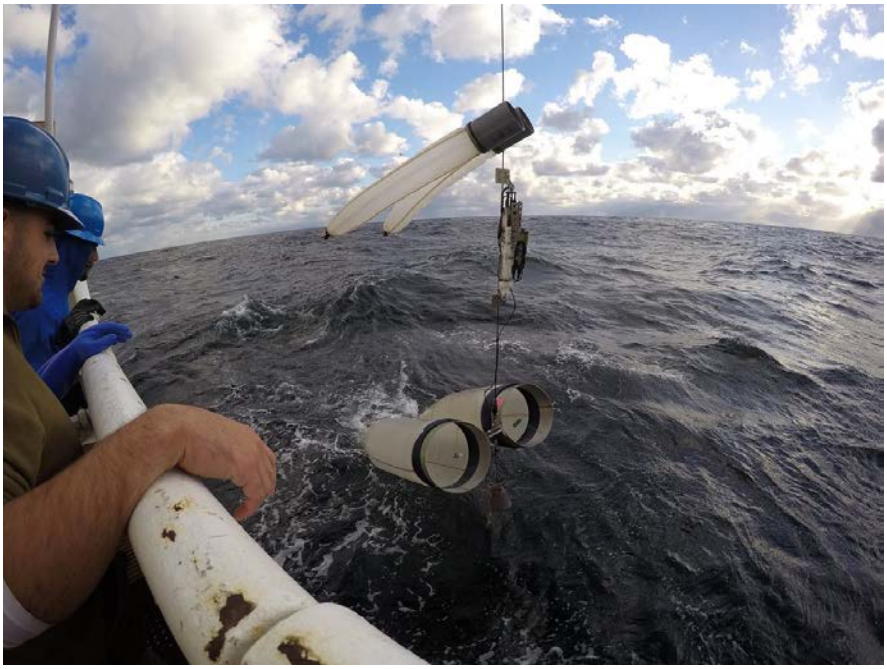

Figure 2. Bongo net array, showing 61 and 20 cm bongo nets being deployed from the starboard side of the *FSV Gordon Gunter.*

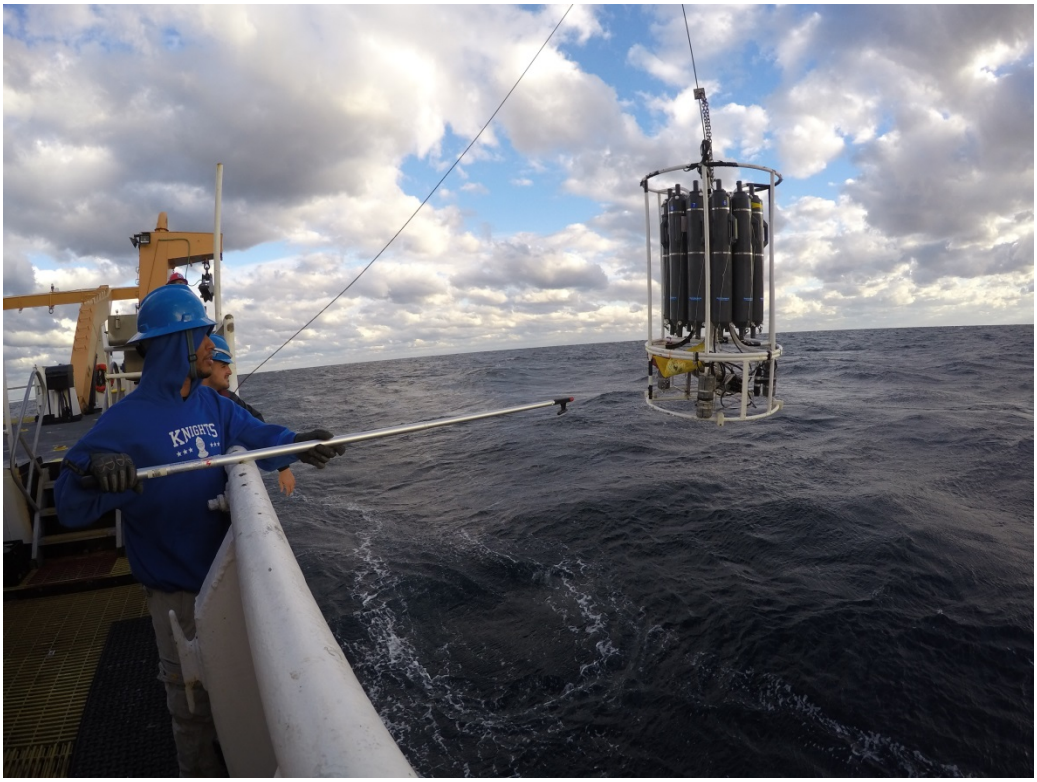

Figure 3. Niskin bottle and CTD 911 rosette being retrieved aboard the FSV *GORDON GUNTER* starboard sampling station.

Figure 4. U. Maine researcher Maura Thomas and the WHOI Imaging FlowCytobot Unit.

Figure 5. Images of Diatoms from the Imaging FlowCytobot Unit.

Figure 6. Seabird and marine mammal observer Jeannine Winkel at her observation post on the *GORDON GUNTER* bridge.

Figure 7. Styrofoam manikin heads, before and after 25 submersions down to as deep as 500 meters. This was a project undertaken by Prout High School oceanography students to demonstrate the effect that water pressure has on the gas bubbles within Styrofoam.

Appendix A.

Raw data from the Seabird Survey Report is available from Carina Gjerdrum

Seabird Survey Report
13 - 25 October, 2015
Canadian Wildlife Service, Environment Canada
45 Alderney Drive, Dartmouth, Nova Scotia, Canada
Carina Gjerdrum carina.gjerdrum@ec.gc.ca
Seabird Observer: Jeannine Winkel

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 Gordon Gunter in October 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. We were particularly interested in surveying in the Gulf of Maine/Bay of Fundy region where we have identified a significant data gap.

Methods

Seabird surveys were conducted from the port side of the bridge of the Gordon Gunter during oceanographic surveys from 13 to 25 October, 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 1339 km of ocean track from 13 to 25 October, 2015 (Figure 1). A total of 2653 waterbirds from 9 families were observed during the surveys; 1659 of the birds sighted were counted in transect (Table 1). Overall, bird densities averaged 4.8 birds/km^2 (ranging from 0 – 650.6 birds/km^2). The highest densities of birds (**>**100 birds/km^2) were observed in Nantucket Sound, in SW Gulf of Maine, and on the eastern tip of George's Bank (Figure 1).

Great shearwater was the most commonly observed species, accounting for 50% of the observations (Table 1). This species breeds in the southern hemisphere but spends its non-breeding season in the North Atlantic. Most were observed on George's Bank and the western Gulf of Maine (Figure 2a). Other members of the family Procellariidae were sighted in far fewer numbers, and included northern fulmar, Cory's shearwater, and Manx shearwater, all breeders from the northern hemisphere.

Waterfowl (Family Anatidae) accounted for 21% of the observations, which were primarily scoters (Table 1). The largest flocks were observed in SW Gulf of Maine and in Nantucket Sound (Figure 2b). Gulls made up a total of 12% of the observations, the majority of which were herring and black-backed gulls (Table 1). These were observed throughout the survey area (Figure 2c). Northern gannets and brown pelicans (7%) were also observed in relatively high numbers, primarily in the northern survey areas (northern gannet, Figure 2d).

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 just 78 marine organisms in addition to the birds were sighted and recorded (Table 2). These included 60

dolphin, 7 whales, 2 Portuguese man-of-war, 7 fish and 2 turtles (Table 2; Figure 3).

Data Storage

All data collected on marine bird, mammal, fish and turtles from the Gordon Gunter 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 Gordon Gunter 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 them on their mission.

Table 1: List of bird species sighted during seabird surveys on board the Gordon Gunter during oceanographic surveys from 13 to 25 October, 2015.

Family	English	Latin	Number observed in transect	Total number observed
Gaviidae	Common Loon	*Gavia immer*	4	10
Procellariidae	Great Shearwater	*Puffinus gravis*	831	1138
	Northern Fulmar	*Fulmarus glacialis*	18	39
	Cory's Shearwater	*Calonectris diomedea*	2	4
	Manx Shearwater	*Puffinus puffinus*	43	51
	Unidentified Shearwaters	*Puffinus* or *Calonectris*	0	1
Hydrobatidae	Leach's Storm-Petrel	*Oceanodroma leucorhoa*	1	2
	Unidentified Storm-Petrels	Hydrobatidae	2	3
Sulidae	Northern Gannet	*Morus bassanus*	69	113
	Masked Booby	*Sula dactylatra*	3	4
	Brown Pelican	Pelecanus occidentalis	40	41
Phalacrocoracidae	Double-crested Cormorant	*Phalacrocorax auritus*	11	22
	Great Cormorant	*Phalacrocorax carbo*	14	21
	Genus: Cormorants	Phalacrocorax	16	49
Anatidae	Canada Goose	*Branta canadensis*	1	70
	Common Eider	*Somateria mollissima*	19	28
	Long-tailed Duck	*Clangula hyemalis*	0	11
	Surf Scoter	*Melanitta perspicillata*	154	212
	Black Scoter	*Melanitta nigra*	13	18
	White-winged Scoter	*Melanitta fusca*	79	105
	Unidentified Ducks	Anatidae	88	297

Scolopacidae	Unidentified Phalaropes	*Phalaropus*	47	77
Laridae	Great Skua	*Stercorarius skua*	9	15
	Unidentified Skuas	*Stercorarius*	2	2
	Parasitic Jaeger	*Stercorarius parasiticus*	2	2
	Pomarine Jaeger	*Stercorarius pomarinus*	3	9
	Long-tailed Jaeger	*Stercorarius longicaudus*	2	4
	Black-legged Kittiwake	Rissa tridactyla	0	2
	Herring Gull	*Larus argentatus*	152	232
	Great Black-backed Gull	*Larus marinus*	32	58
	Laughing Gull	*Larus atricilla*	1	1
	Unidentified Gulls	Laridae	1	2
Alcidae	Unidentified Murres	*Uria*	0	10
	Unidentified Alcids	Alcidae	2	14
TOTALS			**1659**	**2653**

Table 2: List of other marine organisms sighted during seabird surveys on board the Gordon Gunter during oceanographic surveys from 13 to 25 October, 2015.

English	Latin	Total number observed
Common Dolphin	*Delphinus delphis*	46
Unidentified Dolphins	Delphinidae	14
Humpback Whale	*Megaptera novaeangliae*	4
Sperm Whale	*Balaenoptera physalus*	2
Unidentified Cetacean	Cetacea	1
Portuguese Man-Of-War	*Physalia physalia*	2
Ocean Sunfish	*Mola mola*	1
Flying Fish	Exocoetidae	5
Sharks	Elasmobranchii	1
Loggerhead Sea Turtle	*Caretta caretta*	1
Unidentified Turtle		1
Total		78

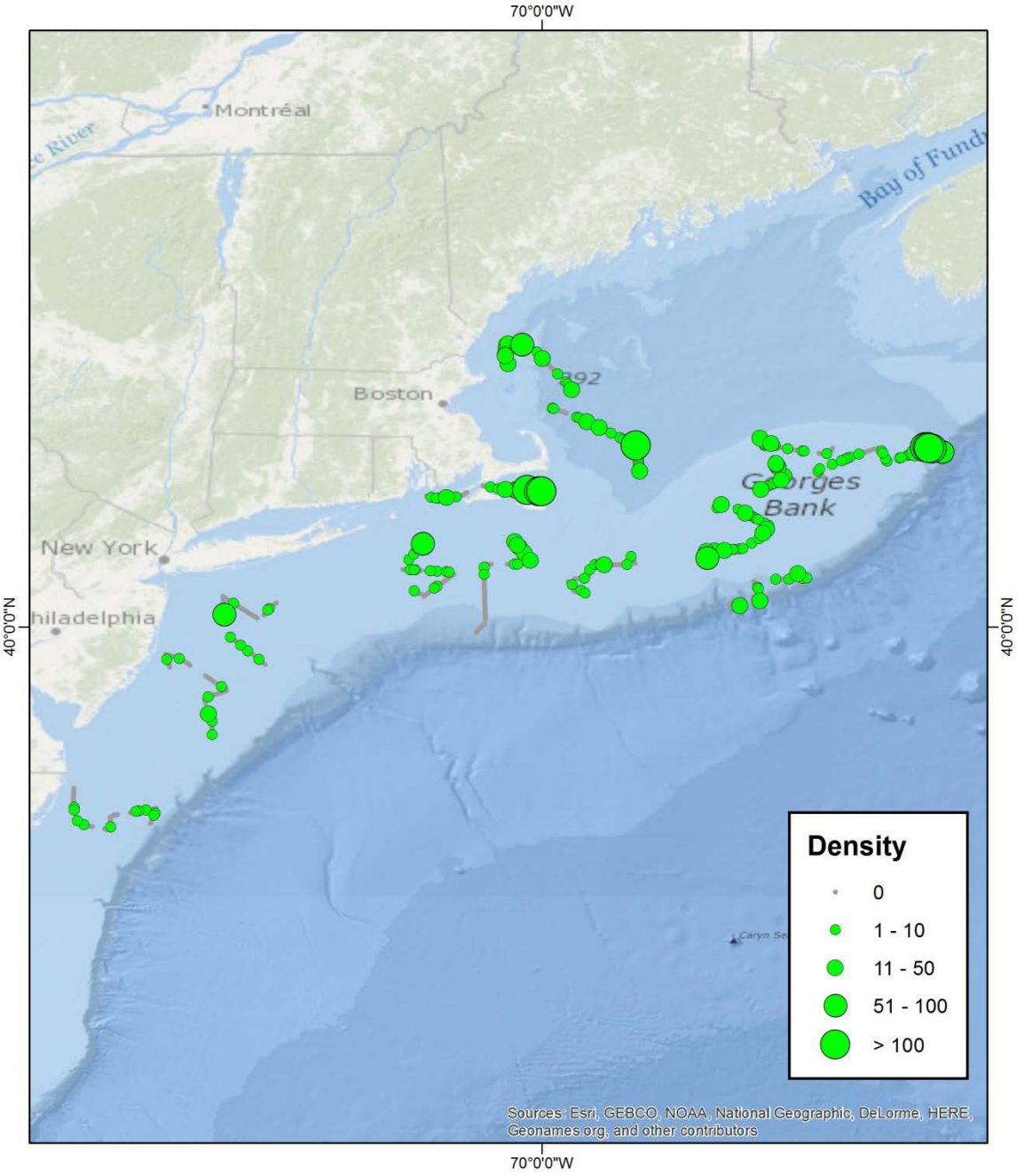

Figure 1. Density (count/km^2) of birds (all species combined) sighted during seabird surveys on board the Gordon Gunter during oceanographic surveys from 13 to 25 October, 2015.

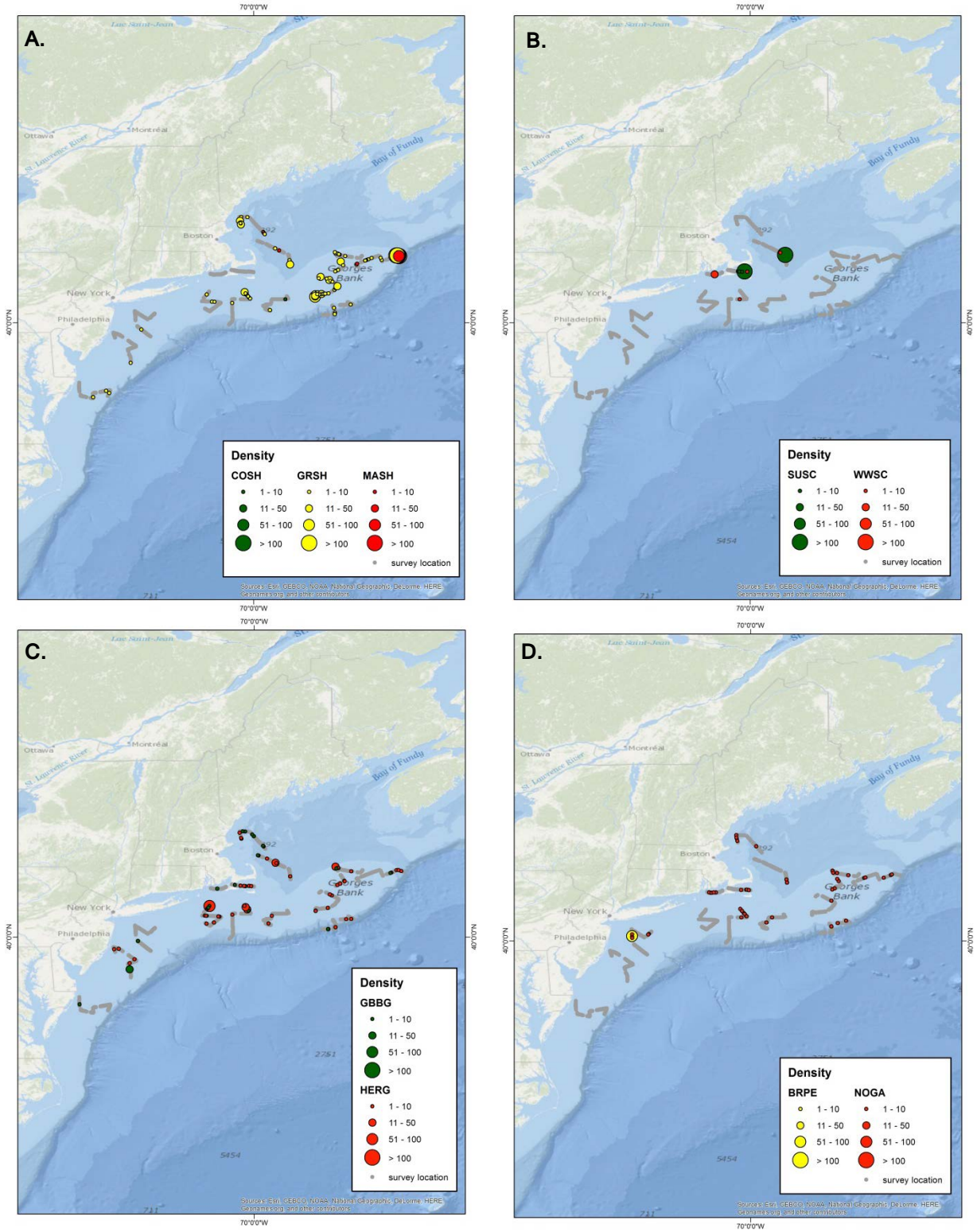

Figure 2. Density (count/km^2) of (A) shearwaters (COSH = Cory's shearwater; GRSH = great shearwater; MASH = Manx shearwater); (B) scoters (SUSC = surf scoter; WWSC = white-winged scoter); (C) gulls (GBBG = great black-backed gull; HERG = herring gull); and (D) Sulidae (BRPE = brown pelican; NOGA = northern gannet) sighted during seabird surveys the Gordon Gunter during oceanographic surveys from 13 to 25 October, 2015.

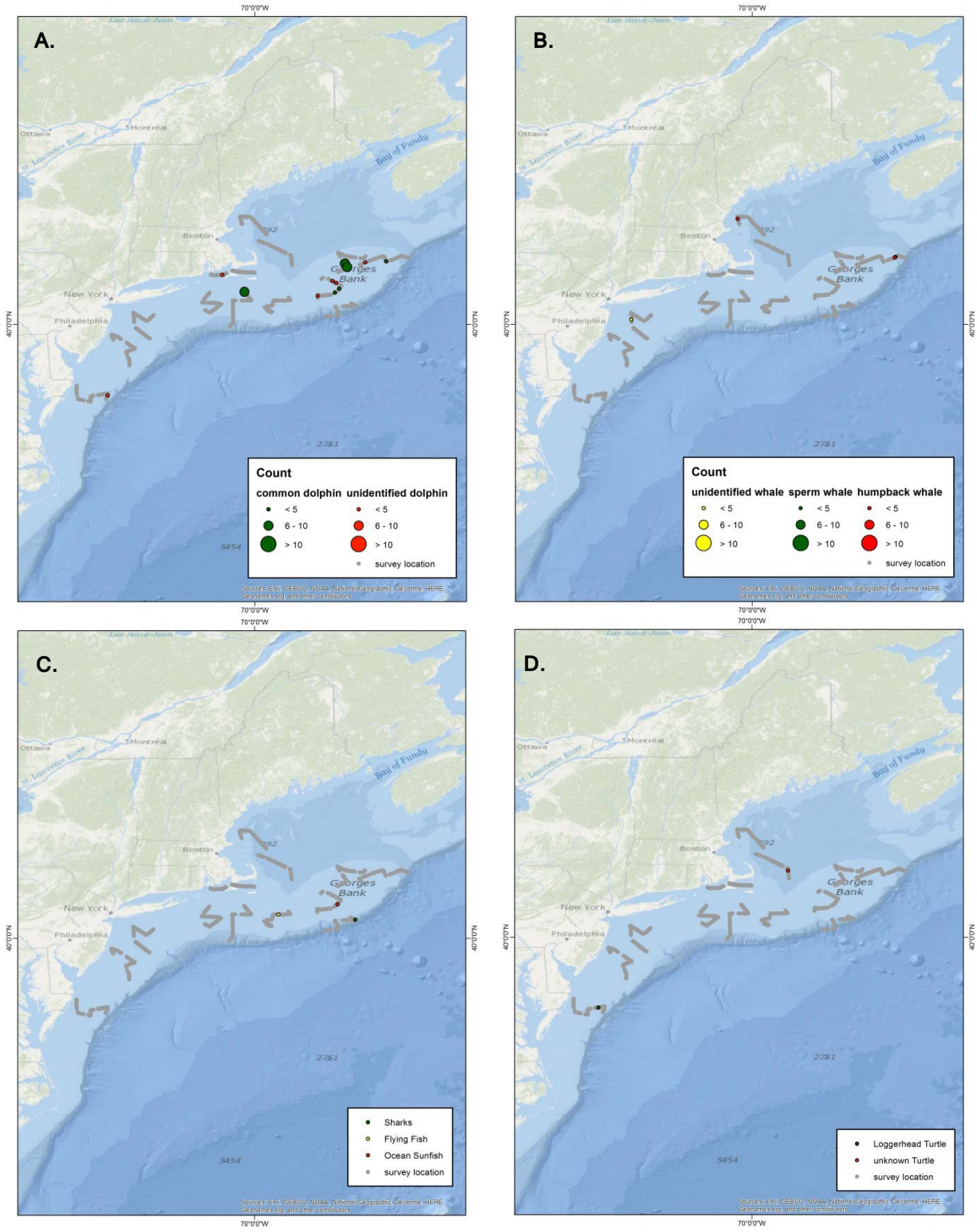

Figure 3. Counts of (A) dolphins; (B) whales; (C) fish; and (D) turtles sighted during seabird surveys on board the Gordon Gunter during oceanographic surveys from 13 to 25 October, 2015.

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