

CRUISE RESULTS  
NOAA Fisheries Research Vessel *Delaware II*  
Cruise No. DE 09-11  
Ecosystems Monitoring Survey and NASA Ground Truth Measurements

CRUISE PERIOD AND AREA

The cruise period was 3 to 20 November 2009. The original cruise plan called for 2 to 20 November but the first day of the cruise was lost due to bad weather and scientific equipment preparation. Three additional days were lost on November 13, 14 and 15 due to bad weather and the loss of a porthole from a large wave striking the starboard side of the vessel. The NOAA fisheries research vessel *Delaware II* sampled at a total of 108 stations, with only partial coverage of the Gulf of Maine. Of these, 17 were located in the Gulf of Maine (GOM), 28 were located on Georges Bank (GB), 34 were in the Southern New England (SNE) area, and 29 were in the Mid-Atlantic Bight (MAB) region.

OBJECTIVES

This cruise was the second in a series of multiple-objective cruises that are going to be 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:

- 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.
- Collection of zooplankton for the Census of Marine Zooplankton Project (CMarZ), based at University of Connecticut, Avery Point.
- Identifications and counts of marine birds along the cruise track by observers Peter Vogel and Tim White, from Staten Island University.
- Deployment of “Acrobat” towed body across chlorophyll and sea surface temperature fronts to assist in ground truthing satellite imagery of these parameters.
- Collection of ichthyoplankton samples using a one-meter square net to locate herring larvae on Georges Bank.
- Collection of nutrient samples from the various depths sampled with the Niskin bottle rosette for University of Maine researcher Dave Townsend.
- 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.

METHODS

The survey consisted of 108 stations at which the vessel stopped to lower instruments over the side (Figure 1). All stations sampled were at randomly stratified locations except for five stations in the GOM, four in the SNE and one on Georges Bank. Four of these non-random stations were at fixed positions in the Gulf of Maine, visited on all Ecosystem Monitoring cruises: Wilkinson Basin, Georges Basin, the Northeast Channel, and the Boston Harbor Liquefied Natural Gas (LNG) terminal. The remaining stops were made for Old Dominion University researchers to collect water samples in coordination with sunrise, sunset or mid-day for primary productivity measurements.

Plankton and hydrographic sampling was conducted at most stations 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. At the randomly designated 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 (Figure 2). The 20 cm bongo sampler was also used to collect samples for biomass analysis from the different regions surveyed. A bell-shaped 45-kg lead weight was attached by an 80-cm 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. A digital 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 to the covered work area for washing the plankton samples into sieves (Figure 3). This is the method we have normally followed aboard the Delaware II, except for the August 2009 cruise, when the nets were rinsed at a wooden table set up outside near the stern. On this cruise we brought a small container (11 ½ ft L x 7 ½ ft W x 7 ½ ft H) on board, which was set up as a plankton lab, complete with a fume hood for sample preservation, a sink with running seawater, stainless steel worktables, a small space heater and ventilation fans for the fume hood and the container inside area (Figures 4 & 5). This was secured to the port side of the stern deck, just aft of the covered work area. By doing the plankton preservations inside this container, we were able to dedicate the entire wet lab area to the NASA and ODU researchers for setting up their filtering apparatuses (Figure 6). The covered trawlway on the stern was now dedicated to launching and retrieval of the Acrobat towed body sampler (Figure 7).

The 61-cm bongo plankton samples were preserved in a 5% solution of formalin in seawater. The CMarZ 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 samples from the 20-cm diameter bongos were frozen. The Dave Townsend U. Maine nutrient samples were also 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. A CTD cast to within 5 m of the bottom was made in the Wilkinson, and Georges basins and the Northeast Channel to provide hydrographic data from below the 200 m limit set for bongo tows. Three Acrobat tows were made, one at station 19 in the Middle Atlantic Bight, one on Nantucket Shoals in the Southern New England area and one from Georges Basin in the Gulf of Maine onto the northern flank of Georges Bank. A 1m x 1m net was also used to search for herring larvae on Georges Bank (Figure 8). Four double oblique tows were made with it on the Georges Bank area. No herring larvae were readily apparent in these samples, which were preserved in ethanol.

Thirty six casts were made with the CTD 911/Niskin bottle rosette. The rosette was equipped with twelve 10-liter Niskin bottles (Figure 9). These casts were made at sunrise, mid-day and sunset. An additional cast was sometimes made during the morning or afternoon, for a total of 3 to 5 casts per day. No rosette casts were made at night. Typically 3 water depths were sampled: near surface, at the chlorophyll-maximum depth, and a sub-chlorophyll-maximum depth. Water samples were filtered by the NASA and ODU researchers to measure particulate and dissolved organic carbon, absorption coefficients of phytoplankton and colored dissolved organic matter to improve the coastal algorithms used to interpret satellite-derived data for estimating these parameters. Field measurements of primary productivity were also made by incubating phytoplankton taken from the different depths in 3 deck incubators (Figure 10).

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. 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.

Samples for Seabird CTD salinity data calibration were obtained twice a day using a 1.7 liter Niskin bottle taking a water sample from an isohaline portion of the water column. Two Winkler titrations were carried out during the cruise to calibrate the dissolved oxygen measurements made during the rosette casts.

Census of Marine Zooplankton (CMarZ) samples were collected using the 20-cm diameter bongos described above at 5 randomly designated stations in each of the four regions sampled: Mid-Atlantic Bight, Southern New England, Georges Bank and Gulf of Maine.

## RESULTS

A summary of routine survey activities is presented in Table 1. Areal coverage for the cruise is shown in Figure 1. Bad weather and the subsequent loss of a port hole in a storm on Georges Bank caused a 3 day delay that prevented coverage of the northern portion of the Gulf of Maine area.

The *Delaware II* sailed at 0800 hours EST on Tuesday, 3 November 2009. This was a delay from the anticipated sailing on Monday afternoon due to bad weather and some scientific equipment problems. The vessel worked its way to the offshore Southern New England area and then headed south, picking up stations along the outer edge of the shelf until Thursday, 5 November, when the forecast of increasing winds led to a change in the cruise track towards the inshore area. At the beginning of this steam across the shelf towards inshore waters, a two hour tow was made with the Acrobat towed body, between stations 19 and 20. Launch and deployment went smoothly using the stern gantry, and the unit collected temperature, salinity, turbidity, chlorophyll, light, nitrate, and oxygen level data as it undulated between the surface and 30 meters during its two hour tow. Working south along the inshore stations provided the vessel with a lee from the strong northwest winds, and good progress was made, so that by Monday, 9 November, the sampling in Mid-Atlantic Bight and most of Southern New England was completed. The southernmost MAB station was dropped in the interest of saving time due to the long steam needed to reach it. On Tuesday, 10 November, two transects were made across the Nantucket Shoals area to count and identify the number of sea ducks and to gather hydrographic data using both the ship's flow-through system instruments and the Acrobat unit which was towed partway along the northernmost transect line. The bird observers did not find large numbers of ducks. The anticipated migration of oldsquaw sea ducks to this area had not yet taken place. After completing the Nantucket Shoals transects the vessel

proceeded on to the southern flank of Georges Bank, where sampling was carried out using bongo nets, the rosette sampler and a square meter net which was used to collect samples of herring larvae. A cursory visual inspection of these meter net samples did not reveal any herring larvae. By Thursday, 12 November, sampling was suspended due to high winds and seas, and the vessel headed for shelter in Provincetown. While enroute to this anchorage a large wave knocked out a porthole on the starboard side of the vessel only slightly above the waterline, in the mess area. Due to quick action by the crew only a minimal amount of water was shipped, but at this point it was decided to head for Woods Hole for both shelter and to make repairs. The vessel docked in Woods Hole on Friday morning, 13 November at 0800. Repairs to the porthole were completed on Monday morning, 16 November and with diminishing seas offshore, the DELAWARE II sailed at 1400 hrs and returned to resume sampling operations on Georges Bank. With the time remaining in the cruise schedule the vessel was only able to complete Georges Bank and 11 random stations in the southern Gulf of Maine, plus the Northeast Channel, Georges Basin, Wilkinson Basin and the Liquefied Natural Gas (LNG) terminal east of Boston Harbor.

Sampling operations were completed at 0100 EST on Friday, 20 November 2009. The DELAWARE II returned to Woods Hole via the Cape Cod Canal and docked in Woods Hole later that morning at 0700.

## DISPOSITION OF SAMPLES AND DATA

The plankton samples and data were delivered to the Ecosystem Monitoring Group of the NEFSC, Narragansett, RI for quality control processing and further analysis. The Census of Marine Zooplankton samples were retrieved from the vessel by Woods Hole Oceanographic Institute researcher Nancy Copley. The Fisheries Oceanography Investigation of the NEFSC, Woods Hole, retained the CTD data and original log sheets. The NASA and ODU researchers retained their samples, data and logs. The NASA laboratory equipment was returned to Greenbelt, MD by the researchers, while the ODU incubators and laboratory equipment were stored at the NMFS facility in Woods Hole for use on subsequent cruises. The Ecosystems Monitoring Laboratory Container was stored next to the Woods Hole NEFSC storage building.

## SCIENTIFIC PERSONNEL

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CAST	STA.	Date (GMT)			TIME (GMT)		LAT	LONG	DEPTH	OPERATION
	mm	did	yy	hr	min			m		
										B=bongo W=water C=CMarZ V=vertical cast(CTD only) R=rosette cast N = nutrient sample
1	1	11	3	2009	17	15	4101	7104.9	44	B, R
2	2	11	3	2009	19	18	4056.2	7048.8	52	B
3	3	11	3	2009	21	18	4041.3	7104.6	59	B, C, R, N
4	4	11	3	2009	23	47	4033.6	7048.7	68	B
5	5	11	4	2009	2	38	4033.7	7012.8	56	B
6	6	11	4	2009	4	34	4023.8	6952.9	74	B
7	7	11	4	2009	5	58	4016.1	6940.7	78	B
8	8	11	4	2009	6	48	4011.3	6944.5	88	B
9	9	11	4	2009	10	39	4011.2	7020.5	111	B
10	10	11	4	2009	13	34	4021.2	7042.5	92	B, C
11	11	11	4	2009	16	3	4003.7	7056.7	193	B
Rosette only	12	11	4	2009	18	7	4003.1	7116.4	158	R, N
	13	11	4	2009	23	27	4001.1	7210.2	78	R, B
	14	11	5	2009	1	6	3956.1	7226.8	66	B
	15	11	5	2009	4	6	3956.1	7302.6	48	B
	15	11	5	2009	4	15	3955.8	7302.6	48	W
	16	11	5	2009	5	51	3941	7258.6	58	B
	17	11	5	2009	6	57	3941.3	7247.1	68	B
	18	11	5	2009	9	3	3936.1	7224.7	115	B
	19	11	5	2009	12	6	3911.3	7246.7	99	R, B
	20	11	5	2009	16	49	3923.8	7320.8	48	B, C, R, N
	21	11	5	2009	20	15	3901.5	7342.5	38	B
	22	11	5	2009	23	5	3908.7	7416.5	21	B, C, R, N
	23	11	6	2009	1	5	3913.7	7432.7	10	B
	24	11	6	2009	3	56	3846.3	7424.8	31	B
	25	11	6	2009	6	21	3828.8	7440.5	24	B
	26	11	6	2009	8	34	3818.8	7500.6	16	B
	27	11	6	2009	10	4	3811.2	7446.7	26	B
	28	11	6	2009	12	29	3748.6	7454.8	24	B, R, N
	29	11	6	2009	16	38	3726.3	7526.8	20	B, C, R, N
	30	11	6	2009	19	48	3703.8	7542.8	14	B, R, N
	31	11	6	2009	23	32	3628.6	7546.7	19	B, R
	32	11	7	2009	4	57	3548.8	7510.7	34	B
	33	11	7	2009	5	54	3553.6	7502.8	37	B
	34	11	7	2009	6	4	3553.9	7502.5	38	W
	35	11	7	2009	8	22	3611	7446.7	363	B
	36	11	7	2009	8	54	3610.1	7445.7	500	V
	37	11	7	2009	11	48	3631.1	7450.7	42	B, C, R, N
	38	11	7	2009	15	27	3658.8	7508.7	38	B
	39	11	7	2009	17	8	3713.5	7505	34	B, C, R, N
	40	11	7	2009	18	43	3723.8	7506.8	34	B

Table 1. STATION OPERATION REPORT FOR CRUISE DE0909

CAST	STA.	Date(GMT)		TIME(GMT)		LAT	LONG	DEPTH	OPERATION	
		mm	dd	yy	hr					min
									B=bongo W=water C=CMarZ V=vertical cast(CTD only) R=rosette cast N = nutrient sample	
		m								
41	39	11	7	2009	22	1	3731.1	7429	82	B, R
42	40	11	8	2009	2	7	3806	7420.8	40	B
43	41	11	8	2009	4	10	3816.1	7400.8	72	B
44	41	11	8	2009	4	20	3815.9	7400.5	73	W
45	42	11	8	2009	7	3	3828.7	7330.3	375	B
46	42	11	8	2009	7	34	3828.5	7330.6	381	W
47	43	11	8	2009	9	11	3832.1	7315	350	B, R, N
48	44	11	8	2009	15	6	3848.5	7354.6	46	B
49	45	11	8	2009	18	2	3853.7	7319.1	70	B, R, N
50	46	11	8	2009	22	26	3921.7	7348.2	37	B, R
51	47	11	9	2009	1	44	3951.1	7354.8	25	B
52	48	11	9	2009	5	19	4026.1	7348.9	32	B
53	48	11	9	2009	5	31	4026.8	7349.2	31	W
54	49	11	9	2009	7	58	4018.7	7318.7	34	B
55	50	11	9	2009	8	28	4021.1	7316.8	34	B
56	50	11	9	2009	8	39	4021.2	7316.4	35	W
57	51	11	9	2009	12	30	4041.4	7236.8	32	B, C, R, N
58	52	11	9	2009	15	11	4053.7	7212.6	24	B
59	53	11	9	2009	18	22	4038.9	7137	74	B, C, R, N
60	54	11	9	2009	20	22	4053.3	7135.2	56	B, C
Rosette only	55	11	9	2009	23	29	4100.1	7059.9	48	R, N
61	56	11	10	2009	2	2	4106.2	7030.7	41	B
62	56	11	10	2009	2	10	4105.9	7030.6	41	W
63	57	11	10	2009	4	31	4106.3	7000.8	24	B
64	58	11	10	2009	7	49	4048.8	6938.7	43	B
65	59	11	10	2009	10	31	4111.2	6918.6	49	B, R, N
Rosette only	60	11	10	2009	17	19	4051.3	7024.1	52	R
66	61	11	11	2009	0	8	4038.7	6924.5	50	B, R
67	62	11	11	2009	3	25	4038.5	6854.7	67	B
68	62	11	11	2009	3	35	4038.6	6854.8	67	W
69	63	11	11	2009	5	7	4046.1	6841.1	63	B
70	64	11	11	2009	6	8	4041.2	6835.1	61	B
71	64	11	11	2009	6	20	4041.8	6835.4	61	W
72	65	11	11	2009	7	21	4036.1	6829	72	B
73	66	11	11	2009	8	45	4031.2	6816.7	99	B
74	67	11	11	2009	12	53	4023.9	6734.5	171	B, C, R, N
75	68	11	11	2009	16	20	4038.8	6728.5	94	B
76	69	11	11	2009	20	46	4053.6	6714.6	86	B, C
77	70	11	11	2009	23	46	4058.5	6651.1	80	B
78	71	11	12	2009	1	3	4048.8	6648.5	110	B
79	72	11	12	2009	6	26	4108.8	6644.9	75	B
80	73	11	12	2009	8	26	4111.3	6704.8	64	B

Table 1. STATION OPERATION REPORT FOR CRUISE DE0909

CAST	STA.	Date (GMT)		TIME (GMT)		LAT	LONG	DEPTH	OPERATION		
		mm	dd	yy	hr				min	m	N = nutrient sample
	81	74	11	12	2009	10	50	4111.2	6728.5	50	B, C
	82	75	11	12	2009	13	21	4105.9	6752.7	47	B
	83	75	11	12	2009	13	31	4106.1	6751.8	49	B
	84	76	11	12	2009	15	21	4051.3	6801.4	66	B
Rosette	only	77	11	16	2009	21	56	4126.0	7007.9	11	R, N
	85	78	11	17	2009	1	15	4133.6	6946.5	24	B
	86	79	11	17	2009	5	26	4143.6	6852.8	168	B
	87	79	11	17	2009	5	52	4144.4	6853.3	170	W
	88	80	11	17	2009	9	2	4136.1	6814.7	37	B
	89	81	11	17	2009	12	13	4133.7	6740.7	18	B, C, R, N
	90	82	11	17	2009	13	55	4143.6	6730.8	55	B
	91	82	11	17	2009	14	11	4144.8	6731.2	53	B
	92	83	11	17	2009	17	46	4131.1	6646.9	73	B
	93	83	11	17	2009	18	6	4131.0	6646.5	73	B, R, N
Rosette	only	84	11	17	2009	23	00	4141.4	6605.2	150	R
	94	85	11	18	2009	1	28	4146.2	6545.2	154	B
	95	85	11	18	2009	1	56	4146.8	6546.2	147	W
	96	86	11	18	2009	3	8	4158.4	6544.8	250	B
	97	86	11	18	2009	3	34	4159.5	6544.9	257	V
	98	87	11	18	2009	5	11	4212.9	6545.9	229	B
	99	87	11	18	2009	5	38	4213.7	6544.9	232	W
	100	88	11	18	2009	8	22	4203.4	6612.5	93	B
	101	89	11	18	2009	9	14	4156	6614.8	82	B
	102	90	11	18	2009	11	36	4211.1	6636.6	209	B, C, R, N
	103	91	11	18	2009	13	38	4218.7	6653	304	V
	104	91	11	18	2009	13	55	4218.7	6653.2	304	B, C
	105	92	11	18	2009	15	8	4224.9	6700.3	366	B, R, N
	106	93	11	18	2009	19	24	4202.9	6702.2	61	B, C, R, N
	107	94	11	18	2009	20	27	4203.3	6708.3	54	B
	108	94	11	18	2009	20	39	4202.8	6708.7	55	B
	109	95	11	18	2009	22	21	4213.8	6718.8	227	B, C, R, N
	110	96	11	19	2009	1	1	4203.8	6738.4	158	B
	111	97	11	19	2009	1	52	4159	6740.6	50	B
	112	97	11	19	2009	2	5	4159.1	6740.8	52	W
	113	98	11	19	2009	4	38	4210.9	6810.5	185	B
	114	99	11	19	2009	7	48	4158.7	6844.2	149	B
	115	99	11	19	2009	8	9	4158.1	6844.8	144	W
	116	100	11	19	2009	9	23	4206.2	6854.8	147	B
Rosette	only	101	11	19	2009	11	32	4216.6	6915.3	214	R, N
	117	102	11	19	2009	13	58	4229.8	6939.8	259	B, R, N
	118	103	11	19	2009	16	9	4243.4	6935	256	B, C, R, N
	119	104	11	19	2009	19	40	4303.4	6950.6	186	B, C
	120	105	11	19	2009	22	15	4303.6	7020.7	121	B
	121	106	11	19	2009	23	42	4253.8	7030.6	75	B, R, N
	122	107	11	20	2009	2	57	4225.2	7036.5	87	B
	123	108	11	20	2009	5	18	4204.9	7032.3	42	B

TOTALS:	Bongo Casts	= 108
	Bongo 6B3Z Samples	= 102
	Bongo 6B3I Samples	= 102
	CTD 19 Water Samples	= 129
	Vertical CTD 19 Casts	= 3
	CTD 19 Casts	= 123
	CMarZ samples	= 20
	U Maine Nutrient Samples	= 87
	Rosette/CTD 911 casts	= 36
	Acrobat Deployments	= 3
	Meter Net Tows	= 4

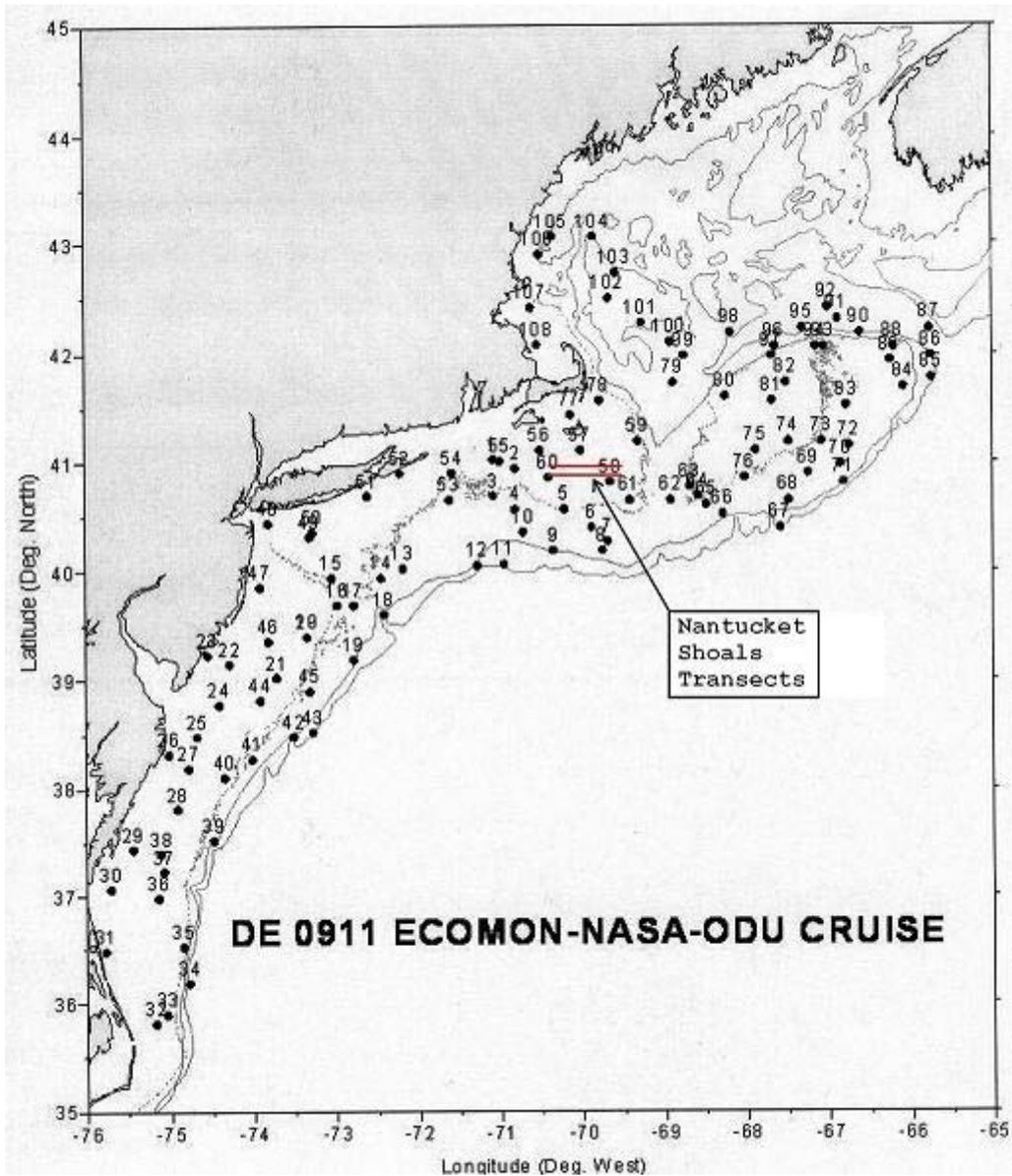


Figure 1. Station locations numbered consecutively for Ecosystems Monitoring Survey and NASA Ground Truth Measurements Cruise DE 09-11, 3 - 20 November 2009.



Figure 2. 20 cm + 61 cm bongo sampling array used for collecting CMarZ samples simultaneously with Ecosystem Monitoring samples.



Figure 3. NOAA researchers Tamara Holzwarth-Davis and Chris Melrose in covered work area of Delaware II getting plankton samples from bongo nets. The lab container is visible in the background.



Figure 4. Outside view of laboratory container. (Balloons were recovered from sea surface).



Figure 5. Internal view of laboratory container.



Figure 6. Delaware II wetlab set up with extra bench and shelf for ODU filtration gear.



Figure 7. Crewmember Richard Logan launches Acrobat unit off the stern of Delaware II.



Figure 8. Meter net being deployed from aft A-frame of Delaware II to search for herring larvae on Georges Bank.



Figure 9. CTD 911 and rosette unit being deployed from aft A-frame of Delaware II.



Figure 10. Incubators on port side of stern deck of Delaware II.