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GoMMAPPS Summer/Fall 2018 Research Cruise Report

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CRUISE REPORT

NOAA Ship *Pisces* Cruise PC18-05

August – October 2018

GoMMAPPS Summer/Fall 2018 Research Cruise

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As part of the Gulf of Mexico Marine Assessment Program for Protected Species (GoMMAPPS), the Southeast Fisheries Science Center (SEFSC) conducted shipboard surveys of the oceanic waters (>100 m deep) of the Gulf out to the U.S. Exclusive Economic Zone (EEZ). The survey was conducted between 11 August and 6 October 2018 onboard the NOAA Ship *Pisces* along prescribed tracklines in a "double saw-tooth" configuration (Figure 1). A total of 7,480 km of survey effort were planned. Tracklines were spaced at 120 km and oriented to be perpendicular to bathymetry (Figure 1).

The cruise was segmented into three legs, totaling 51 sea-days:

Leg	Date	Location	Days at Sea
1	DEP: 11 Aug 2018	Key West, FL	18
	ARR: 28 Aug 2018	Pascagoula, MS	
2	DEP: 1 Sep 2018	Pascagoula, MS	17
	ARR: 17 Sep 2018	Galveston, TX	
3	DEP: 21 Sep 2018	Galveston, TX	16
	ARR: 6 Oct 2018	Pascagoula, MS	

Survey participants are listed in Table 1 and daily survey operations are summarized in Table 2.

Overall, the primary goal of this survey was to collect data on the distribution and abundance of marine mammals in the U.S. waters of the Gulf of Mexico (GOM) using visual survey teams and passive acoustic monitoring. Twenty-one species of cetaceans are known to routinely inhabit continental shelf (20 m to 200 m) and oceanic (>200 m) waters of the U.S. GOM. In the continental shelf waters, the most common cetacean species are common bottlenose and Atlantic spotted dolphins. Oceanic waters are inhabited by species including sperm whales, dwarf and pygmy sperm whales, beaked whales, and other large (e.g., killer whales, short-finned pilot whales, Risso's dolphins) and small (e.g., pantropical spotted dolphins) delphinids. Though other species of baleen whales are occasionally sighted, GOM Bryde's whales are the only baleen whale resident to the GOM and are most readily found in a small strip of water in the northeastern GOM, from De Soto Canyon southward along the continental slope, usually between depths of 180 m and 360 m.

Cruise objectives

The specific objectives of this survey were to:

1. Conduct a two-team visual line transect survey to estimate the abundance and spatial distribution of cetacean stocks in U.S. Gulf of Mexico waters
2. Conduct passive acoustic surveys simultaneous with visual surveys to provide supplemental information on cetacean abundance and spatial distribution

3. Collect data on the distribution and abundance of seabirds and other marine life
4. Periodically collect oceanographic and environmental data utilizing scientific echosounders (EK80) to quantify acoustic backscatter from small fish and zooplankton
5. Collect vertical profiles of hydrographic parameters (e.g., temperature, salinity, oxygen concentration) using CTD and XBTs
6. Recover and redeploy autonomous acoustic moorings

Visual Survey Operations

The survey design was similar to that conducted during the GoMMAPPS surveys in the summer of 2017 (GU17-03) and winter of 2018 (GU18-01), which used the two independent visual observer teams approach.

The independent teams approach with Distance sampling was implemented to estimate the detection probabilities for marine mammal sightings. This method used two teams of visual marine mammal observers that operate independently of one another. During this approach, one survey team with two observers was stationed on the vessel's flying bridge (height above water = 15 m) and the second team, also with two observers, was stationed on the wings of the bridge deck (height above water = 12.5 m). Each visual survey team utilized two pedestal-mounted, 25x150 mm "bigeye" binoculars located on the port and starboard sides of the ship. A centralized data recorder located inside the ship's chemistry laboratory communicated with both teams via discreet VHF channels to maintain independence of the teams. Observers used the bigeye binoculars to determine and relay the bearing and radial distance of sightings to the data recorder. The location of groups sighted close to the ship without bigeye binoculars were estimated in degrees and meters. Marine mammal sightings were defined as systematic records of cetacean groups consisting of one or more individuals observed at the same location and time.

Visual survey effort commenced daily at approximately 0730 and ended at 1930 (EDT for leg 1 and CDT for legs 2 and 3) with 30 to 60-minute meal breaks depending on operational requirements and survey conditions. Survey speed was typically 18 km hr^{-1} (10 kt) but varied with ship traffic and sea conditions such as ocean currents. Data were recorded by the data recorder using a custom written visual data acquisition program (VisSurvey) installed on a networked laptop.

Observers were considered "on effort" whenever the ship was on a prescribed trackline or transit line, at survey speed, and the visual team was actively searching for cetaceans through the bigeyes. Observers scanned the water using the bigeye binoculars from 10° right and left of the ship's bow to the beam (90° left or right depending on the side); i.e., the left observer scanned from 10° right to 90° left and the right observer scanned from 10° left to 90° right. Whenever an observer suspected or had in fact seen a marine mammal, a cue (marine mammal, splash, blow, etc.) was immediately entered in the data program and the team went "off effort." A cue is a time and location stamp in the database that captures the spatial and temporal data of a sighting. After sightings were identified to the lowest taxonomic level possible and group size enumerated, the sighting was entered in the visual data program by the data recorder. Group size estimates were recorded independently by each observer. Observers

were instructed to only enter values for sightings they observed entirely. Group size was counted as the minimum, maximum, and best number of animals for each sighting.

Observers were considered to be "off effort" whenever the ship was maneuvering and turning onto a new trackline, if other operations were taking place (e.g., safety drills), during bad weather (rain, sea state >6, poor visibility due to fog, lightning within 4 nm), and whenever not actively searching for cetaceans through the bigeyes. Sightings observed under such conditions were recorded as off effort. Off-effort sightings may also have included naked-eye observations and sightings detected by non-mammal observers, mammal observers off duty, or other crew (including ship's crew).

For each sighting (either on- or off-effort), time, position, bearing and reticle, species, group size, behavior, and associated animals (e.g., seabirds, fish) were recorded. An attempt was made to photograph animals that closely approached the ship.

This survey, was primarily conducted in "passing mode" whereby the ship maintains a steady course and speed along the trackline while the visual teams identify the sighting to species level if possible and count the number of individuals in the sighting. This differs from surveys prior to 2017 and should be considered when comparing these data to historical datasets. Under certain circumstances, a "closing mode" technique was employed. Closing mode entails maneuvering the ship to more closely approach a sighting. Closing mode was used sparingly and was restricted to sightings of special interest determined by the Field Party Chief (FPC).

Basic survey parameters were automatically recorded by the survey program every minute and include the ship's position, heading, effort status, observer positions, and environmental conditions (e.g., wind speed, sea surface temperature, etc.). At the start of the survey day and at 20-minute time intervals thereafter, the survey program prompts observers for an update of the subjective environmental variables (e.g., glare, sea state, cloud cover, etc.) and sighting conditions.

Visual Survey Results

During this cruise, 6,472.6 km of trackline were visually surveyed on effort (Table 2, Figure 1). Sighting conditions were fair to good throughout most of the survey, with sea states of 2-4 on most survey days (Figure 2). There were 280 marine mammal sightings from 11 confirmed species during the survey, not including unidentified taxa (Table 3). A diverse suite of oceanic dolphin and small whale species were encountered including pantropical spotted dolphins (*Stenella attenuata*), Risso's dolphins (*Grampus griseus*), pygmy/dwarf sperm whales (*Kogia* sp.), beaked whales (Unid. Ziphiids and Mesoplodonts), and pilot whales (*Globicephala* sp.; Table 3, Figures 3 and 5). Continental shelf species included common bottlenose dolphins (*Tursiops truncatus*) and Atlantic spotted dolphins (*Stenella frontalis;* Figure 3). There were a total of 98 sperm whale (*Physeter macrocephalus*) sightings (Figure 4). During this cruise, sperm whale sightings were entered as soon as the observer finished counting individuals seen at the location of the cue (the same way all sightings were entered). This differs from methods used in some SEFSC surveys prior to GoMMAPPS where observers spent additional time intervals counting sperm whales that surfaced after the initial detection. Therefore, sperm whale group size estimates and sighting definitions are likely not comparable between this survey and

previous studies in the Gulf of Mexico. These differences will be accounted for when estimating abundance.

Marine mammal biopsy sampling

No biopsy samples were collected during PC18-05.

Passive Acoustic Survey

Towed Array

Passive acoustic surveys using a towed hydrophone array were conducted concurrent with visual surveys during daylight hours when environmental conditions allowed. Passive acoustic surveys were suspended during portions of the tracklines that occurred in water depths shallower than 75 m, in sea states greater than 6, and when lightning storms were within 2 miles. Passive acoustic monitoring for odontocetes was conducted using a modular towed hydrophone array deployed approximately 300 m behind the ship and weighted with 13.6 kg (30 lbs) lead wire. Hydrophone depth was not measured on this cruise due to a faulty pressure sensor in the towed array; depth averaged 12 ± 1.3m on prior cruises at this speed, tow distance, and weighting.

The custom-built five-element mixed-frequency oil-filled end array (Rankin *et al.* 2013) included paired pre-amplifier and hydrophone elements capable of recording a broad range of frequencies. Sensors 1, 3, and 5 were optimized for greater detection ranges for mid-frequency recordings by using APC International 42-1021 hydrophones with custom-built pre-amplifiers. The APC 42-1021 hydrophones have a -212 dB re V/uPa sensitivity with a flat frequency response (+/- 4 dB) from 1 to 45 kHz. The corresponding pre-amplifiers provided a highpass filter with 45 dB gain above 5 kHz. Sensors 2 and 4 were optimized for recording the full bandwidth of high-frequency echolocation signals by using Reson TC4013 hydrophones with custom-built pre-amplifiers. The TC4013 hydrophones have a -212 dB re V/uPa sensitivity with a flat frequency response (+/- 2 dB) from 5 to 160 kHz. The corresponding pre-amplifiers provide a high-pass filter with 50 dB gain above 5 kHz. Data from sensors 1, 2, 4, and 5 were digitized for recording with a custom 12 channel SailDAQ soundcard (www.sa-instrumentation.com) sampling 16 bits at 500 kHz, yielding a recording bandwidth of 1-250 kHz. SailDAQ output from sensors 1 and 5 were routed through a custom Magrec amplifier and Mark of the Unicorn (MOTU) Traveler mk3 audio interface for real-time aural monitoring (Appendix A).

While the array was deployed, acoustic signals were monitored by a team of two acoustic technicians who rotated through a primary and on-call secondary position every 1.5-2 hours. During mealtimes, visual and acoustic teams went off monitoring effort, but acoustic data were still recorded. The software Pamguard (v.2.00.13; Gillespie *et al.* 2008) was used to control the SailDAQ to record acoustic data and metadata to hard-disk, and for real-time monitoring, including logging effort and encounter details and obtaining bearings to acoustic detections. All acoustic data were continuously recorded as four minute, 4-channel wav files to 2 TB external SATA hard drives. Acoustic field technicians continuously monitored data aurally and visually through spectrographic analysis using both Pamguard and Ishmael (Mellinger 2001) software and detected and localized acoustically-active odontocetes in real-time using Pamguard's automated click detectors, hyperbolic bearing calculator, and manual target motion analyses as well as Ishmael's hyperbolic bearing calculator for manually-selected

whistles. Acoustic localizations were mapped and compared with visual sighting locations using a custom-written acoustic version of VisSurvey. The acoustic VisSurvey version is capable of receiving and plotting visual sighting information along with acoustic bearings and localizations to improve correlation of acoustic and visual detections in real-time. Metadata describing acoustic encounters included individual click detections with corresponding time, localization, and localization quality information.

Sonobuoys

Directional sonobuoys were used for acoustic detection, localization, and recording of low-frequency sounds produced by baleen whales which are too low in frequency to be detectable by the towed array system. Sonobuoys were deployed during daylight hours concurrent with visual surveys. The sonobuoy deployment strategy was to 1) deploy a single sonobuoy at predetermined stations where the trackline intersected the 250 m isobath; and 2) opportunistically deploy at least two sonobuoys spaced 5 km apart within 2 km of all visually-sighted baleen whales.

The expendable Directional Frequency Analysis and Ranging (DIFAR) sonobuoys contain a compass in the sensor head and transmit three types of continuous signal back to the ship on a VHF radio carrier in an analog multiplexed format. The three signals are acoustic sound pressure, east/west particle velocity, and north/south particle velocity. The acoustic signal frequency range is approximately 10 Hz to 4,000 Hz, which is well suited for large whale vocalizations that have their greatest sound energy concentrated below 1,000 Hz. Prior to deployment, all sonobuoys were programmed for DIFAR mode, a hydrophone depth of 122 m, and a broadcast duration of 8 hours. The VHF radio signals transmitted by the sonobuoys were received by two omni-directional antennas mounted on the flying bridge, 15 m above the waterline: (Diamond X30 144 MHz [primary] on the port side and MORAD Custom 168 MHz [backup]) on the starboard side. The signal gain from the 144 MHz and 168 MHz antennas was enhanced by Advanced Receiver Research custom 140-144 MHz and P160VDG 160-170 MHz preamplifiers, respectively (Appendix B). The radio reception ranges from the sonobuoys (indicated by the presence of the DIFAR pilot tones at 7.5 and 15 kHz) reached up to 40 km, though signal quality typically began to deteriorate at approximately 20-25 km. When the ship was running at survey speed (approximately 10 kts) each sonobuoy could be effectively received and recorded for one to two hours before the ship moved out of radio reception range; however, sonobuoy sites were often located near transect turns and could be received for over two hours in these cases.

The amplified sonobuoy signals were split in the lab and received on up to three WinRadios (G39WSBe), each tuned to the broadcast frequency programmed for one of the deployed sonobuoys. Analog signals from the three WinRadios were digitized with an RME Fireface UC audio interface sampling 16 bits at 48 kHz. Using Pamguard (Gillespie *et al.* 2008) v1.15.08 software with a custom DIFAR demultiplexing module (Miller *et al.* 2015), digitized acoustic data were recorded directly to computer hard-drives as 1 or 2 channel, 48 kHz wav files and were stored on 2 TB SATA disks housed in an external RAID enclosure. Additionally, Pamguard DIFAR and Logger modules were used to record sonobuoy deployment locations, ship trackline from GPS, recording effort, and metadata logs (Appendix B). The two acoustic

field technicians only cursorily monitored the recordings for data quality and received radio signal strength while focusing their effort on towed array monitoring.

Passive Acoustics Results

During the survey, 493 hours of acoustic data were recorded from the towed array yielding over 7.45 TB of data. Of those, 421 hours were monitored in real-time (Table 2) yielding 399 cetacean detections (Table 4, Figure 6). During real-time monitoring, acoustic detections were broadly categorized as Risso's dolphin clicks, sperm whale clicks, dwarf/pygmy sperm whale clicks, beaked whale (Family Ziphiidae) clicks, dolphin (Family Delphinidae) vocalizations (whistles and clicks), or unidentified odontocetes (clicks only; Table 4, Figure 6). Preliminary acoustic detections include three Risso's dolphin encounters, 124 sperm whale encounters, 12 Kogia species encounters, and 16 unidentified beaked whale encounters. Sperm whale encounters may represent either individuals or groups of individuals. Additional unidentified odontocete encounters may be identified as beaked whale encounters in post-processing at a future date. Acoustic detections of odontocetes that were not identifiable to the species level were made throughout the survey and were correlated with visual sightings when localization was possible. These recordings with visually-verified species identifications will be reanalyzed and verified in post processing to develop acoustic species classification algorithms for acoustic species identification. Acoustic data will also be used to improve estimates of sperm whale and beaked whale abundance.

Over the course of the survey, 37 sonobuoys were deployed, of which 33 successfully transmitted a signal, yielding 76 hours of recordings (Figure 7). Of the total sonobuoys, 35 (including replacements for failed buoys) were deployed at 32 predetermined stations; 28 stations were on the main tracklines and four stations were on the fine-scale western Gulf lines. The final two sonobuoys were deployed opportunistically in the presence of baleen whale sightings. One opportunistic buoy was deployed close enough to a station buoy to be recorded as a pair that may allow call localizations. The other opportunistic buoy may have been close enough to a station buoy to allow paired-buoy localizations. Sonobuoy data were only sporadically monitored in real-time, yielding three probable Bryde's whale detections (Figure 6). Additional detections may occur in post-processing. Post-processing will include baleen whale call detection, and localization when possible.

Passive Acoustic Mooring

As part of a collaborative SEFSC & SIO long-term passive acoustic monitoring project, three High-frequency Acoustic Recording Package (HARP) moorings were opportunistically serviced during this cruise (Figure 8). The HARP instruments continuously record sounds up to 100 kHz for up to one year with the objective of collecting calibrated long-term recordings of ambient noise and cetacean vocalizations to evaluate long-term trends in cetacean occurrence. The HARP mooring at the Green Canyon site was refurbished on 28 September 2018, and the moorings at the Mississippi Canyon and Main Pass sites were recovered on 3 October 2018.

Scientific Echosounder (EK80) Data Collection

EK80 data were collected beginning at sunset and until the commencement of acoustic survey effort the following day. The backscatter data are stored on hard drives for archiving and

further analysis. Calibration of the EK80 was not possible during this cruise. GOM cetacean surveys conducted prior to 2017 collected scientific echosounder data throughout both day and night; this may have impacted detectability of some species (e.g., beaked whales, striped dolphins) and should be considered when comparing data between current and historic datasets.

Environmental Data

Environmental data were collected at predetermined stations using a conductivity, temperature and depth sensor (CTD) unit and expendable bathythermographs (XBT). CTD casts recorded vertical profiles of salinity, temperature, and oxygen content to a maximum depth of 3441 m. XBT profiles recorded temperature to a maximum depth of 760 m. Environmental data including water temperature, salinity, and weather conditions (e.g., wind speed, wind direction) were continuously collected *in situ* via the ship's Scientific Computer System (SCS) and recorded in the visual marine mammal sighting database. CTD casts were made daily, typically before the start of the mammal survey day. Data were collected on a total of 45 CTD stations (Figure 9). XBT casts were made at regular intervals along the trackline throughout the cruise. A total of 42 XBT stations were sampled (Figure 9).

Seabird Survey

Seabird observers conducted counts of all birds detected within a 300-m strip transect whenever the ship was cruising along tracklines or transit lines. The number of species detected per leg ranged from 38 to 43. Rare species for the GoM included red-billed tropicbirds, red-footed boobies, and a Neotropic cormorant. Additional information is available in the GoMMAPPS seabird trip reports (https://www.boem.gov/GOMMAPPS/, accessed Mar. 13, 2019).

Data and Sample Disposition

All data collected during PC18-05 including visual survey data, passive acoustic data, EK80 data, SCS data, XBT, and CTD data are archived and managed at the Southeast Fisheries Science Center (SEFSC) in Miami, FL with backup copies at the SEFSC Pascagoula Laboratory. The data presented here are preliminary and subject to change as further auditing and analyses continue.

Permit and Funding Source

The Southeast Fisheries Science Center was authorized to conduct marine mammal research activities during the cruise under MMPA Research Permit No. 14450-04, issued to the SEFSC by the NMFS Office of Protected Resources. This study was funded by the U.S. Department of the Interior, Bureau of Ocean Energy Management through Interagency Agreement M17PG00013 with the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA). Sonobuoys were provided at no cost by the Navy Living Marine Resources program and the Sonobuoy Liason Working Group.

References

Gillespie, D., Gordon, J., Mchugh, R., Mclaren, D., Mellinger, D., Redmond, P., Thode, A., Trinder, P., Deng, X. Y., and 30. (2008). "PAMGUARD: Semiautomated, open source software for real-time acoustic detection and localisation of cetaceans," Proceedings of the Institute of Acoustics 30.

Mellinger, D. K. (2001). "Ishmael 1.0 User's Guide. NOAA Technical Report OAR-PMEL-120," (NOAA Pacific Marine Environmental Laboratory, Seattle), p. 30.

Miller, B., Barlow, J., Calderan, S., Collins, K., Leaper, R., Olson, P., Ensor, P., Peel, D., Donnelly, D., Andrews-Goff, V., Olavarria, C., Owen, K., Rekdahl, M., Schmitt, N., Wadley, V., Gedamke, J., Gales, N., and Double, M. (2015). "Validating the reliability of passive acoustic localisation: a novel method for encountering rare and remote Antarctic blue whales," Endangered Species Research 26, 257-269.

Rankin, S., Barlow, J., Barkley, Y., and Valtierra, R. (2013). "A Guide to Constructing Hydrophones Arrays for Passive Acoustic Data Collection During NMFS Shipboard Cetacean Surveys," in *NOAA-TM-NMFS-SWFSC-511*.

Table 1. List of Participants

Name	Legs	Affiliation	Duty
Anthony Martinez	1, 2, 3	SEFSC, Miami	Field party chief (FPC)
Melissa Soldevilla	1	SEFSC, Miami	Lead acoustician
Laura Dias	1	CIMAS, Miami	Lead data manager, marine mammal observer
Katrina Ternus	1, 2, 3	Riverside, Miami	Acoustician
Carrie Sinclair	1, 2, 3	SEFSC, Pascagoula	Marine mammal observer
Mary Applegate	1, 2, 3	CIMAS, Miami	Data manager, marine mammal observer
Carol Roden	1, 2	CIMAS, Miami	Marine mammal observer
Melody Baran	1, 2, 3	CIMAS, Miami	Marine mammal observer
Rachel Hardee	1, 2, 3	CIMAS, Miami	Marine mammal observer
Richard Holt	1, 2, 3	CIMAS, Miami	Marine mammal observer
Heidi Malizia	1, 2, 3	CIMAS, Miami	Marine mammal observer
Gina Rappucci	2, 3	Riverside, Miami	Lead data manager
Jesse Wicker	2, 3	CIMAS, Miami	Marine mammal observer
Kerry Dunleavy	2	CIMAS, Miami	Acoustician
Amy Brossard	3	CIMAS, Miami	Marine mammal observer
Matt Maiello	3	SEFSC, Miami	Marine mammal observer
Amanda Debich	3	CIMAS, Miami	Acoustician
Chris Haney	1	Terra Mar	Sea bird observer
Dan Bauer	1	Terra Mar	Sea bird observer
James Panaccione	2	USFWS	Sea bird observer
Nicholas Metheny	2, 3	GoMMAPPS volunteer	Sea bird observer
Peter Blank	3	GoMMAPPS volunteer	Sea bird observer

Affiliations: SEFSC = NOAA Southeast Fisheries Science Center; CIMAS = Cooperative Institute for Marine and Atmospheric Studies; USFWS = United States Fish and Wildlife Service, Lacombe, LA

Table 2. Daily survey operations and effort during PC18-05 including the visual and acoustic effort, the average sea state, number of marine mammal sightings, number of acoustic detections from the towed array, number of sonobuoys deployed, and the number of Acoustic Recording Packages (HARPs) deployed or recovered.

Survey Leg	Date	Visual Effort (km)	Ave. sea state	Num. sights	Acoustic Effort (hr)	Num. Ac. Dets.	Num. SBs	ARP deploy/ recover
Leg 1	11 Aug	0	NA	0	0	0	0	0
	12 Aug	143.6	2.5	5	8.3	8	1	0
	13 Aug	159.8	2.6	3	10.0	8	1	0
	14 Aug	154.1	2.9	2	9.6	5	1	0
	15 Aug	169.9	3.5	1	9.9	3	2	0
	16 Aug	146.1	4.5	1	9.0	3	0	0
	17 Aug	184.0	3.4	0	10.0	5	1	0
	18 Aug	162.8	3.2	6	10.1	9	0	0
	19 Aug	178.6	2.6	4	10.1	5	0	0
	20 Aug	141.3	2.2	16	10.0	18	1	0
	21 Aug	138.7	0.8	13	9.6	7	0	0
	22 Aug	149.7	2.8	12	9.5	19	2	0
	23 Aug	181.7	2.5	6	10.1	7	1	0
	24 Aug	167.2	0.8	14	10.1	13	0	0
	25 Aug	156.2	3.6	7	10.0	13	2	0
	26 Aug	167.4	3.9	1	10.0	4	0	0
	27 Aug	148.7	4.0	3	8.5	8	0	0
	28 Aug	0	NA	0	0	0	0	0
Leg 2	1 Sep	0	NA	0	0	0	0	0
	2 Sep	9.0	5.0	0	5.5	4	1	0
	3 Sep	168.4	4.1	1	10.1	7	1	0
	4 Sep	169.8	3.0	14	10.1	14	2	0
	5 Sep	132.4	2.6	7	9.4	10	0	0
	6 Sep	169.2	3.8	12	11.4	13	2	0
	7 Sep	150.9	3.0	2	9.1	10	1	0
	8 Sep	167.7	2.7	12	10.2	6	0	0
	9 Sep	181.7	3.0	2	9.9	5	1	0
	10 Sep	133.4	3.5	9	9.3	11	0	0
	11 Sep	170.4	5.0	2	9.7	4	1	0
	12 Sep	0	NA	0	0.2	0	0	0
	13 Sep	170.3	3.5	2	9.5	6	1	0
	14 Sep	167.4	2.1	14	9.7	13	0	0
	15 Sep	151.6	2.5	22	9.6	20	2	0
	16 Sep	167.5	3.9	16	9.6	18	2	0

Survey Leg	Date	Visual Effort (km)	Ave. sea state	Num. sights	Acoustic Effort (hr)	Num. Ac. Dets.	Num. SBs	ARP deploy/ recover
	17 Sep	0	NA	0	0	0	0	0
Leg 3	21 Sep	0	NA	0	0	0	0	0
	22 Sep	147.9	4.6	3	8.9	6	4	0
	23 Sep	152.3	3.1	4	9.5	12	1	0
	24 Sep	170.9	2.4	11	9.7	6	0	0
	25 Sep	172.8	3.6	4	9.4	15	2	0
	26 Sep	149.4	2.9	0	9.5	2	0	0
	27 Sep	118.1	3.1	22	10.3	25	0	0
	28 Sep	109.3	2.5	11	8.7	14	1	1
	29 Sep	173.5	4.0	8	10.4	8	0	0
	30 Sep	158.1	4.5	0	10.0	5	0	0
	1 Oct	106.9	5.0	1	11.2	3	0	0
	2 Oct	12.7	4.0	2	11.4	10	0	0
	3 Oct	62.3	4.0	1	6.1	6	0	2
	4 Oct	153.0	3.9	3	9.8	7	3	0
	5 Oct	125.8	3.9	1	8.1	7	0	0
	6 Oct	0	NA	0	0	0	0	0
Total		**6472.6**	**3.3**	**280**	**420.7**	**402**	**37**	**3**

Table 3. Marine mammal sightings during each leg of PC18-05

Species	Leg 1	Leg 2	Leg 3	Total
Atlantic spotted dolphin	8	1	2	11
Bottlenose dolphin	9	4	2	15
Bottlenose/Spotted dolphin	1	1	1	3
Clymene dolphin	0	1	0	1
Cuvier's beaked whale	1	0	0	1
Dwarf sperm whale	0	1	0	1
Gervais' beaked whale	1	0	0	1
Killer whale	0	0	2	2
Melon-headed/Pygmy killer whale/False killer whale	2	0	0	2
Pantropical spotted dolphin	9	8	3	20
Pilot whales	0	2	1	3
Pygmy/Dwarf sperm whale	9	4	4	17
Risso's dolphin	1	0	0	1
Sei/Bryde's/Fin Whale	2	0	0	2
Sperm whale	3	53	42	98
Stenella sp.	9	6	1	16
Striped dolphin	0	1	0	1
unid. dolphin	28	24	5	57
unid. large whale	2	1	2	5
Unid. Mesoplodont	2	1	1	4
unid. odontocete	6	5	5	16
Unid. Ziphiid	4	3	0	7
Total*	**94**	**115**	**71**	**280**

*Total number of sightings per leg does not equal sum of species sightings as some sightings were mixed species.

Table 4. Towed array marine mammal acoustic detections during each leg of PC18-05

Species	Leg 1	Leg 2	Leg 3	Total
Sperm whale	8	58	58	124
Kogiidae	4	4	4	12
Ziphiidae	7	6	3	16
Risso's dolphin	2	0	1	3
Odontocete	33	12	19	64
Delphinid	80	61	40	181
Total*	**133**	**141**	**125**	**399**

*Total number of detections per leg does not equal sum of species detections as some detections were mixed species.

Figure 1. Planned survey tracklines and accomplished survey effort during PC18-05

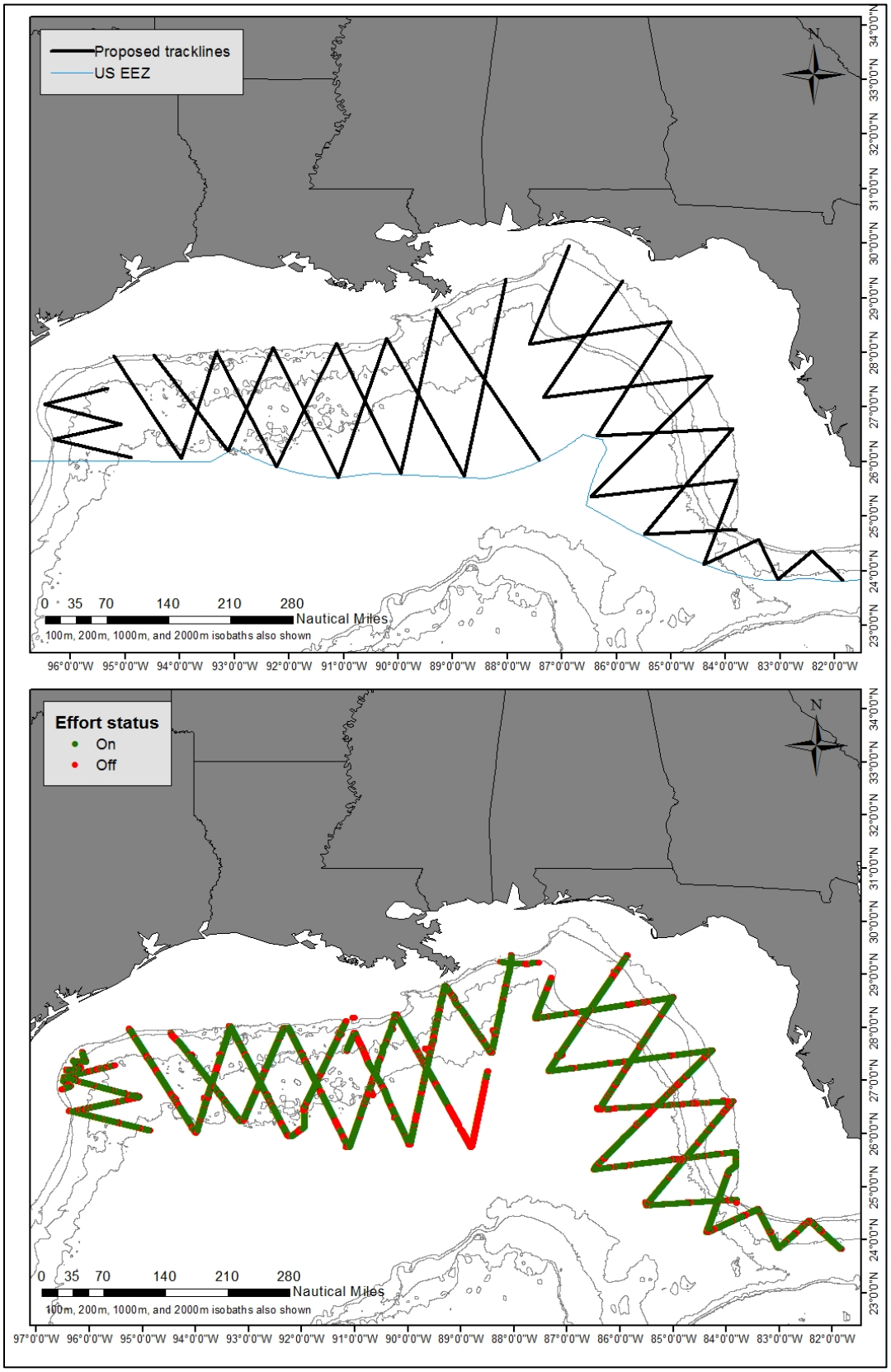


Figure 2. Sea state conditions on the trackline during survey effort for PC18-05

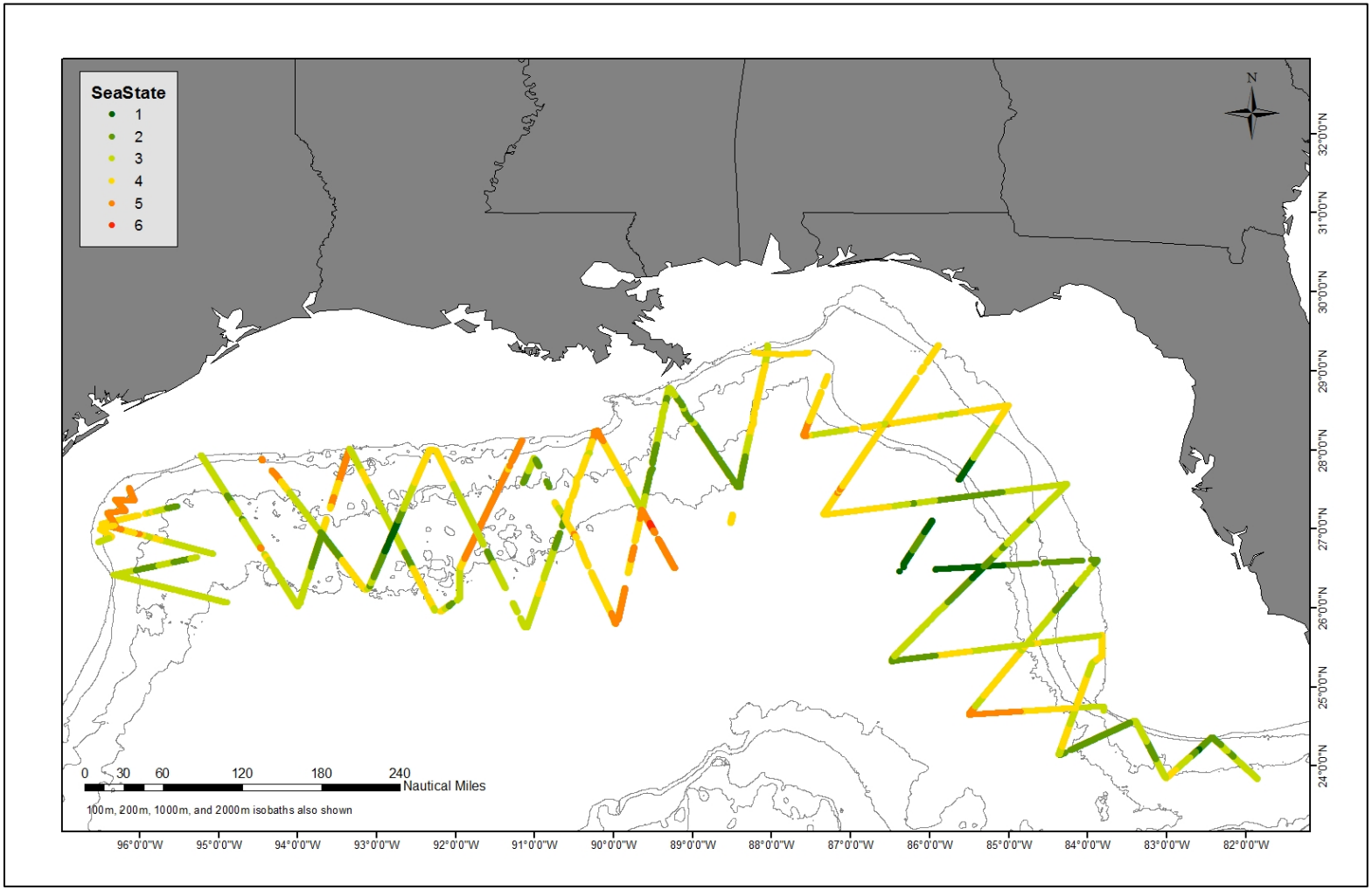


Figure 3. Dolphin sighting locations during PC18-05

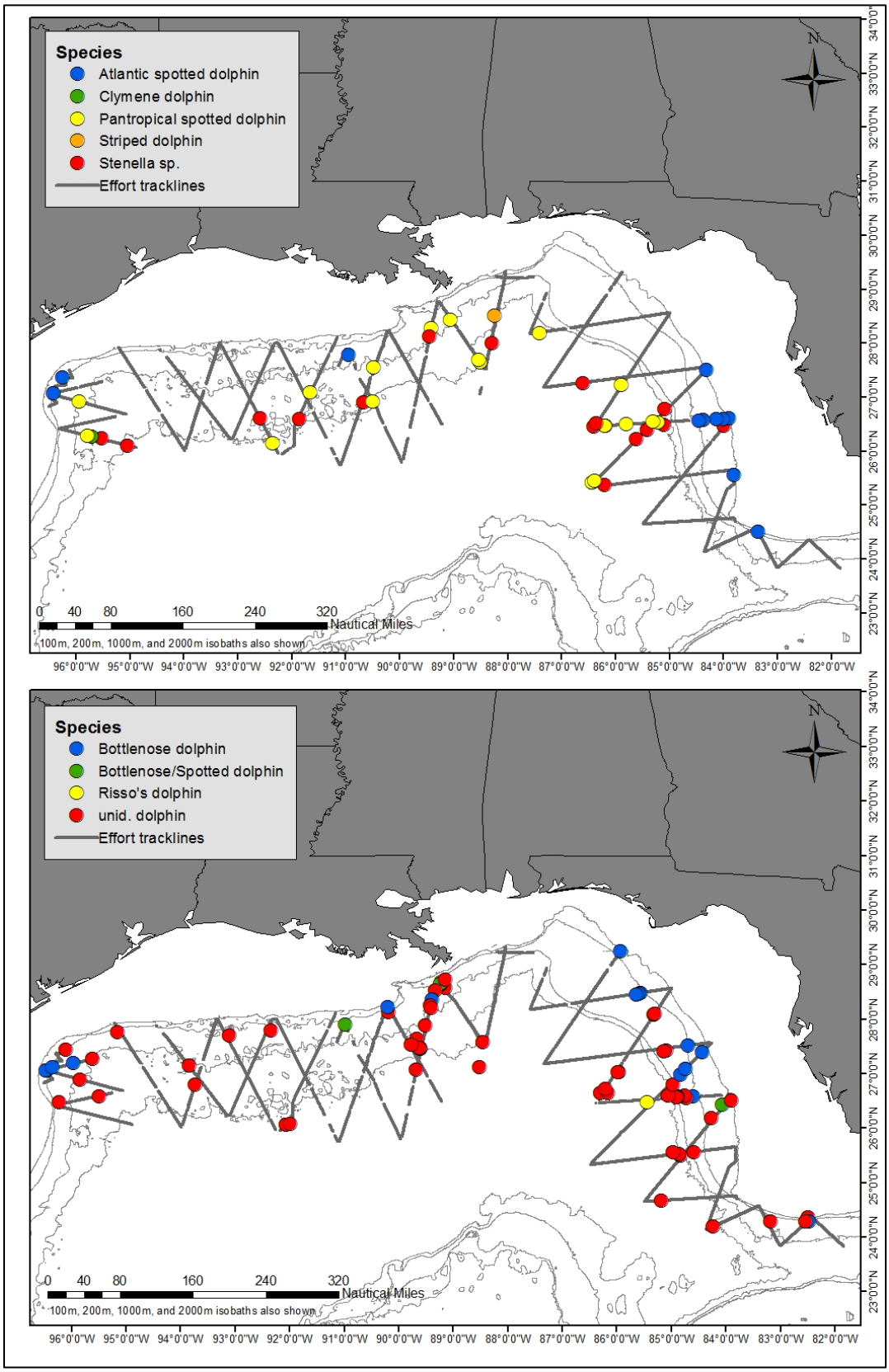


Figure 4. Large whale sightings during PC18-05

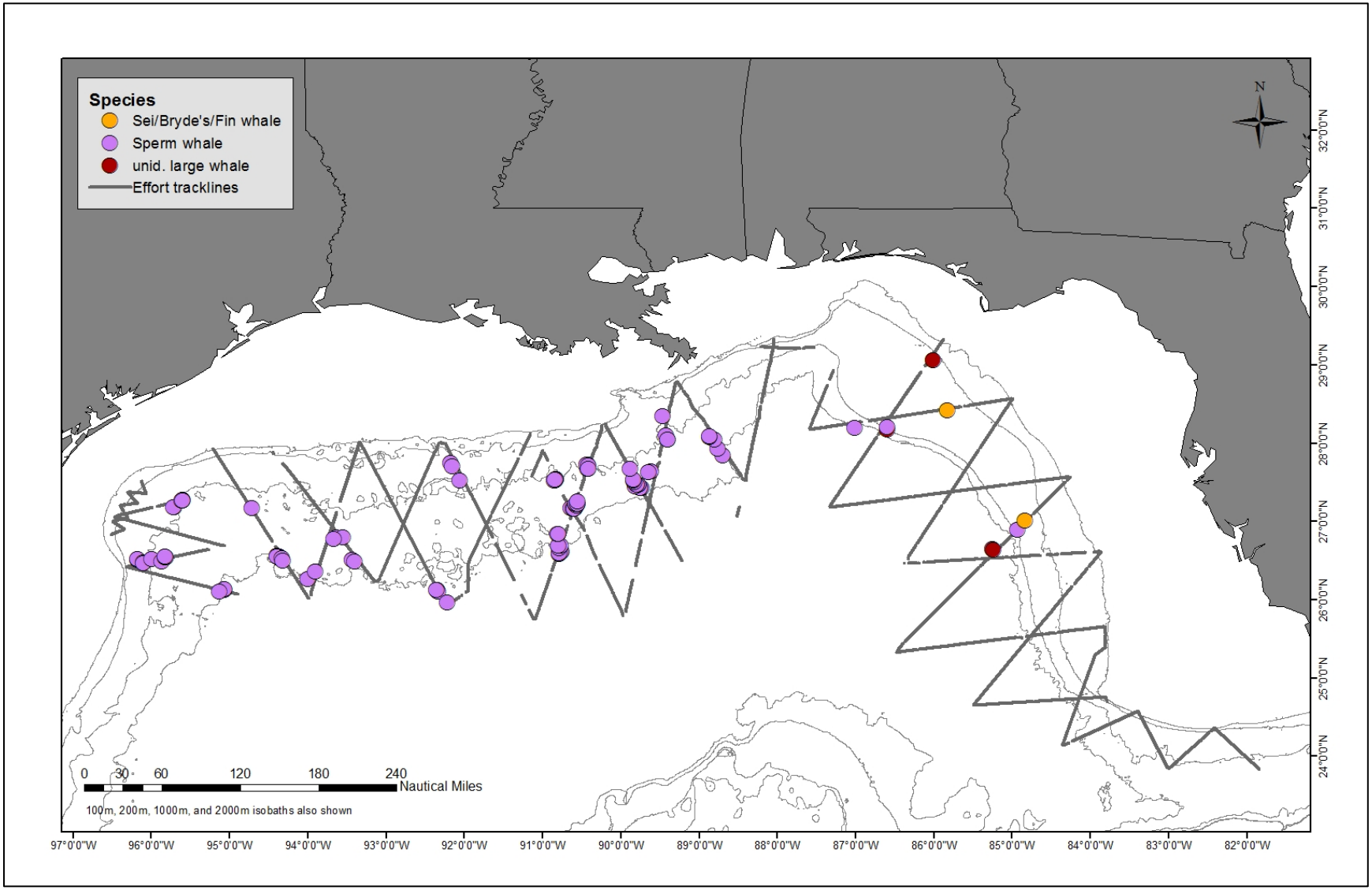


Figure 5. Small whale sightings during PC18-05

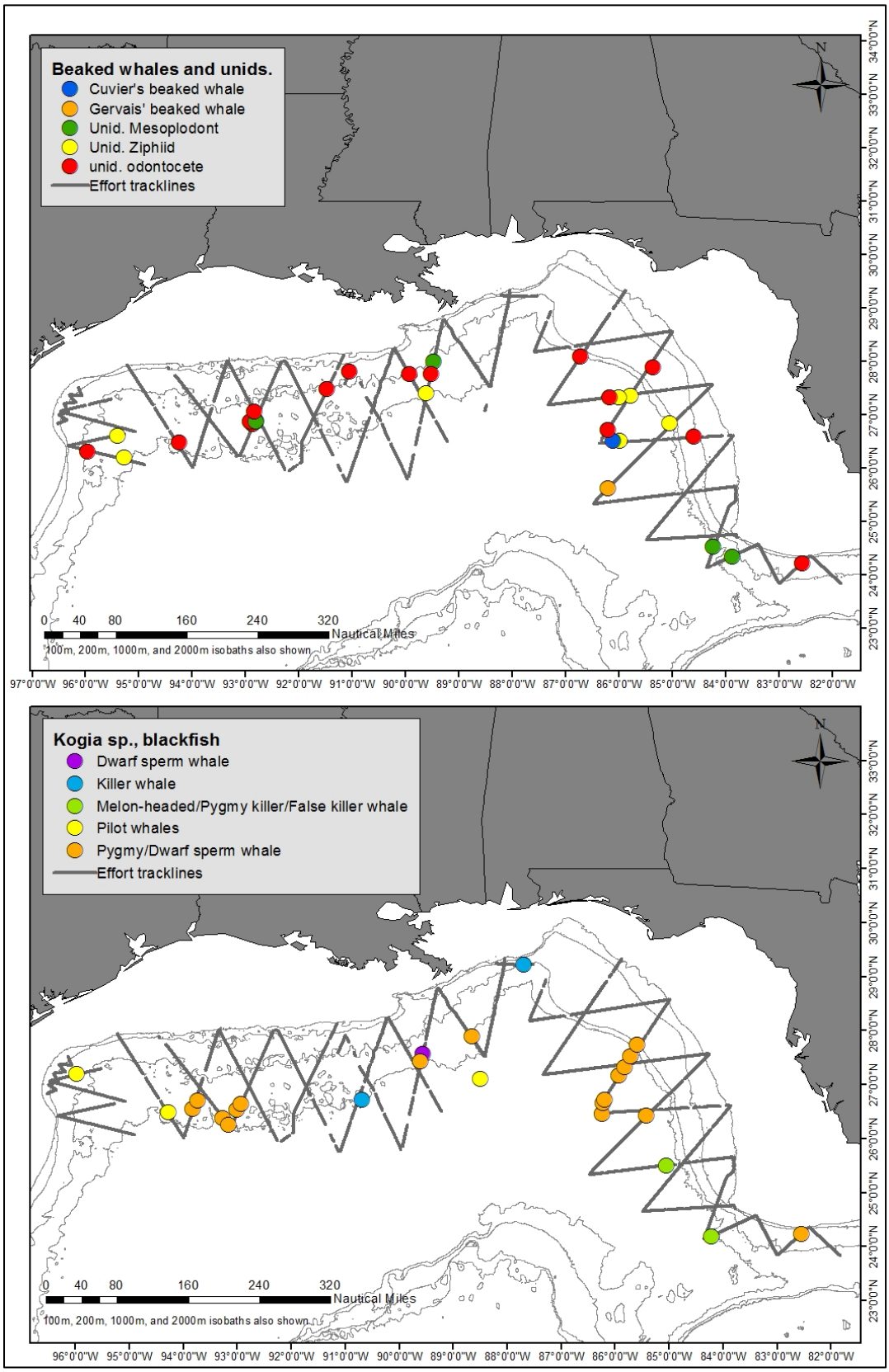


Figure 6. Passive acoustic towed array survey effort and detections during PC18-05

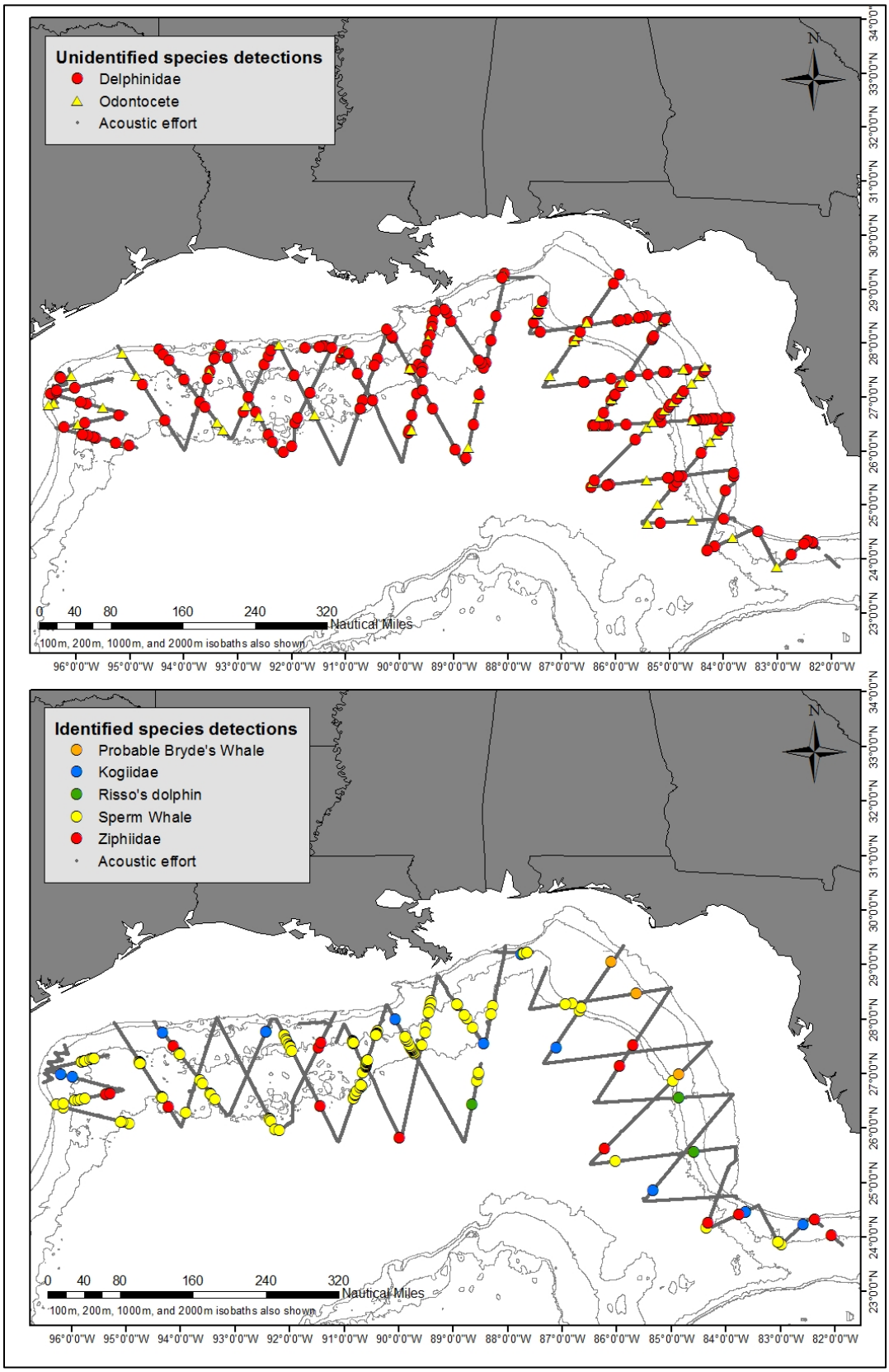


Figure 7. Sonobuoys deployed during PC18-05

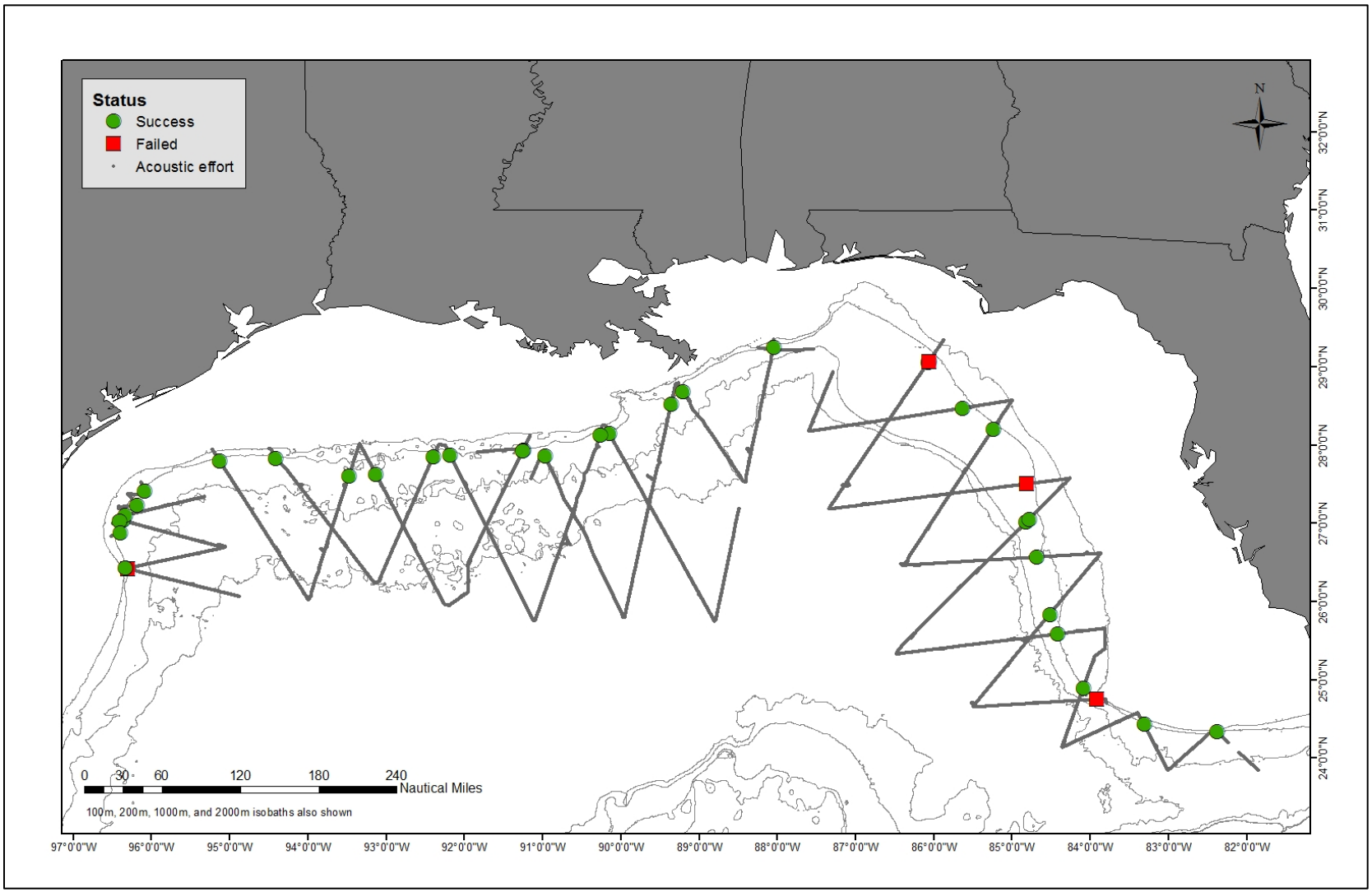


Figure 8. High-frequency Acoustic Recording Package (HARP) moorings deployed or recovered during PC18-05

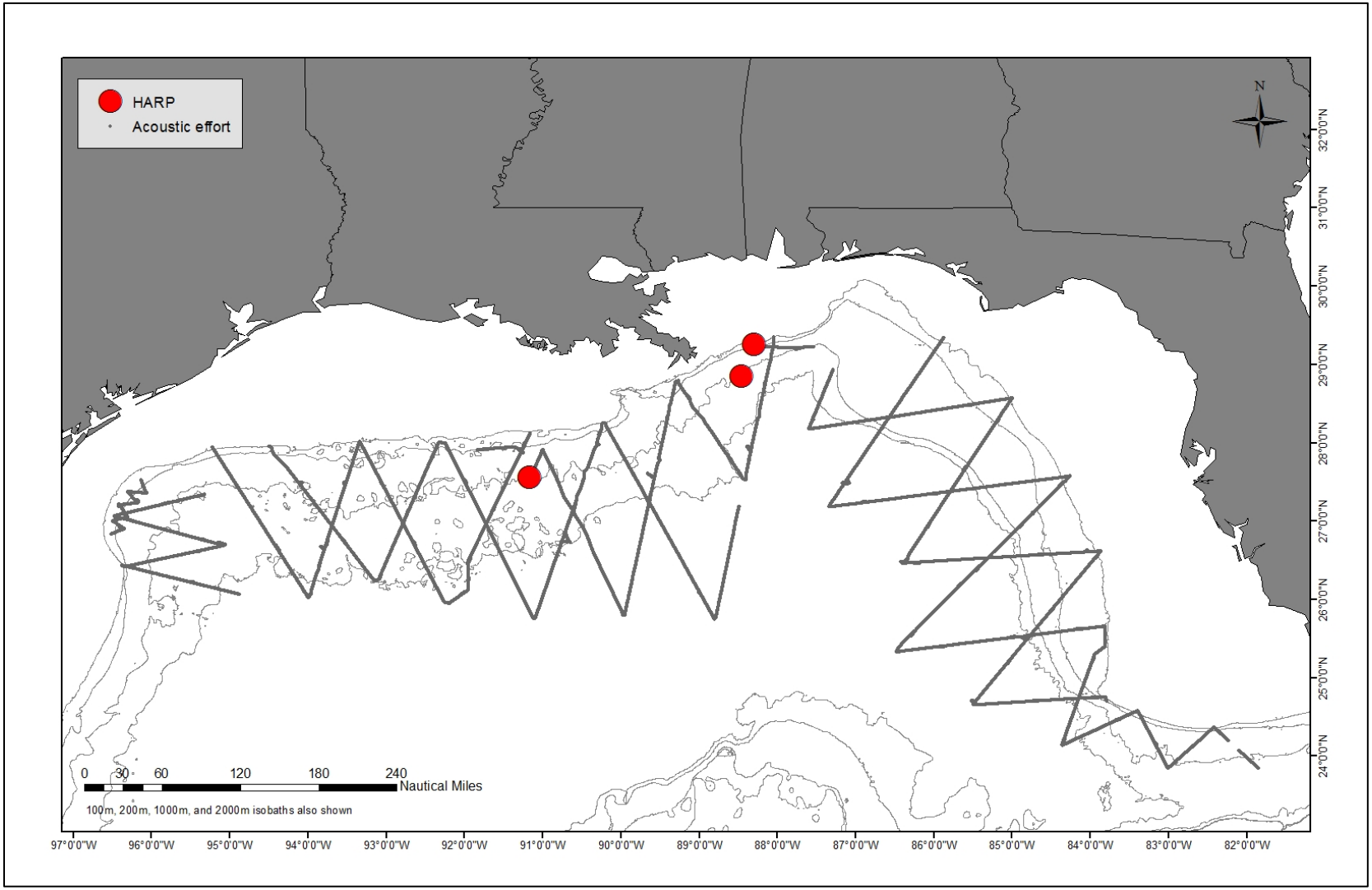
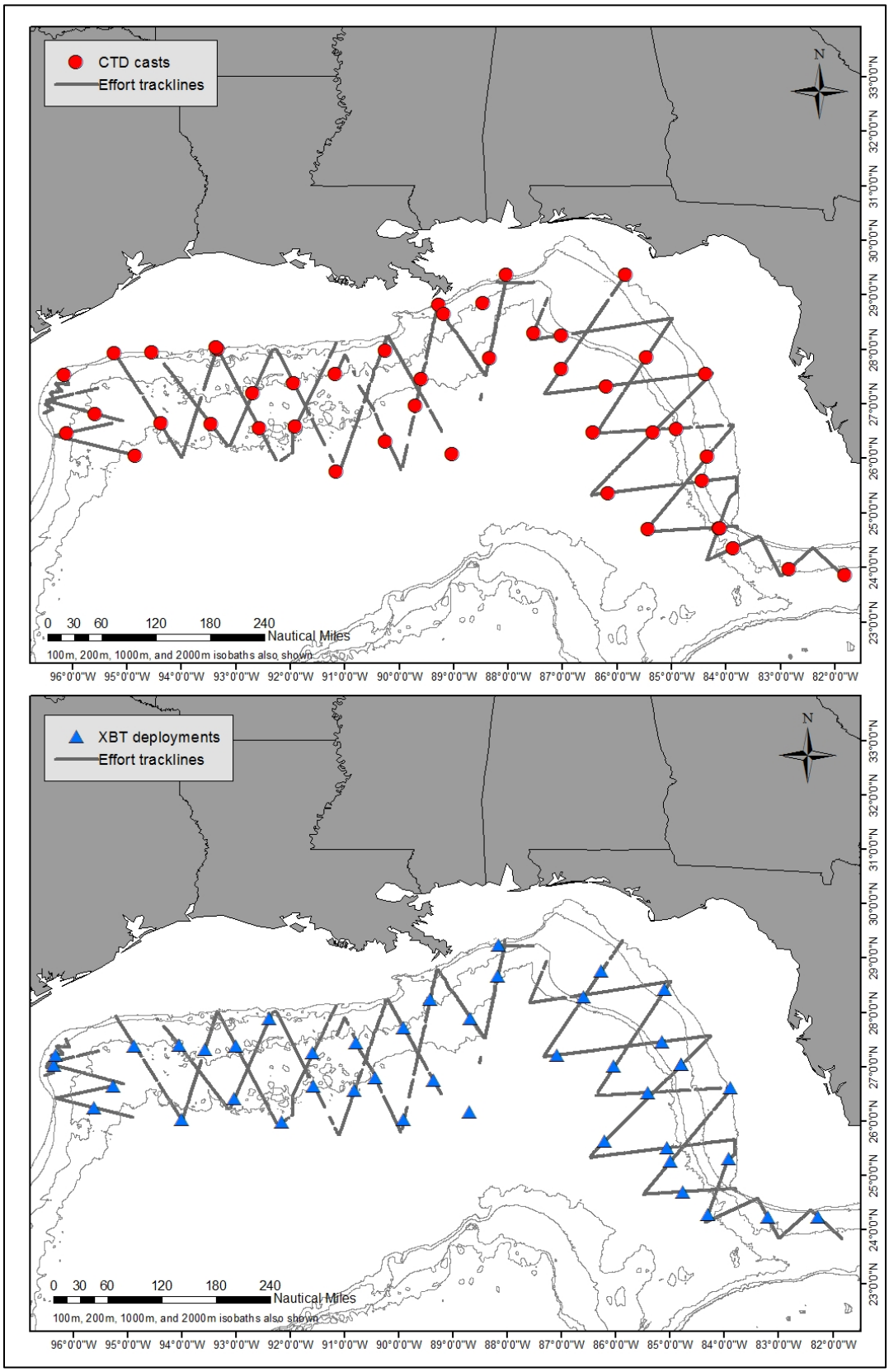
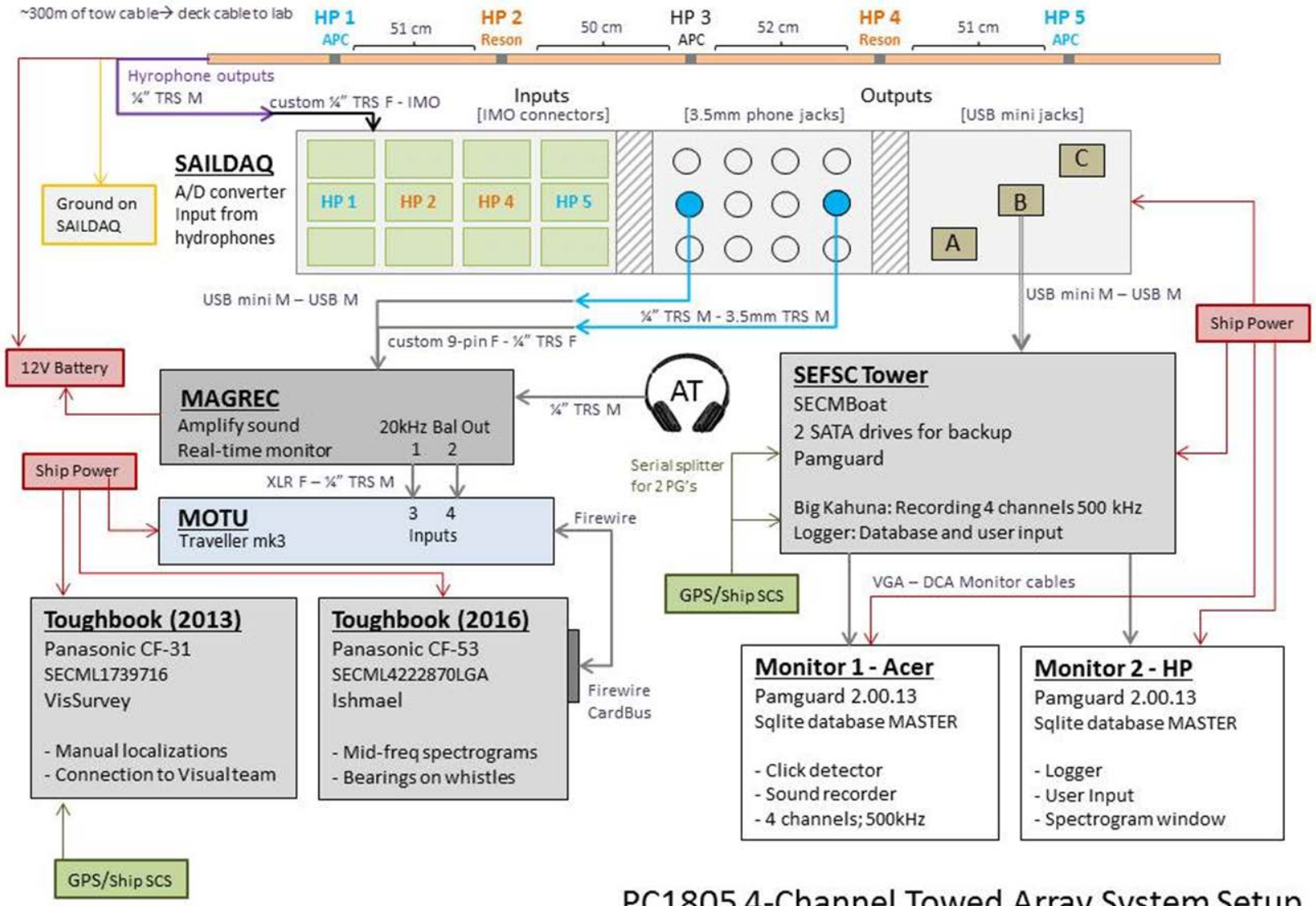


Figure 9. Hydrographic profile sampling stations during PC18-05



Appendix A: Acoustic setup diagram including towed hydrophone array, acoustic recording hardware, data inputs, and software.



Appendix B: Sonobuoy setup diagram including mounted antenna configuration, radio receivers, acoustic recording hardware, data inputs, and software.