

The search for the S.S. PUERTO RICAN using side-scan sonar:
L1-85-NC and L2-85-NC Cruise Report

by

Robert K. Hall and Michael Torresan

U.S. Geological Survey
345 Middlefield Rd.
Menlo Park, Ca. 94025

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L1-85-NC and L2-85-NC: Cruise Report

Purpose:

The objective of the cruises was to accurately locate the 5000 ton sunken stern section of the oil tanker S.S. PUERTO RICAN. The cruises were undertaken at the request of the U.S. Coast Guard. The first cruise was from 28 to 30, March (L1-85-NC) and the second cruise from 2 to 3, April (L2-85-NC), 1985.

On November 3 at 1230 PST the 5000 ton stern section (measuring 45 m (150 ft) x 27 m (88 ft) x 27 m (88 ft)) of the S.S. PUERTO RICAN sank in about 730 m (2400 ft) of water. The Coast Guard located the stern at 37° 30.6' N and 123° 02.2' W (figure 1). The Coast Guard estimates that the stern section sank with 8500 barrels of oil, and has been leaking at a rate of 20 barrels of oil per day. The bow section that remained afloat was towed back to San Francisco on November 18.

Participants L1-85-NC

Participant	Affiliation	Position
J. Gardner	USGS	Co-Chief Scientist
M. Field	USGS	Co-Chief Scientist
R. Hall	USGS	Geologist
K. Kinoshita	USGS	Chief Navigator
G. Tate	USGS	E.T.
T. Kelly	USGS	E.T.
M. Boyle	USGS	E.T.
R. Vaill	USGS	E.T.
D. Myers	USGS	Watchstander
E. Hemphill	USGS	Navigator
L. Bisagno	USGS	Watchstander
E. Maple	USGS	Navigator
S. McGee	NOAA/USCG	Observer

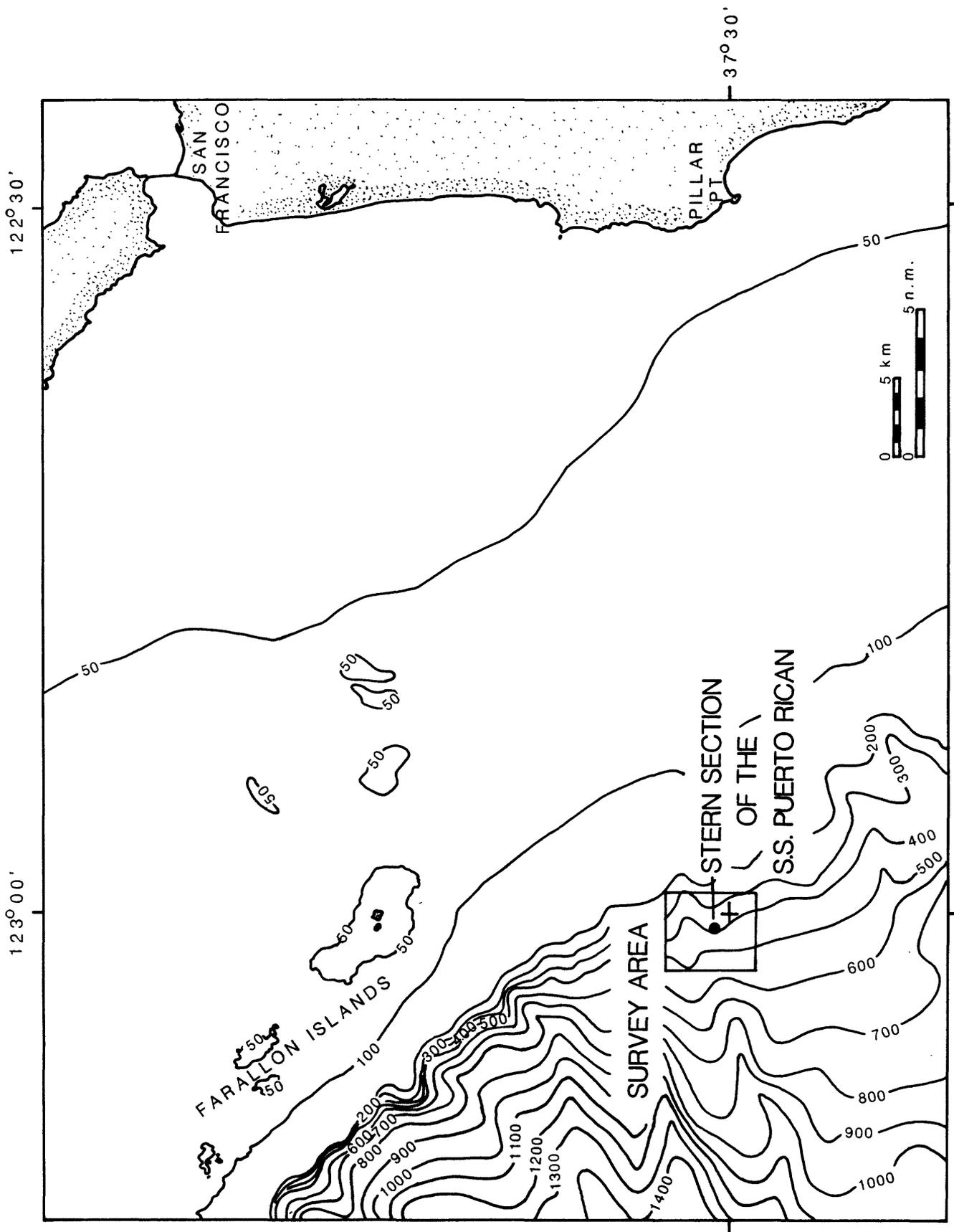


Figure 1. Location map of survey area with position of S.S. PUERTO RICAN sunken stern section.

K. F. Bishop	USCG	Observer
D. Rome	USCG	Observer
J. Haugen	USCG	Observer
R. Umbdenstock	Salvage Rep.	Observer
J. Davis	Visitor	Reporter
D. Kopec	Tiburon Center for Environmental Studies	Observer
A. McClenaghan.	USGS	Captain, S.P. Lee

Participants L2-85-NC

Participants	Affiliation	Position
R. Hall	USGS	Co-Chief Scientist
M. Torresan	USGS	Co-Chief Scientist
T. Kelly	USGS	E.T.
M. Boyle	USGS	E.T.
K. Kinoshita	USGS	Chief Navigator
T. Reiss	USGS	Geologist
E. Hemphill	USGS	Navigator
D. Myers	USGS	Watchstander
L. Timothy	USGS	Watchstander
S. McGee	NOAA/USCG	Observer
W. Albert	USCG	Observer
A. Ramirez	USCG	Observer
R. Hyde	USCG	Observer
A. McClenaghan.	USGS	Captain, S.P. Lee

Equipment Systems Employed

Navigation:

Navigation for L1-85-NC and L2-85-NC surveys employed Loran-C, radar, doppler sonar and dead reckoning supplemented by satellite navigation. The integrated navigation is generally accurate to within 300-500 meters.

Geophysical Profiling Systems:

Both surveys utilized 3.5-kHz and 12-kHz high-resolution seismic profiling systems, and an EG&G SMS 990 side-scan sonar with a SMS 960 recorder. The side-scan sonar system processes the data in real time to provide an accurate plan view (acoustic image) of the sea floor. This

system incorporates a set of 59-kHz variable-pulse-width transducers mounted in a hydrodynamically stable towed "fish," that has a resolution of 1/400 of the selected scan range. At a 500 m (1640 ft) scan range the fish covers a 1 km (3280 ft) swath. The side-scan sonar fish is towed above the bottom at 10 per cent of the scan range. For both surveys the side-scan sonar was set to record at a 500 m scan range, giving a 1000-m swath, and was towed 50 meters off the bottom at a speed of 2 to 3 knots. At this speed, depending on the tow cable length, the side-scan sonar fish trailed the ship by 10 to 15 minutes (0.75 to 1 n.m.). After detecting and accurately locating a sonar target the scan range was reduced (expanding the view) to more clearly delineate the target. The side-scan recorder was set to record the optimum reflectance, with the gain set at 0.00 so that a target with the reflectance of steel would show as a bright spot, and not be masked by echoes returning from the surrounding seafloor morphology.

Results: L1-85-NC

The S. P. LEE departed the Port of Redwood City at 0620 PST (1420 GMT) on March 28. The side-scan sonar fish was deployed at 1310 PST (2110 GMT), March 28, in 130 m (426 ft) of water. Line 1 and line 2 resulted in no potential targets. A potential target was detected on line 3 (figure 2), at 2100 PST (0515 GMT), March 28. The sonar target is situated about 300 m (908 ft) west of the last known position of the S.S. PUERTO RICAN's stern section, in 472 m

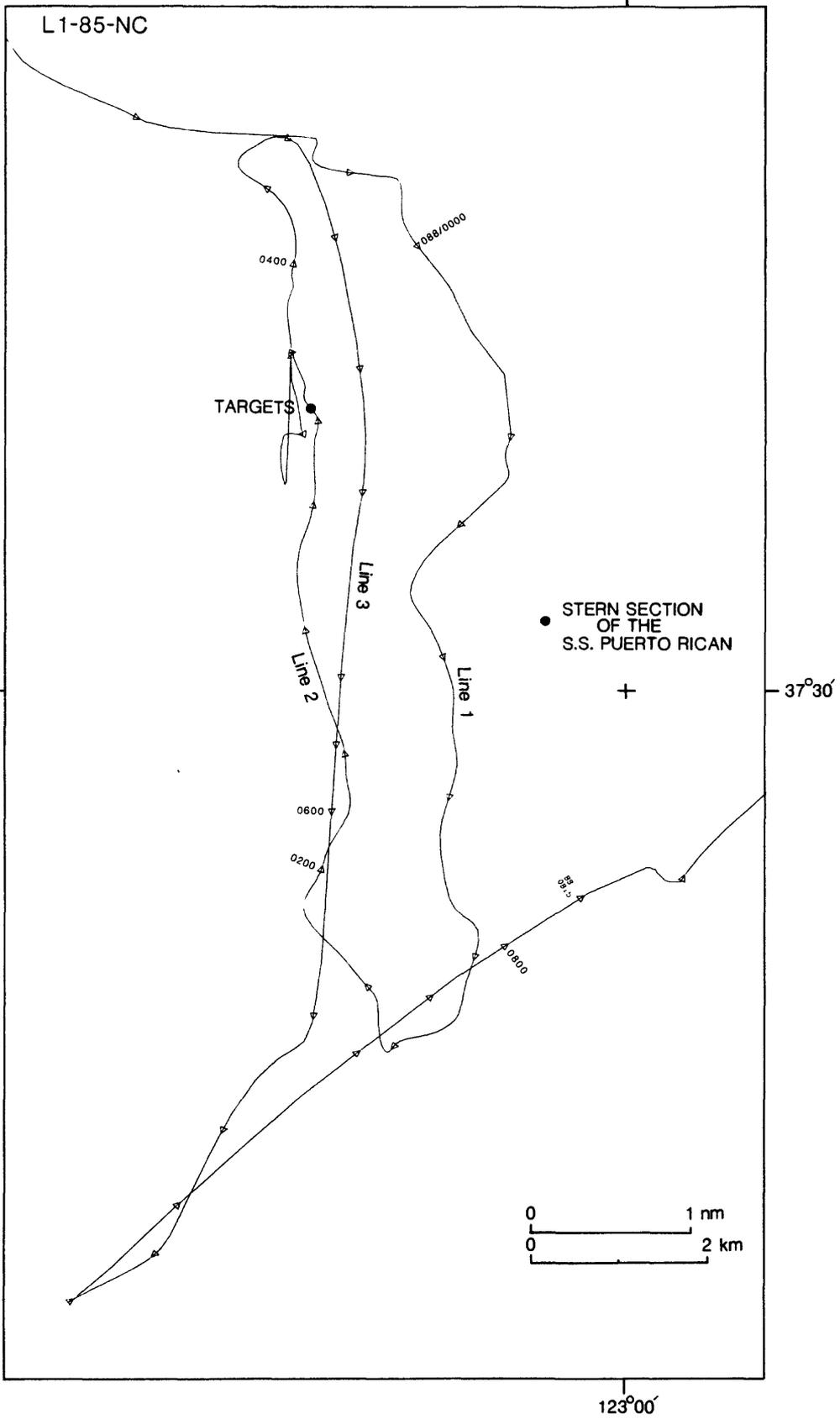


Figure 2. Trackline map of L1-85-NC.

(1548 ft) of water, and the target's dimensions are 45 m (147 ft) x 25 m (82 ft) (figure 3). The side-scan sonar record indicates that the target plowed a furrow, roughly 100 m (328 ft) x 25 m (82 ft), along the seafloor.

Three survey lines were completed during L1-85-NC (figure 2). Total data collection time was approximately 9 hours, in which 93 line kilometers (50 n.m.) of side-scan sonar, 56 line kilometers (30 n.m.) of 3.5-kHz bathymetry, and 88 line kilometers (48 n.m.) of 12-kHz bathymetric data were collected. The quality of the data is fair to poor primarily because of rough seas. The integrated Loran-C navigation was unreliable because the speed log was inoperative. The ship's bridge Loran-C and radar fixes on the South Farallon Islands were used to update the navigation between satellite fixes.

At 2200 PST (0600 GMT) on March 28, the survey was stopped because the side-scan sonar cable had loosened and backlashed on the winch. An attempt was made to repair the loose cable, but rough seas prevented a safe and effective repair of the side-scan cable and winch. The cruise was terminated at 0000 PST (0800 GMT), March 29.

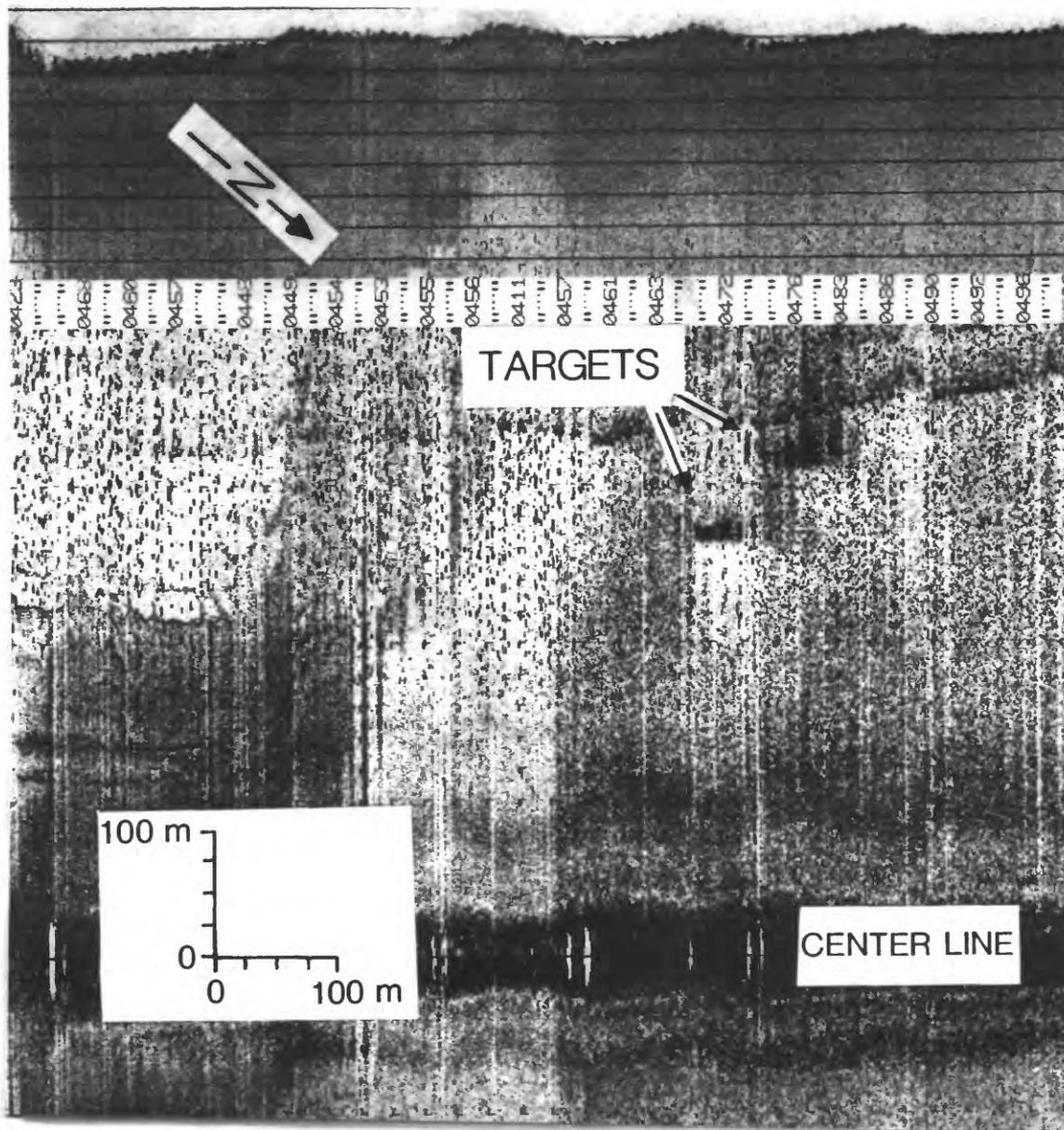


Figure 3. Side-scan sonar record of targets (possible sunken vessels) that were detected on line 3 of L1-85-NC. Shape and dimensions of these targets suggest that neither is the stern section of the S.S. PUERTO RICAN.

Results: L2-85-NC

Nine survey lines were completed during cruise L2-85-NC (figure 4). Total data collection time was 16 hours, in which 68 line kilometers (38 n.m.) of side-scan sonar, 3.5-kHz bathymetry, and 12-kHz bathymetry data were obtained. The quality of the data is generally good. Navigation for L2-85-NC was more reliable than L1-85-NC because we used a Northstar Loran-C receiver.

The S.P. LEE departed the Port of Redwood City at 1800 PST (0200 GMT) on April 2, 1985. The side-scan sonar was deployed at 0045 PST (0845 GMT), April 3. Lines 1 and 2 found no potential targets. The target detected in L1-85-NC was located again on line 3 at 0752 PST (1552 GMT), April 3. The dimensions of this target suggests that it is not the Puerto Rican. Lines 4 and 5 resulted in no further identification of this target.

During the course of the survey a local fisherman relayed the coordinates of his position when his nets caught on a large obstacle. He also observed oil bubbling to the surface. Lines 6-9 were run over this location. The 3.5-kHz and the 12-kHz bathymetry recorded a strong hyperbola from a target on lines 6 and 7, but the target was not seen by the side-scan sonar.

Line 8 detected a target at 1621 PST (0021 GMT), April 3, in a water depth of 380 m (1246 ft). The target was detected 225 m (738 ft) east of the ship's track (center

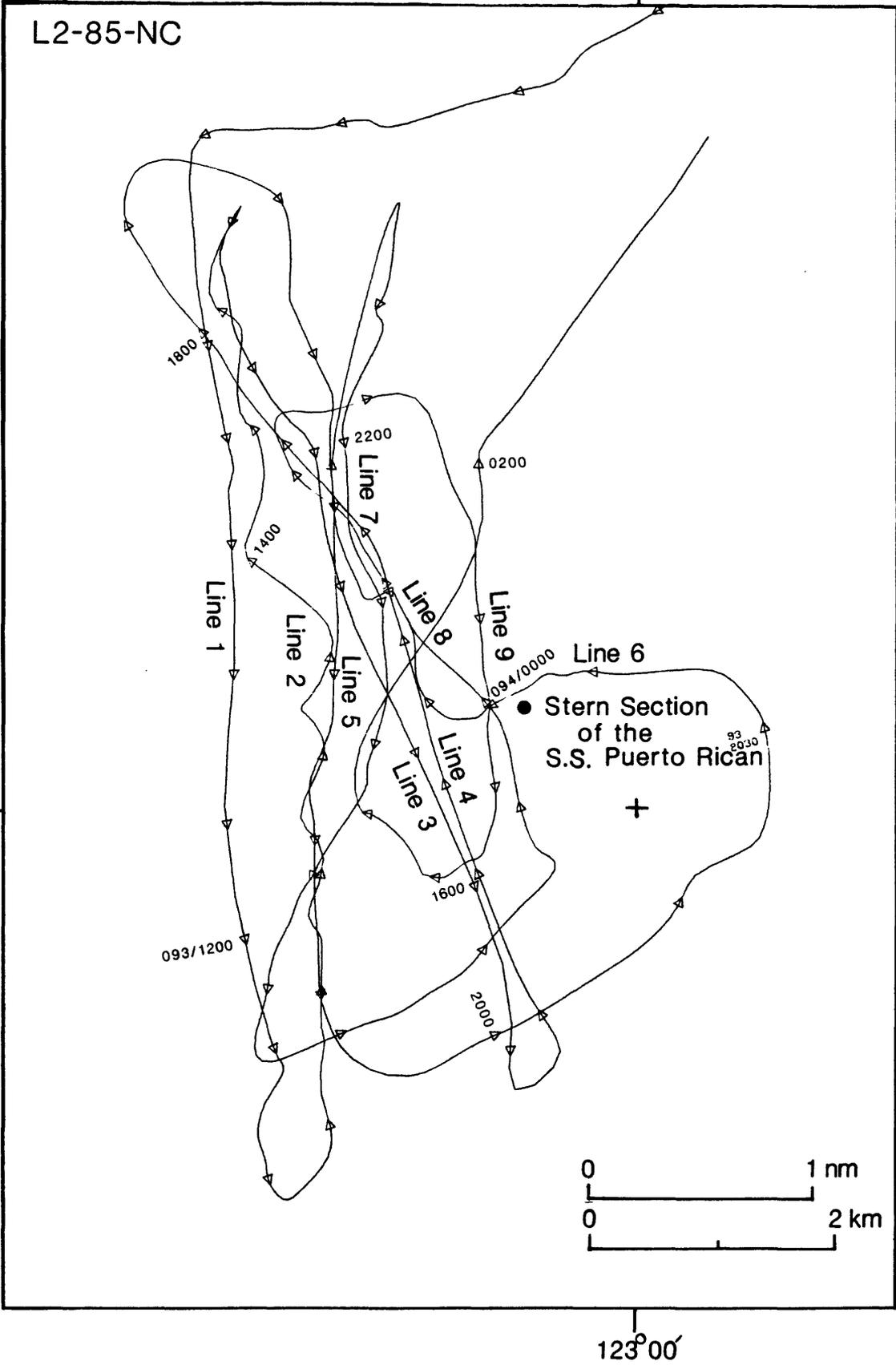


Figure 4. Trackline map of L2-85-NC with location of the S.S. PUERTO RICAN stern section at 37° 30.6' N and 123° 00.7' W.

line of the side-scan image, figure 5). The target has a high acoustic reflectance and dimensions of 45 m (150 ft) x 27 m (88 ft). The physical appearance, reflectivity and dimensions of the acoustic target, and the presence of an oil slick on the surface at the location suggests that this target is the sunken stern section of the S.S. PUERTO RICAN. Line 9 was run parallel to the slope in order to cross the target at a different angle. At 1734 PST (0134 GMT), April 3, the target was detected again in roughly 380 m (1246 ft) of water (figure 6).

Interpretation

Figures 6 and 7 were used to determine the resting angle and orientation of the target. The apparent height of the target was determined by the formula given in figure 7. The apparent height of the target was determined to be less than the actual height of the sunken stern, indicating that the target is tilted to one side. The target, located at $37^{\circ} 30.6' N$ and $123^{\circ} 00.7' W$, is determined to be resting on a 3° slope pointing $304^{\circ} NW$, and tilting to starboard from $0-45^{\circ}$.

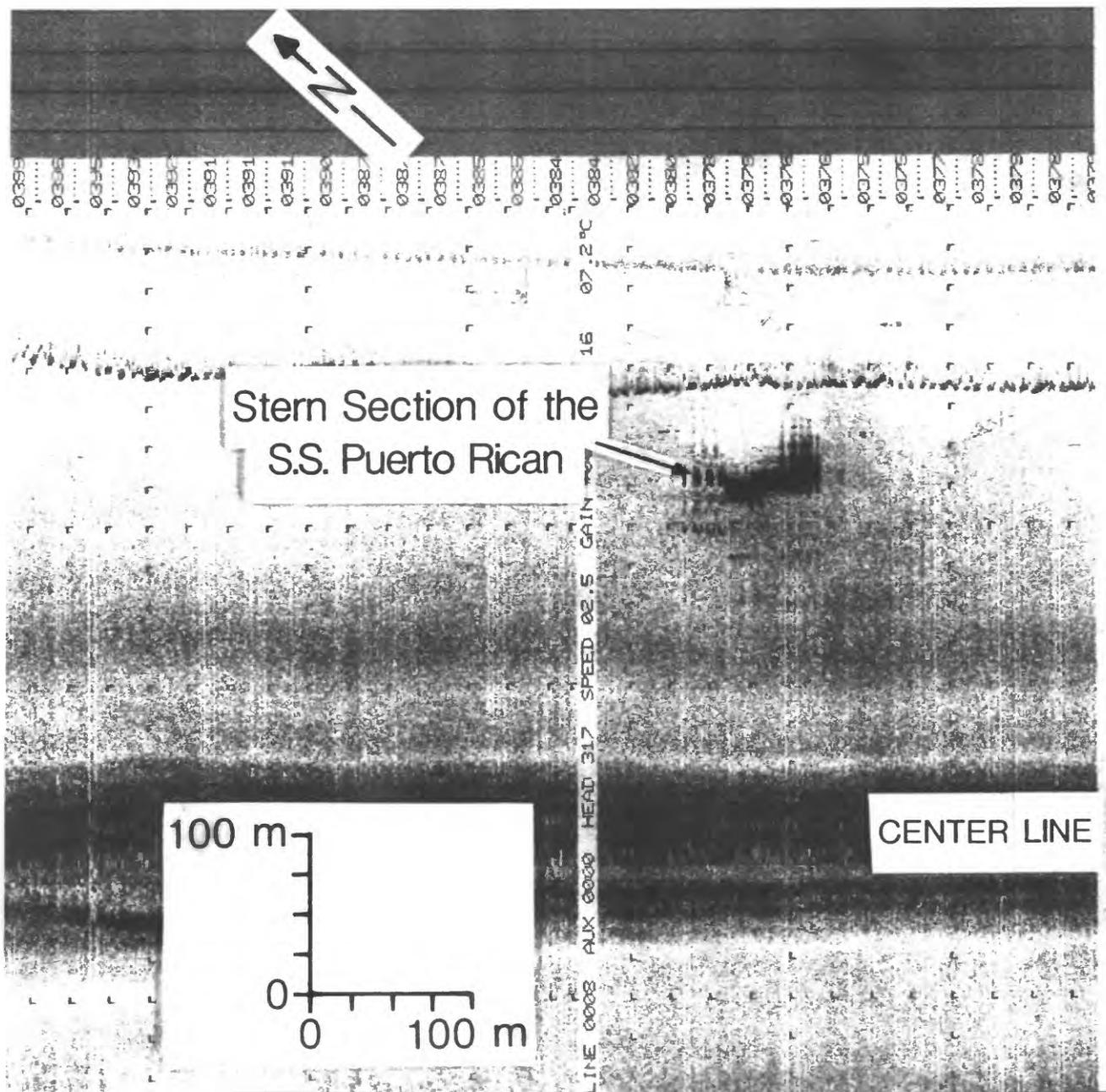


Figure 5. Side-scan sonar record of the sunken stern section of the S.S. PUERTO RICAN (upper right hand corner) taken on line 8 of L2-85-NC. The acoustic image of the target reveals that the stern section is pointing 304° NW, and tilting to starboard.

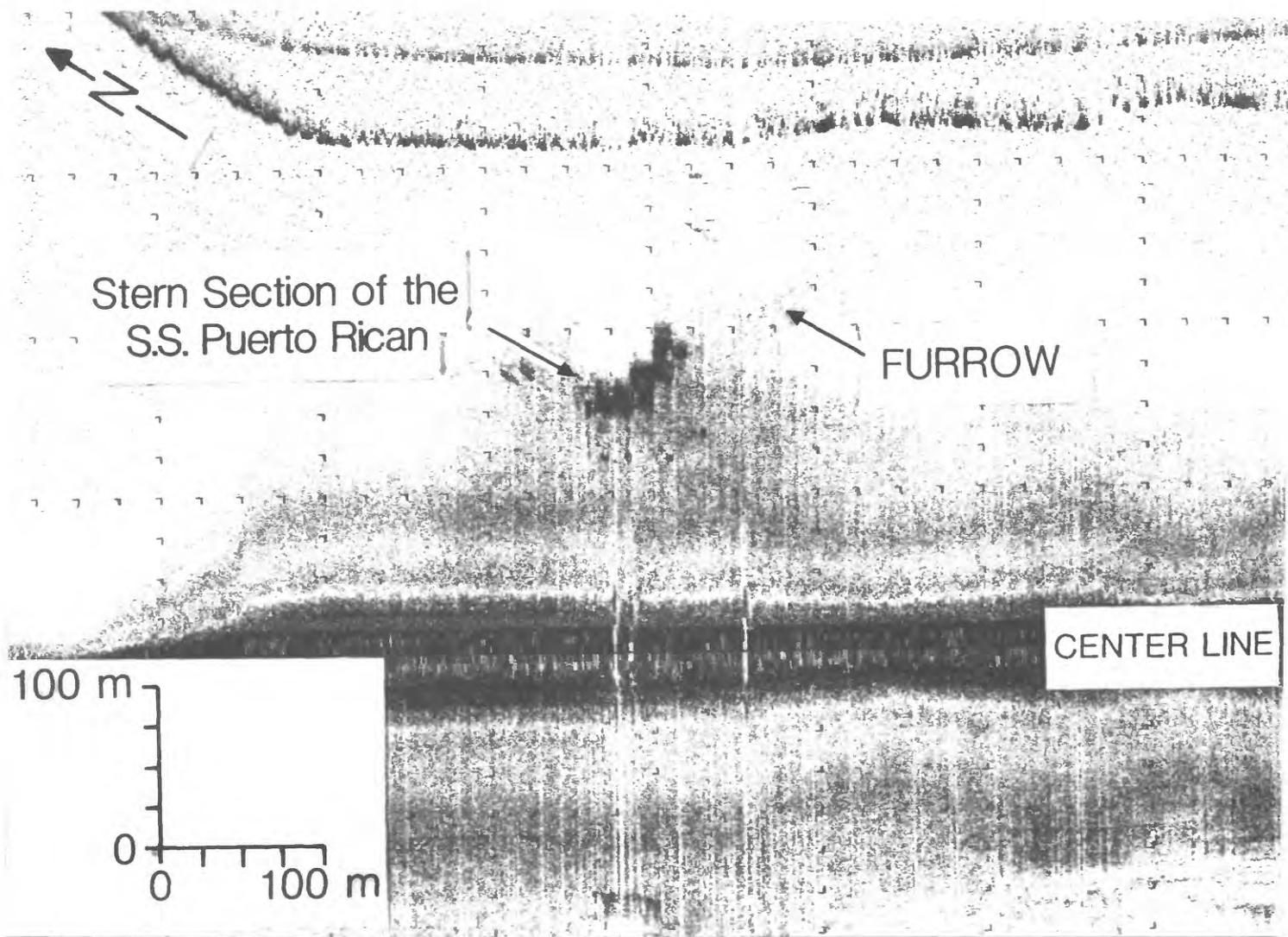
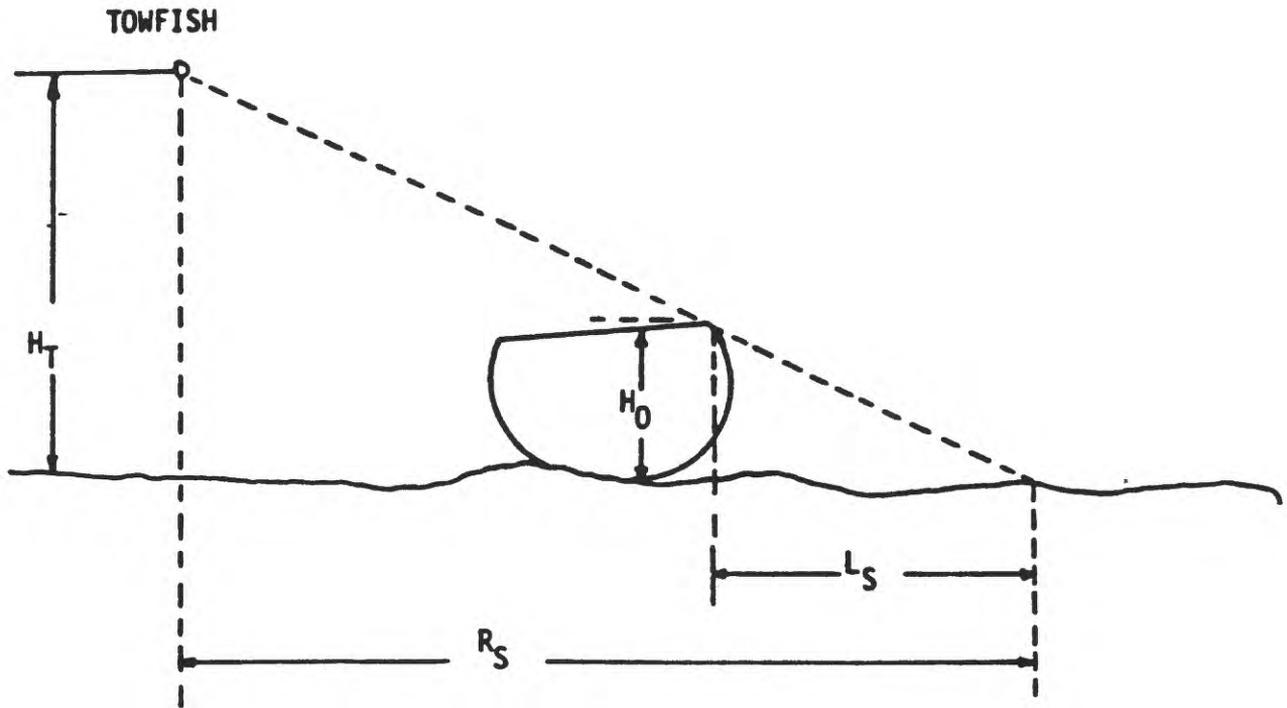


Figure 6. Side-scan sonar record of the S.S. PUERTO RICAN (upper half center) taken on line 9. This image indicates that the vessel is pointing down a 3° slope. A furrow is seen extending out from the stern to the upper right of the record (roughly upslope).



$$H_o = H_t \frac{L_s}{R_s}$$

Where:

- H_o = Object height
- L_s = Shadow length
- R_s = Shadow range
- H_t = Towfish height

Figure 7. An idealized schematic of how the height of the object was determined from the side-scan images in figures 5 and 6. The object height was found to be less than the actual height of the stern section indicating that the stern is tilted to one side from 0-45°.