Cruise Report

HB15-03 Leg 2: Turtle tagging study during June/July 2015

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SUMMARY

To estimate the amount of time sea turtles are available to line-transect abundance surveys, the NOAA ship *Henry B. Bigelow* was used to capture and tag 3 loggerhead sea turtles (*Caretta caretta*) and 1 Kemp's ridley turtle (*Lepidochelys kempii*) that were located on the southern flank of Georges Bank during 23 Jun – 2 Jul 2015. These captures also allowed an opportunity to collect associated biological information from these tagged animals. A Puma fixed wing unmanned aerial system was deployed for the first time from a large ship and was used to expand the ability to detect turtles over the standard searching with high powered binoculars and naked eye. A high-frequency acoustic recording package (HARP) was deployed near Corsair Canyon and will be recording passive acoustic data for one year. In addition to searching for turtles to tag, marine mammals and large fish species sightings were recorded, passive acoustic recordings were made, and samples of potential turtle prey were taken using a visual plankton recorder, a Sound Metrics Didson 300 imaging sonar, and a paired Go-Pros video system.

OBJECTIVES

As part of the current AMAPPS project as well as historic NOAA projects, millions of dollars have been spent on line-transect aerial surveys for protected species, yet the availability of protected species to aerial surveys is not well known, particularly for sea turtles northeast of Long Island. Data from satellite relayed data loggers can inform estimates of sea turtle availability. To address this need, our motivating objective was to locate, capture, sample, and satellite tag loggerhead sea turtles in the poorly understood area from the southern flank of Georges Bank through the Scotian Shelf.

The overall goal of Leg 2 of the NOAA ship *Henry B. Bigelow* summer cruise was to focus on sea turtle species, but to also collect priority information on marine mammal acoustics and oceanography. The specific objectives were:

1) Use big eyes, binoculars and Puma fixed wing unmanned aerial systems to locate sea turtles
2) Capture, bring on board, sample, and satellite tag hard-shelled sea turtles (primarily loggerheads)
3) Deploy a high-frequency acoustic recording package (HARP) along the shelf break near Corsair Canyon, to record passive acoustic data for one year
4) Collect passive acoustic data via towed hydrophone array, particularly for detection of beaked and sperm whales
5) Opportunistically record data on marine mammal visual sightings
6) Use conductivity, temperature and depth (CTDs) recorders to collect information on water column structure, particularly with reference to the large warm core rings along the shelf break

7) Be prepared to deploy instruments to assess gelatinous zooplankton, if large aggregations exist.

CRUISE PERIOD AND AREA

The total cruise period was originally scheduled for 23 days, from 7 June – 2 July 2015; however, several cruise days were lost due to due to shortage of shipboard crew members, ongoing repairs, and lack of necessary supplies. The final cruise period for the second leg was 23 June – 2 July 2015.

The study area for Leg 2 included the shelf break area from south of Newport, and along the southern flank of Georges Bank into Canadian waters (Figure 1). The study region was between 40°N - 43°N latitude, and between 65°W - 71°W. This included waters within the US and Canadian economic exclusive zones (EEZ).

METHODS

UNMANNED AIRCRAFT SYSTEMS (UAS) TEAM

To increase our ability to sight and mark the location of sea turtles, we partnered with the NOAA UAS program to create a team that operated three fixed-wing Puma unmanned aircraft systems. The NOAA RQ-20 Puma were operated in accordance with the AeroVironment Puma Operator's Manual, NOAA Aircraft Operations Center (AOC) Airworthiness Certificate, Federal Aviation Administration (FAA) Certificate of Authorization(s) and a documented Standard Operating Procedures (SOP). This UAS mission was the first NOAA UAS mission aboard a NOAA ship in the Atlantic Ocean. It was also the first NMFS-permitted activity using UASs for turtle research. The mission was also unique in that we operated the UASs beyond the line of sight.

VISUAL TURTLE SIGHTING TEAM

Transects were conducted during daylight hours. The direction of the transect was adjusted to optimize sighting conditions. Surveying was conducted in most weather conditions, except not in heavy rain or in seas that were too rough for safe small boat operations. Survey speed was adjusted according to sighting conditions. We sometimes surveys at 10 kts, but more typically at about 5 kts.

Most visual observers were located on the flying bridge (15.1 m above the sea surface). In the beginning of the cruise, we also had visual observers located on the anti-roll tank (11.8 m above the sea surface), but that platform was not optimal because it was difficult for those observers to follow a sighting as the ship maneuvered in preparation for small boat deployment.

The visual sighting team was part of a dynamic larger sightings, capture, and turtle handling team. When staff was not working on other science missions, all eight members of this team as well as scientific staff with other responsibilities (CS, Puma UAS team, oceanography, acoustics, and blood processing) were all supporting visual sightings operations. The size of this team shrank when scientists were needed for other functions. Observers utilized high-powered "big-eye" binoculars (Fujinon, 25x150), hand-held binoculars, and naked eyes to scan from the bow of the ship to approximately 90˚ port and starboard. One member of the team, on a rotating basis, was typically assigned to record data with VisSurv-NE.

When an animal group (porpoise, dolphin, whale, seal, turtle or a few large fish species) was detected, the following data were recorded with VisSurv-NE:

1) Time sighting was initially detected, recorded to the nearest second,

2) Species composition of the group,
3) Radial distance between the team's platform and the location of the sighting, 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 ship's track line; measured by a polarus mounted near the observer or a polarus at the base of the binoculars,
5) Best estimate of group size,
6) 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.

Although we recorded marine mammal sightings, we never altered our trackline to collect more information. Because the focus of the survey was to find sea turtles, our survey effort was optimized for turtles rather than standardized line transect data collection; hence our sightings are not appropriate for standard line transect abundance estimates.

In addition to the sightings data, the following effort data were recorded opportunistically:

1) Time of recording
2) Weather conditions: swell direction relative to the ship's travel direction and height (in meters), apparent Beaufort sea state in front of the ship, presence of light or thick haze, rain or fog, amount of cloud coverage, visibility (i.e., approximate maximum distance that can be seen), and glare location and strength of glare within the glare swath (none, slight, moderate, severe).

At the same time, the location (latitude and longitude) of the ship when this information was entered was recorded by the ship's GPS via the ship's sensor SCS system which was connected to the data entry computers.

TURTLE SAMPLING TEAM

When a hardshelled turtle was located, we deployed a work boat (or fast rescue boat) to capture the turtles using a large dipnet. When conditions permitted, we sometimes left the work boat in the water to optimize our response time. All captured turtles were transferred to the NOAA Ship *Henry B. Bigelow* for biological sampling under Dr. Michael James' Canadian licenses.

We completed basic sampling (measured the length and width of captured turtles, photographed, flipper and PIT tagged, and took biopsy samples for genetic analysis); plus we also measured weight and body depth, took biopsy samples for stable isotope analysis, and took blood samples to analyze for testosterone levels (to identify sex) and general blood chemistry (for health assessment).

We used epoxy to attach 2 Sea Mammal Research Unit's (SMRU) Fastloc GPS Satellite Relay Data Logger (SRDL) to a central carapace scute of 2 captured turtles. The SMRU satellite tags were programmed to transmit every day, though local conditions often prevent the tags from transmitting. Specifications for the SMRU Fastloc GPS Satellite Relay Data Loggers (SRDLs) are provided in Appendix E1. The Fastloc GPS supplies highly accurate locations. The tag also uses precision wet/dry, pressure, and temperature sensors to form individual dive (max depth, shape, time at depth, etc.) records along with temperature profiles and binned summary records. We also have custom-made variables to assess the average duration of a surfacing bout and average duration of a diving bout. The SMRU tag stores

information in its memory and then relays an unbiased sample of detailed individual dive records and summary records.

PASSIVE ACOUSTIC TEAM

The passive acoustic team consisted of two people who operated the system opportunistically, when the situation allowed for the deployment of the towed hydrophone array. During each shift, one person was designated as the primary data collector with the second person as stand-by.

The towed hydrophone array was deployed during nighttime hours, along the shelf break and offshore, in waters 100 m or greater in depth. The array was comprised of two modular, oil-filled sections (the end-array and in-line array), separated by 30 m of cable. The end-array consisted of 3 "mid-frequency" elements (APC International, 42-1021), 2 "high-frequency" elements (Reson, TC 4013), and a depth sensor (Keller America, PA7FLE). The in-line array consisted of 3 "mid-frequency" elements (APC International, 42-1021). The array was towed 300 m behind the ship. Array depth typically varied between 8 – 12 m when deployed at the typical survey speed of 10 kts. Sound speed data at the tow depth of the array were extracted from morning CTD casts.

Acoustic data from the towed hydrophone array were routed to a custom-built Acoustic Recording System that encompassed all signal conditioning, including A/D conversion, filtering, and gain. Data were filtered at 1000 Hz, and variable gain between 20 – 40 dB was added depending on the relative levels of signal and noise. The recording system incorporated two National Instruments soundcards (NI USB-6356). One soundcard sampled the six mid-frequency channels at 192 kHz, the other sampled the two high-frequency channels at 300 – 500 kHz, both at a resolution of 16 bits. Digitized acoustic data were recorded directly onto laptop and desktop computer hard drives using the software program Pamguard (http://www.pamguard.org/home.shtml), which also recorded simultaneous GPS data, continuous depth data, and allowed manual entry of corresponding notes. Two channels of analog data were also routed to an external RME Fireface 400 soundcard and a separate desktop computer, specifically for the purpose of real-time detection and tracking of vocal animals using the software packages WhalTrak and Ishmael.

OCEANOGRAPHY

Physical water characteristics and distribution and densities of various fish and planktonic trophic levels were documented using: Seabird 19+ and 911 CTD, Video Plankton Recorder (VPR), 61cm bongo net, a midwater trawl, paired Go-Pro cameras, a Didson high definition imaging sonar, and multifrequency Simrad EK60 echosounders.

Scientific interest was focused on gelatinous zooplankton in areas where sea turtles were captured. All oceanographic and plankton sampling was opportunistic. Since gelatinous zooplankton is damaged by nets and thus not sampled quantitatively, three imaging systems were deployed in addition to the bongo nets. Since all plankton sampling methods employed indicated extremely low concentrations of gelatinous zooplankton sampling targeting gelatinous zooplankton was given low priority. Oceanographic transects were conducted across interesting features caused by two warm core rings in the sampling area.

Larger gelatinous zooplankton were targeted using a dual visual sampling platform. The first system was a Sound Metrics Didson 300 imaging sonar mounted in a steel cage. The Didson was set to sample a small area, with a focus of 1.04 m. The second system was a video net. It consisted of two Go-Pros facing each other separated by 148.2 cm and boomed out 70 cm. With the cameras set to 1080 wide and the refraction of the water, this allowed the overlapping video coverage of the two cameras to record one square meter when dropped

vertically through the water column. A Star-Oddi DST –CTD was also attached to the platform to record water quality. A mechanical flow meter was mounted on a rod perpendicular to the Go-Pro booms to measure the water current during cast stops. Both the Didson 300 and the Go-Pro video system sampled the same area. During cast the platform was lowered to 100 m then brought to the surface pausing for 2 min at 7 depths (100, 75, 50, 40, 30, 20, and 10 m).

VPR tows used a Seascan V-fin mounted, internally recording, black and white VPR. The VPR was also equipped with a Seabird Fastcat CTD, a Wetlabs fluorometer / turbidity sensor and a Benthos altimeter. The VPR sampled at 16 frames per second with each frame representing a known volume of water. A second SEACAT 19+ CTD profiler was mounted above the V-fin to provide real time data on gear depth and oceanographic conditions. Tows were conducted at 3 – 4 kts speed through the water to minimize image frame overlap. VPR tows were conducted in two formats; in a tow-yo fashion, oscillating between the surface and a predetermined depth, and in a stepped double oblique tow to match the Go-Pro and Didson deployments.

Plankton and hydrographic sampling was conducted by making double oblique tows using the 61-cm bongo net and a Seabird 19+ CTD. The tows were made to approximately 5 m above the bottom, or to a maximum depth of 200 m. Samples were rinsed from the nets and preserved in a 5% formaldehyde seawater solution. In addition to the Seabird 19+ deployed with the plankton nets and imaging systems a Seabird 911 CTD with a 12 niskin bottle rosette, a wet labs fluorometer/turbidity sensor, a Seabird dissolved oxygen sensor, and a PAR sensor was deployed opportunistically to generate oceanographic transects across canyons, across the shelf slope area and across oceanographic features like the Gulf Steam or warm core rings. The 911 was deployed in a vertical fashion with the ship holding station to within 10 m of the bottom.

Specialized bongo sampling was conducted for Michael Ford (Oceanographer, Marine Ecosystems Division, NOAA Fisheries, Smithsonian Environmental Research Center) targeting gelatinous zooplankton. All gelatinos zooplankton present were measured at sea then the samples were preserved in acid Lugols Solution for further identification.

Acoustic backscatter was collected using multi-frequencies (18, 38, 70, 120, and 200 kHz) on a Simrad EK60. The EK60 collected active acoustic data continuously throughout a cruise, mostly in active mode and occasionally in passive mode. The EK60 were set to transmit at 1 ping per second, which allowed the EK60 to ping as fast as they could given the sample range of 3000 m and signal processing time. In general, the EK60 transmitted once every 5 – 6 sec when off the continental shelf. In active mode, each frequency transmitted a 1-ms CW pulse. EK60 data were stored on a portable hard drive, archived at the NEFSC, and sent to NOAA's National Geophysical Data Center for permanent archive.

RESULTS

The scientific personnel are in Table 1 and Figure 2.

UNMANNED AIRCRAFT SYSTEMS (UAS) TEAM

Flight time (portions of three days) was much lower than expected due to health and logistics issues as well as NOAA vessels not being mission-ready. There were also significant challenges associated with the Pumas: computer, navigation, and nadir issues; 2 of 3 payloads did not work; Department of Defense Warning area confusion; and resolution and rewind limitations. Resolution appeared to be acceptable only in optimal conditions.

Although turtles were spotted by visual teams in all of the days that the Puma operated, no transfer of turtle locations from the Puma team to the visual team occurred. This may have been hampered by reduced air time, resolution issues, lack of real time rewind, complications with location labels, or mission novelty. As this was a pioneering mission in many regards, its true contribution will be in how well it helps us to prepare for future missions.

VISUAL TURTLE SIGHTING TEAM

Of the 10 calendar days encompassed by the cruise, 8 were scheduled science days in the study area, with a potential for 192 science hours (based on a 24 hour work schedule). The ship was mission ready for 54% of those hours. The weather prevented or hampered our work in at least 4 of the mission ready days. See Table 2 for a brief summary of the main science activities on each day.

During the on-effort tracklines, the visual team sighted at least 9 cetacean species or species groups, 2 turtle species or species groups, and 4 fish species or species groups (Tables 3 and 4). For cetaceans, the visual team detected 86 groups for a total of 511 individuals. A total of 13 turtles were sighted, as well as several ocean sunfish, manta rays, and tunas (Table 4). Distribution maps of sighting locations of the cetaceans, turtles, and fishes are displayed in Figures 3 – 5.

TURTLE SAMPLING TEAM

We were captured four sea turtles (Table 5). Three of the turtles were loggerheads which were large enough to carry standard satellite tags. We applied two AMAPPS-funded satellite tags to the first two loggerheads captured, and we applied a Canadian-funded satellite tag to the last loggerhead captured. Tracks of the AMAPPS-funded satellite tags (Figure 6) are updated and displayed at http://www.nefsc.noaa.gov/psb/turtles/turtleTracks.html.

PASSIVE ACOUSTIC DETECTION TEAM

Passive acoustic data were collected using the towed hydrophone array during three evenings, for a total of 17.5 hrs. Towed array data collection covered approximately 332 km. Data were post-processed to identify all acoustic detections of beaked whales (Figure 7). There were 16 definite acoustic detections of beaked whales, the majority of which were Cuvier's beaked whales (Table 6).

The high-frequency acoustic recording package (HARP) was deployed on 26 June 2015, at approximately 41.06ºN 66.35ºW (Figure 7, site 1).

OCEANOGRAPHY

Environmental variables collected via the ship's onboard sensors were recorded every second and stored in a user created file (Table 7). A total of 8 Didson and 16 Go-Pro samples were taken. Data are being stored and processed by the Coonamessett Farm Association. A total of five VPR hauls were conducted on Leg 2. Data are stored by the NEFSC Oceanography Branch and available by request. Across both HB15-03 legs, 26 bongo tows and 53 CTDs were conducted. See Figure 8 for locations of CTDs during Leg 2. Data are available through the NEFSC Oceanography Branch website.

DISPOSITION OF THE DATA

All visual and passive acoustic data collected will be maintained by the Protected Species Branch at the Northeast Fisheries Science Center (NEFSC) in Woods Hole, MA. Visual sightings data will be archived in the NEFSC's Oracle database and later submitted to SEAMAP OBIS.

All hydrographic data collected will be maintained by the Fishery Oceanography Branch at the NEFSC in Woods Hole, MA. Hydrographic data can be accessed through the Oceanography web site http://www.nefsc.noaa.gov/epd/ocean/MainPage/ioos.html or the NEFSC's Oracle database.

Plankton samples which were not transferred to Michael Ford will be maintained by the Fishery Oceanography Branch (at the NEFSC in Narragansett RI) and may be sent to Poland for identification. Plankton data will become accessible through the NEFSC's Oracle database after they are processed.

Didson and Go-Pro zooplankton image samples are being stored and processed by the Coonamessett Farm Association.

All active acoustic data are archived and maintained by the NEFSC Data Management Services (DMS) branch at the NEFSC. In addition, all EK60 data are archived and maintained at NOAA's NGDC in Boulder, CO.

PERMITS

This research was authorized under the US Permit No. 16556 issued to the NEFSC and the Canadian Permit No. M-15-07 issued to Dr. Michael James.

ACKNOWLEDGEMENTS

The funds for this project came from the Bureau of Ocean Energy Management (BOEM) and the US Navy through the respective Interagency Agreements for the AMAPPS project. Staff time was provided for by Coonamessett Farm Foundation, the NOAA OAR UAS program, and the NOAA Fisheries Service, Northeast Fisheries Science Center (NEFSC), Protected Species Branch, Oceanography Branch, and Behavioral Ecology Branch.

Appendix 1

Software specification for FA_15A deployment (Loggerhead GPS Argos)

Valid for dates in years 2015 to 2018

Transmitting via ARGOS
Argos page transmission sequences:

Until day 150: 0 1 2 1 3 4 1 2 3 0 1 2 3 0 1 2 3 1 3 1

Until day 1464: 0 1 3 1 3 4 1 3 1 3 0 1 3 0 3 1 3 1 3 1
An additional diagnostics page (5) is sent every 60 transmissions

Argos airtest for up to 17 hours:
Transmission interval is chosen randomly between 48 and 72 seconds

Satellite availability (UTC):
00: -- on --
01: -- on --
02: -- on --
03: -- on --
04: -- on --
05: -- on --
06: -- on --
07: -- on --
08: -- on --
09: -- on --
10: -- on --
11: -- on --
12: -- on --
13: -- on --
14: -- on --
15: -- on --
16: -- on --
17: -- on --
18: -- on --
19: -- on --
20: -- on --
21: -- on --
22: -- on --
23: -- on --

Transmission targets:

70000 transmissions after 200 days

Normal interval between Argos transmissions: 44 secs
In Haulouts: ON (one tx every 44 secs) for first 1 day
then cycling OFF for 0, ON for 1 day

Check sensors every 4 secs
When near surface (shallower than 6m), check wet/dry every 1 sec

Consider wet/dry sensor failed if wet for 30 days or dry for 99 days
Dives start when wet and below 1.5m for 20 secs
and end when dry, or above 1.5m
Do not separate 'Deep' dives
No cruises
A haulout begins when dry for 6 mins
and ends when wet for 40 secs

Dive shape (normal dives):
5 points per dive using broken-stick algorithm

Dive shape (deep dives):
none

CTD profiles: max 250 dbar up to 2 dbar in 1 dbar bins.
Note: these values should now be given in cbar. They have been auto-converted from dbar because CTD_HI_RES_PRESSURE is not specified

Temperature: Collected, Stored.
Conductivity: Not collected.
Salinity: Not collected.
Fluorescence: Not collected.
Oxygen: Not collected.
Light level: Not collected.
Construct a single profile for each 4-hour period.
During profile, sample CTD sensor every 4 seconds when deeper than 2500 m, every 4 seconds when shallower than 2500 m.
Each profile contains 10 cut points
consisting of 0 fixed points, minimum depth, maximum depth, 8 broken-stick points

GPS fixes:
Number of GPS attempts allowed: unlimited
Cut-off date for GPS attempts: 150 days (then increase interval to 0x normal)
Discard results with fewer than 5 satellites
Haulouts: Increase interval to 12x normal after first success in haulout

TRANSMISSION BUFFERS (in RAM):
Dives in groups of 2 (2.22222 days @ 15 dives/hour): 400 = 1600 bytes
No 'deep' dives
Haulouts: 30 = 120 bytes
6-hour Summaries in groups of 1 (10 days): 40 = 160 bytes
No Timelines
No Cruises
No Diving periods
No Spot depths
No Emergence records
No Dive duration histograms
No Max depth histograms
6-hour Depth & Temperature histograms in groups of 1 (10 days): 40 = 160 bytes
CTD casts (8.33333 days): 50 = 200 bytes
GPS fixes (variable: 35.4167 days if interval is 10 mins): 5100 = 20400 bytes
No Spot CTD's
No Vemco VMT's

TOTAL 22640 bytes (of about 21000 available)

MAIN BUFFERS (in 24 Mb Flash):
Dive in groups of 2 (2.22222 days @ 15 dives/day): 400 x 144 bytes = 57600 bytes
No 'deep' dives
Haulout: 30 x 32 bytes = 960 bytes
6-hour summaries in groups of 1 (10 days): 40 x 88 bytes = 3520 bytes
6-hour Depth & Temperature histograms in groups of 1 (10 days): 40 x 32 bytes = 1280 bytes
No timelines
No cruises
No diving periods
No spot depths
No emergence records
No Duration histograms
No Max depth histograms
CTD casts (8.33333 days): 50 x 64 bytes = 3200 bytes
GPS fixes (variable: 35.4167 days if interval is 10 mins): 5100 x 152 bytes = 775200 bytes
No spot CTD's
No Vemco VMT's

TOTAL 822 kb (from 8192 kb available)

PAGE CONTENTS:

PAGE 0 (Argos, 247 bits):
PTT NUMBER OVERHEAD (28-bit code)
----------[8 bits: 0 - 7]

PAGE NUMBER
----------[3 bits: 8 - 10]

DIVE group in format 0:
Normal dives transmitted in groups of 2
Time of start of last dive: max 7 days 12 hours @ 10 secs= 64800
tx as raw 16 bits in units of 1 (range: 0 to 65535) OK
(recommended sell-by 7 days 11 hours, actual: 7 days 6 hours is OK)
Number of records: raw 2 bits in units of 1 (range: 0 to 3)
Reason for end: -- not transmitted --
Group number: -- not transmitted --
Max depth: -- not transmitted --
Dive duration: odlog 3/7 in units of 4 s (range: 0 to 130302 s)
Mean speed: -- not transmitted --
Profile data (5 depths/times, 0 speeds):
Depth profile: Lookup with 64 bins: <1,1-2,2-3,3-4,4-5,5-6,6-7,7-8,8-9,9-10,10-11,11-12,12-13,13-14,14-15,15-16,16-17,17-18,18-19,19-20,20-22,22-24,24-26,26-28,28-30,30-32,32-34,34-36,36-38,38-40,40-42,42-44,44-46,46-48,48-50,50-52,52-54,54-56,56-58,58-60,60-62,62-64,64-66,66-68,68-70,70-75,75-80,80-85,85-90,90-95,95-100,100-110,110-120,120-130,130-140,140-150,150-160,160-170,170-180,180-190,190-200,200-220,220-240, >240 in units of 0.1 m (range: 0 to 240 m)
Profile times: raw 10 bits in units of 1 permille (range: 0 to 1023 permille)
Speed profile: -- not transmitted --
Temperature : -- not transmitted --
Light : -- not transmitted --
Residual: -- not transmitted --
Calculation time: -- not transmitted --

Surface duration: odlog 3/7 in units of 4 s (range: 0 to 130302 s)
Dive area: raw 9 bits in units of 2 permille (range: 0 to 1022 permille)
----------[236 bits: 11 - 246]

Available bits used exactly
=== End of page 0 ===

PAGE 1 (Argos, 247 bits):
PTT NUMBER OVERHEAD (28-bit code)
----------[8 bits: 0 - 7]

PAGE NUMBER
----------[3 bits: 8 - 10]

SUMMARY group in format 0:
Transmitted in groups of 1
Record could be in buffer for 10 days
End time: max 10 days 6 hours @ 1 hour= 246
tx as raw 8 bits in units of 1 (range: 0 to 255) OK
(recommended sell-by 10 days 5 hours, actual: 10 days is OK)
Number of records: raw 1 bits in units of 1 (range: 0 to 1)
Cruising time: -- not transmitted --
Haulout time: raw 10 bits in units of 1 permille (range: 0 to 1023 permille)
Dive time: raw 10 bits in units of 1 permille (range: 0 to 1023 permille)
Deep Dive time: -- not transmitted --
Normal dives:
Avg max dive depth: Lookup with 64 bins: <1,1-2,2-3,3-4,4-5,5-6,6-7,7-8,8-9,9-10,10-11,11-12,12-13,13-14,14-15,15-16,16-17,17-18,18-19,19-20,20-22,22-24,24-26,26-28,28-30,30-32,32-34,34-36,36-38,38-40,40-42,42-44,44-46,46-48,48-50,50-52,52-54,54-56,56-58,58-60,60-62,62-64,64-66,66-68,68-70,70-75,75-80,80-85,85-90,90-95,95-100,100-110,110-120,120-130,130-140,140-150,150-160,160-170,170-180,180-190,190-200,200-220,220-240, >240 in units of 0.1 m (range: 0 to 240 m)
SD max dive depth: Lookup with 64 bins: <1,1-2,2-3,3-4,4-5,5-6,6-7,7-8,8-9,9-10,10-11,11-12,12-13,13-14,14-15,15-16,16-17,17-18,18-19,19-20,20-22,22-24,24-26,26-28,28-30,30-32,32-34,34-36,36-38,38-40,40-42,42-44,44-46,46-48,48-50,50-52,52-54,54-56,56-58,58-60,60-62,62-64,64-66,66-68,68-70,70-75,75-80,80-85,85-90,90-95,95-100,100-110,110-120,120-130,130-140,140-150,150-160,160-170,170-180,180-190,190-200,200-220,220-240, >240 in units of 0.1 m (range: 0 to 240 m)
Max max dive depth: Lookup with 64 bins: <1,1-2,2-3,3-4,4-5,5-6,6-7,7-8,8-9,9-10,10-11,11-12,12-13,13-14,14-15,15-16,16-17,17-18,18-19,19-20,20-22,22-24,24-26,26-28,28-30,30-32,32-34,34-36,36-38,38-40,40-42,42-44,44-46,46-48,48-50,50-52,52-54,54-56,56-58,58-60,60-62,62-64,64-66,66-68,68-70,70-75,75-80,80-85,85-90,90-95,95-100,100-110,110-120,120-130,130-140,140-150,150-160,160-170,170-180,180-190,190-200,200-220,220-240, >240 in units of 0.1 m (range: 0 to 240 m)
Avg dive duration: odlog 3/7 in units of 4 s (range: 0 to 130302 s)
SD dive duration: odlog 3/7 in units of 4 s (range: 0 to 130302 s)
Max dive duration: odlog 3/7 in units of 4 s (range: 0 to 130302 s)
Avg surface duration: odlog 3/7 in units of 4 s (range: 0 to 130302 s)
SD surface duration: odlog 3/7 in units of 4 s (range: 0 to 130302 s)
Max surface duration: odlog 3/7 in units of 4 s (range: 0 to 130302 s)
Avg speed in dive: -- not transmitted --
Number of dives: odlog 2/4 in units of 1 (range: 0 to 235.5)
Deep dives:
Avg max dive depth: -- not transmitted --
SD max dive depth: -- not transmitted --

Max max dive depth: -- not transmitted --
Avg dive duration: -- not transmitted --
SD dive duration: -- not transmitted --
Max dive duration: -- not transmitted --
Avg surface duration: -- not transmitted --
SD surface duration: -- not transmitted --
Max surface duration: -- not transmitted --
Avg speed in dive: -- not transmitted --
Number of dives: -- not transmitted --
Avg SST: -- not transmitted --
----------[113 bits: 11 - 123]

DEPTH & TEMPERATURE histogram group in format 0:

Histogram with 5 depth bins:
Transmitted in groups of 1
Record could be in buffer for 10 days
End time: max 10 days 6 hours @ 1 hour= 246
tx as raw 8 bits in units of 1 (range: 0 to 255) OK
(recommended sell-by 10 days 5 hours, actual: 10 days is OK)
Number of records: raw 1 bits in units of 1 (range: 0 to 1)
Max. max depth: -- not transmitted --
Dry temperature: -- not transmitted --
Dry usage: raw 10 bits in units of 1 permille (range: 0 to 1023 permille)
Surface temperature: -- not transmitted --
Surface usage (< 1 m): raw 10 bits in units of 1 permille (range: 0 to 1023 permille)
5 depth bins:
Depth band temperature: -- not transmitted --
Usage of depths 1 to 2 m: raw 10 bits in units of 1 permille (range: 0 to 1023 permille)
Usage of depths 2 to 3 m: raw 10 bits in units of 1 permille (range: 0 to 1023 permille)
Usage of depths 3 to 4 m: raw 10 bits in units of 1 permille (range: 0 to 1023 permille)
Usage of depths 4 to 5 m: raw 10 bits in units of 1 permille (range: 0 to 1023 permille)
Usage of depths 5 to 2999 m: raw 10 bits in units of 1 permille (range: 0 to 1023 permille)
----------[79 bits: 124 - 202]

DIAGNOSTICS in format 0:

GPS zero satellites: wraparound 13 bits in units of 1 (range: 0 to 8191)
GPS 1-4 satellites: wraparound 13 bits in units of 1 (range: 0 to 8191)
GPS 5 or more satellites: wraparound 13 bits in units of 1 (range: 0 to 8191)
GPS reboots: wraparound 5 bits in units of 1 (range: 0 to 31)
----------[44 bits: 203 - 246]

Available bits used exactly
=== End of page 1 ===

PAGE 2 (Argos, 247 bits):
PTT NUMBER OVERHEAD (28-bit code)
----------[8 bits: 0 - 7]

PAGE NUMBER
----------[3 bits: 8 - 10]

GPS in format 1:

Timestamp: max 3 days @ 1 sec= 259200
tx as raw 18 bits in units of 1 (range: 0 to 262143) OK
(recommended sell-by 2 days 23 hours, actual: 2 days 21 hours is OK)
n_sats: raw 3 bits in units of 1 (range: 5 to 12)
GPS mode: -- not transmitted --
Best 8 satellites:
Sat ID's: raw 5 bits in units of 1 (range: 0 to 31)
Pseudorange: raw 15 bits in units of 1 (range: 0 to 32767)
Signal strength: -- not transmitted --
Doppler: -- not transmitted --
Max signal strength: -- not transmitted --
Noisefloor: -- not transmitted --
Max CSN (x10): -- not transmitted --
----------[181 bits: 11 - 191]

HAULOUT in format 0:
Number of records: raw 1 bits in units of 1 (range: 0 to 1)
Haulout number: wraparound 5 bits in units of 1 (range: 0 to 31)
Start time: max 21 days 12 hours @ 2 mins= 15480
tx as raw 14 bits in units of 1 (range: 0 to 16383) OK
(recommended sell-by 21 days 11 hours, actual: 21 days is OK)
End time: max 21 days 12 hours @ 2 mins= 15480
tx as raw 14 bits in units of 1 (range: 0 to 16383) OK
(recommended sell-by 21 days 11 hours, actual: 21 days is OK)
Duration: -- not transmitted --
cf. Max duration is 1 day
Reason for end: -- not transmitted --
Contiguous: -- not transmitted --
----------[34 bits: 192 - 225]

DIAGNOSTICS in format 1:

TX number: wraparound 14 bits in units of 5 (range: 0 to 81915)
Driest (max wet/dry): raw 7 bits in units of 2 (range: 0 to 254)
----------[21 bits: 226 - 246]

Available bits used exactly
=== End of page 2 ===

PAGE 3 (Argos, 247 bits):
PTT NUMBER OVERHEAD (28-bit code)
----------[8 bits: 0 - 7]

PAGE NUMBER
----------[3 bits: 8 - 10]

GPS in format 0:

Timestamp: max 382 days @ 1 sec= 33004800

tx as raw 25 bits in units of 1 (range: 0 to 3.35544e+07) OK
(recommended sell-by 381 days 23 hours, actual: 380 days is OK)
n_sats: raw 3 bits in units of 1 (range: 5 to 12)
GPS mode: -- not transmitted --
Best 8 satellites:
Sat ID's: raw 5 bits in units of 1 (range: 0 to 31)
Pseudorange: raw 15 bits in units of 1 (range: 0 to 32767)
Signal strength: -- not transmitted --
Doppler: -- not transmitted --
Max signal strength: -- not transmitted --
Noisefloor: -- not transmitted --
Max CSN (x10): -- not transmitted --
----------[188 bits: 11 - 198]

HAULOUT in format 0:
Number of records: raw 1 bits in units of 1 (range: 0 to 1)
Haulout number: wraparound 5 bits in units of 1 (range: 0 to 31)
Start time: max 21 days 12 hours @ 2 mins= 15480
tx as raw 14 bits in units of 1 (range: 0 to 16383) OK
(recommended sell-by 21 days 11 hours, actual: 21 days is OK)
End time: max 21 days 12 hours @ 2 mins= 15480
tx as raw 14 bits in units of 1 (range: 0 to 16383) OK
(recommended sell-by 21 days 11 hours, actual: 21 days is OK)
Duration: -- not transmitted --
cf. Max duration is 1 day
Reason for end: -- not transmitted --
Contiguous: -- not transmitted --
----------[34 bits: 199 - 232]

DIAGNOSTICS in format 2:

TX number: wraparound 14 bits in units of 5 (range: 0 to 81915)
----------[14 bits: 233 - 246]

Available bits used exactly
=== End of page 3 ===

PAGE 4 (Argos, 247 bits):
PTT NUMBER OVERHEAD (28-bit code)
----------[8 bits: 0 - 7]

PAGE NUMBER
----------[3 bits: 8 - 10]

CTD PROFILE in format 0:

End time: max 7 days 12 hours @ 4 hours= 45
tx as raw 6 bits in units of 1 (range: 0 to 63) OK
(recommended sell-by 7 days 11 hours, actual: 7 days is OK)
CTD cast number: -- not transmitted --
Note: these old-style dbar pressures are internally converted to cbar
Min pressure: -- not transmitted --
Max pressure: raw 8 bits in units of 1 dbar (range: 2 to 257 dbar)
Min temperature: raw 12 bits in units of 0.01 (range: 0 to 40.95 = -5 to 35.95 °C in steps of 0.01 °C)

Max temperature: raw 12 bits in units of 0.01 (range: 0 to 40.95 = -5 to 35.95 °C in steps of 0.01 °C)
Number of samples: -- not transmitted --
10 profile points 0 to 9 (from total of 10 cut points):
Temperature:
Min pressure is sent separately
Max pressure is sent separately
8 broken stick pressure bins: raw 8 bits in units of 1 bin (range: 0 to 255 bin)
10 x Temperature: raw 8 bits in units of 3.92157 permille (range: 0 to 1000 permille)
Temperature residual: -- not transmitted --
Temperature bounds : -- not transmitted --
Conductivity bounds : -- not transmitted --
Salinity bounds : -- not transmitted --
Min DOxy: -- not transmitted --
Max DOxy: -- not transmitted --
Min fluoro: -- not transmitted --
Max fluoro: -- not transmitted --
Min Light: -- not transmitted --
Max Light: -- not transmitted --
----------[182 bits: 11 - 192]

HAULOUT in format 0:
Number of records: raw 1 bits in units of 1 (range: 0 to 1)
Haulout number: wraparound 5 bits in units of 1 (range: 0 to 31)
Start time: max 21 days 12 hours @ 2 mins= 15480
tx as raw 14 bits in units of 1 (range: 0 to 16383) OK
(recommended sell-by 21 days 11 hours, actual: 21 days is OK)
End time: max 21 days 12 hours @ 2 mins= 15480
tx as raw 14 bits in units of 1 (range: 0 to 16383) OK
(recommended sell-by 21 days 11 hours, actual: 21 days is OK)
Duration: -- not transmitted --
cf. Max duration is 1 day
Reason for end: -- not transmitted --
Contiguous: -- not transmitted --
----------[34 bits: 193 - 226]

DIAGNOSTICS in format 3:

ADC offset: raw 6 bits in units of 25 A/D units (range: 0 to 1575 A/D units)
Max depth ever: raw 7 bits in units of 5 m (range: 0 to 635 m)
Driest (max wet/dry): raw 7 bits in units of 2 (range: 0 to 254)
----------[20 bits: 227 - 246]

Available bits used exactly
=== End of page 4 ===

PAGE 5 (special diagnostics page sent every 60 transmissions)
PTT NUMBER OVERHEAD (28-bit code)
----------[8 bits: 0 - 7]

PAGE NUMBER
----------[3 bits: 8 - 10]

TX number: wraparound 18 bits in units of 1 (range: 0 to 262143)
Current state: raw 3 bits in units of 1 (range: 0 to 7)
Tag time (mm:ss): raw 12 bits in units of 1 secs (range: 0 to 4095 secs)
ADC offset: raw 12 bits in units of 1 A/D units (range: 0 to 4095 A/D units)
Tag hours: wraparound 16 bits in units of 1 hours (range: 0 to 65535 hours)
Wet/dry status: raw 2 bits in units of 1 (range: 0 to 3)
Wet/dry fail count: wraparound 8 bits in units of 1 (range: 0 to 255)
Body number: raw 16 bits in units of 1 (range: 0 to 65535)
Max depth ever: raw 15 bits in units of 0.1 m (range: 0 to 3276.7 m)
Latest reset hour: raw 16 bits in units of 1 hours (range: 0 to 65535 hours)
Number of resets: wraparound 8 bits in units of 1 (range: 0 to 255)
Wettest (min wet/dry): raw 8 bits in units of 1 (range: 0 to 255)
Driest (max wet/dry): raw 8 bits in units of 1 (range: 0 to 255)
GPS zero satellites: wraparound 14 bits in units of 1 (range: 0 to 16383)
GPS 1-4 satellites: wraparound 14 bits in units of 1 (range: 0 to 16383)
GPS 5 or more satellites: wraparound 14 bits in units of 1 (range: 0 to 16383)
GPS reboots: wraparound 4 bits in units of 1 (range: 0 to 15)
Number of depth spikes: wraparound 8 bits in units of 1 (range: 0 to 255)
Number of CTD samples: wraparound 22 bits in units of 1 (range: 0 to 4.1943e+06)
----------[218 bits: 11 - 228]

UNUSED
----------[18 bits: 229 - 246]

=== End of page 5 ===

Table 1. Scientific personnel involved in the HB15-03 Leg 2 survey. FN = Foreign National.

Personnel	Title	Organization
Haas, Heather	Chief Scientist	NOAA NEFSC, Woods Hole, MA
Broughton, Elisabeth	Oceanography Lead	NOAA NEFSC, Woods Hole, MA
Haver, Samara	Turtle / Acoustic	Integrated Statistics, Woods Hole, MA
Hoffman, Paul	Puma monitor	NOAA Aircraft Operations Center
Izzi, Annamaria	Acoustics lead	Integrated Statistics, Woods Hole, MA
Jacobs, Todd	Puma lead	NOAA OAR UAS Program
James, Mike (FN)	Turtle ecologist	Fisheries and Oceans Canada
Kellog, Loren	Small boat operator	Integrated Statistics, Woods Hole, MA
Matzen, Eric	Lead for small boat ops	Integrated Statistics, Woods Hole, MA
Miller, Shea	Turtle ecologist	Coonamessett Farm Foundation, MA
Milliken, Henry	Small boat operator	NOAA NEFSC, Woods Hole, MA
Patel, Samir	Turtle ecologist	Coonamessett Farm Foundation, MA
Rogers, Mark	Puma UAS Pilot/PIC	NOAA UAS Office

Table 2. Summary of daily activities during HB15-03 Leg 2.

Date	Brief summary of main science activities
23 June	Waited out a storm at dock and then waited overnight for Ship's crew to come on duty for a morning departure. While at dock we practiced small boat deployments.
24 June	Transited from Newport south towards the shelf break and practiced small boat operations. Passive acoustic operations at night.
25 June	Puma in air, small boat in water. Good weather in am, no turtles sighted. Passive acoustic operations at night.
26 June	Small boat not working; steamed to HARP location, deployed HARP, did oceanographic transect through warm core ring. Passive acoustic operations at night.
27 June	Good weather day; Puma in air, used fast rescue boat with limitations; caught 2 turtles. Stopped science to depart for Boston at 3:30pm; no passive acoustic operations.
28 June	Arrive Boston in afternoon. No passive acoustic operations.
29 June	Depart Boston to transit to Georges Bank. No passive acoustic operations.
30 June	Arrive Georges Bank at dawn. Flew Puma. Caught 2 turtles.
1 July	Puma flights in morning. Turtles sighted. Deteriorating weather, did oceanographic transect. Stopped science to depart for Newport. No passive acoustic operations.
July 2	Arrive Newport in am.

Table 3. Number of groups and individuals of cetacean species detected by the visual observers during the survey.

Species		Number of groups	Number of individuals
Atlantic spotted dolphin	*Stenella frontalis*	1	6
Bottlenose dolphin	*Tursiops truncatus*	5	52
Common dolphin	*Delphinus delphis*	10	69
Fin whale	*Balaenoptera physalus*	13	15
Fin/sei whales	*B. physalus or B. borealis*	4	6
Pilot whales spp.	*Globicephala spp.*	8	56
Risso's dolphin	*Grampus griseus*	9	37
Sei whale	*Balaenoptera borealis*	1	1
Sperm whale	*Physeter macrocephalus*	6	10
Striped dolphin	*Stenella coeruleoalba*	1	50
Unid. dolphin	*Delphinidae*	21	200
Unid. large whale	*Mysticeti*	7	9
TOTAL CETACEANS		**86**	**511**

Table 4. Number of groups and individuals of large fish and turtles detected by the visual observers during the survey.

Species		Number of groups	Number of individuals
Manta rays spp.	*Manta spp.*	2	2
Ocean sunfish	*Mola mola*	3	4
Shark spp.		1	1
Tuna spp.		2	2
Leatherback turtle	*Dermochelys coriacea*	3	3
Loggerhead turtle	*Caretta caretta*	8	8
Unid hardshell turtle	*Chelonioidea*	2	2
TOTAL ALL SPECIES		**21**	**10**

Table 5. Information on captured turtles.

Date	Latitude	Longitude	Species	Curved Carapace Length	Type of Tags
Jun 27	41° 10.73’	65° 31.91’	loggerhead	73.1	Left and right rear flipper, PIT, and SMRU satellite tags
Jun 27	41° 10.48’	65° 40.43’	loggerhead	67.0	Left and right rear flipper, PIT, and SMRU satellite tags
Jun 30	41° 24.32’	65° 10.30	Kemp’s ridley	30.5	PIT tag
Jun 30	41° 21.26’	65° 14.08	loggerhead	55.8	Left and right rear flipper, PIT, Canadian satellite, and Vemco tags

Table 6. Summary of acoustic detections of individual beaked whales during HB15-03 Leg 2. Towed array data were collected for approximately 17.5 hrs during the survey, covering 33 km. Acoustic detections of beaked whales are classified as “definite”, “probable”, or “possible”, based on the spectral and temporal characteristics of the echolocation clicks and the entire acoustic event.

Species	Total	Definite	Probable	Possible
Cuvier’s beaked whale	18	11	1	6
Gervais’ beaked whale	11	4	1	6
UNID Mesoplodont	4	1	2	1
Total	**33**	**16**	**4**	**13**

Table 7. SCS data collected once /sec during the survey and stored in a user created file.

Date (MM/DD/YYYY)	
Time (hh:mm:ss)	TSG-Conductivity (s/m)
EK60-38kHz-Depth (m)	TSG-External-Temp (ºC)
EK60-18kHz-Depth (m)	TSG-InternalTemp (ºC)
ADCP-Depth (m)	TSG-Salinity (PSU)
ME70-Depth (m)	TSG-Sound-Velocity (m/s)
ES60-50kHz-Depth (m)	MX420-Time (GMT)
Doppler-Depth (m)	MX420-COG (º)
Air-Temp (ºC)	MX420-SOG (Kts)
Barometer-2 (mbar)	MX420-Lat (DDMM.MM)
YOUNG-TWIND-Direction (º)	MX420-Lon (DDMM.MM)
YOUNG-TWIND-Speed (Kts)	Doppler-F/A-BottomSpeed (Kts)
Rel-Humidity (%)	Doppler-F/A-WaterSpeed (Kts)
Rad-Case-Temp (ºC)	Doppler-P/S-BottomSpeed (Kts)
Rad-Dome-Temp (ºC)	Doppler-P/S-WaterSpeed (Kts)
Rad-Long-Wave-Flux (W/m^2)	High-Sea Temp (ºC)
Rad-Short-Wave-Flux (W/m^2)	POSMV – Time (hhmmss)
ADCP-F/A – GroundSpeed (Kts)	POSMV – Elevation (m)
ADCP-F/A – WaterSpeed (Kts)	POSMV – Heading (º)
ADCP-P/S – GroundSpeed (Kts)	POSMV – COG (Kts)
ADCP-P/S – WaterSpeed (Kts)	POSMV – SOG (Kts)
Gyro (º)	POSMV – Latitude (DDMM.MM)
POSMV – Quality (1=std)	POSMV – Longitude (DDMM.MM)
POSMV – Sats (none)	POSMV – hdops (none)

Figure 1. Survey area covered during HB15-03 Leg 2. The US exclusive economic zone (EEZ) and the 100 m, 200 m, 1000 m and 2000m depth contours are also displayed.

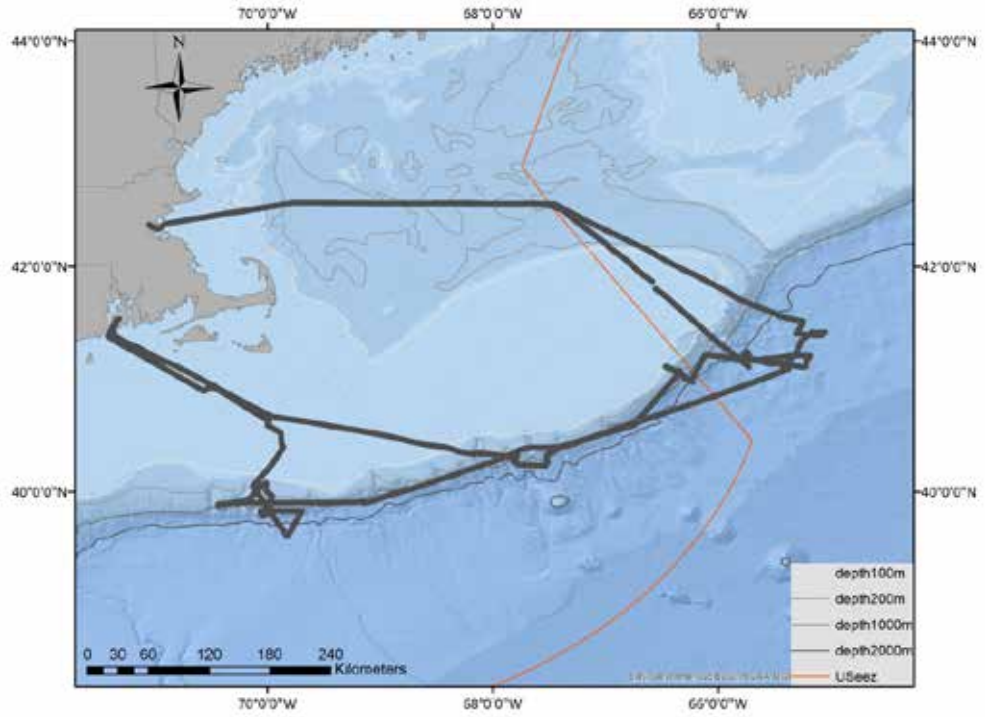

Figure 2. Organization of scientific staff into teams.

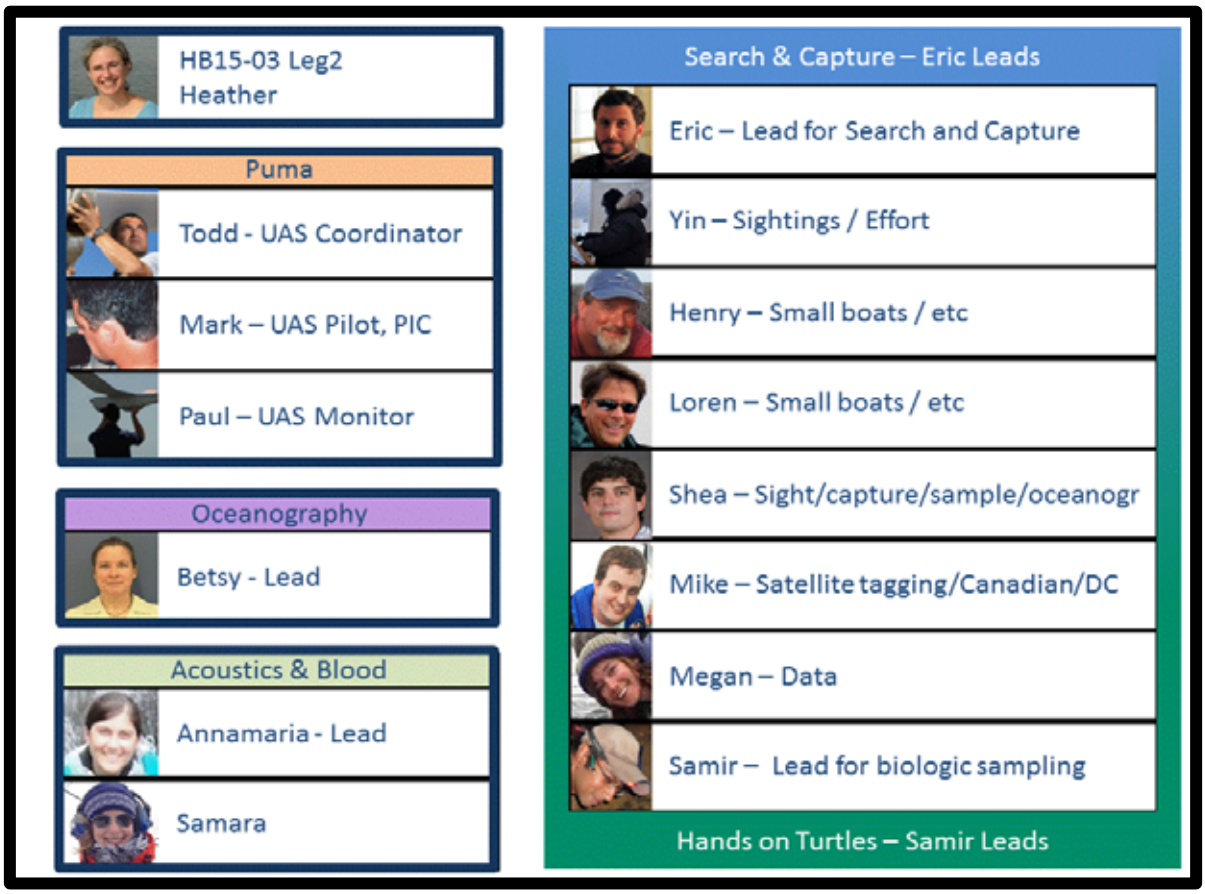

Figure 3. Location of large whale sightings during HB15-03 Leg 2.

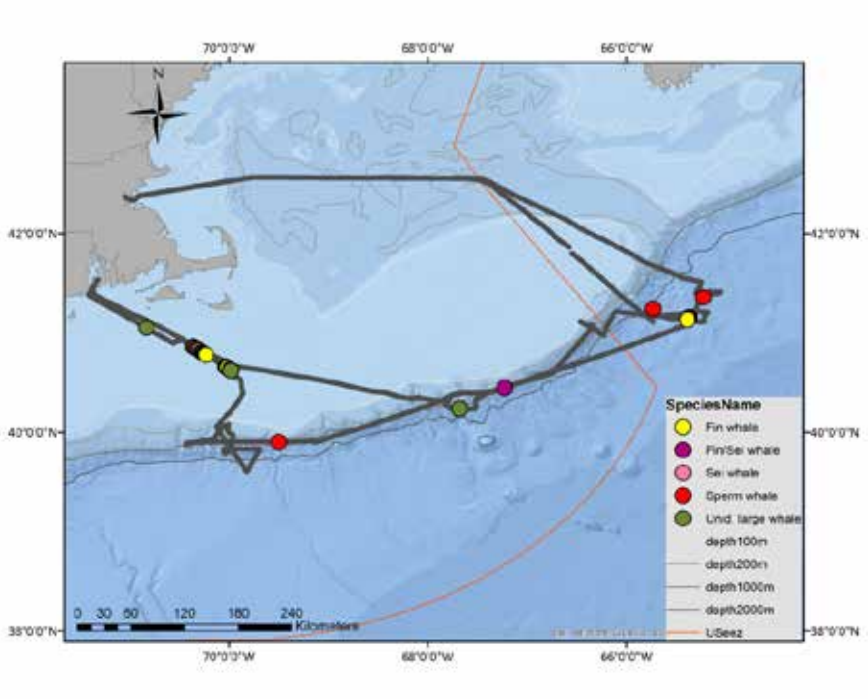

Figure 4. Location of delphinid sightings during HB15-03 Leg 2.

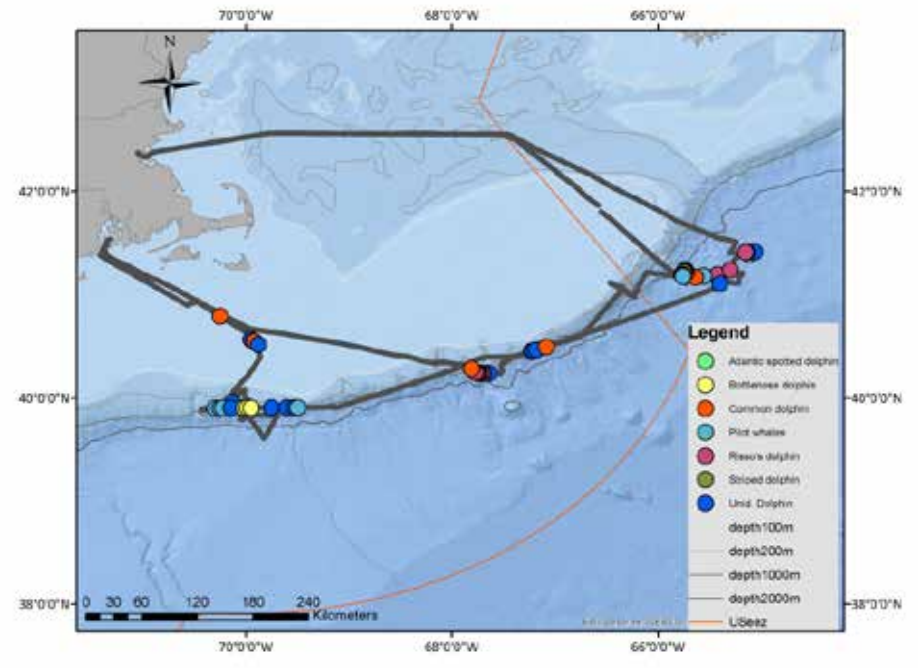

Figure 5. Location of sharks, rays and turtles sighted during HB15-03 Leg 1.

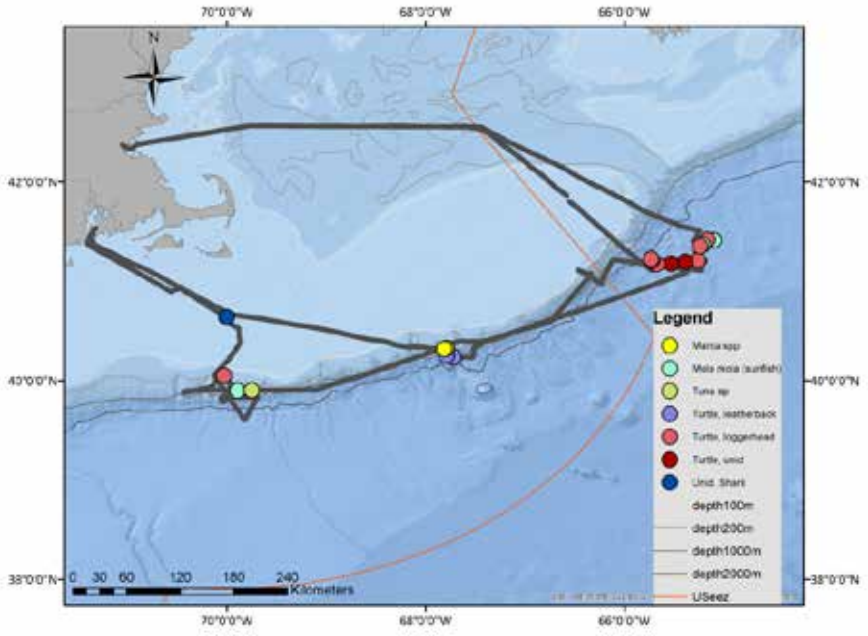

Figure 6. Tracks of the two loggerheads with AMAPPS-funded satellite tags.

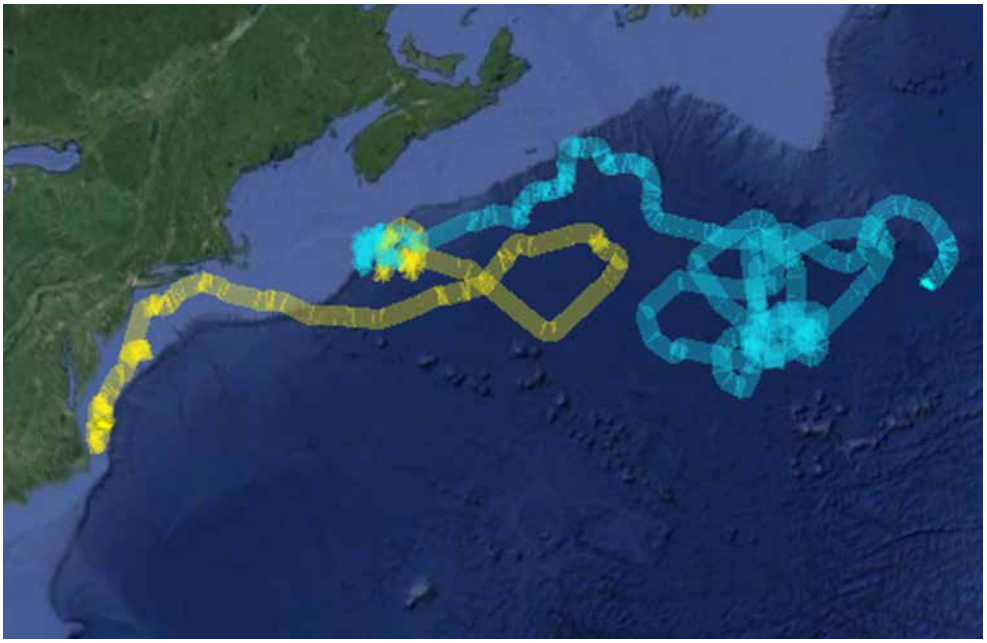

Figure 7. Map showing areas where the towed hydrophone array was deployed (gray lines) and the corresponding acoustic detections of beaked whales. Green dots indicate detections of Cuvier's beaked whales; orange dots indicate Gervais' beaked whales. The magenta triangles show the positions of HARP (high-frequency acoustic recording package) deployments. Site 1 was deployed during Leg 2 of this survey; sites 2 & 3 had been deployed previously.

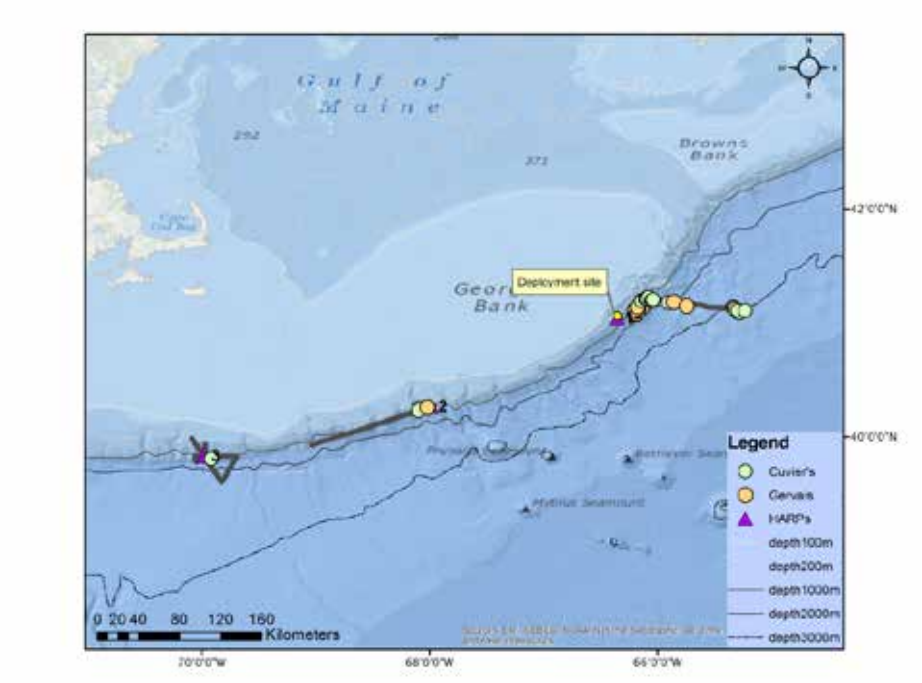

Figure 8. Locations of deployments of CTD and bongo (green dots) and VPR (yellow triangles).