

24 September 2010

CRUISE RESULTS
NOAA Fisheries Research Vessel *Delaware II*
Cruise No. DE 10-04
Northeast Shelf Ecosystem Monitoring Late Spring Survey
and Climate Variability on the East Coast

CRUISE PERIOD AND AREA

The cruise period was 26 May to 09 June 2010. The NOAA fisheries research vessel *Delaware II* sampled at a total of 146 stations. Of the standard EcoMon stations, 29 were located in the Gulf of Maine (GOM), 29 were located on Georges Bank (GB), 30 were in the Southern New England (SNE) area, and 30 were in the Mid-Atlantic Bight (MAB) region.

OBJECTIVES

This cruise was the fourth in a series of multiple-objective cruises that are being done in collaboration with NASA and Old Dominion University. As always, the primary objective of the cruise was to assess changing biological and physical properties that influence the sustainable productivity of the living marine resources of the northeast continental shelf ecosystem. Key parameters measured for the Ecosystem Monitoring Program included ichthyoplankton and zooplankton composition, abundance and distribution, plus water column temperature and salinity. However, we worked with our colleagues from NASA and Old Dominion University to enhance the application of ocean color remote sensing to coastal ecosystems by “ground truthing” SeaWiFS and MODIS-Aqua data with ship-based water column measurements. This field data was also used to derive region-independent ocean color algorithms for primary productivity, particulate organic carbon and dissolved organic carbon.

Secondary objectives of this cruise included:

1. Vertical CTD casts to within 5 meters of the bottom in Gulf of Maine deep basin areas to provide hydrographic data detailing the incursion of Labrador Current water into this region.
2. Sampling at the site of the liquefied natural gas (LNG) terminal east of Boston Harbor, to collect ongoing environmental data.
3. Collection of zooplankton for the Census of Marine Zooplankton Project (CMarZ), based at University of Connecticut, Avery Point.
4. Collection of zooplankton samples for carbon and nitrogen isotope analysis from the four regions surveyed, using the 20-cm bongo sampler for NASA researcher Antonio Mannino.
5. Collection of zooplankton for DNA analysis of *Calanus finmarchicus* by Geneviève Parent, in association with Laval University and the Canadian Division of Fisheries and Oceanography.
6. Collection of zooplankton from the deep basins of the Gulf of Maine for foraminifera community analysis being conducted by Lloyd Keigwin of the Woods Hole Oceanographic Institution.
7. Collection of zooplankton for the University of Rhode Island.
8. Collection of nutrient samples from various depths sampled with the Niskin bottle rosette for University of Maine researcher Dave Townsend.

9. Collection of Gulf Stream water samples for analysis of oil contamination from the Deepwater Horizon Oil Spill for NEFSC, EPD, Sandy Hook Laboratory.
10. Collection of offshore water for use in ocean acidification experiments by NEFSC, Milford Laboratory.
11. Collection of sediment from the deep basins of the Gulf of Maine using a ponar grab for DNA probing by Alison Cleary, URI.
12. Identifications and counts of marine birds along the cruise track by observers Marie Martin, and Mike Sylvia from City College of New York.

METHODS

The survey consisted of 146 stations at which the vessel stopped to lower instruments over the side (Table 1; Figure 1A and B). Of the 128 61-cm bongo stations sampled (Table 1; Figure 1A), 118 were at randomly stratified locations. Five non-random GOM stations were at fixed positions visited on all Ecosystem Monitoring cruises: Wilkinson Basin, Georges Basin, Jordan Basin, the Northeast Channel, and a terminal for off-loading liquefied natural gas located east of Boston harbor. Five more stations were randomly selected from the western Gulf of Maine to improve coverage of that region for collection of Atlantic mackerel larvae. In addition, the CLiVEC group selected 17 non-random stations for water sampling when a random station was not reached during optimal daily sampling intervals, and one non-random station was selected to collect water from the Gulf Stream for oil analysis.

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 m above the bottom, or to a maximum depth of 200 m. All plankton tows were conducted at a ship speed of 1.5 – 2.0 knots. Plankton sampling gear consisted of a 61-cm diameter aluminum bongo frame with two 335-micron nylon mesh nets. 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 to collect additional plankton samples for a variety of researchers (Table 1). Stations with 20-cm bongo collections were chosen haphazardly to fulfill sample needs from all regions for the various researchers. A mechanical flowmeter was suspended within the mouth of each 61-cm sampler to determine the amount of water filtered by each net. No flowmeters were used in the 20-cm bongos. The plankton sampling gear was deployed off the starboard stern quarter of the vessel using an A-frame and a Sea-Mac winch that was placed on the aft deck specifically for this cruise. After retrieval, the bongo frames were carried into a covered work area on the port side of the aft deck and placed on tables for wash down of the nets to obtain the plankton samples. This workspace allowed for much easier removal of the samples, particularly during inclement weather. The 61-cm bongo plankton samples were preserved in a 5% solution of formalin in seawater. Most samples from the 20-cm diameter bongos were preserved in 95% ethanol, which was changed once at 24 hours after the initial preservation. The NASA nitrogen and carbon isotope biomass samples from the 20-cm diameter bongos were frozen. 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. CTD casts using the 911 CTD to within 5 m of the bottom were made at most stations with depth greater than 200-m including Wilkinson Basin and the Northeast Channel to provide hydrographic data from below the 200-m limit set for bongo tows.

Samples were collected using the 20-cm diameter bongos and methods described above for five separate projects (Table 1; Figure 1A). Census of Marine Zooplankton (CmarZ) samples were collected at five stations in each of three of the regions sampled: Mid-Atlantic Bight, Georges Bank,

and Gulf of Maine and four haphazardly designated stations in the Southern New England region. Ten zooplankton samples were collected for NASA from the four regions surveyed. Samples for Laval University / DFO were collected at three haphazardly designated stations in both the Mid-Atlantic Bight and Southern New England regions. Wilkinson Basin, Georges Basin, Jordan Basin, the Northeast Channel Collection were sampled to collect for foraminifera community analysis being conducted by Lloyd Keigwin of the Woods Hole Oceanographic Institution. Three stations with high catches of krill were selected in the Gulf of Maine for samples collections for URI.

Forty-four casts were made with the CTD 911/Niskin bottle rosette to collect sub-surface water samples for the CLiVEC project (Table 1; Figure 1B). The rosette was equipped with twelve 10-liter Niskin bottles. These casts were made at sunrise, mid-day and sunset. When time permitted, an additional sample was collected to coincide with satellite overpass times. No rosette casts were made at night. Typically three water depths were sampled to analyze particulate and dissolved organic carbon, absorption coefficients of phytoplankton and colored dissolved organic matter: near surface, at the chlorophyll-maximum depth, a sub-chlorophyll-maximum depth. Additional depths were sometimes sampled to collect water to measure the stable oxygen isotope ratio ($^{17}\text{O}/^{16}\text{O}$ relative to air) and dissolved oxygen levels. Field measurements of primary productivity were made by incubating phytoplankton taken from the different depths in two deck incubators on the fantail of the ship. Seawater was also collected for similar analyses from the ships flow-thru system from approximately 30 stations to calibrate these near-surface waters with rosette samples and satellite overpass data. Finally, a total of one hundred eighty-five nutrient samples were collected for University of Maine researcher Dave Townsend at forty-three of the stations sampled with the rosette.

Samples for Seabird CTD salinity data calibration were obtained approximately twice a day using a 1.7-liter Niskin bottle taking a water sample from an isohaline portion of the water column (Table 1). Calibration of the CTD salinities and chlorophyll-*a* from the surface flow-through system was undertaken while the ship was underway. Sample analysis for these calibrations followed the protocol outlined in the Ecosystem Monitoring Program Operations Manual.

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 flow-through seawater system. A WETStar CDOM fluorometer and a C-star transmissometer were also plumbed into vessels underway flow-through seawater system. Data from those instruments and the thermosalinograph, and the fluorometer at 10-second intervals was logged into the Scientific Computer System (SCS). The data records were given a time-date stamp by the GPS unit.

Gulf Stream surface water was sampled from six stations for oil analysis from the Deepwater Horizon oil spill in the Gulf of Mexico (Table 1; Figure 1B). Samples were collected at five stations along the offshore portion of the cruise track. Stations were selected by examining daily Satellite Sea Surface Temperature (SST) images sent from the Mid-Atlantic Region Coastal Ocean Observing System (MARCOOS with University of Delaware, and Rutgers University). These images allowed us to select stations along our track nearest the influence of Gulf Stream waters. Four 1-liter glass jars were lowered just below the waters surface to collect surface waters. Jars were brought back on deck and a subsample from each jar was poured into a vial containing 0.5-ml hydrochloric acid. Both the jars and vials were labeled and placed in the freezer.

Four 5-liter carboys of seawater were collected from the ships flow-thru system for use by the NEFSC, Milford Laboratory in ocean acidification experiments (Table 1). Collection location was chosen based the cruise track by Milford Lab personnel.

Sediment samples from three stations in the Gulf of Maine region were collected using a Ponar grab (Table 1). The presence of muddy sediments was used to choose stations, based on sediment type indicated on NOAA charts. Alison Cleary of the University of Rhode Island processed samples on deck for future DNA analysis.

RESULTS

The *Delaware II* sailed at 0900 hours EDT on Wednesday, 26 May 2009, and proceeded southwest to the first station. A summary of routine survey activities is presented in Table 1. Areal coverage for the cruise is shown in Figure 1. The weather during the cruise was very good; only two stations were dropped because of rough seas. Pictures and text were submitted to the Research Communications Branch who posted a blog online. Archives of the blog can be viewed at <http://nefsc.wordpress.com/2010/05/27/let-the-ecosystem-monitoring-begin/>.

The Delaware II returned to Woods Hole via the Cape Cod Canal and docked at 0700 Wednesday, 10 June 2010.

DISPOSITION OF SAMPLES AND DATA

The plankton samples collected with the 61-cm bongo and data were delivered to the Ecosystem Monitoring Group of the NEFSC, Narragansett, Rhode Island for quality control processing. The plankton samples were subsequently sent to Zakład Sortowania i Oznaczania Planktonu (ZSIOP) in Szczecin, Poland for sorting and identification.

The plankton samples collected with the 20-cm bongo were delivered to the various investigators. The Census of Marine Zooplankton samples and Lloyd Keigwin's samples were retrieved from the NEFSC, Woods Hole Laboratory by Woods Hole Oceanographic Institute researcher Nancy Copley. Antonio Mannino offloaded the NASA samples. The samples for Laval University / DFO were shipped to Geneviève Parent at Laval University. Alison Cleary off loaded the URI samples.

The Oceanography Branch of the NEFSC, Woods Hole, retained the CTD data and original log sheets.

The CLiVEC researchers retained all samples and data associated with their portions of the project.

Nutrient samples collected for University of Maine researcher Dave Townsend were placed in a freezer NEFSC, Narragansett, Rhode Island for future deliver.

Gulf Stream water samples for analysis of oil contamination from the Deepwater Horizon Oil Spill were delivered to the NEFSC, EPD, Sandy Hook Laboratory.

Water collected for use in ocean acidification experiments were picked-up by personnel from the NEFSC, Milford Laboratory.

Alison Cleary, URI, offloaded sediment samples from the deep basins of the Gulf of Maine.

SCIENTIFIC PERSONNEL

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Table 1. Summary of routine sample activities conducted at 146 stations at which the *Delaware II* stopped to lower instruments over the side during Cruise No. DE 10-04 numbered in consecutive station order. Latitude and Longitude are shown in decimal degrees.

Station Information				61-cm Bongo		20-cm Bongo					Vertical CTD Cast		Water Collection				Ponar	
				335 micron mesh		165 micron mesh							Rosette	Flow-thru	Surface Water		Flow-thru	
Cons #	Latitude	Longitude	Name	Bongo	CmarZ	NASA	Laval U. / DFO	WHOI/Keigwin	URI	Seacat	911	CLIVEC	CLIVEC	Nutrients ¹	for oil analysis ²	for Milford	Sediment Grab	
1	41.104	-71.112	5-2 SNE	1	1									1		2		
2	41.021	-71.079	5-3 SNE	2														
3	41.104	-70.579	9-3 SNE	3										2				
4	41.062	-70.279	9-1 SNE	4														
5	40.729	-70.513	10-4 SNE	5														
6	40.521	-71.112	6-2 SNE	6	2													
7	40.479	-71.879	6-5 SNE	7														
8	40.354	-71.912	6-4 SNE	8										3		3		
9	40.187	-71.746	6-1 SNE	9			1											
10	40.146	-72.046	2-1 SNE OFFSHORE	10														
11	40.021	-72.213	2-2 SNE	11										4		5		
12	39.854	-72.179	2-3 SNE	12														
13	39.729	-71.979	3-1 SNE	13												2010001		
14	39.728	-72.537	NR1											5		3		
15	39.729	-72.946	2-4 SNE	14						1								
16	39.396	-73.346	73-3 MAB	15			2											
17	39.313	-73.779	73-4 MAB	16														
18	39.104	-73.812	73-2 MAB	17														
19	39.146	-73.379	74-1 MAB	18														
20	39.062	-73.318	NR2											6		4		
21	38.771	-73.112	75-2 MAB	19			3			2								
22	38.562	-73.213	76-3 MAB	20		1								7				
23	38.515	-73.690	NR3											8		4		
24	38.438	-74.446	69-2 MAB	21			4							9				
25	38.187	-74.612	69-1 MAB	22	3													
26	37.896	-74.513	69-4 MAB	23						3								
27	37.729	-74.579	70-1 MAB	24														
28	37.604	-74.279	71-2 MAB	25	4									10		7		
29	37.438	-74.446	68-1 MAB	26										1		12	2010002	
30	37.338	-74.593	NR4											11		4		
31	36.812	-75.379	65-3 MAB	27	5									12		3		
32	36.646	-75.079	65-1 MAB	28	6					4								
33	36.062	-74.979	61-1 MAB	29										13		2	2010003	
34	36.021	-74.846	62-1 MAB	30														
35	36.020	-74.712	NR5														2010004	
36	35.979	-74.979	61-2 MAB	31														
37	35.687	-75.313	44-2 MAB	32													2010005	
38	35.896	-75.513	40-1 MAB	33		2												
39	36.483	-75.632	NR6											14		3		
40	36.687	-75.679	38-1 MAB	34														
41	36.771	-75.912	37-2 MAB	35														
42	37.146	-75.446	65-2 MAB	36			3			5				15		3		
43	37.313	-75.446	65-4 MAB	37	7													
44	37.562	-75.346	65-5 MAB	38														
45	37.812	-75.146	32-1 MAB	39										16		3		
46	38.812	-75.046	25-1 MAB	40														
47	38.812	-74.513	69-3 MAB	41						6						2		
48	39.015	-74.260	NR7											17				
49	39.187	-74.112	73-1 MAB	42						7								
50	39.313	-74.246	20-2 MAB	43														

Table 1. Continued.

Station Information			61-cm Bongo		20-cm Bongo					Vertical CTD Cast		Water Collection					Ponar
Cons #	Latitude	Longitude	Name	Bongo	CmarZ	NASA	Laval U. / DFO	WHOI/Keigwin	URI	Seacat	911	Rosette CLIVEC	Flow-thru CLIVEC	Nutrients ¹	Surface Water for oil analysis ²	Flow-thru for Milford	Sediment Grab
51	39.687	-73.979	17-1 MAB	44								18		3			
52	40.313	-73.479	1-2 SNE	45						8							
53	40.438	-73.479	11-1 SNE	46								19		3			
54	40.313	-72.946	1-3 SNE	47						9							
55	40.229	-72.713	1-1 SNE	48			5										
56	40.396	-72.779	1-4 SNE	49													
57	40.562	-72.179	5-1 SNE	50													
58	40.979	-71.912	2-1 SNE INSHORE	51								20		3			
59	40.812	-71.746	6-3 SNE	52		4				10				4			
60	40.497	-71.165	NR8									21					
61	40.229	-70.679	7-1 SNE	53			6										
62	40.353	-70.218	NR9									22		3			
63	40.396	-70.079	10-1 SNE	54	8												
64	40.521	-69.579	10-3 SNE	55						11							
65	40.812	-69.412	9-2 SNE	56	9												
66	40.896	-69.013	10-5 SNE	57		5											
67	40.562	-68.713	13-1 GB	58													
68	40.396	-69.146	10-2 SNE	59													
69	40.146	-69.112	11-1 SNE	60						12						1	
70	40.229	-68.313	15-1 GB	61							2			10			
71	40.342	-68.298	NR10									23					
72	40.604	-68.246	13-5 GB	62													
73	40.896	-68.446	19-6 GB	63	10												
74	40.979	-68.079	19-7 GB	64		6				13							
75	40.979	-67.912	19-4 GB	65													
76	40.937	-67.846	13-2 GB	66													
77	40.646	-67.112	14-2 GB	67	11							24		4	2010006		
78	40.771	-66.979	13-4 GB	68													
79	40.854	-67.112	13-3 GB	69													
80	41.021	-67.112	13-6 GB	70						14							
81	40.982	-66.842	NR11									25		3			
82	40.937	-66.479	18-1 GB	71		7											
83	41.396	-66.279	16-3 GB	72								26		2			
84	41.438	-66.112	17-2 GB	73													
85	41.646	-66.112	16-6 GB	74													
86	41.687	-66.112	16-2 GB	75						15							
87	42.225	-65.766	NE CHANNEL GOM	76				1			3			10			
88	42.271	-65.946	29-3 GOM	77							4						
89	42.146	-66.379	22-1 GB	78								27		4			
90	41.979	-66.746	16-7 GB	79													
91	41.812	-66.846	16-5 GB	80						16							
92	41.771	-66.446	16-8 GB	81								28		5			
93	41.521	-66.679	16-1 GB	82	12												
94	41.396	-67.013	16-4 GB	83								29		3			
95	41.438	-67.479	19-1 GB	84													
96	41.313	-67.746	19-5 GB	85													
97	41.438	-67.879	19-3 GB	86													
98	41.562	-68.146	20-3 GB	87	13												
99	41.271	-68.246	19-2 GB	88													
100	41.354	-68.579	23-1 GOM	89													

Table 1. Continued

Station Information			61-cm Bongo		20-cm Bongo					Vertical CTD Cast		Water Collection					
			335 micron mesh		165 micron mesh					Seacat	911	Rosette	Flow-thru	Surface Water		Flow-thru	Ponar
Cons #	Latitude	Longitude	Name	Bongo	CmarZ	NASA	Laval U. / DFO	WHOI/Keigwin	URI			CLIVEC	CLIVEC	Nutrients ¹	for oil analysis ²	for Milford	Sediment Grab
101	41.333	-68.848	NR12									30		5			
102	41.354	-69.146	24-3 GOM	90						17							
103	41.271	-69.513	55-1 SNE	91													
104	41.521	-69.679	25-2 GOM	92								31		3			
105	42.187	-69.479	28-2 GOM	93	14							32		3			
106	42.500	-69.667	WILKINSON BASIN GOM	94				2	1		5			10		1	
107	42.438	-68.912	28-1 GOM	95													
108	42.062	-69.013	24-1 GOM	96						18							
109	41.812	-68.879	24-2 GOM	97		8						33		5			
110	41.812	-67.812	20-2 GB	98	15							34		3			
111	41.937	-67.746	20-1 GB	99													
112	42.229	-67.779	29-4 GOM	100													
113	42.271	-67.679	29-2 GOM	101													
114	42.542	-67.697	GEORGES BASIN GOM	102				3									
115	42.937	-67.079	36-2 GOM	103	16												
116	43.021	-67.313	36-3 GOM	104													
117	43.271	-67.479	36-4 GOM	105													
118	43.604	-67.246	36-1 GOM	106													
119	44.062	-66.846	34-2 GOM	107								35		5			
120	44.229	-67.246	351-1 GOM	108		9						36		6		2	
121	44.104	-67.246	34-1 GOM	109													
122	44.003	-67.760	NR13									37					
123	43.979	-67.912	38-2 GOM	110													
124	44.021	-68.313	39-1 GOM	111													
125	43.354	-68.412	38-5 GOM	112	17												
126	43.400	-67.700	JORDAN BASIN GOM	113				4				38		4			
127	43.146	-67.912	36-5 GOM	114					2			39		5		3	
128	42.897	-68.160	NR14									40		4			
129	42.687	-68.379	29-1 GOM	115	18												
130	43.193	-68.923	NR15									41		1			
131	43.396	-69.146	38-3 GOM	116					3								
132	43.687	-69.646	40-1 GOM	117	19					19							
133	43.229	-69.713	37-4 GOM	118													
134	43.187	-69.846	37-1 GOM	119													
135	43.271	-70.079	27-2 GOM	120													
136	43.022	-70.098	NR16									42		4			
137	42.943	-70.084	Mack11	121													
138	42.943	-70.251	Mack7	122													
139	42.812	-70.179	26-1 GOM	123		10											
140	42.680	-70.447	Mack5	124													
141	42.642	-70.528	NR17									43		4			
142	42.417	-70.613	LNG GOM	125													
143	42.348	-70.613	NR18									44		6			
144	42.187	-70.646	63-1 GOM	126													
145	41.942	-70.205	Mack3	127													
146	41.859	-70.372	Mack4	128													
Total				128	19	10	6	4	3	19	5	44	30	185	6	1	3

1. Number of nutrient samples collected at each station.

2. Sample number corresponds to number on the chain of custody form.

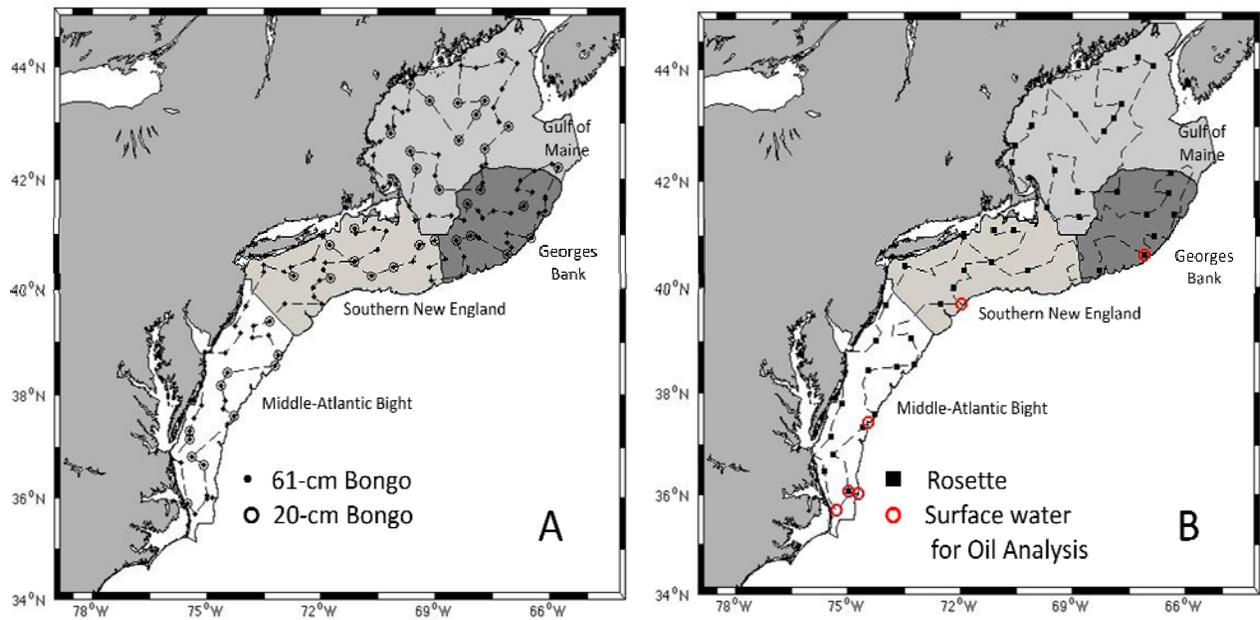


Figure 1. Map of sample locations showing Bongo collections (A) and Water collections made during Cruise No. DE 10-04.