Appendix G – December 2010 SEASWITI Monitoring:
Vessel Survey and Towed Array Report

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Jacksonville (JAX) Southeast Anti-Submarine Warfare Integration Training Initiative (SEASWITI)

Marine Species Monitoring

VESSEL MONITORING SURVEYS

TRIP REPORT

3–5 December 2010

HDR

ACRONYMS AND ABBREVIATIONS

ASW	Anti-Submarine Warfare
dB	decibel
ESA	Endangered Species Act
HRC	Hawaii Range Complex
HDR EOC	HDR Environmental Operations & Construction, Inc.
ICMP	Integrated Comprehensive Monitoring Program
JAX	Jacksonville Range Complex
kHz	kilohertz
km	kilometer
km^2	square kilometers
m	meter
MMPA	Marine Mammal Protection Act
MFAS	Mid-Frequency Active Sonar
NM	nautical mile
OPAREA	operating area
SEASWITI	Southeast Anti-Submarine Warfare Integration Training Initiative
SPUE	Sightings Per Unit Effort
SWFSC	Southwest Fisheries Science Center
USWTR	Undersea Warfare Training Range

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Section 1 Introduction

On 4 December 2010, an Anti-Submarine Training Exercise (ASW) event occurred in the Jacksonville Range Complex (JAX) off the eastern coast of Florida within the U.S. Navy's proposed boundaries of the Undersea Warfare Training Range (USWTR). A U.S. Navy frigate was involved with the ASW event that included a Mid-Frequency Active Sonar (MFAS) component conducted over a one-day period. ASW events occur periodically throughout the year and allow the Navy to fulfill essential training requirements.

As part of the compliance requirements of the Marine Mammal Protection Act (MMPA) of 1972 and the Endangered Species Act (ESA) of 1973, the Navy developed the Integrated Comprehensive Monitoring Program (ICMP). The ICMP applies by regulation to those activities on Navy training ranges and operating areas (OPAREAs) for which the Navy sought and received incidental take authorizations. In order to support the Navy in meeting regulatory requirements for monitoring established under the Final Rules and to provide a mechanism to assist with coordination of program objectives under the ICMP, monitoring of marine mammals and sea turtles during this exercise included visual and acoustic surveys from a 133-foot research vessel.

The results of marine mammal monitoring reported here are part of a long-term monitoring effort under the U.S. Navy's Marine Species Monitoring Program **(**Contract # N62470-10-D-3011) issued to HDR Environmental Operations & Construction, Inc. (HDR EOC).

Section 2 Methods

Study Area

The Navy's Jacksonville OPAREA lies off the eastern coast of the Georgia/Florida border. Protected marine species monitoring conducted during the JAX Southeast Anti-Submarine Warfare Integration Training Initiative (SEASWITI) ASW training event was focused on the lower southeastern quadrant of the proposed boundaries of the USWTR box within the JAX OPAREA (see **Figure 1**). The area surveyed was approximately 105 to 133 kilometers (km) (56 to 72 nautical miles (NM)) offshore, covers an area approximately 928 square kilometers (km^2) in size, and ranges in bottom depth from 40 to 500 meters (m).

Vessel-Based Monitoring

Vessel-based monitoring effort was performed over a 3-day period from 3 to 5 December 2010 (see **Tables 1, 2,** and **3**). Survey methods were consistent with currently accepted Distance Sampling theory (Buckland et al. 2001) and followed previously established protocols for marine mammal monitoring vessel surveys conducted by HDR in the Hawaii Range Complex (HRC) (Fulling 2010).

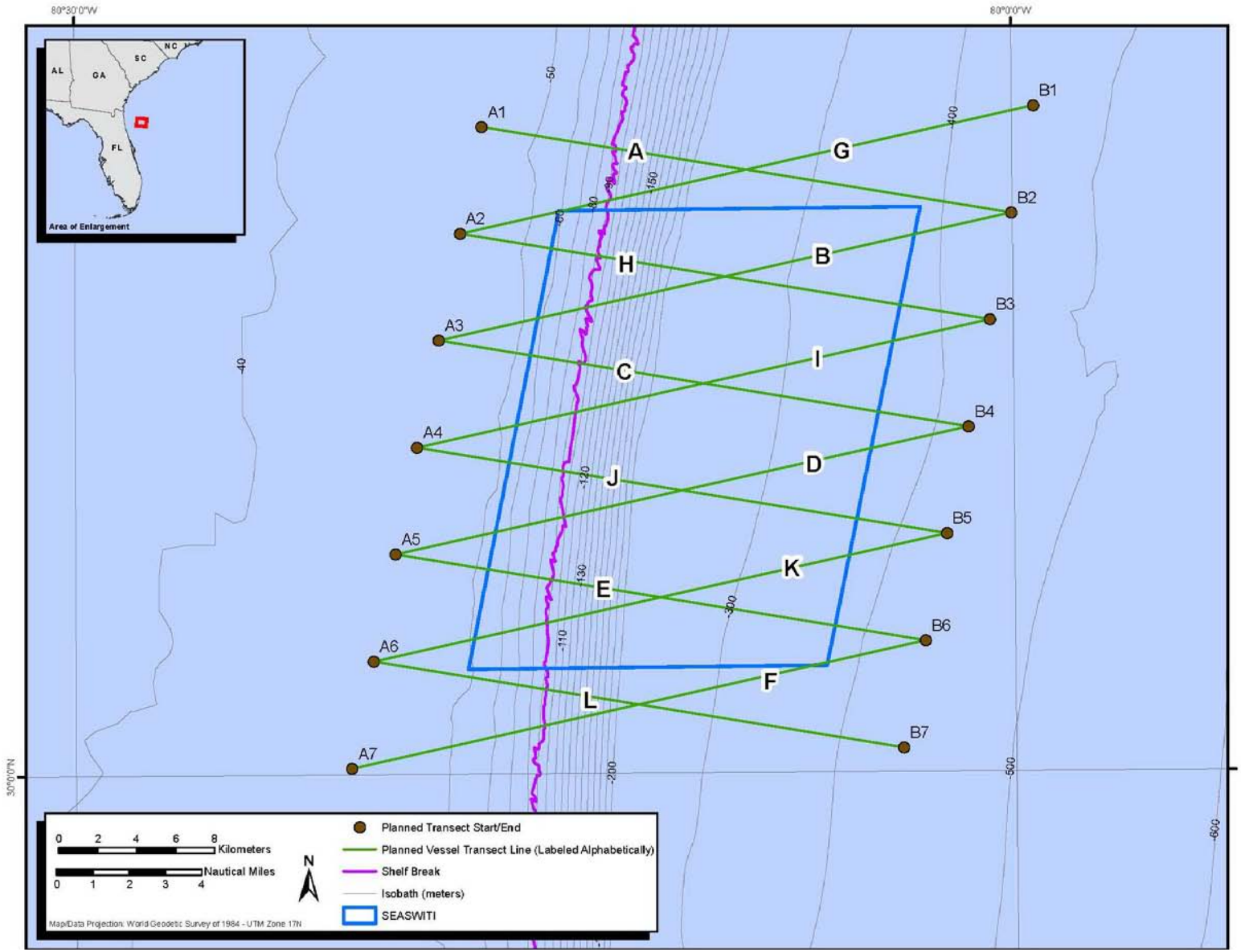

Figure 1. Predetermined Tracklines for the Survey Effort for JAX SEASWITI 2010.

Table 1. Summary of JAX ASW Visual Monitoring Effort

Date	Description	Start Time	Stop Time	Total Survey Minutes*	Total On-Effort Minutes
December 3	Transect survey (Pre-Event)	8:24	17:27	542	325
December 4 (**ASW**)	Transect survey (During-Event)	7:02	17:18	621	477
December 5	Transect survey (Post-Event)	7:02	12:42	339	275
Total				**1,502 (25 hours)**	**1,077 (18 hours)**

Note: * Total Survey Minutes reflect minutes occupied in the range/area of interest and include both on-effort (systematic) and off-effort (random) total minutes.

Table 2. Summary of JAX ASW Monitoring Effort by Trackline Coverage

Date	Description	On-Effort NM (km)	Off-Effort NM (km)	Total Daily Effort NM (km)
December 3	Transect survey (Pre-Event)	42.88 (79.47)	18.97 (35.16)	61.85 (114.63)
December 4 (**ASW**)	Transect survey (During Event)	52.23 (96.80)	16.12 (29.88)	68.35 (126.68)
December 5	Transect survey (Post-Event)	36.72 (68.05)	6.91 (12.82)	43.63 (80.87)
Totals		**131.83 (244.32)**	**42.0 (77.86)**	**173.83 (322.18)**

Table 3. Summary of JAX ASW Acoustic Monitoring Effort

Date	Description	Start Time	Stop Time	Total Distance (km)	Total Survey Minutes*
December 3	Transect survey (Pre-Event)	07:30	08:47	18.9	77
		11:02	12:05	12.8	63
		12:20	17:25	74.8	305
December 4 (**ASW**)	Transect survey (During-Event)	07:18	12:15	64.7	297
		12:45	17:20	57.5	275
December 5	Transect survey (Post-Event)	06:58	11:35	69.6	277
		12:05	17:15	69.6	310
Total				**367.9 (km)**	**1,604 (27 hours)**

Note: * Total Survey Minutes reflect all minutes within and outside of the specified area of interest and include all minutes while the hydrophone array was recording.

The observation platform was the *R/V White Holly*, a 133-foot vessel based in Fernandina Beach, Florida. A total of 3 days of surveys, one pre, one during, and one post, were conducted following pre-determined transect lines covering the southeast quadrant of the proposed boundaries of the USWTR box (see **Tables 1, 2,** and **3;** and **Figure 1**).

- Visual marine mammal and sea turtle observations were conducted during daylight hours using 25x150 "Big Eye" platform-mounted reticled binoculars, 7x50 hand-held reticled binoculars, and unaided eyes. Digital cameras and digital video were used to document sightings for species identification, group size estimation, and to gather information during focal follow events. Data were recorded on paper sighting sheets as well as using WinCruz data logging software developed by Southwest Fisheries Science Center (SWFSC).
- Digital acoustic recordings and information logs were gathered during daylight hours for acoustic detections of marine mammals using a towed hydrophone array built by Seiche Measurements Limited and leased to HDR through E&P Environmental Services - RPS. Acoustic monitoring for marine mammals was completed aurally with Sennheiser headphones and visually with PAMGUARD during daylight hours on 3, 4, and 5 December 2010. Monitoring was conducted in conjunction with visual monitoring each day with the exception of 5 December, when visual monitoring was suspended at approximately 12:30 EST due to rough sea conditions. The passive acoustic monitoring system consisted of six main components: a 400m hydrophone tow cable, a 100 m deck cable, a data processing unit, two laptops, an acoustic analysis software package, and headphones for aural monitoring. The hydrophone tow cable was deployed directly off the stern of the *White Holly*. Approximately 375 m of the cable was towed astern of the vessel. The cable was loaded onto a mechanical winch, which was utilized to facilitate cable deployment and retrieval. The hydrophone cable contains four spherical hydrophone elements (-205 dB re 1V/µPa sensitivity) and a depth gauge (0 to 2.5 bar pressure range). The four hydrophone elements are separated into two pairs, which have a 200 m separation. Three of the hydrophone elements are broadband (2 to 200 kHz frequency response) and the fourth element is for sampling lower frequencies (10 Hz to 45 kHz frequency response). Preamplifiers are also embedded into the tow cable just ahead of each hydrophone element. The four-element linear hydrophone array permits a large range for sampling marine mammal vocalizations, including the low frequency moans of Bryde's whales (70 to 250 Hz) and the ultra high frequency clicks of pygmy sperm whales (60 to 200 kHz). PAMGUARD software was used during the collection and initial classification process. Audio detections were saved as .wav file format for subsequent analysis. A detailed description of methods used is provided in **Appendix A**. A post-cruise analysis of the recordings and field notes was performed by Dr. Julie Oswald with Bio-waves, Inc., to determine whether all detections contained sounds produced by marine mammals. RAVEN bio-acoustic analysis software was used to examine spectrograms, frequency spectra, and waveforms during this post-cruise analysis period.

All vessel observers (see **Table 4**) were experienced with line-transect survey methodology, had experience in identification of Atlantic marine mammal and sea turtle species, were knowledgeable of marine mammal biology and behavior, and had previous experience conducting marine mammal and sea turtle observations from vessels. The passive acoustic operator was highly trained in the detection of marine mammals using the towed Seiche hydrophone array.

Table 4. Observers and Roles

Observer	Role(s)
Greg Fulling	Chief Scientist/Cruise Leader
Dan Engelhaupt	Survey Coordinator/Visual Observer
Mark Cotter	Visual Observer
Keri Lestyk	Visual Observer
Amy Engelhaupt	Visual Observer
Cathy Bacon	Visual Observer
Melody Baran	Visual Observer
Rebecca Snyder	Passive Acoustic Operator

Visual survey effort included and overlapped the southeast quadrant of the proposed USWTR box (approximately 928 km^2) and consisted of waypoints designed to extend beyond the range boundaries during each survey day. Based on the height of the White Holly flying bridge, it was determined that observers using 25 x 150 big eye binoculars would be able to see a minimum of 6 NM away from the vessel in calm conditions. Two sets of six tracklines in a sawtooth pattern running from west to east and north to south, measuring 28 km per west–to–east segment, were observed during "systematic" efforts throughout the surveys and attempted to provide a total survey coverage area of approximately 928 km^2 (see **Figure 1**). Planned lines were followed when possible, but exact transects were subject to modifications as a result of high Beaufort sea state and Navy restrictions around the ASW ship during exercises (see **Tables 1** and **2,** and **Figures 2–5**).

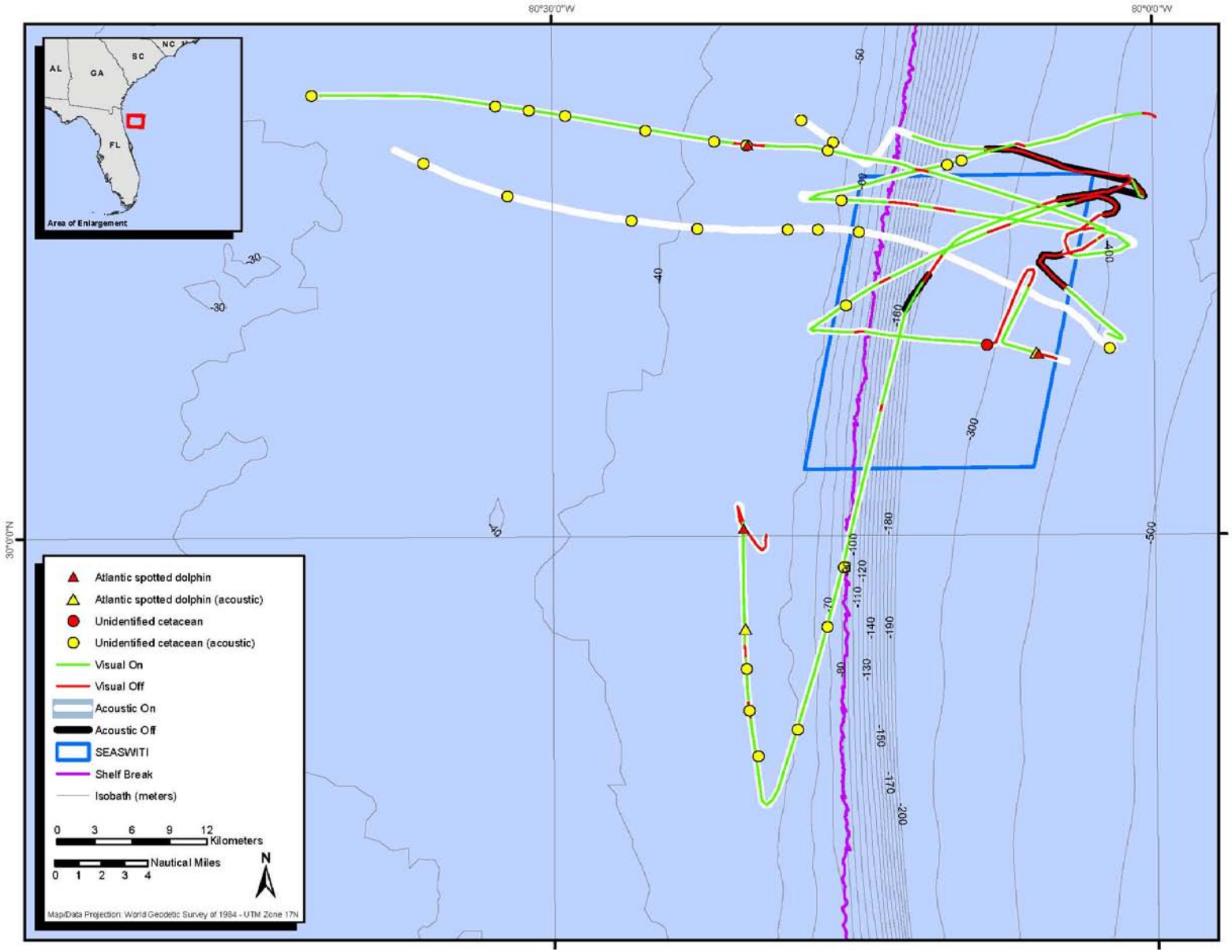

Figure 2. Location of All Cetacean Sightings/Detections During Survey Period (December 3–5).

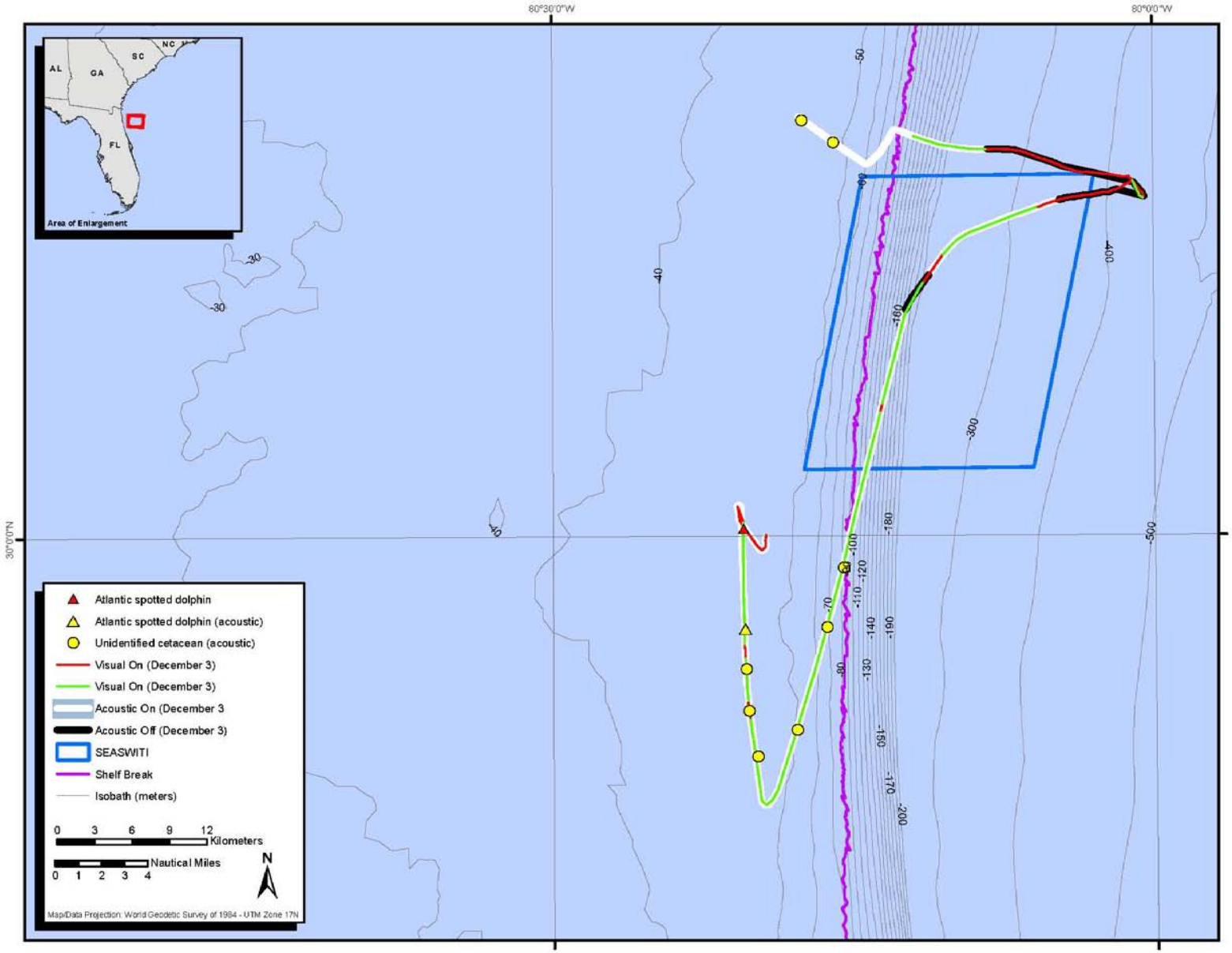

Figure 3. Location of Cetacean Sightings/Detections Pre-ASW (December 3).

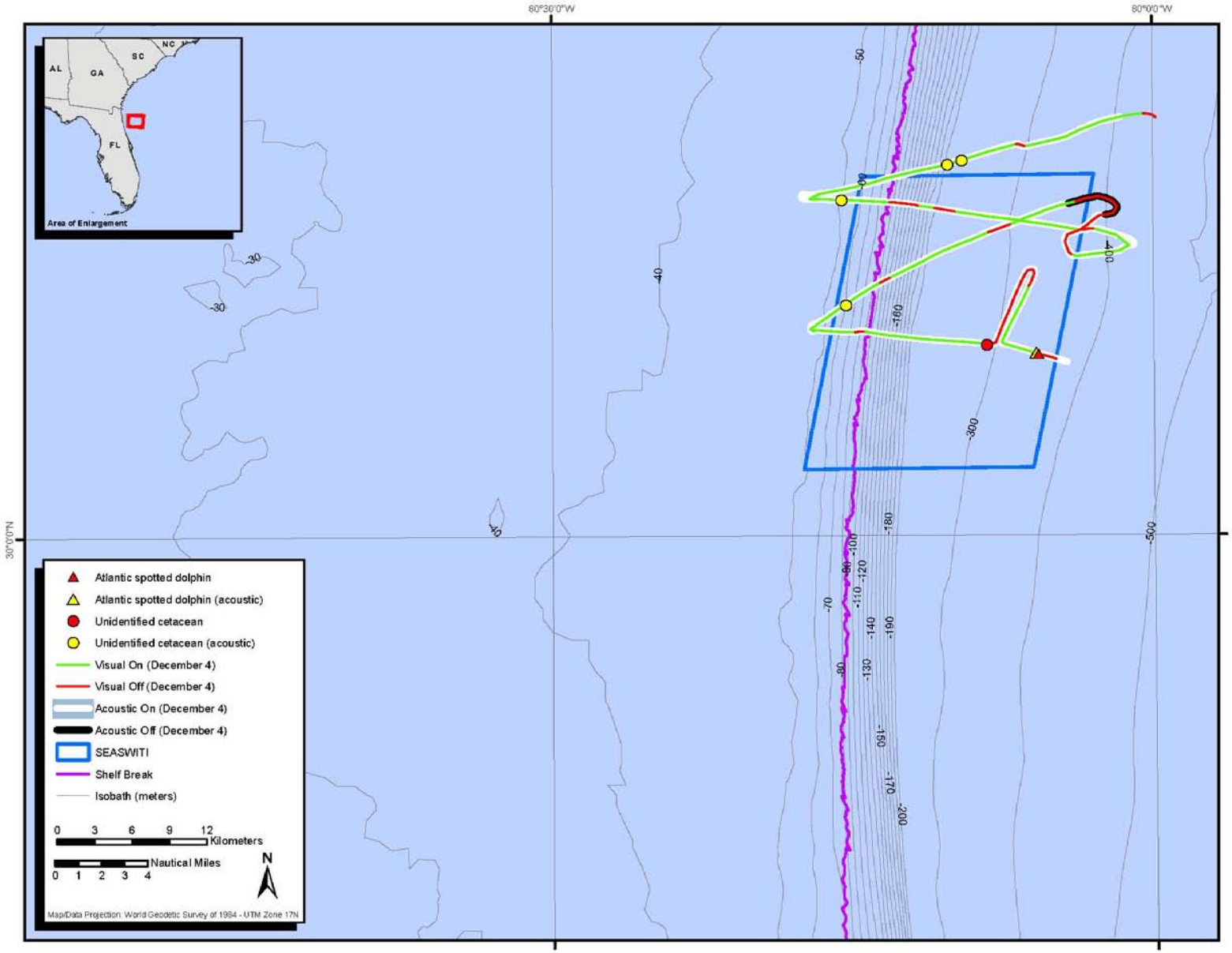

Figure 4. Location of Cetacean Sightings/Detections During ASW (December 4).

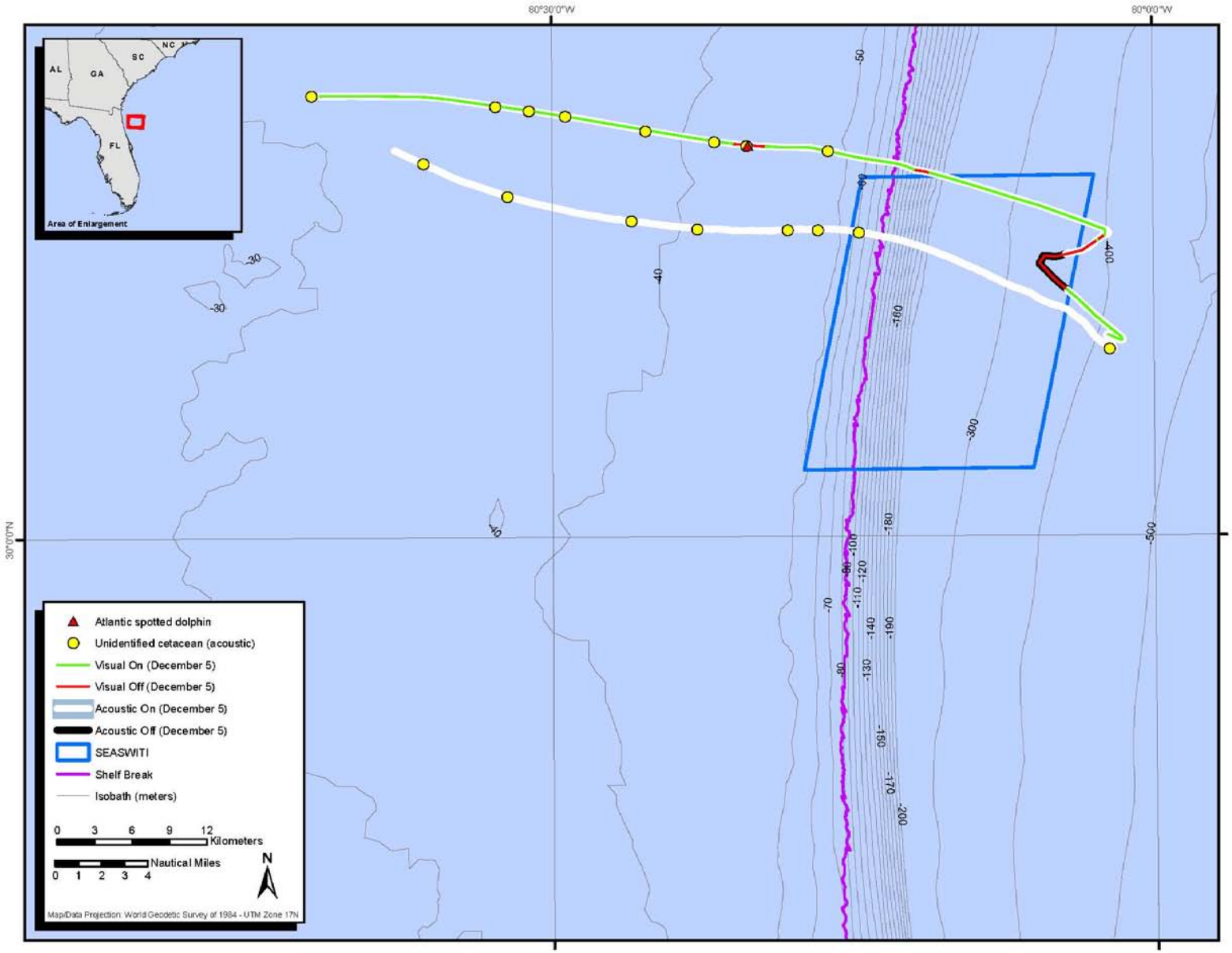

Figure 5. Location of Cetacean Sightings/Detections Post-ASW (December 5).

The general survey approach was as follows:

1. Follow pre-determined transect lines and waypoints using methods described in the cruise plan until a visual sighting is made. A survey speed of approximately 8 knots was attempted while on-effort, but might have varied slightly based on weather conditions and strong currents associated with the Gulf Stream experienced throughout the area. Once a marine mammal sighting was visually detected, a slower speed was established in an attempt to conduct a focal follow from a distance so as not to alter the natural behavior with the survey vessel. Environmental variables such as sea state, glare, and visibility are recorded throughout the survey.
2. Upon sighting a marine mammal/sea turtle group, record basic sighting information per established protocol using WinCruz data logging software. If Navy ships were within the visual range of observers at the time of sighting, approximate distance and direction from the survey ship will be noted. As outlined in the AFAST LOA and monitoring plan, information is to include (1) species identification and group size; (2) location and relative distance from the ASW site if available; (3) the behavior of marine mammals and sea turtles including standard environmental and oceanographic parameters; (4) date, time, and visual conditions associated with each observation; (5) direction of travel relative to true north; and (6) duration of the observation.
3. If the sighting appears suitable for a focal follow (i.e. calm sea state conditions allow constant visual tracking and the animals show no avoidance/attraction behavior towards the monitoring vessel), the vessel will slow to a suitable speed and maintain a safe distance required to obtain detailed behavior information as possible and logical, for a minimum of 5 minutes, including digital photographs and video.
4. If the sighting is not selected for a focal follow, and species and group size are unknown, the vessel will attempt to remain with the sighting to obtain digital photographs for species identification confirmation and to estimate group size/composition.

Section 3 Results

Survey Effort

Observers visually surveyed approximately 132 NM (244 km) of systematic (on-effort) trackline and 174 NM (322 km) of combined systematic and random (lines covered in transit to the next trackline) tracklines during 3 days for more than 18 hours of on-effort status (see **Tables 1** and **2**). Acoustic monitoring was conducted for approximately 27 total hours. Beaufort sea states ranged from 4 to 6 causing numerous course changes throughout the cruise. During the evening of December 4, sea conditions in the area were deemed by the Captain as too dangerous to stay within the specified survey area and the vessel was moved towards calmer near-shore waters until daylight on December 5 (see **Figure 5**). A detailed description of environmental, oceanographic, and sighting conditions was collected using the program WinCruz data logging software and is available in an MS Excel formatted spreadsheet. Marine mammal sightings per unit effort (SPUE) was calculated as the total survey effort (hours/km/NM) divided by the total number of marine mammal visual sightings (n=4). Marine mammal effort corrected acoustic detections were calculated as the total survey effort (hours) divided by the total number of

marine mammal acoustic detections (n=30). For this monitoring exercise, the SPUE for marine mammals was equal to 1 sighting per 6.3 hours, 80.5 km, and 43.5 NM and the acoustic detections for marine mammals was equal to 1 detection per 1.1 hours.

Visual Sightings

Due to extremely poor sighting conditions dominated by high Beaufort sea, marine mammal and sea turtle sightings in the area were lower than expected. No sightings of sea turtles were made during the cruise. Four sightings of cetaceans were recorded during 25 hours of survey time (see **Figure 2**, **Table 5**). One sighting of Atlantic spotted dolphins (*Stenella frontalis*) was made on the pre-ASW survey day of December 3, 2010 (see **Figure 3**, **Table 5**). One sighting of unidentified cetaceans and one sighting of Atlantic spotted dolphins (*Stenella frontalis*) was made on the ASW event day of December 4, 2010 (see **Figure 4**, **Table 5**). One sighting of Atlantic spotted dolphins (*Stenella frontalis*) was made on the post-ASW survey day of December 5, 2010 (see **Figure 5**, **Table 5**). Two of the four visual sightings were on the track lines within the specified survey area during on-effort status and two sightings of marine mammals were outside of the survey area, but were listed as opportunistic on-effort survey time. Digital photographs were collected during one cetacean sighting and used to confirm species identification. Sightings included two groups of Atlantic spotted dolphins (*Stenella frontalis*) in water depths between 40 and 50 meters, one group of Atlantic spotted dolphins (*Stenella frontalis*) in water depths between 300 and 400 meters, and one sighting of unidentified marine mammals in water depths between 200 and 300 meters of water (see **Figure 2, Table 5**).

Acoustic Detections

Thirty acoustic detections during nearly 27 hours of survey effort were collected by E&P Environmental Services - RPS during the cruise and are presented in **Appendix B**. The post-cruise analysis determined all thirty detections were found to contain sounds produced by marine mammals (see **Figure 2**, **Table 6**). Four types of marine mammal sounds were identified using the following criteria:

1. Delphinid whistles: narrowband, frequency modulated sounds (5–18 kilohertz [kHz]).
2. Delphinid clicks: broadband high frequency clicks (most contained no energy below 15 kHz) with short (< 1 second) inter-click intervals.
3. Sperm whale clicks: broadband, high frequency clicks with a frequency peak at 5–8 kHz.
4. Possible beaked whale clicks: very high frequency, relatively narrowband clicks centered at approximately 35 kHz.

Nine detections of marine mammals were made on the pre-ASW survey day of December 3, 2010 (see **Figure 3**, **Table 6**). Five detections of marine mammals were made on the ASW event day of December 4, 2010 (see **Figure 4**, **Table 6**). Sixteen detections of marine mammals were made on the post-ASW survey day of December 5, 2010 (see **Figure 5**, **Table 6**). Eleven of the 30 acoustic detections were on the track lines within the specified survey area of interest and 19 detections of marine mammals were outside of this survey area but included in total acoustic survey time. Acoustic detection #9 and #14 were associated with visual sighting events with one group of Atlantic spotted dolphins (*Stenella frontalis*) in water depths between 40 and

Table 5. Summary of Visual Sightings

Sighting No.	Date	Species	Group Size Best/High/Low			Calves	Start Time	Stop Time	Beaufort Sea State	Latitude	Longitude	Vert. Angle (ret.)	Distance off Track (km)	Heading	Bottom Depth (m)	Navy Ship Present (Yes/No)	Behavioral Summary
1	12/3/10	SF	19	25	13	-	16:46	17:24	5	30.006	-80.342	> 15	< 50	140	< 50	No	Seen naked eye as they approached vessel to bow-ride. Several began to peel off and mill in small groups (2–6) approximately 300 meters from our vessel in a parallel course as we slowed the vessel to observe. Non-evasive.
2	12/4/10	Unid	2	2	2	-	15:49	15:50	5	30.138	-80.139	3	6	270	250	Yes	Fast travel. Brief glimpse. Lost in chop while attempting to reacquire, forced to relocate for Navy vessel. Non-evasive.
3	12/4/10	SF	4	6	6	-	17:11	17:17	5	30.131	-80.096	> 15	< 50	100	300	Yes	Seen naked eye as they approached vessel to bow-ride. Non-evasive.
4	12/5/10	SF	6	6	3	1	9:10	9:20	5	30.283	-80.337	> 15	< 50	320	< 50	No	Seen naked eye as they approached vessel to bow-ride. Quickly dispersed after brief bow-ride. Non-evasive.

Key:
SF = Atlantic spotted dolphin (*Stenella frontalis*)
Unid = Unidentified cetacean

Table 6. Post-Cruise Summary of Acoustic Detections

Detection No.	Date	Detection Files	Total Number of Minutes	Likely Sound Source	Latitude	Longitude	Bottom Depth (m)	Sonar Present (Yes/No)	Characteristics Used to Classify Sounds
1	12/3/10	HDR_NAV_LF_20101203_123049 through HDR_NAV_LF_20101203`_123615	(LF) 08:18	sperm whale	30.301	-80.292	40	No	Low-frequency clicks (center frequency approximately 7 kHz) with long, regular inter-click interval
2	12/3/10	HDR_NAV_LF_20101203_123933 through HDR_NAV_LF_20101203_125959; HDR_NAV_HF 20101203_125156 through HDR_NAV_HF_20101203_125913	(LF) 32:35 (HF) 14:34	sperm whale - likely continuation of previous detection	30.285	-80.266	40	No	Low-frequency clicks (center frequency approximately 7 kHz) with long, regular inter-click interval
3	12/3/10	HDR_NAV_LF_20101203_182841 through HDR_NAV_LF_20101203_184841; HDR_NAV_HF_20101203_183714 through HDR_NAV_HF_20101203_184431	(LF) 40:00 (HF) 14:34	delphinid	29.978	-80.259	80	No	High-frequency, broadband clicks with regular inter-click intervals
4	12/3/10	HDR_NAV_LF_20101203_184841	(LF) 20:00	delphinid	29.935	-80.273	60	No	Click trains with regular inter-click intervals, different click trains heard on hyd 2 and hyd 3, PAMGUARD display shows sound source crossing the bow
5	12/3/10	HDR_NAV_LF_20101203_192907, HDR_NAV_HF_20101203_193823, HDR_NAV_HF_20101203_194540	(LF) 10:50 (HF) 14:34	sperm whale	29.861	-80.298	50	No	Low-frequency broadband clicks with a peak frequency at approximately 7 kHz and long inter-click intervals (sperm whales)
6	12/3/10	HDR_NAV_LF_20101203_202948	(LF) 20:00	delphinid and sperm whale	29.842	-80.331	40	No	Numerous broadband clicks (delphinid), clicks with peak frequency at approximately 7 kHz (sperm whale)
7	12/3/10	HDR_NAV_LF_20101203_202948	(LF) 20:00	delphinid	29.875	-80.338	40	No	Narrowband whistles (5–18 kHz)

Detection No.	Date	Detection Files	Total Number of Minutes	Likely Sound Source	Latitude	Longitude	Bottom Depth (m)	Sonar Present (Yes/No)	Characteristics Used to Classify Sounds
8	12/3/10	HDR_NAV_LF_20101203_204949	(LF) 20:00	delphinid	29.905	-80.340	40	No	Whistles
9	12/3/10	HDR_NAV_LF_20101203_214324	(LF) 04:04	delphinid	29.934	-80.341	40	No	Whistles
10	12/4/10	HDR_NAV_HF_20101204_133026	(HF) 07:17	delphinid	30.271	-80.159	200	No	Very faint high frequency clicks with regular inter-click interval
11	12/4/10	HDR_NAV_LF_20101204_140334	(LF) 13:26	delphinid	30.268	-80.171	200	No	Whistles and burst pulses
12	12/4/10	HDR_NAV_LF_20101204_144952, HDR_NAV_HF_20101204_144614	(LF) 02:59 (HF) 07:17	sperm whales and delphinids	30.243	-80.259	50	No	High-frequency delphinid clicks, low-frequency sperm whale clicks
13	12/4/10	HDR_NAV_LF_20101204_193926	(LF) 09:19	sperm whales and delphinids	30.167	-80.256	60	Yes	High-frequency delphinid clicks, low-frequency sperm whale clicks
14	12/4/10	HDR_NAV_LF_201012-4_220330	(LF) 09:11	delphinids	30.132	-80.098	300	Yes	Clicks with regular inter-click intervals and frequency spectra, whistles
15	12/5/10	HDR_NAV_LF_20101205_115614	(LF) 16:53	delphinids	30.320	-80.700	30	No	Whistles
16	12/5/10	HDR_NAV_LF_20101205_124343	(LF) 12:25	delphinids	30.312	-80.547	30	No	Whistles
17	12/5/10	HDR_NAV_LF_20101205_130202, HDR_NAV_LF_20101205_130327, HDR_NAV_HF_20101205_125909	(LF) 09:49 (HF) 07:17	delphinids and sperm whales	30.309	-80.519	30	No	Whistle and sperm whale clicks
18	12/5/10	HDR_NAV_LF_20101205_131205	(LF) 20:00	sperm whales	30.305	-80.489	30	No	Low-frequency clicks with peak frequency at approximately 7 kHz, and long inter-click intervals - sperm whales (hyd 3 and 4)

Detection No.	Date	Detection Files	Total Number of Minutes	Likely Sound Source	Latitude	Longitude	Bottom Depth (m)	Sonar Present (Yes/No)	Characteristics Used to Classify Sounds
19	12/5/10	HDR_NAV_LF_20101205_133651	(LF) 01:08	sperm whales - continuation of previous detection	30.294	-80.422	30	No	Low-frequency clicks with peak frequency at approximately 7 kHz, and long inter-click intervals - sperm whales
20	12/5/10	HDR_NAV_LF_20101205_134906	(LF) 10:43	sperm whales - continuation of previous detection	30.286	-80.365	40	No	Low-frequency clicks with peak frequency at approximately 7 kHz, and long inter-click intervals - sperm whales
21	12/5/10	HDR_NAV_LF_20101205_141019 - HDR_NAV_LF_20101205_142446, HDR_NAV_HF_20101205_141159	(LF) 16:40 (HF) 02:20	delphinid and continuation of sperm whale detection	30.283	-80.338	40	No	A few delphinid clicks, many sperm whale clicks
22	12/5/10	HDR_NAV_LF_20101205_143626, HDR_NAV_HF_20101205_143831- HDR_NAV_HF_20101205_144548	(LF) 08:27 (HF) 14:34	sperm whales (continuation of previous detection) and possible beaked whales	30.279	-80.270	40	No	Sperm whale clicks, possible beaked whale clicks (35 kHz)
23	12/5/10	HDR_NAV_LF_20101205_174730	(LF) 20:00	delphinids	30.135	-80.037	400	No	Whistles
24	12/5/10	HDR_NAV_LF_20101205_192731 through HDR_NAV_LF_20101205_194233; HDR_NAV_HF_20101205_193535 through HDR_NAV_HF_20101205_194252	(LF) 27:30 (HF) 14:34	sperm whales	30.220	-80.245	60	No	Low-frequency clicks with peak frequency at approximately 7 kHz, and long inter-click intervals - sperm whales

Detection No.	Date	Detection Files	Total Number of Minutes	Likely Sound Source	Latitude	Longitude	Bottom Depth (m)	Sonar Present (Yes/No)	Characteristics Used to Classify Sounds
25	12/5/10	HDR_NAV_LF_20101205_194233 through HDR_NAV_LF_20101205_195601; HDR_NAV_HF_20101205_195009 through HDR_NAV_HF_20101205_195539	(LF) 23:20 (HF) 12:09	sperm whales - continuation of previous detection	30.222	-80.279	40	No	Low-frequency clicks with peak frequency at approximately 7 kHz, and long inter-click intervals - sperm whales
26	12/5/10	HDR_NAV_LF_20101205_195601 through HDR_NAV_LF_20101205_200800; HDR_NAV_HF_20101205_195539 through HDR_NAV_HF_20101205_201013	(LF) 16:30 (HF) 21:51	sperm whales - continuation of previous detection	30.222	-80.304	40	No	Low-frequency clicks with peak frequency at approximately 7 kHz, and long inter-click intervals - sperm whales
27	12/5/10	HDR_NAV_LF_20101205_202237 through HDR_NAV_LF_20101205_203510; HDR_NAV_HF_20101205_203204 through HDR_NAV_HF_20101205_205018	(LF) 32:18 (HF) 25:20	sperm whales - continuation of previous detection	30.223	-80.379	40	No	Low-frequency clicks with peak frequency at approximately 7 kHz, and long inter-click intervals - sperm whales
28	12/5/10	HDR_NAV_HF_20101205_205018 through HDR_NAV_HF_20101205_211405	(HF) 23:35	sperm whales - continuation of previous detection	30.229	-80.434	30	No	Low-frequency clicks with peak frequency at approximately 7 kHz, and long inter-click intervals - sperm whales
29	12/5/10	HDR_NAV_HF_20101205_213556 through HDR_NAV_HF_20101205_215030	(HF) 21:51	sperm whales - continuation of previous detection	30.247	-80.537	30	No	Low-frequency clicks with peak frequency at approximately 7 kHz, and long inter-click intervals - sperm whales
30	12/5/10	HDR_NAV_HF_20101205_220504	(HF) 07:17	sperm whales - continuation of previous detection	30.271	-80.607	30	No	Low-frequency clicks with peak frequency at approximately 7 kHz, and long inter-click intervals - sperm whales

LF = Low Frequency Recordings
HF = High Frequency Recordings

50 meters and one group of Atlantic spotted dolphins (*Stenella frontalis*) in water depths between 300 and 400 meters respectively (see **Figures 3** and **4, Tables 5** and **6**). Thirteen detections were classified as sperm whales, five detections were classified as sperm whales and delphinids, one detection (#22) was classified as sperm whales and possible beaked whales, and eleven detections were classified as delphinids (see **Figure 2, Table 6**).

Several recordings that had been identified in the field by the passive acoustic operator as containing delphinid clicks also contained clicks produced by sperm whales. Typically, sperm whales do not click when at the surface and therefore there are often periods of silence in between periods of clicking. In the field, these periods of silence were labeled as breaks between separate detections; however, many of these separate detections were likely the same group. The following detections should be grouped into single detections:

1. Detections 1 and 2
2. Detections 18–20, 22
3. Detections 24–30

The result of grouping detections is a lowering of the total acoustic detections (n=30) collected in the field to those determined during post-analysis (n=20). A percentage of time where marine mammal vocalizations were heard on the hydrophone compared to the total survey minutes on-effort was 28.5% (see **Table 7**). A more detailed description of the acoustic observer's daily notes and observations collected during the cruise was provided in an Excel spreadsheet format and is available upon request.

Table 7. Post-Cruise Percentage of Marine Mammal Vocalizations by Survey Effort

Date	Description	Start Time	Stop Time	Total Survey Minutes	Vocalizations Heard (Minutes)*	% Marine Mammal Vocalizations
December 3	Transect survey (Pre-Event)	07:30	08:47	77	26	33.7%
		11:02	12:05	63	0	0.0%
		12:20	17:25	305	126	41.3%
December 4 (**ASW**)	Transect survey (During-Event)	07:18	12:15	297	89	29.9%
		12:45	17:20	275	31	11.2%
December 5	Transect survey (Post-Event)	06:58	11:35	277	90	32.4%
		12:05	17:15	310	95	30.6%
Total				**1,604 (27 hours)**	**457 (7.5 hours)**	**28.5%**

* Time from first detection to last detection

Behavior

No visible evidence of distress or unusual behavior was observed for the pre-ASW survey, during ASW survey, and post-ASW survey periods (see **Table 3**). Three of the four visual sightings were with dolphins that approached the survey vessel to bow-ride. Detailed focal follow sessions were not possible after initial sightings due to sustained bow-riding encounters and as a result of difficulties associated with relocating small groups of dolphins in very rough seas.

Section 4 Recommendations

Based on a review of the sound files recorded during the SEASWITI monitoring cruise, a more in-depth acoustic analysis is recommended. This analysis should include the following:

1. Localization of sperm whale clicks. Several long detections of sperm whales were recorded during this cruise. In order to determine whether these detections were made up of one group or several, it is necessary to apply localization methods. This could be accomplished using PAMGUARD or Ishmael software.
2. Examine all recordings made during this cruise for the presence of beaked whale clicks. Possible beaked whale clicks were noted during detection 22. A more detailed examination of these clicks is necessary to determine whether or not they were produced by beaked whales. If confirmed as beaked whales, automated detectors could be developed using PAMGUARD software to examine the entire data set for the presence of beaked whale clicks.

Section 5 Acknowledgements

We would like to thank Vince Backen and the crew of the R/V White Holly. These data were obtained under National Marine Fisheries Service permit no. 14451 issued to Joseph R. Mobley, Jr.

Section 6 References

Buckland et al. 2001. Buckland, S.T., D.R. Anderson, K.P. Burnham, J.L. Laake, D.L. Borchers, and L. Thomas. 2001. *Introduction to distance sampling: Estimating abundance of biological populations*. Oxford University Press.

Fulling, G. 2010. *RIMPAC 2010. Marine Species Monitoring. Passive acoustic monitor deployment and small vessel-based monitoring surveys, 17-15 July 2010.* Final field summary report. Submitted to NAVFAC Pacific, EV2 Environmental Planning under contract # N62470-10-D-3011 by HDR Environmental Operations & Construction. 15 pp.

APPENDIX A

Passive Acoustic Monitoring Methods – E&P Environmental Services (RPS)

A *Seiche Measurements* passive acoustic monitoring (PAM) system was utilized for the Navy SEASWITI program. The PAM system consists of six main components: a 400 m hydrophone tow cable, a 100 m deck cable, a data processing unit, two laptops, an acoustic analysis software package, and headphones for aural monitoring.

The hydrophone cable (Serial Number: SM. 1393; SM. 1341) contains four spherical hydrophone elements (-205 dB re 1V/µPa sensitivity) and a depth gauge (0 to 2.5 bar pressure range). The four hydrophone elements are separated into two pairs, which have a 200 m separation. Three of the hydrophone elements are broadband (2 to 200 kHz frequency response) and the fourth element is for sampling lower frequencies (10Hz to 45 kHz frequency response). Preamplifiers are also embedded into the tow cable just ahead of each hydrophone element. The four-element linear hydrophone array permits a large range for sampling marine mammal vocalizations, including the low frequency moans of Bryde's whales (70 to 250 Hz) and the ultra high frequency clicks of pygmy sperm whales (60 to 200 kHz).

The data processing unit processed the raw data from the hydrophones through two external sound cards, a *National Instruments DAQ* card and an *ASIO Fireface* card (contained within a *RME Fireface 800* unit). The *National Instruments DAQ* sound card was used sample raw audio at 500 kHz and is used to detect beaked whales, *Kogia* species, porpoises, and delphinid (echolocation) clicks up to up to 250 kHz. The *ASIO Fireface* sound card was used to sample audio at 96 kHz and is used to detect mysticete, delphinid, and non-delphinid odontocetes (including sperm whale) vocalizations up to 48 kHz. The data processing unit also contains a *Measurements and Computing* data logger for the depth gauge, digital signal amplifiers, an *UltraLink Pro* audio mixer, and an *UltraCurve Pro* graphic equalizer.

The two sound cards supplied low and high frequency digital audio feeds to two laptops that contain a suite of software for monitoring cetacean acoustics. *PAMGUARD* (Beta version 1.9.01) was the primary software utilized on the Navy SEASWITI survey. The International Federation on Animal Welfare (IFAW) software including *Logger 2000, Rainbow Click, Whistle*, and *Rainbow Click Porpoise* was available as secondary software, but was not used for the survey. One laptop was configured for monitoring high frequency clicks and the second laptop was configured for monitoring low frequency moans, creaks, whistles, clicks, and burst pulses.

The high frequency laptop received the raw audio from the *National Instruments DAQ* sound card and contained *PAMGUARD* modules for monitoring and recording high frequency cetacean clicks. The low frequency laptop received raw audio from the *ASIO Fireface* sound card and contained a more elaborate configuration of *PAMGUARD* modules than the high frequency monitoring laptop, including a click detector, whistle and moan detector, spectrogram, depth gauge display and tracker, map with a direct GPRMC GPS feed from an external GPS, and a sound recorder. Although the system was setup to monitor for mysticetes, the low frequency moans and creaks produced by mysticetes are often masked by vessel noise and can be extremely difficult to detect. All other cetacean vocalizations can be detected over vessel and other anthropogenic noise. Raw audio from the *ASIO Fireface* sound card was monitored aurally with *Sennheiser* headphones.

The hydrophone tow cable was deployed directly off the stern of the *White Holly*. Approximately 375 m of the cable was towed astern of the vessel. The cable was loaded onto a mechanical winch, which was utilized to facilitate cable deployment and retrieval.

Acoustic monitoring for marine mammals was completed aurally with *Sennheiser* headphones and visually with *PAMGUARD* during daylight hours on 3, 4, and 5 December 2010. Monitoring was conducted in conjunction with visual monitoring each day with the exception of 5 December, when visual monitoring was suspended at approximately 12:30 pm due to rough sea conditions.

PAMGUARD contains a suite of modules and plug-ins that can be utilized by an operator to facilitate the detection of marine mammal vocalizations. Three plug-ins, including whistle and moans contour identification, click train identification, and click type identification were incorporated into the *PAMGUARD* configurations for the Navy SEASWITI survey. The low frequency cetacean monitoring system contained the whistle and moans contour identification and click train identification plug-ins. The high frequency system contained the click train identification and click type identification plug-ins.

The whistle and moans contour identification plug-in provides a method for the operator to visualize potential delphinid whistles and mysticete moans. The plug-in is a component of the whistle and moans detector module. The whistle and moans contour identifier does not identify species nor are all identified contours cetacean in origin. The identifier processes audio data that has undergone a series of noise removal and thresholding processes, including click removal, median filter, average subtraction, and Gaussian kernel smoothing. The whistle and moans contour identification plug-in searches for contours developed by tonal sounds based upon settings specified by the operator. The parameters of the identifier allow for the frequencies to be limited as well as provide minimum settings for the contour length and size. The identifier was setup to search for contours produced between 4 and 24 kHz in frequency that were also a minimum of 10 time slices and 20 pixels in size in the spectrogram display for the Navy SEASWITI survey. Each identified contour was highlighted on one channel from each pair of hydrophones in the spectrogram display (**Figure A-1**). Contours were not highlighted on the second channel from each pair of hydrophones so that all identified contours could be reviewed to filter out contours produced from non-cetacean tonal sounds. Low amplitude tones are often overlooked by the identifier.

The click train identification plug-in recognized patterns in a series of clicks based upon the consistency of the inter-click interval and bearing. As with the whistle and moans contour identifier, the click train identifier does not identify species. Identified click trains are assigned a color in the click detector module display (**Figure A-2**).

The click type identification plug-in provides a template from which cetacean clicks may be matched to species through a series of operator specified criteria. Clicks are classified based upon five criteria, energy band comparison, peak frequency position, peak frequency width, mean frequency, and click length. Energy band comparisons examine the acoustic energy between two frequency bands, the test and control bands. Each band is specified by the operator based upon the range in frequencies produced by the species in question. In order for a click to

meet the energy band criteria for a given species, the acoustic energy must lie within the specified regions and the ration between the test band must exceed the controlled band by a specified number of decibels. The remaining four criteria establish limits for frequency range (peak frequency position), minimum number of spectral peaks (peak frequency width), mean frequency, and click length. **Figure A-3** provides the general criteria used for the identification of beaked whales. Click type identification criteria were set for beaked whales and *Kogia* species for the Navy SEASWITI survey. False detections are periodically identified as species. During such cases, the operator eliminates false detections through an analysis of individual click frequency spectra and waveforms.

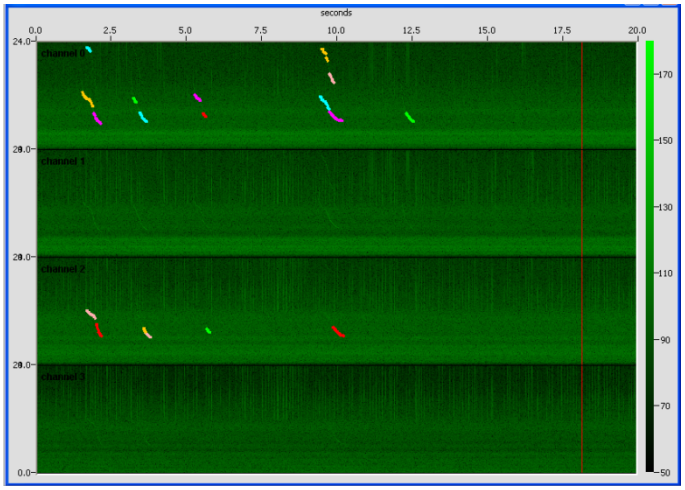

Figure A-1: Spectrogram display with identified tonal contours on delphinid whistles. Spectrogram displays 1 and 3 have the identifier enabled, whereas spectrograms 2 and 4 have the identifier disabled. Spectrograms 1 and 2 represent the two hydrophones comprising the first pair of hydrophone elements and spectrograms 3 and 4 represent the two hydrophones comprising the second pair of elements in the hydrophone array.

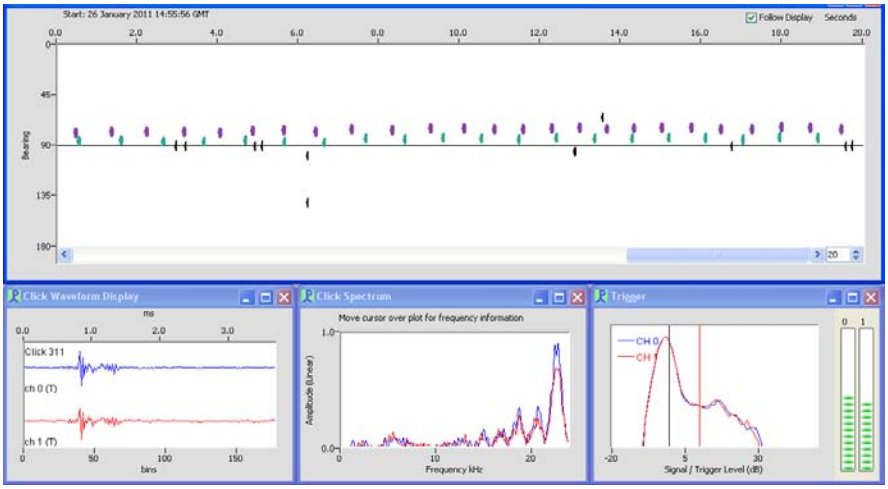

Figure A-2: Click detector display with two sperm whale click trains. One click train is colored purple while the second train is blue.

Although *PAMGUARD* contains a suite of modules and plug-ins to assist in the detection of marine mammal vocalizations, the decision on whether detections were cetacean in nature was dependent upon the operator who based the decision on experience and exposure to cetacean vocalizations and typical background noise characteristics.

Ranges to vocalizing cetaceans were largely determined subjectively based upon the signal to noise ratio. Higher signal to noise ratios indicated the vocalizing marine mammals were closer to the hydrophone array and weaker signals indicated the mammals were further away from the array. When cetacean clicks were detected over a period greater than three minutes, individual clicks from distinct click trains were tracked in the *PAMGUARD* click detector module. When tracked, a bearing line to the detected click was plotted on the map display. After several clicks were tracked, an estimated range was determined through the least-squares fit function. The estimated range and associated error were then displayed on the map (**Figure A-4**).

A variety of additional information was included for acoustic detections. This included hours of operation, number of functional hydrophone elements, hydrophone element separation, monitoring location on the vessel, length of hydrophone cable (m), length of hydrophone cable deployed (m), weight on cable if any, hydrophone towing depth (m), hydrophone tow depth variability (m), hydrophone positions astern of vessel, deployment method, sampling rates, time of first detection, time of last detection, vessel activity, noise score, signal detection score, aurally detected with hydrophones, first detected by, correlated with visual detection, cetacean or phocid classification, species if confirmed with visuals, estimated range, localized via triangulation, calculated range if localized via triangulation, coordinates of vessel upon detection, recording information, non-biological noise characterizations, and additional comments.

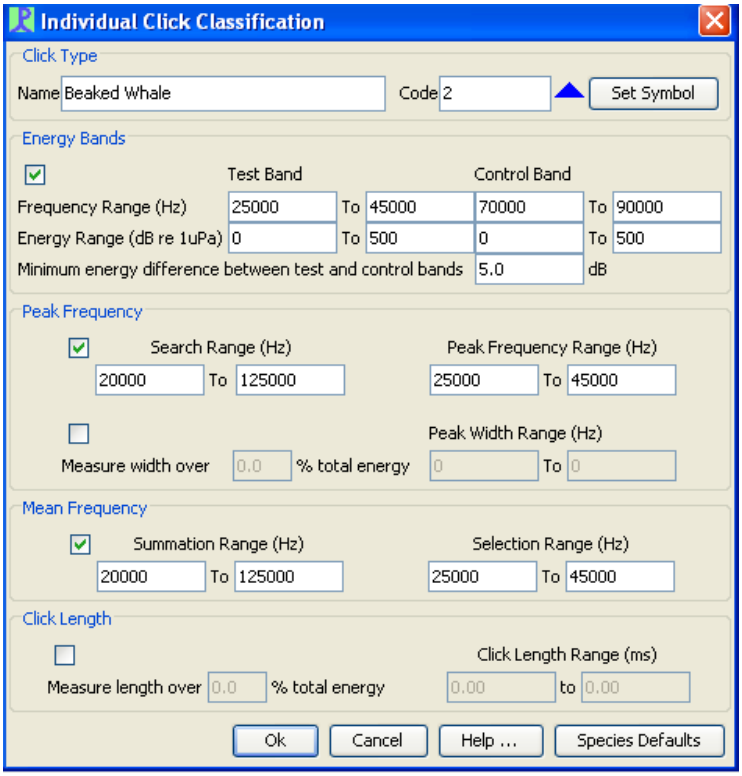

Figure A-3: Click type identification criteria for beaked whales.

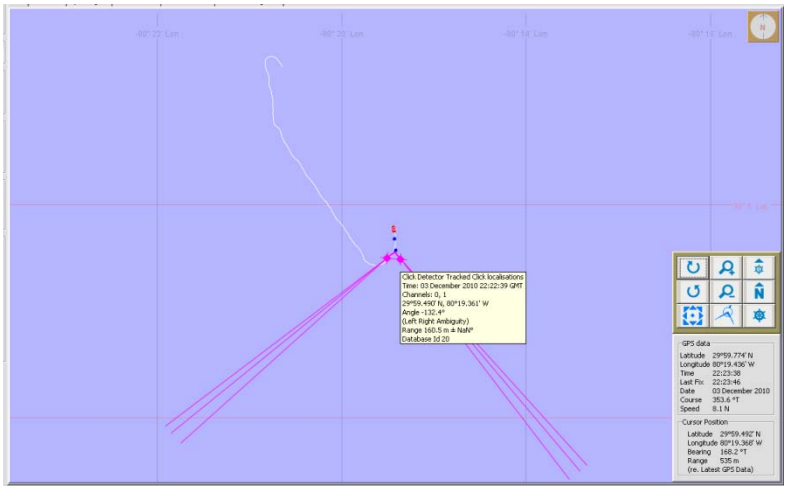

Figure A-4: *PAMGUARD* map display with localized delphinid clicks. Text box indicates date and time of detection, estimated range, and location of click source.

APPENDIX B

Acoustic Detection Data Collected During the Cruise by E&P Environmental Services – RPS

Table A-1 shows the original acoustic detection data collected during the JAX SEASWITI ASW 2010 survey cruise acoustic monitoring efforts.

Table A-1. Acoustic Detection Data Collected During the Cruise by E&P Environmental Services – RPS

Detection No.	Date	Species if known	Start Time	Stop Time	Latitude	Longitude	Bottom Depth (m)	Comments (i.e. whistles, clicks, etc.)
1	December 3	Unknown Delphinid	07:31	07:38	30.301	-80.292	40	Broadband Clicks 5-24kHz
2	December 3	Unknown Delphinid	07:45	08:04	30.285	-80.266	40	Broadband Clicks 5-24kHz; Echolocation Clicks to 75kHz
3	December 3	Unknown Delphinid	13:43	13:50	29.978	-80.259	80	Broadband Clicks 5-24kHz
4	December 3	Unknown Delphinid	14:03	14:30	29.935	-80.273	60	Broadband Clicks 5-24kHz; Sweeping Whistles 6-12kHz
5	December 3	Unknown Delphinid	14:39	14:55	29.861	-80.298	50	Broadband Clicks 5-24kHz
6	December 3	Unknown Delphinid	15:23	15:35	29.842	-80.331	40	Broadband Clicks 5-24kHz; Echolocation Clicks to 75kHz
7	December 3	Unknown Delphinid	15:40	15:42	29.875	-80.338	40	Sweeping Whistles 5-7kHz
8	December 3	Unknown Delphinid	15:55	16:04	29.905	-80.340	40	Broadband Clicks 5-24kHz; Echolocation Clicks to 75kHz; Sinusoidal and Sweeping Whistles 6-18kHz
9	December 3	Atlantic Spotted Dolphin, *Stenella frontalis*	16:32	17:25	29.934	-80.341	40	Broadband Clicks 5-24kHz; Echolocation Clicks to 75kHz; Sinusoidal and Sweeping Whistles 6-18kHz
10	December 4	Unknown Delphinid	08:30	08:32	30.271	-80.159	200	Broadband Clicks 8-22kHz
11	December 4	Unknown Delphinid	08:36	09:40	30.268	-80.171	200	Broadband Clicks 5-24kHz; Sweeping Whistles 12-16kHz
12	December 4	Unknown Delphinid	09:47	10:10	30.243	-80.259	50	Broadband Clicks 5-24kHz
13	December 4	Unknown Delphinid	14:34	15:00	30.167	-80.256	60	Broadband Clicks 5-24kHz
14	December 4	Atlantic Spotted Dolphin, *Stenella frontalis*	17:09	17:14	30.132	-80.098	300	Broadband Clicks 5-24kHz; Echolocation Clicks to 75kHz; Sweeping Whistles 6-18kHz
15	December 5	Unknown Delphinid	06:58	07:16	30.320	-80.700	30	Broadband Clicks 5-24kHz; Echolocation Clicks to 75kHz; Sweeping Whistles 4-10kHz
16	December 5	Unknown Delphinid	07:53	07:53	30.312	-80.547	30	Convex Whistle 6-10kHz
17	December 5	Unknown Delphinid	08:03	08:06	30.309	-80.519	30	Broadband Clicks 5-24kHz

Detection No.	Date	Species if known	Start Time	Stop Time	Latitude	Longitude	Bottom Depth (m)	Comments (i.e. whistles, clicks, etc.)
18	December 5	Unknown Delphinid	08:14	08:32	30.305	-80.489	30	Broadband Clicks 5-24kHz; Echolocation Clicks to 75kHz
19	December 5	Unknown Delphinid	08:38	08:50	30.294	-80.422	30	Broadband Clicks 5-24kHz; Echolocation Clicks to 75kHz
20	December 5	Unknown Delphinid	08:58	09:01	30.286	-80.365	40	Broadband Clicks 5-24kHz; Echolocation Clicks to 75kHz
21	December 5	Unknown Delphinid	09:07	09:28	30.283	-80.338	40	Broadband Clicks 5-24kHz; Echolocation Clicks to 75kHz
22	December 5	Unknown Delphinid	09:33	09:47	30.279	-80.270	40	Broadband Clicks 5-24kHz; Echolocation Clicks to 75kHz
23	December 5	Unknown Delphinid	12:51	13:02	30.135	-80.037	400	Broadband Clicks 5-24kHz; Echolocation Clicks to 75kHz; Sweeping Whistles 8-16kHz
24	December 5	Unknown Delphinid	14:38	14:45	30.220	-80.245	60	Broadband Clicks 5-24kHz; Echolocation Clicks to 75kHz
25	December 5	Unknown Delphinid	14:52	14:57	30.222	-80.279	40	Broadband Clicks 5-24kHz
26	December 5	Unknown Delphinid	15:02	15:10	30.222	-80.304	40	Broadband Clicks 5-24kHz; Echolocation Clicks to 75kHz
27	December 5	Unknown Delphinid	15:33	15:53	30.223	-80.379	40	Broadband Clicks 5-24kHz; Echolocation Clicks to 75kHz
28	December 5	Unknown Delphinid	15:55	16:19	30.229	-80.434	30	Broadband Clicks 5-24kHz
29	December 5	Unknown Delphinid	16:36	16:52	30.247	-80.537	30	Broadband Clicks 5-24kHz; Echolocation Clicks to 75kHz
30	December 5	Unknown Delphinid	17:05	17:09	30.271	-80.607	30	Broadband Clicks 5-24kHz

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