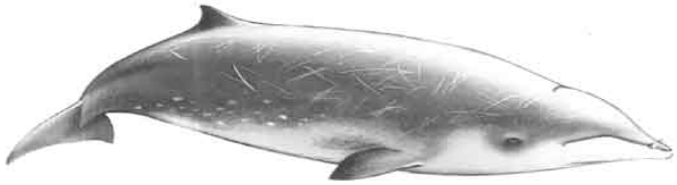
Cruise Results
NOAA Fisheries Research Vessel Delaware II
Cruise No. DE - 0613, Parts I & II
Passive Acoustic Testing (Part I) & Marine Mammal Habitat Survey (Part II)



Cruise Period and Area

Part I of the survey was conducted aboard the NOAA RV Delaware II from 31 July - 4 August, 2006. The primary area of operations was in slope/shelf waters around Georges Bank and western portion of Browns Bank (Figure 1).

Part II of the survey was conducted from 12-16 August in the western Gulf of Maine (Figure 1).

Objectives

Part I The primary objectives of acoustic monitoring during the cruise were to: (1) test and further develop Pamguard software, and in particular to test the Pamguard – Ishmael interface and collect data, for testing and ground proofing 3-D localisation methods; and (2) set up a hydrophone array for NEFSC Protected Species Branch (PSB) and install International Fund for Animal Welfare (IFAW) software on a PSB computer for the detection of sperm whales, right whales and harbor porpoises, and to train PSB personnel in their operation. Secondary objectives were to: (1) conduct visual surveys for marine mammals; and (2) test and calibrate hand-held computers and software for future cetacean line-transect surveys.

Part II - The primary objectives were to: (1) collect information on the relationship between cetaceans and potential prey using an IGYPT mid-water trawl; (2) collect information on oceanographic features using CTD data; and (3) conduct visual surveys for marine mammals. Secondary objectives were to: (1) collect photo identification data on pilot whales; and (2) obtain biopsy samples from bow riding animals.

Methods

Part I: Vessel speed was generally either 10 or 5 knots. 10 knots is the maximum speed for the

vessel and is generally considered to be a reasonable speed for visual line transect surveys. For some parts of each day, during the night, and when carrying out certain acoustic tests, speed was reduced to 5 knots in order to reduce noise. Visual survey operations were conducted during daylight hours (~0700 to 1800), weather conditions permitting. The survey was conducted along predetermined track lines that primarily encompassed shelf/slope around Georges Bank and across the western edge of Brown's Bank. Segments of this region are known to be summer habitat for sperm whales, right whales and harbor porpoises.

Hydrophone arrays

Three hydrophone arrays were deployed. All three were similar in that they consisted of trailing end having a 10m long, approx 30mm diameter, oil filled section containing the active elements and all were on approximately 400m reinforced towing cable. The first was a hydrophone belonging to PSB, recently purchased from Ecologic, UK. This contains three 'low' frequency hydrophone elements with a bandwidth of 100Hz to 40kHz. These may be used for monitoring right whales and other baleen whales as well as most odontocetes species such as sperm whales. The PSB array also contains two high frequency (2kHz to 200kHz) elements, which are used to monitor for harbour porpoise. The other two streamers were originally built for the SWSS sperm whale project in the Gulf of Mexico and were loaned to PSB for the purposes of this cruise. Each contained a pair of AQ-4 elements with a 3m spacing; one array contained a pinger which could be used to generate chirp sounds for alignment of the system. Signals from two AQ-4 hydrophone elements were amplified using Magrec amplifiers. Output from the amplifiers was input to a multi channel MOTU soundcard, as well as various other sound cards connected to other computers being used in the trials. No hydraulic winches were available for the deployment of the hydrophones, which were deployed and recovered by hand. Since the hydrophone lines would need to be reeled in for the collection of CTD data, CTD data were not collected. Standard sound velocity curves for the Gulf of Maine are, however, available and sea surface temperature from the cruise is available. In addition, PSB provided a comprehensive physical parameter digest following the cruise.

Pamguard trials

The purposes of the Pamguard trials were to: (1) test Pamguard data pathways in real time; (2) test the TCP interface, which allows Ishmael to send locations to Pamguard, in real time; (3) collect multi channel data, using multiple streamers in the vicinity of a known sound source at a known location for further testing and development of multi- channel 3-D tracking algorithms both within Ishmael and Pamguard; and (4) compare acoustic detections and localizations with those of a visual survey team.

The three hydrophone streamers were deployed: (1) off a gantry crane on the starboard side of the vessel, (2) through a roller block close to the middle of the transom, (3) and through a block close to the port side of the vessel. Due to a lack of suitable attachment points, particularly on the port side of the vessel, and the difficulty of recovering and deploying streamers by hand, only a single hydrophone geometry was tested. The port and starboard hydrophones were streamed to their full length of 400m. The middle hydrophone was deployed to approximately half its total length, 200m. This arrangement allowed both small- and large-aperture acquisitions.

For array alignment, a chirp signal (5 to 15kHz sweep, duration either .1 or .2s) was transmitted approximately every 10 seconds from a transducer in the mid point of the port streamer. Additional alignment will be carried out using noise from the ships propeller and depth sounder, both of which were clearly audible.

Continuous data collection

The latest version of Pamguard software was run more or less continuously on a laptop computer. The software was set up for two-hydrophone operation and included the IFAW click and whistle detection algorithms implemented in 2005. The software was thoroughly debugged during the *Charles Darwin* cruise earlier this year and performed reliably for the duration of the RV *Delaware II* cruise.

Ishmael software was run on two computers. One, equipped with an 8 channel MOTU traveller sound card, was used to acquire continuous acoustic data from the three streamers and write that data to disk. The other, using an Edirol sound card, was used to test real time tracking of both real animal and artificial pinger sounds. In total, a few hundred gigabytes of recording were made which will be used for tracking algorithm development through the rest of the year.

Real time Ishmael / Pamguard data exchange

Following development work prior to the cruise, Ishmael could send detection data to Pamguard using a TCP protocol. Pamguard modules to display Ishmael data on the Pamguard map were added on the first day of the cruise and tested on a number of occasions. After some initial debugging of the exchange protocol, both the data link and the graphics performed well, enabling Ishmael detection data to be overlaid with ease on Pamguard. Additional functionality to display data on the spectrograms is still to be written.

Pinger buoy experiments

In order to test existing Ishmael and Pamguard tracking functionality and to develop better algorithms in the future, data were collected using fisheries pingers attached to drifting buoys equipped with recording GPS's. (Fisheries pingers are devices designed to alert porpoises to the presence of fishing nets in order to reduce entanglement mortalities). Two buoys were deployed, each with one pinger 10m below the surface and another at the end of a 100m line. A dive computer was also attached to the end of the line, so that by monitoring the depth of the lower element, the angle of the line and consequently the true position of the lower pinger, could be estimated. The buoys were deployed 1 nautical mile apart for a period of approximately three hours. During that time, the RV *Delaware II* followed a rectangular path around the buoys, passing them at varying distances. Data from both the straight sections of the track and the curved sections will be analyzed to assess the accuracy with which we are able to track signals at varying distances.

Multi channel recordings were made throughout the buoy experiment. Following recovery of the buoys, position data from the GPS units and depth data from the dive computers were successfully downloaded.

PSB hydrophone setup
A PSB computer was set up with IFAW software for porpoise and right whale detection and also with Logger software for collection of GPS data. (It is hoped to upgrade this to Pamguard software in the future, when Pamguard is further tested and right whale detection has been implemented). Unfortunately, the high frequency hydrophone elements failed shortly after deployment. The National Instruments data acquisition card also did not appear to be working properly, being unable to run at the gain setting required for porpoise detection.

At the end of the cruise, the PSB array was stripped down and the porpoise hydrophones removed. These, along with the National Instruments card have been brought back to the UK. A PSB acoustician was trained in how to set up and operate the software and also received unexpected training in stripping and reassembling an Ecologic hydrophone array. How to complete repair of the array and resolve problems with the National Instruments card will be discussed following tests in the coming weeks.

Right whale detection ran throughout the cruise. The detector is known to have a small false alarm rate. Normally, this is 1 or 2 false detection per day. The detector was made slightly more sensitive for the *RV Delaware II* cruise. Each time a candidate detection was made, a short recording was also automatically made, using a buffer system to acquire sound data from one minute before the actual detection. These recordings will be examined by a human operator to check for right whale sounds.

Visual sampling
During survey operations scientific personnel formed a single sighting team of three observers. The survey team followed standard line-transect procedures similar to that described in Palka (1995)[a]. The team was located on the flying bridge, 7.9 m above the water line. The scientists rotated through three observation positions where the center person was the recorder and surveyed using the naked eye, while the starboard and port observer searched through 25x150 power binoculars. Every 30 minutes people rotated positions from port to center to starboard to rest to port again.

The starboard observer searched waters on the starboard side and a small overlap area on the port side, that is, from 10° port of the track line to 90° starboard, where 0° is on the track line. The port-side observer searched waters on the port side and a small overlap area on the starboard side, that is, from 10° to starboard of the track line to 90° port. The recorder sat in between the two binocular observers and concentrated searching close to the ship and on the track line, that is, they searched from 30° port to 30° starboard of the track line.

[a] Palka, D. 1995. Abundance estimate of the Gulf of Maine harbor porpoise. Pp. 27-50 In: A. Bjørge and G.P. Donovan (eds.) Biology of the Phocoenids. Rep. int Whal. Commn Special Issue 16.

When an animal group (dolphins, whales, seals) was detected the following factors were recorded onto a computerized data entry device:

1) time of sighting, recorded to the nearest second,
2) species composition of the group,
3) radial distance between the team's platform and where the sighting was initially detected, estimated either visually when not using the binoculars or by reticles when using binoculars,
4) bearing between the line of sight to the group and the track line; measured by a polarus mounted on the binoculars,
5) best, high and low estimate of group size,
6) initial direction of swim,
7) number of calves,
8) initial sighting cue,
9) initial behavior of the group, and
10) any comments on unusual markings or behavior.

The location (latitude and longitude) of a sighting was determined subsequently using an algorithm which used dead reckonings between recorded positions of the ship (see below). Ship's position was recorded every minute.

In addition to the above sighting data, effort data were logged by the recorder, and environmental data were obtained every minute on the ship's fishery scientific computer system (FSCS). Effort data was updated every time one of them changed, and included:

1) time of recording,
2) position of each observer, and
3) weather conditions: swell direction and height, Beaufort sea state, presence of rain or fog, percentage of cloud coverage, visibility (i.e., approximate distance to the horizon), vertical and horizontal position of the sun, and glare width and strength.

Environmental data included:

1) time of recording,
2) latitude and longitude of ship's position,
3) ship's bearing,
4) ship's speed over the ground,
5) wind speed and direction,
6) bottom depth,
7) surface water temperature, and
8) EK500 (18, 38, 120kHz) acoustic data.

Part II
Fishing
After arriving in deep water (~200m) east of Cape Cod the RV *Delaware II* conducted two test tows of the IGYPT trawl, which was equipped with SCANMAR sensors (door and wing spread, height, and depth). The test tows were conducted with the codend open, since the goal was to determine the best towing speed and scope, and ensure that the sensors were mounted correctly. SCANMAR readings were compared to reference values provided by the NEFSC Resource Ecosystem Branch.

Fishing operations were conducted along transect lines (Figure 2) between 0000-1200 hours to ensure that both night and day periods were sampled. Fishing positions were based on visual monitoring of EK500 (18, 38, and 120kHz) display monitors.

Visual sampling
During daylight hours (0700-1888) two observers collected marine mammal sightings following a modified version of the protocols described above. The observers maintained alternating one hour watches and searched in a 180°arc in front of the vessel. Observers self-recorded their sightings and environmental/effort data.

Oceanographic sampling
At most fishing stations and/or transect end points, a SEACAT[1] 19 Profiler (CTD) was used to measure temperature, depth, and salinity of the water column.

Data Management
Sightings, fishing, and oceanographic data will be processed and computerized at the NEFSC Laboratory at Woods Hole, Massachusetts. The acoustic data will be processed by Pamguard Project researchers.

Results

Part 1 – Hydrophone arrays
The hydrophone arrays were towed 425.6 nautical miles in a U shaped transect pattern that bracketed the western, southern and eastern flanks of Georges Bank, and crossed the western edge of Browns Bank (Figure 1). The hydrophone-pinger calibration study was conducted west of Munson Canyon in approximately 370 m water depth.

Around 1400 hrs on 3 August one of the hydrophone cables snapped and 380m of 14mm diameter polyurethane/kevlar cable including a 10m of oil filled (Isopar M) section. It was not possible to retrieve the cable and Canadian officials were notified. Concomitantly, one of the generators on the ship failed, thus the remaining two hydrophones were hauled in and the vessel returned to Woods Hole.

Prototype data entry system
NEFSC Data Management Support staff tested a prototype of a new sightings survey data entry system. The system as tested consists of two tablet computers (Fujitsu Stylistic 1050D, Motion LS800), and PDA (HP iPAQ 9724), and a GPS receiver (Socket) networked with both Bluetooth and WiFi using an access point (Cisco Wireless Access Point 1200). The tests were to evaluate the suitability of the tablets, the iPAQ and the effectiveness of the wireless communications on shipboard. The computers were responsive and the screens viewable. The battery life was good and much better than anticipated once settings were suitably determined. The wireless configuration worked well within the distance constraints: with the access point either inside on the bridge or outside on the flying bridge and the main computer on the flying bridge, the user with the mobile computer could roam outside on the forward half of the ship. Communications with a roaming computer on the aft half of the ship were not possible with a reasonably simple wireless set up.

Further development of the system needs to address several issues: 1) character recognition needs to be constrained reliably to numeric entries only, 2) new sighting functionality needs to be streamlined to ensure a single gesture to establish a new sighting, and 3) the role of the wireless communications may be reconsidered to have 'on demand' rather than real time communications with the server computer. In addition the prototype needs to be extended to include GPS logging on the tablet computers, trackline and sighting position display, data backup and logging, and trip and daily set up routines. The next stage should also include development of sighting data entry on a PDA with internal GPS as a more suitable roaming data entry unit than the current Mobile LS800.

Visual survey
Visual searching covered approximately 203.6nm of hydrophone track line (Figure 1). Most of the survey transects on Leg 1 (139.7 nm; 68.6%) were in Beaufort sea state 3 or less (Table 1).

The number of groups and individuals of each species detected are found in Table 2. Humpback whales (*Megaptera novaeangliae*) and common dolphins (*Delphinus delphis*) were the most frequently sighted species on Leg 1. Locations of marine mammal sightings are displayed in Figure 1.

All large whale sightings in Canadian waters were reported as specified in the Canadian Fishing License and SARA Permit issued to NEFSC.

Part 2 – Marine mammal habitat
Six tows were conducted using the IGYPT trawl (Figure 2). The tows were conducted at a range of water depths (30 to 160m), based on visual inspection of the EK500 monitor. The first four tows were either "water hauls" (i.e., empty) or contained a few shrimp like animals and one or two small fishes. The 5th tow contained 5.2kg of northern shrimp (*Pandalus borealis*), and the 6th tow caught 36kg of northern shrimp and 208.4kg of spiny dogfish (*Squalus acanthias*).

Hydrographic Characteristics
Nine CTD casts were made (Figure 2), at which water temperature, depth and salinity were measured from the surface to within 10 m of the bottom.

Visual survey
Marine mammal searching was conducted along 173.5 nm of the survey track line, and most of the survey transects (102.3 nm; 59.0%) were in Beaufort sea state 3 or less (Table 1). Five cetacean species were encountered, each represented by a single sighting (Table 2; Figure 2). Thirteen digital images of long-finned pilot whales were collected for NEFSC photo identification studies.

No sea turtles were detected during Parts 1 and 2.

Personnel List (Scientific): Part I:

Name	Title	Organization
Gordon T. Waring	Chief Scientist	NMFS, NEFSC, PSB, Woods Hole, MA
John Nicolas	Mar. Mammal Spec.	NMFS, NEFSC, PSB, Woods Hole, MA
Beth Josephson	Contract Researcher	NMFS, NEFSC, PSB, Woods Hole, MA
Kimberly Murray	Res. Fish. Biol.	NMFS, NEFSC, PSB, Woods Hole, MA
Nan Logan	Information Tech. Spec.	NMFS, NEFSC, PSB, Woods Hole, MA
Beth Josephson	Contract Researcher	NMFS, NEFSC, PSB, Woods Hole, MA
Cynthia Christman	Contract Researcher	NMFS, NEFSC, PSB, Woods Hole, MA
Sofie VanParjis	Zoologist	NMFS, NEFSC, PSB, Woods Hole, MA
Doug Gillespie	Acoustician	International Fund for Animal Welfare, UK
Hisham Qayum	Acoustician	NOAA, PMEL, OSU, Newport, OR

Part II:

Gordon T. Waring	Chief Scientist	NMFS, NEFSC, PSB, Woods Hole, MA
John Nicolas	Mar. Mammal Spec.	NMFS, NEFSC, PSB, Woods Hole, MA
Chris Orphanides	Zoologist	NMFS, NEFSC, PSB, Woods Hole, MA
Tim Cole	Res. Fish. Biol.	NMFS, NEFSC, PSB, Woods Hole, MA

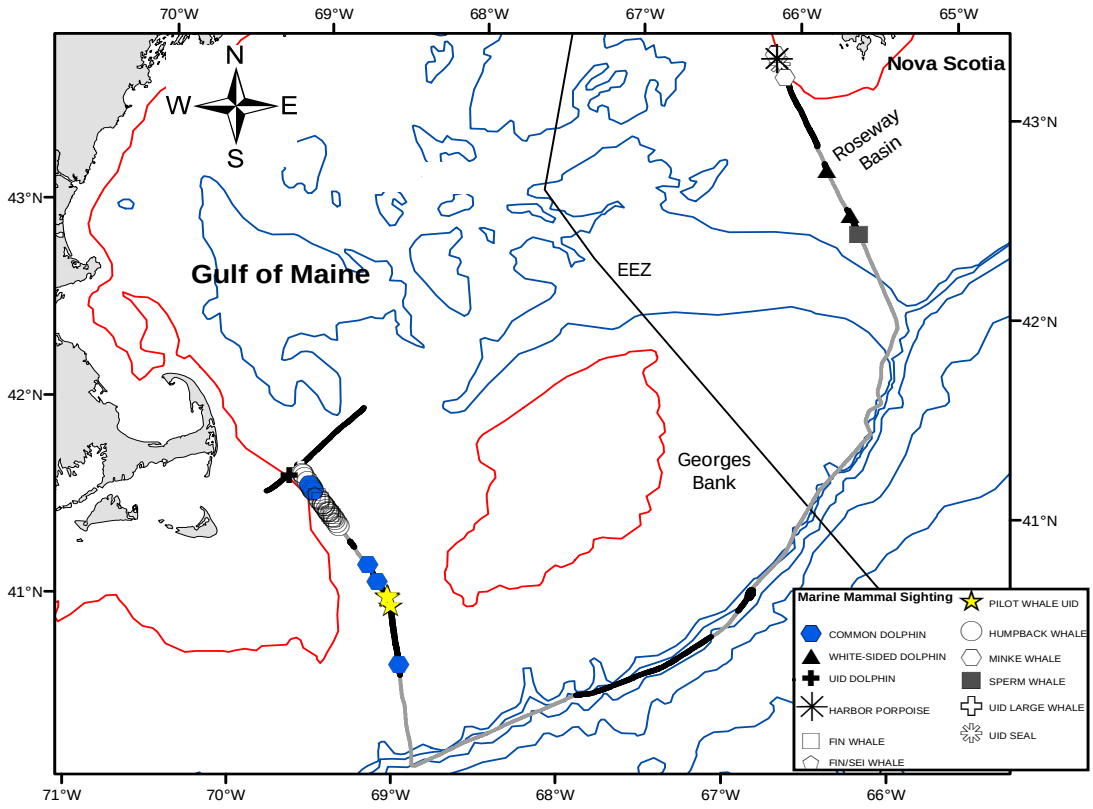


Figure 1. Survey region, hydrophone transect lines (gray), visual survey transect lines (black), and animal sightings from DE-0613 Leg 1 marine mammal survey.

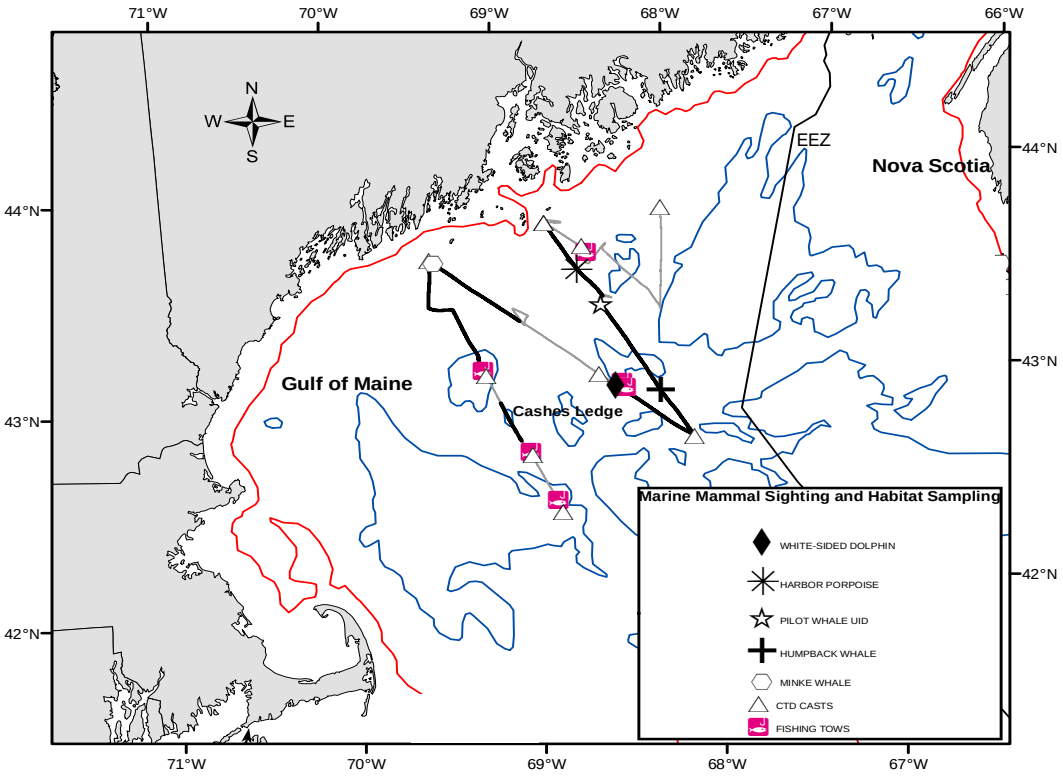


Figure 2. . Survey region, visual survey transect lines (black), fishing and oceanographic stations, and animal sightings from DE-0613 Leg 2 marine mammal survey.

Table 1. Length (and percentage) of track line (nm) surveyed during primary mode in Beaufort sea state conditions 0-5

Beaufort sea state	Leg 1 track line length	Leg 1 % of total	Leg 2 track line length	Leg 2 % of total
0	6.6	3.3	0.0	0.0
1	33.3	16.4	0.0	0.0
2	37.3	18.3	58.0	33.5
3	62.5	30.7	44.3	25.5
4	63.9	31.4	38.2	22.0
5	0.0	0.0	33.0	19.0
Total	203.6	100.0	173.5	100.0

Table 2. List of species detected during the R/V DELAWARE II Marine Mammal Survey, July 31-August 15, 2006. Included are 1) number of sightings of groups of each species on each leg of the survey, and 2) best estimates of total number of individual animals seen for each species.

		Leg 1		**Leg 2**	
Common Name	**Latin Name**	**groups**	**individuals**	**groups**	**individuals**
Common dolphin	*Delphinus delphis*	11	88		
White-sided dolphin	*Lagenorhynchus acutus*	3	46	1	35
Harbor porpoise	*Phocoena phocoena*	2	2	1	7
Unidentified dolphin		1	1		
Pilot whale	*Globicephala sp.*	4	18	1	100
Fin whale	*Balaenoptera physalus*	5	6		
Fin/Sei whale		2	2		
Sperm whale	*Physeter macrocephalus*	1	1		
Humpback whale	*Megaptera novaeangliae*	26	38	1	1
Minke whale	*Balaenoptera acutorostrata*	3	3	1	1
Unidentified Large whale		7	8		
Unidentified seal		2	2		