CRUISE INSTRUCTIONS: NOAA SHIP NANCY FOSTER

Cruise Title: **Characterization of midwater seafloor habitats of the Buck Island Reef National Monument (BIRNM), St. Croix and southwest Puerto Rico**

Cruise Number NF-06-03-USVI

Period of Cruise:

DEP: 3/13/06 Ship transit to Frederiksted, St. Croix
ARR: 3/18/06 Ship arrive Frederiksted, St. Croix, USVI
DEP: 3/21/06 Begin seafloor mapping St. Croix, USVI
ARR: 4/2/06 Disembark at San Juan, Puerto Rico

Area of Operation: Buck Island National Monument St. Croix and La Parguera, Puerto Rico

1.0 Scientific Objectives:

The Center for Coastal Monitoring and Assessment (CCMA) will be conducting the third year of an ongoing scientific research mission onboard the NOAA ship Nancy Foster. The purpose of the cruise will be to continue to collect swath bathymetry and acoustical backscatter data in three high priority areas within the USVI and Puerto Rico. Scientists will collect high resolution multibeam in mid-water depths approximately 20 to 1000 meters so as to continue to characterize seafloor habitats within the USVI and Puerto Rico. The objective of this project is to collect a multibeam bathymetry dataset with 100% seafloor ensonification, along with multibeam backscatter suitable for seafloor characterization. Multibeam data will be collected to conform to IHO Order 1 (<100m) and Order 2 (>100m) accuracy standards. The strategies developed for each survey area will take into account the minimum depths, general bathymetry, and time allotment. The delineation and identification of seafloor habitats will be assisted by the use of a moderate depth Remotely Operated Vehicle (ROV). The vehicle has video and frame camera capability to depths of 1000 meters and will be used to conduct transects within areas mapped during this mission.

2.0 Schedule of Operations:

2.1 Daily Schedule:

See Table 1

18 March (Friday): Nancy Foster arrives in Frederiksted, St. Croix
Survey NF: Survey team installs survey gear, does a gear shake-down of multibeam unit and survey planning.
ROV: ROV team remaining survey gear, does a gear shake-down of ROV unit and video planning.

19 March (Sunday):
Survey NF: Survey team installs survey gear, does a gear shake-down of multibeam unit and survey planning.
ROV: ROV team remaining survey gear, does a gear shake-down of ROV unit and video planning.

20 March (Monday):
Survey NF: Survey team installs survey gear, does a gear shake-down of multibeam unit and survey planning.
ROV: ROV team remaining survey gear, does a gear shake-down of ROV unit and video planning.
Other: Press Briefing. Science party mission meeting.

21 March (Tuesday):
Transit/Patch Test NF: (0800-1200) Ship transit from Frederiksted to Buck Island. Survey team conducts Patch Test to calibrate the Multibeam Echosounder (MBES) system.
ROV: (1200-2000) ROV Buck Island Priority area.
Survey NF: (2000-2400) MBES Buck Island Priority area.

22 March (Wednesday):
Survey NF: (2400-0800) MBES Buck Island Priority area.
ROV: (0800-1600) ROV Buck Island Priority area.
Survey NF: (1600-2400) MBES Buck Island Priority area.

23 March (Thursday):
Survey NF: (2400-0800) MBES Buck Island Priority area.
ROV: (0800-1600) ROV Buck Island Priority area.
Survey NF: (1600-2400) MBES Buck Island Priority area.

24 March (Friday):
Survey NF: (2400-0800) MBES USVI Alternate area.
ROV: (0880-1600) ROV Buck Island Priority area.
Transit/Survey NF: (1600-2400) Transit to Escollo Grappler (Puerto Rico).

25 March (Saturday):
Survey NF: (2400-0800) MBES Escollo Grappler.
ROV: (0800-1600) ROV Escollo Grappler.
Survey NF: (1800-2400). MBES Escollo Grappler.

26 March (Sunday):
Transit NF: (2400-0800) Transit to Parguera.
ROV: (0800-1600) ROV Parguera Priority.
Survey NF: (1600-2400) MBES Parguera Priority.

27 March (Monday):
Survey NF: (2400-0800) MBES Parguera Priority.
ROV: (0800-1600) ROV Parguera Priority.
Survey NF: (1600-2400) MBES Parguera Priority.

28 March (Tuesday):
Survey NF: (2400-0800) MBES Parguera Priority.

ROV: (0800-1600) ROV Parguera Priority.
Survey NF: (1600-2400) MBES Parguera Priority.

29 March (Wednesday):
Survey NF: (2400-0800) MBES Parguera Priority.
ROV: (0800-1600) ROV Parguera Priority.
Survey NF: (1600-2400) MBES Parguera Priority.

30 March (Thursday):
Survey NF: (2400-0800) MBES Parguera Alternate.
ROV: (0800-1600) ROV Parguera Alternate.
Survey NF: (1600-2400) MBES Parguera Alternate.

31 March (Friday):
Survey NF: (2400-0800) MBES Parguera Alternate.
ROV: (0800-1600) ROV Parguera Alternate.
Survey NF: (1600-2400) MBES Parguera Alternate.

1 April (Saturday):
Survey NF: (2400-0800) MBES Parguera Alternate.
ROV: (0800-1600) ROV Parguera Alternate.
Survey NF: (1600-2400) MBES Parguera Alternate.

2 April (Sunday):
Transit NF: (2400-1400) Transit to San Juan Puerto Rico.
Demobilization: (1400-1800) Demobilization

2.2 Watches:

Vessel operations will typically be a ~ 24 hour workday. A "give and take" operation cycle will be instituted during these workdays via consultation between the Chief Scientist and Commanding Officer in order to balance crew complement with demands of day-night operations. One crew member will be required on deck to work the winch for the ROV and CTD casts.

In Science Party, the Field Party Chief is responsible for organization of operations and data, respectively.

3.0 Map of Operations:

(See Figures 1 and 2)

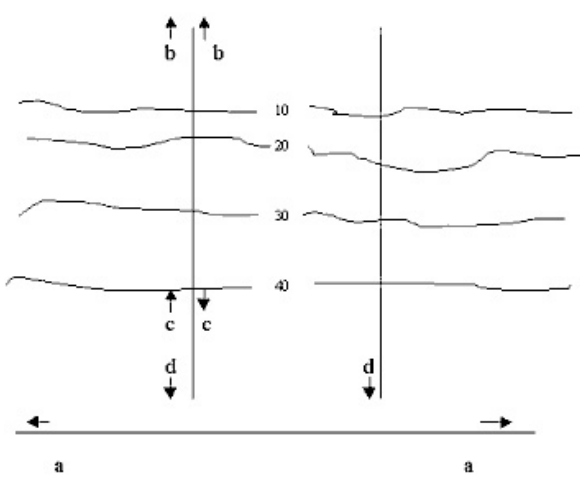
4.0 Description of Operations:

Multibeam Operations:

Survey Schedule/Personnel:
A timeline has been developed for the installation and calibration of the multibeam systems, as well as the data acquisition periods for surveying. A team from the NOAA Marine and Aviations Operations (NMAO) will be responsible for the installations of the Simrad EM 1002 and Reson 8124 multibeam systems and ancillary sensors. NMAO will be installing the multibeam transducers and acquisition systems on the NOAA ship NANCY FOSTER (NF) during scheduled drydock maintenance. NMAO and Kongsberg Simrad will perform the Harbor Acceptance Test (HAT) and the Sea Acceptance Test (SAT) procedures offshore of Charleston, South Carolina in February 2006. They will also provide informal training to the CCMA Biogeography Program team, survey technicians and independent contractors. Final calibrations and confidence checks will occur on March 21st, 2006 in the vicinity of Buck Island, St. Croix for the Nancy Foster. Survey operations will continue for 13 days, demobilization is scheduled for April 2rd, in San Juan, Puerto Rico (Figures 1 and 2).

Patch Test:
The patch test will be performed before surveying operations commence. The patch test calibration will quantify any residual biases from the alignment between the motion sensor, gyro and the multi-beam transducer. The patch test also quantifies the time lag (latency) between the time positioning data is received, and the time the computed position reaches the acquisition system. To ensure quality results from the patch test procedure it is necessary to have a relatively calm sea state, collection of clean data and a helmsman that can stay online during the procedure. Static transducer draft, settlement and squat corrections, sound velocity corrections, and preliminary tide corrections will be applied to the data prior to bias determination. The general patch test procedure requires

multibeam data collection along a series of transects as described in Figure 3. Alternatively, yaw bias can also be determined by surveying two lines on each side of a submerged object in relatively shallow water (Fig. 4). Patch test results will be calculated with CARIS's v5.4 calibration program in the following order: Latency, pitch, roll and yaw.



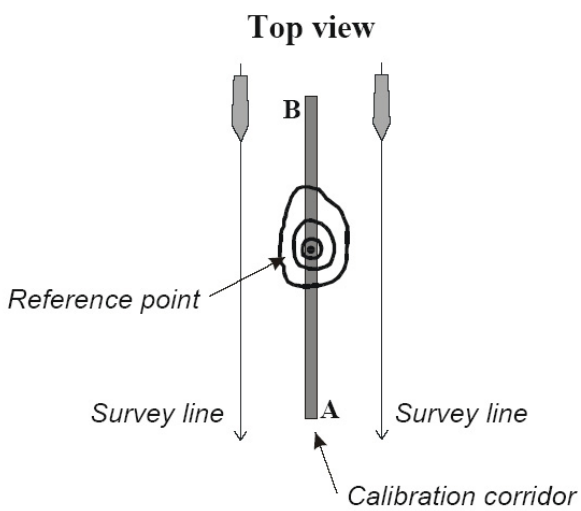


Fig 3. a = Roll, b = Latency, c= Pitch, d= Yaw **Fig. 4** Yaw bias test performed on submerged object

An area 1.5 nautical miles west of Buck Island has been identified (Fig. 5) to provide the steep and smooth slope with little change in across track depth to accurately assess the latency, pitch and yaw biases for the NF. Two planned survey lines (1&2) oriented perpendicular to slope are parallel and spaced apart to ensure abundant overlap of outer beams. Offshore of the slope is a relatively deep and flat area that will be used to perform the roll segment of the patch test. An area that was used for conducting a previous patch test near Butler Bay has mapped a submerged wreck at a depth of 26 meters (Fig. 6). This wreck is described as Wreck 2, dimensions of 56 m x 13 m x 4.6 m, location at 17 45 10.20 N, 064 53 43.71 W and is described in detail in the NF-04-06 patch test report. Wreck 2 can be used as an alternative option to determine yaw bias utilizing a submerged feature instead of a slope. In the immediate vicinity is a fish haven obstruction charted at 11.5 fathoms that can also be used for the yaw bias test.

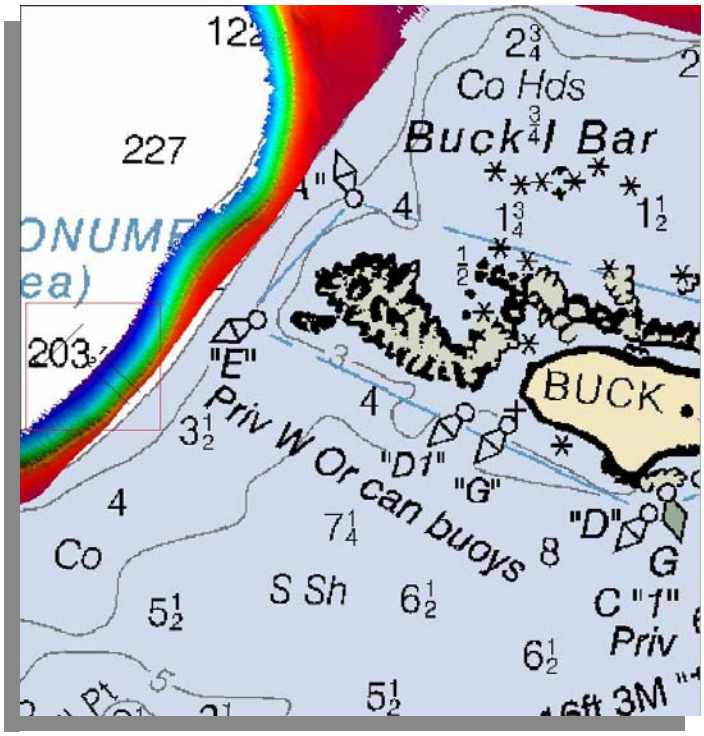


Fig 5 Primary patch test line plan

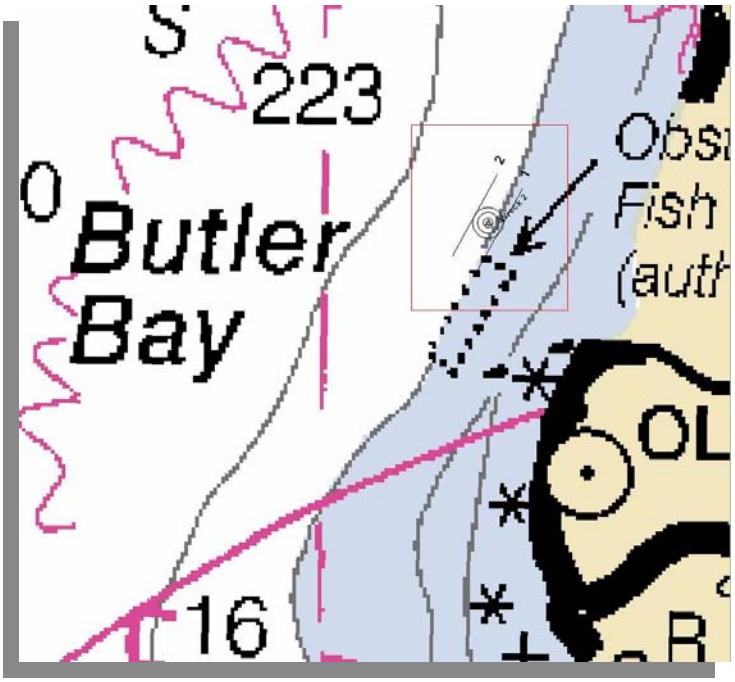


Fig. 6 Alternative yaw test line plan

The lines will be surveyed in the following order at the primary patch test location. Vessel speed should be consistent for the roll, pitch and yaw transects. Vessel speeds should be varied up to 5 knots for the latency section of the patch test.

Preliminary Patch Test Area (ref Fig. 5)

Order	Line	Direction	Speed	Bias Measured
1	1	SE	Normal	P1a
2	1	NW	Normal	P1b, Y1a
3	1	SE	Fast	L1a
4	1	SE	Slow	L1b
5	2	NW	Normal	Y1b
6	3	NE	Normal	R1a
7	3	SW	Normal	R1b

Alternative Yaw Bias Test (ref Fig. 6)

Order	Line	Direction	Speed	Bias Measured
1	1	SW	Normal	Y2a
2	2	SW	Normal	Y2b

Sufficient time between passes on the same line will be given to ensure ship propeller disturbances have cleared and will not impact data quality. Additional lines can be included and the schedule is preliminary.

Data Acquisition Methodology:

Upon the completion of the verifiable patch test, the area north of Buck Island will be surveyed, followed by Escollo Grappler, and finishing with SW Puerto Rico. A line plan has been developed for the 2006 proposed project areas, totaling 4,444 nautical line miles. Due to the shoal depths along SW Puerto Rico (approx.10 fath/18.3 m) a line spacing of 55 meters is required to provide sufficient coverage and accounts for 4067 nautical miles, including line splits for the shoaler areas. Reducing the anticipated coverage area will be required. The line plan is generally orientated parallel with the contours to maximize swath coverage and improve acoustic returns. The line plan has taken into account water depths, swath width filters and overlap requirements (Table 2). Restricting the swath limit ensures the data will meet IHO standards, and make the data cleaning process more efficient. All deep survey areas will be accepting soundings 55° from nadir, port and starboard, with 10% swath overlap. Areas shoaler than 55 meters will accept 60° port and starboard with a 10% overlap. Surveying operations in the shallow water should ideally be performed during daylight hours at higher tides to maximize swath widths, and for vessel safety reasons. Surveying during calm waters and steady piloting of the vessel will improve data quality. This is a preliminary line plan and field adjustments may be required.

The EM1002 data packets will be logged in Coastal Oceanographics Hysweep navigation program to create real time coverage maps to ensure coverage. During line turns data will be transferred to CARIS processing stations where preliminary zoned tides, swath filters and SVP cast corrections will be applied. The preliminary data will be used to create preliminary sun-illuminated Base surfaces for QA/QC analysis and then exported into geo tiff format. These geo tiffs will be superimposed on top of the charts in Coastal Oceanographics Hypack for additional line planning and navigation purposes.

Data Quality Assurance/Quality Control Methodology:

To ensure that the data collected meets IHO Level 1 & 2 standards several quality assurance/quality control measures will be implemented. The velocity of sound through the water column will be derived from conductivity, temperature, and depth measurements (CTD casts) collected no more than 4 hours apart. A CTD cast will be will be taken prior to the commencement of daily multibeam operations. Spatial variability will be taken into account as well as temporal variability when determining cast locations. These locations will be recorded and each cast will be compared to the previous to identify any significant changes in the water column. Turns will be limited and vessel speed will be adjusted to ensure that no less than 3.2 beam foot prints, center-to-center, fall within 3 m, or a distance equal to 10 percent of the depth, whichever is greater, in the along track direction. System confidence checks prior to, and during, multibeam operations will be conducted. These include position checks, lead lines and bar checks. Cross lines totaling 5% of main scheme will also be collected across each of the survey areas. Comparison of singlebeam, priors' and multibeam data will be used as an independent verification of the survey.

ROV Operations:

Benthic habitats in deep waters (>20m and <1000m) around the United States Virgin Islands (USVI) and southwestern Puerto Rico will be visually-characterized using a remotely operated underwater vehicle (ROV). This data will be collected to train and validate an automated benthic habitat characterization technique which uses fine-scale (<5 m) multibeam data.

Two independent and distinct sampling designs were chosen to acquire images of the benthic habitat: one for training and the other for validating the automated habitat characterization technique. Both designs were chosen for their ability to overcome the constraints of cost and time associated with sampling a very large area (>100 square km). A design using non-random transects defined *a priori* was chosen to provide representative training data for the entire study region. This design was chosen to ensure that representative benthic habitat features and transitional areas would be adequately included in the training dataset. Transect placement for training data was aided by visual examination of fine-scale multibeam data collected in prior to the day of sampling (data collected in 2004, 2005 and 2006) and moderate-scale GEODAS bathymetry data (GEODAS, 2005).

A random sampling design was used to position transects for the validation dataset. These transects were placed using randomly positioned geographic coordinates within each study area. Transect's mid points were placed on random points and oriented as a compromise between bathymetric slope and predominant wind direction to reduce sampling cost. The length of transects for both datasets represent approximately 1 hour of sampling (2 km). Tthe ROV sampling frame will include only depths between 20 and 500 meters for safety reasons (Figures 7 through 9).

A total of 65 transects make up the sample size: 32 transects for validation and 33 for training. This estimate was based on working 8 hours each day for a total of 13 days. The total time was divided into 4 days around Buck Island, 1 day around Escollo Grappler and 8 days around southwestern Puerto Rico. Table 3 provides the number and identity of transect types for each region. Estimated transit time between transects, an ROV speed of 1m s^{-1} (2 knots), and bathymetric slope were incorporated into the estimation of sampling effort.

Table 3: Summary of ROV transect work in the three 2006 Study Regions

Region	Study Area (km^2)	Work Days	Number of Training Transects	Number of Validation Transects	Total Number of Transects
Buck Island	25.22	4	11	9	20
Escollo Grappler	40.31	1	2	3	5
Puerto Rico Priority	262	3	10	5	15
Puerto Rico Alternate	318	5	10	15	25

GEODAS, 2005. NOAA's GEOphysical Data System (GEODAS). Website http://www.ngdc.noaa.gov/mgg/geodas/geodas.html, accessed September, 2005.

5.0 Requirements and Equipment:

5.1 Vessel Provided:

1) Hand held radios for communication between bridge and deck.
2) EM 1002 and Reson 8124 multibeam Shipboard multibeam, CARIS Processing station, Hypack, Velociwin
3) CTD's 100m and1000 m depth rating.

5.2 Program Provided:

	Equipment	Leg
1)	Underwater video + camera equipment + tow bodies (ROV) (Vendor TBD).	Charleston
2)	6 USB 250GB Maxtor 5000XT harddrives (CCMA).	USVI
3)	Five high end laptops and two flat screen monitors.	USVI
4)	CARIS and ArcGIS	USVI

6.0 Scientific Personnel:

6.1 Chief Scientist Authority

The Chief Scientist has the authority to revise or alter the technical portions of the instructions provided that, after consultation with the Commanding Officer, it is ascertained that the proposed changes will not: 1) jeopardize the safety of the personnel on the ship, 2) exceed the time allotted for the project, 3) result in undue additional expense, or 4) alter the general intent of the Project Instruction.

6.2 Scientific Personnel List:

Chief Scientist: Tim Battista
Lead Hydrographer: Mike Stetcher
ROV Lead: Matt Kendall (3/21-3/23) and Charlie Menza (3/23- 4/2)

Male:	Organization:	ROV	Multibeam	Legs
Tim Battista	NOAA		X	USVI/PR
Mike Stetcher	NOAA		X	USVI/PR
Bryan Costa	NOAA		X	USVI/PR
Matt Kendall	NOAA	X		USVI
Charlie Menza	NOAA	X		USVI/PR
Ken Buja	NOAA	X		USVI/PR
Jay Lazar	NOAA		X	USVI/PR
Adel Sterling	HMRG		X	USVI/PR
Henry Tonnemacher	NPS	X		USVI
Michael Nemeth	UPRM	X		PR
Hector Ruiz	UPRM	X		PR
Jose Rivera	UPRM		X	pr
Jeff Snyder	Contractor	X		USVI/PR
Matt Cook	Contractor	X		USVI/PR

Female	Organization:	ROV	Multibeam	Legs
Ada Otter	NOAA		X	USVI/PR
Monica Cisternelli	NOAA		X	USVI/PR

TASK TEAMS

ROV

1) **(USVI) Kendall ,** Menza, Snyder, Cook, Buja, Tonnemacher.
2) **(Puerto Rico) Menza,** Snyder, Cook, Buja, Nemeth, Ruiz.

MULTIBEAM

1) **NF Team A (2400-0800): Stetcher**, Costa
2) **NF Team B (1600-2400): Lazar**, Otter.
3) **Processing (0800-1600):** Cisternelli, Sterling

Person in **bold** is field party chief – responsible for prepping rest of team. Multibeam team members will rotate positions throughout the cruise.

Identification: All scientific personnel planning to board the ship should have in their possession at the time of boarding, a proper photo identification card (agency ID, drivers license, etc.).

6.4 History Reports:

Upon acceptance of this proposal, and receipt by the Chief Scientist of the forms, the Chief Scientist will forward completed copies of the NOAA Health Services Questionnaire for all embarking scientific personnel to the Commanding Officer for review at lease 7 days in advance of the cruise.

7.0 Miscellaneous Activities:

None known at this time.

7.1 Bridge Activities:

It is requested that a copy of the ship's *Deck Log - Weather Observation Sheet NOAA 77-13d* for and digital SCS data for the entire cruise be provided to the Chief Scientist upon departure of the science party or transmitted within 2 weeks thereafter.

8.0 Modification of Cruise Instructions:

Additional operations and ancillary projects, not covered under the main project, may be performed on a "not to interfere" basis. The Chief Scientist is responsible for determining the priority of the additional work, provided that any changes are discussed with the Commanding Officer and do not constitute a risk to the safety of the ship or personnel and do not significantly change the schedule for this cruise. If the requirements for the additional work place significantly different requirements on the ship, amendments to the Cruise Instructions must be prepared and approved.

9.0 Ancillary Tasks:

Ship's personnel conduct ancillary tasks. Instructions for ancillary tasks routinely assigned to Marine Operations Center ships are contained in *Marine Operations Center Directive 1803.00, Ancillary Tasks for NOAA Vessels*.

10.0 Hazardous Materials:

An inventory list and a *Material Safety Data Sheet* for each hazardous material will accompany hazardous material brought on board NANCY FOSTER by scientific parties. This information should be provided to the Commanding Officer. On departure from the ship, scientific parties will provide an inventory of hazardous material to the Commanding Officer showing that all hazardous material brought on board have been properly used up or removed in suitable waste containers. No anticipated hazardous materials is anticipated to be brought onboard.

The *Material Safety Data Sheet* is normally available from the manufacturer of the hazardous product. Procedures followed for use of chemicals will be those outlined in the *Chemical Hygiene Plan for Chemical Labs* aboard NOAA ships. The Science Party will provide a small spill containment kit appropriate for these chemicals.

11.0 Navigation:

Survey and ROV operations will be operated using DGPS. Navigation information via Hypack software will be fed to the Bridge monitor from the Wet and Dry labs via cable.

12.0 Communications:

A progress report on operations prepared by the Chief Scientist may be relayed to the program office. Sometimes it is necessary for the Chief Scientist to communicate with another vessel, aircraft, or shore facility. Through various modes of communication, the ship is able to maintain contact with the Marine Operations Center on an as needed basis. These methods will be made available to the Chief Scientist upon request, in order to conduct official business. Due to a new directive from Marine Operations Center, the ship must charge the science party for all calls made

on the cell or sky-cell telephone. INMARSAT, Sky Cell and cellular communication costs shall be reimbursed to the ship for telephone calls made by all scientific personnel. Currently, Sky Cell and cellular telephone services are about $0.89 per minute and INMARSAT Mini-M is around $1.68 per minute for voice. These charges will be assessed against the program after NANCY FOSTER receives the bill. There is generally a three-month delay receiving the bill for review. The Chief Scientist will be required to keep a log of all calls made by the science party. The program will also provide a cell phone to be kept on the bridge.

13.0 Disposition of Data:
The Chief Scientist is responsible for the disposition of data.

14.0 Reports:
The requirement for a formal cruise report by the Chief Scientist is left to the discretion of the CCMA Center Director. A Ship Operations Evaluation Form is to be completed by the Chief Scientist(s) and forwarded to:
Office of Marine and Aviation Operations
Program Services and Outsourcing Division
SSMC3, Room 12872
1315 East-West Highway
Silver Spring, MD 20910-3282

15.0 Cruise Instruction Approvals:

The Marine Operations Center and NANCY FOSTER will acknowledge receipt of these instructions.

Submitted by:

_____	_____
Dr. Russell Callender Center Director, Center for Coastal Monitoring and Assessment	Mr. Timothy A. Battista Biogeographic Team, Center for Coastal Monitoring and Assessment
Date_____	Date_____

Approved by:

_____
Captain Gary Bulmer, NOAA
Commanding Officer, Marine Operations Center Atlantic

Date_____

Table 1. Nancy Foster operation schedule.

			Time																							
DAY	DATE	LOCATION	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mon	18-Mar	STX	MOBILIZATION/TRAINING/PRESS																							
Sun	19-Mar	STX																								
Mon	20-Mar	STX																								
Tue	21-Mar	STX	OFF DUTY								NF Transit Buck/Patch Test				ROV Buck Priority								Multibeam Buck Priority			
Wed	22-Mar	STX	Multibeam Buck Priority								ROV Buck Priority								Multibeam Buck Priority							
Thu	23-Mar	STJ/STT	Multibeam Buck Priority								ROV Buck Priority								Multibeam Buck Priority							
Fri	24-Mar	STJ/STT	Multibeam USVI Alternate								ROV Buck Priority								TRANSIT Escollo Grappler							
Sat	25-Mar	STJ/STT	Multibeam Escollo Grappler								ROV Escollo Grappler								Multibeam Escollo Grappler							
Sun	26-Mar	STJ/STT	TRANSIT Paguera								ROV Paguerra Priority								Multibeam Paguerra Priority							
Mon	27-Mar	STJ/STT	Multibeam Paguerra Priority								ROV Paguerra Priority								Multibeam Paguerra Priority							
Tue	28-Mar	STJ/STT	Multibeam Paguerra Priority								ROV Paguerra Priority								Multibeam Paguerra Priority							
Wed	29-Mar	STJ/STT	Multibeam Paguerra Priority								ROV Paguerra Priority								Multibeam Paguerra Priority							
Thu	30-Mar	STJ/STT	Multibeam Paguerra Alternate								ROV Paguerra Alternate								Multibeam Paguerra Alternate							
Fri	31-Mar	STJ/STT	Multibeam Paguerra Alternate								ROV Paguerra Alternate								Multibeam Paguerra Alternate							
Sat	1-Apr	STJ/STT	Multibeam Paguerra Alternate								ROV Paguerra Alternate								Multibeam Paguerra Alternate							
Mon	2-Apr	STT	TRANSIT San Juan														DEMOBILIZATION									

Figure 1. Buck Island, USVI Priority (multibeam and ROV) and Alternate Areas (multibeam).

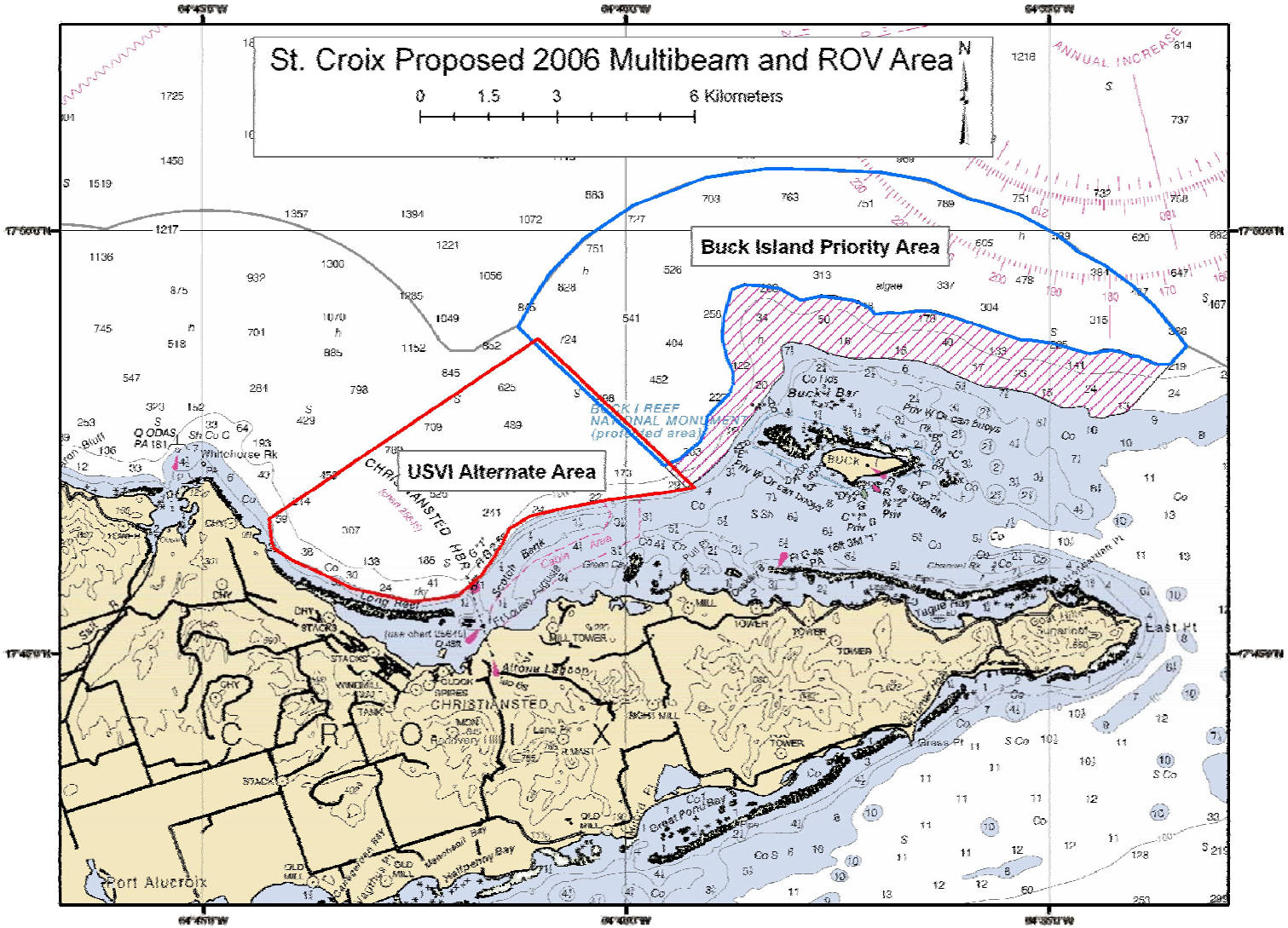


Figure 2. Parguera Puerto Rico Priority (multibeam and ROV) and Alternate Areas (multibeam and ROV).

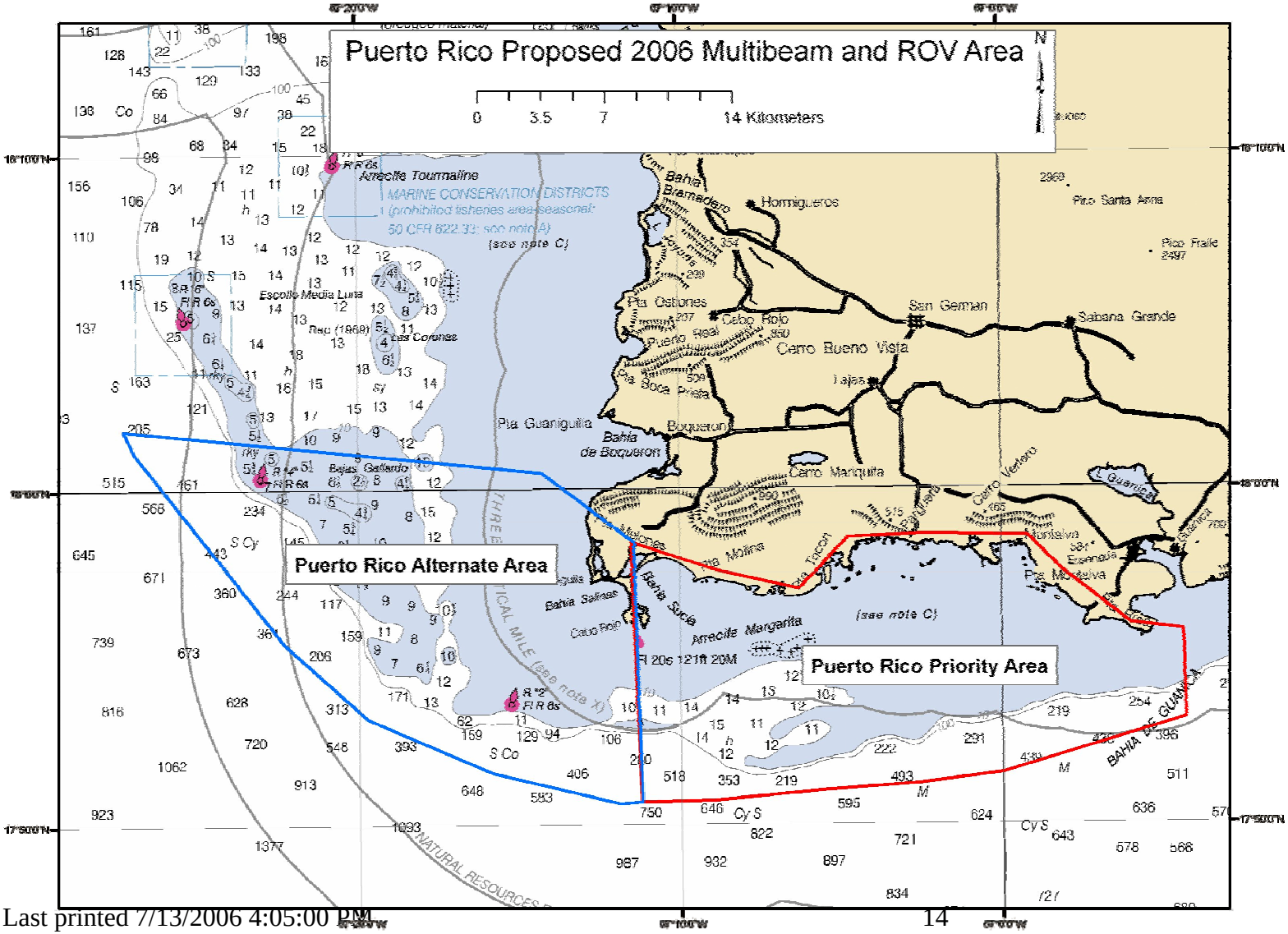


Table 2. Line Spacing Specifications

Depth (Fath)	Depth (M)	Depth (ft)	Swath Angle (Degrees)	Swath Overlap (%)	Line Spacing (M)	Line Spacing (ft)
5	9.1	30.0	55	10	23.5	77.1
10	18.3	60.0	55	10	47.0	154.2
15	27.4	90.0	55	10	70.5	231.4
20	36.6	120.0	55	10	94.0	308.5
25	45.7	150.0	55	10	117.5	385.6
30	54.9	180.0	55	10	141.0	462.7
40	73.2	240.0	55	10	188.0	617.0
50	91.4	300.0	55	10	235.1	771.2
75	137.2	450.0	55	10	352.6	1156.8
100	182.9	600.0	55	10	470.1	1542.4
125	228.6	750.0	55	10	587.7	1928.0
150	274.3	900.0	55	10	705.2	2313.6
175	320.0	1050.0	55	10	822.7	2699.2
200	365.8	1200.0	55	10	940.2	3084.8
250	457.2	1500.0	55	10	1175.3	3856.0
300	548.6	1800.0	55	10	1410.4	4627.2
350	640.1	2100.0	55	10	1645.4	5398.4
400	731.5	2400.0	55	10	1880.5	6169.6
450	823.0	2700.0	55	10	2115.6	6940.8
500	914.4	3000.0	55	10	2350.6	7712.0
550	1005.8	3300.0	55	10	2585.7	8483.2
600	1097.3	3600.0	55	10	2820.7	9254.4
650	1188.7	3900.0	55	10	3055.8	10025.6
700	1280.2	4200.0	55	10	3290.9	10796.8

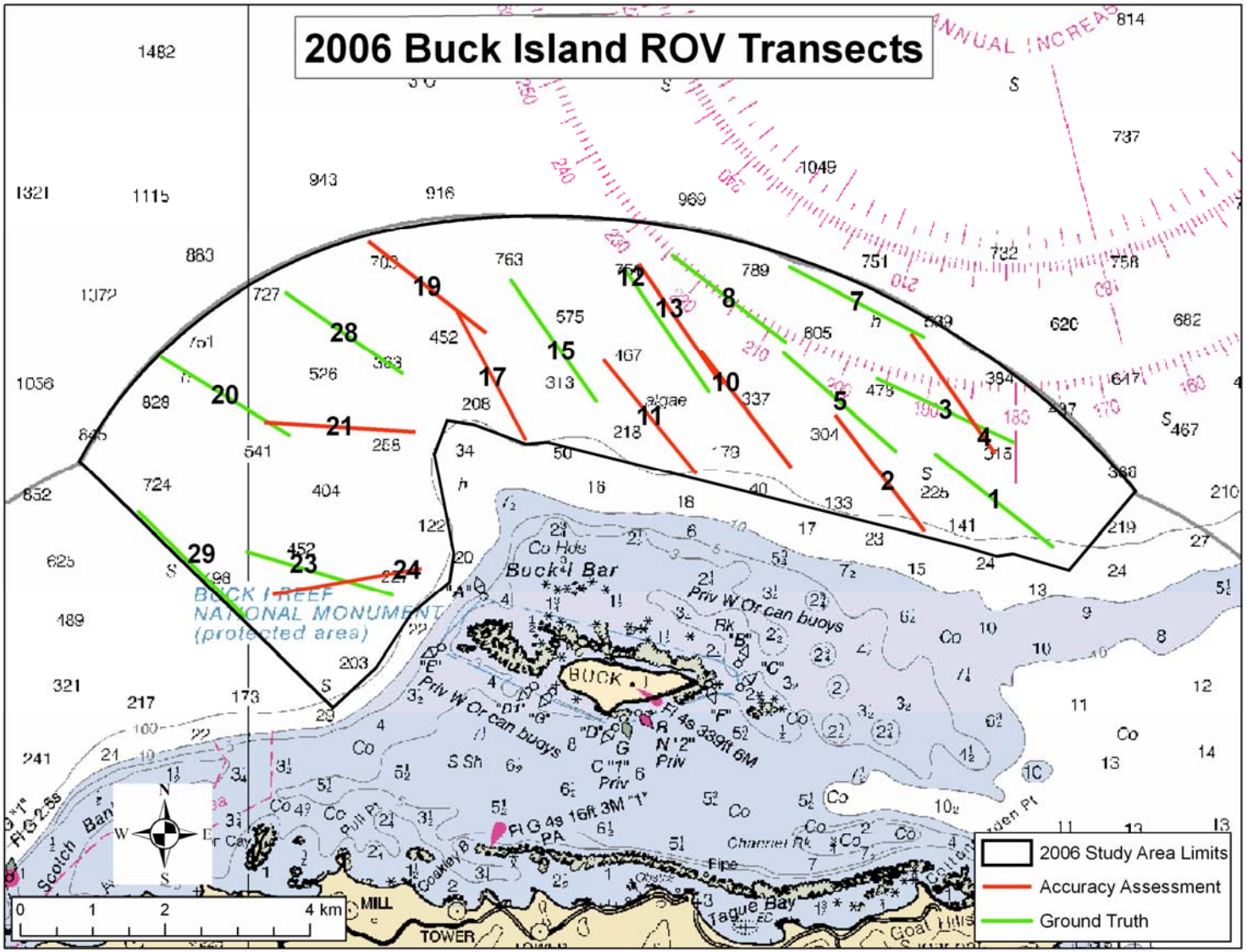
L=2 d tan (a/2) * (1-s)

a = Multibeam Swath Angle

d = Water Depth (ft)

s = Swath Sidelap

Figure 7. Buck Island ROV transects.



Las

Figure 8. Escollo Grappler, Puerto Rico ROV transects.

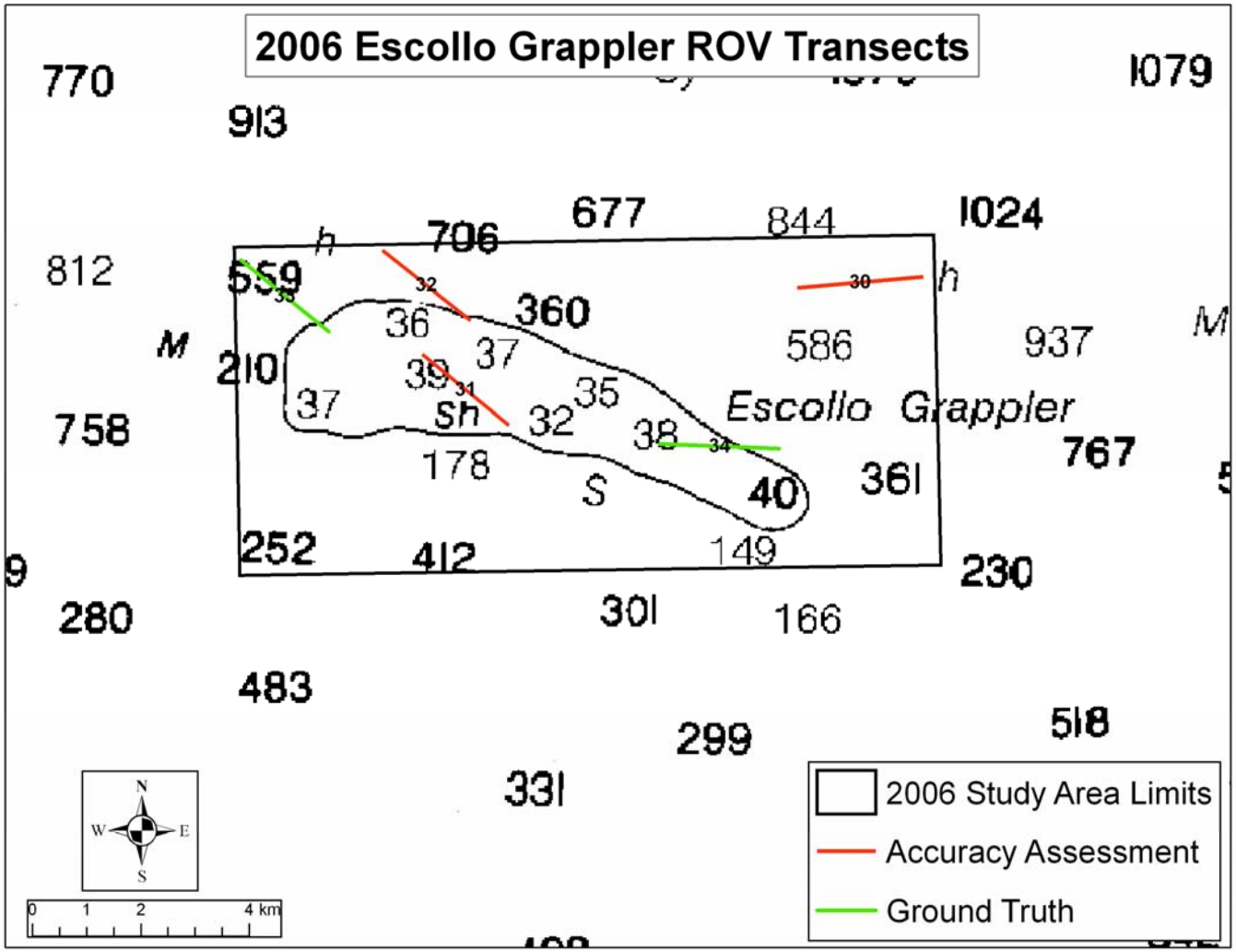
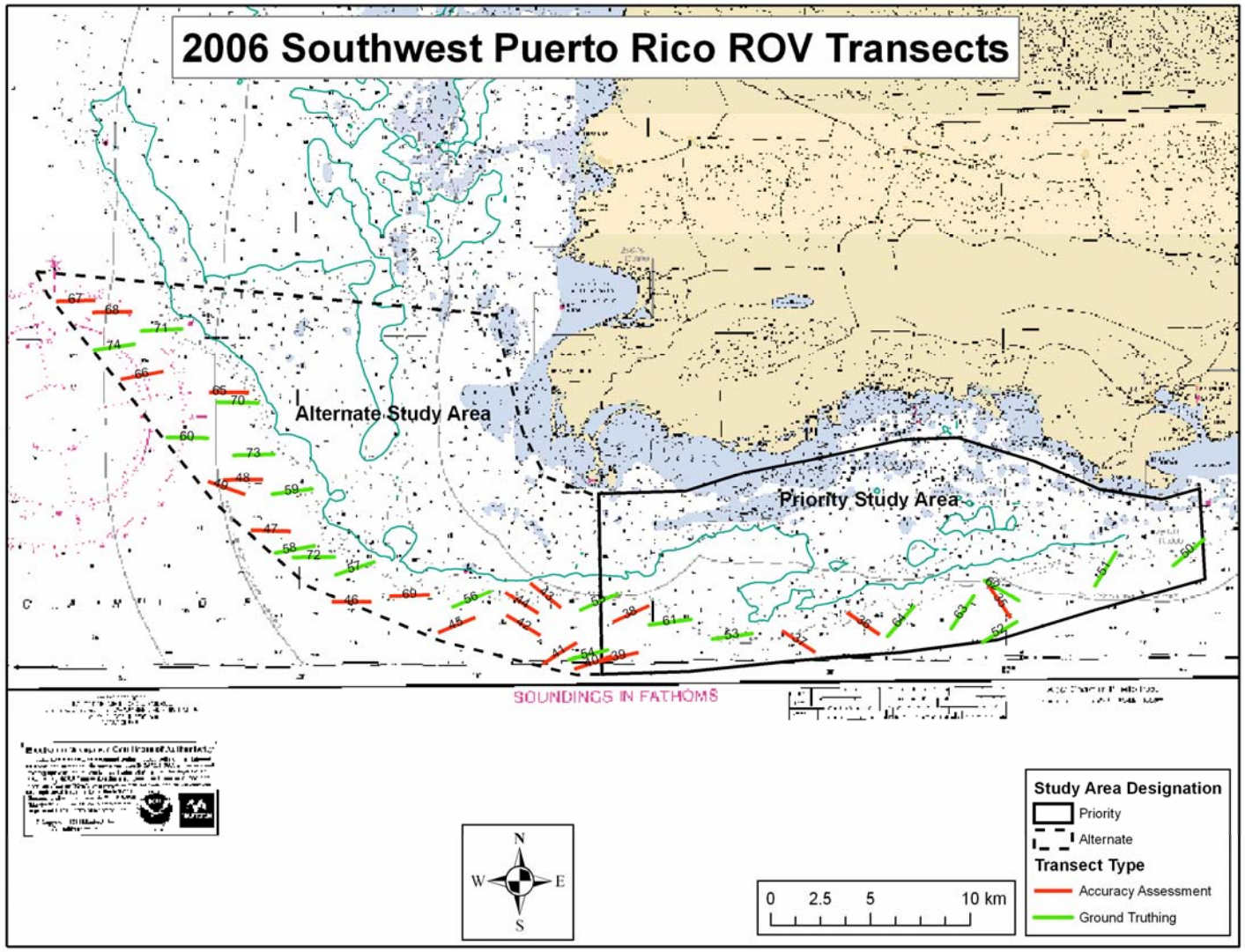



Figure 9. Parguera Puerto Rico Priority and Alternate ROV transects.