Chapter 12
Navigation Project Clearance and Object Detection
--Mechanical Bar Sweeps and Side Scan Sonar

12-1. General Scope

A number of tools are available to confirm if a project is clear to a prescribed grade. Acoustic techniques include vertical and multibeam systems covered in previous chapters. This chapter covers use of side scan sonar and mechanical sweeping techniques to detect small objects or shoals lying above project grade.

12-2. Channel Clearance Bar Sweeps

Clearing channels or determining the elevations of underwater obstructions is done by bar sweeps. Channel sweeps are often performed using sweep rafts or sweep barges. In other applications, channels may be routinely monitored and/or swept clear by bar sweeps to ensure safe navigation to a certain depth. A bar sweep has particular application in blasted or cut rock dredging construction where hull clearance verification is especially critical. In many cases, a bar sweep represents a more reliable clearance verification than that obtained by acoustic methods. A heavy bar is suspended vertically below the barge and is maintained at the project or clear depth required.

a. Channel clearance sweep requirements. The Sault Ste. Marie (Soo) Area Office (Detroit District) began deploying sweep rafts in the St. Mary's River (MI) around 1930. The purpose was to certify clear grades in the approach channels around the Soo Locks. Channel depths swept vary from 27 to 30 feet. The original channel was designed based on a design draft of 25.5 feet. Channels in hard rock areas are cut to 28.0 feet with very little overdredging below that level due to the hard material. Commercial ore carriers will typically load close to the 28.0 foot level. The channels that produce the most dangerous grounding hazards to commercial vessels are those constructed in native bedrock. The next most dangerous channels are those cut through glacial deposits containing boulders. Commercial vessel groundings in other channels constructed in soft material have not proven significant. Vessel loadings are driving the need to clear the channels free of navigation hazards. Vessels typically load to 0.3-foot clearances above the swept clear grade reported by the Corps. Groundings (holings) on commercial vessels have occurred on the west approach to the Soo Locks due to loading too close to the clear grade.

b. Detroit District sweep rafts. The Detroit District operated four sweep rafts on the Detroit River, St. Claire River, and St. Mary's River. They were wooden rafts or barges 120- to 130-ft-long, with a 15-foot beam and 4-foot draft. The sweep system dragged six in-line, 21-ft-long by 2.5-inch diameter solid steel bars; each bar weighing approximately 600 lb. This resulted in a clearing swath of some 120-ft (see Figure12-1). The bars were suspended by a 3/8-inch diameter cable wound on manually operated reels designed to raise and lower the bars by 0.1-ft increments, or as rapid as a person can reel up the cable. The bars are suspended along the center of the raft with a 1-ft overlap between adjacent bars.

(1) Three observers are required to monitor the sweep bars--each person responsible for two bars. Concurrent river stage observations are required to continually adjust the depth of the bar. Sweeping is done at a slow speed (slightly greater than drift velocity) in order to keep the bar(s) suspended vertically at the proper depth. Strikes are detected by manual feel of vibration in the cables suspending the bar. When the bar "strikes" a hazard, the position is fixed and the height above grade determined. Individuals monitoring the suspended cables are able to determine the relative hardness and softness of a struck object by feel and sound in the wires. The raft is towed, pushed and maneuvered by a 45-foot harbor tug. The tug requires a two-person crew. The tug was traditionally powered by a 170 HP engine using low power to avoid dragging the head anchor. Control of the sweeping is done using a headwire anchor about 600 feet upstream, as shown in Figure 12-1. The tug drops the anchor, connects to the tow line, and the sweep

pulled downstream to the sweep area while letting out cable. Sweeping is performed with the tug attached to the fixed-length tow line, the sweep and tug held by the anchor to prevent them from going downstream, and pulling the sweep back and forth on the cable. The length of the cable payed out represents the radius of the sweep. Sweeping begins at one side of the channel. The bars are wheeled down and set at depth, corrected for river stage. After each swept arc, an additional 100 ft of cable is payed out downstream and the next arc swept. This provides a 20-foot overlap between sweep arcs. Upon completion of sweeping, the cable is picked up onto the drum of the hoist and the anchor brought back aboard.

(2) Horizontal positioning was accomplished using sextant resection from fixed targets along the river bank, and later electronic positioning. For sextant positioning, an "arc chart" of the channel was prepared consisting of two families of constant sextant angle circles. Positions of the beginning and end of the arc swept are determined by sextant resection. When a strike was detected, the resected position from two observed sextant angles could be quickly plotted aboard the sweep raft.

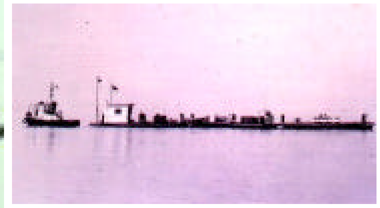
(3) Locations of any snagged obstructions (i.e., strikes above grade) are precisely positioned, and the pinnacle or obstruction elevation is measured by sweeping at successively higher elevations until it is cleared. It is estimated the accuracy of mechanical sweep raft clear elevations is ± 0.2 feet. A "strike plot" is prepared showing all contacts encountered. Sweep rafts often work in conjunction with a derrick boat or crane barge to remove strikes. A derrick boat clears the strike either by dragging a bar over the area or by blind pattern digging with a clam shell bucket.

(4) The total crew required for a sweep operation was nine persons:

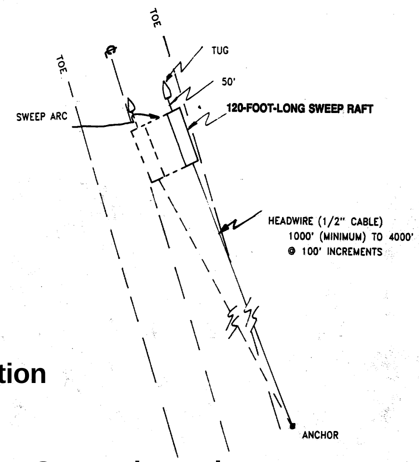
- (1) Party Chief
- (1) Sweep Foreman
- (2) Tug boat operators
- (3) Bar sweep tenders -- "Chairpersons"
- (1) Gage reader (ashore)
- (1) relief

(5) In the mid to late1980s, the Detroit District began using 32-transducer (130-ft) multiple transducer systems to sweep the Detroit River and St. Mary's River. Other districts also once deployed similar bar sweep systems. They too have gone to more efficient multiple transducer and multibeam acoustic methods. Although labor-intensive and slow sweep production relative to current acoustic methods, these bar sweep systems provided reliable, certifiable channel clearance verification in rock cut areas.

c. Wire sweeps. Wire sweeping methods were commonly performed by the US Coast & Geodetic Survey for sweeping wide areas, usually in deeper (non-maintained) approaches to navigation projects. Wire sweeps were rarely performed by USACE since they were not considered as reliable as the bar sweep methods described above. The US Lake Survey District last performed wire sweeps at Cleveland Harbor, Lake Erie, in the early 1980s.



Bar cable winch and monitoring station



Cross channel sweep process

Figure 12-1. 130-Ft Sweep Raft (Detroit District--Soo Area Office)

12-3. Side Scan Sonar

Side scan sonar offers a high-resolution tool that provides a general depictive map on both sides of a survey vessel's path--Figure 12-2. Side scan sonar will not provide absolute elevations of objects; it will, however, provide relative elevations off the surrounding sea floor from which an approximate top elevation may be estimated. Side scan is a practical method for obtaining detailed acoustical pictures of the sea floor called sonographs, usually printed on a paper medium in analog form. Newer systems provide digital side scan records which can be permanently recorded. Digital side scan systems, when coupled with multibeam survey systems, have application in performing precise strike detection surveys or final acceptance surveys in critical navigation channels.

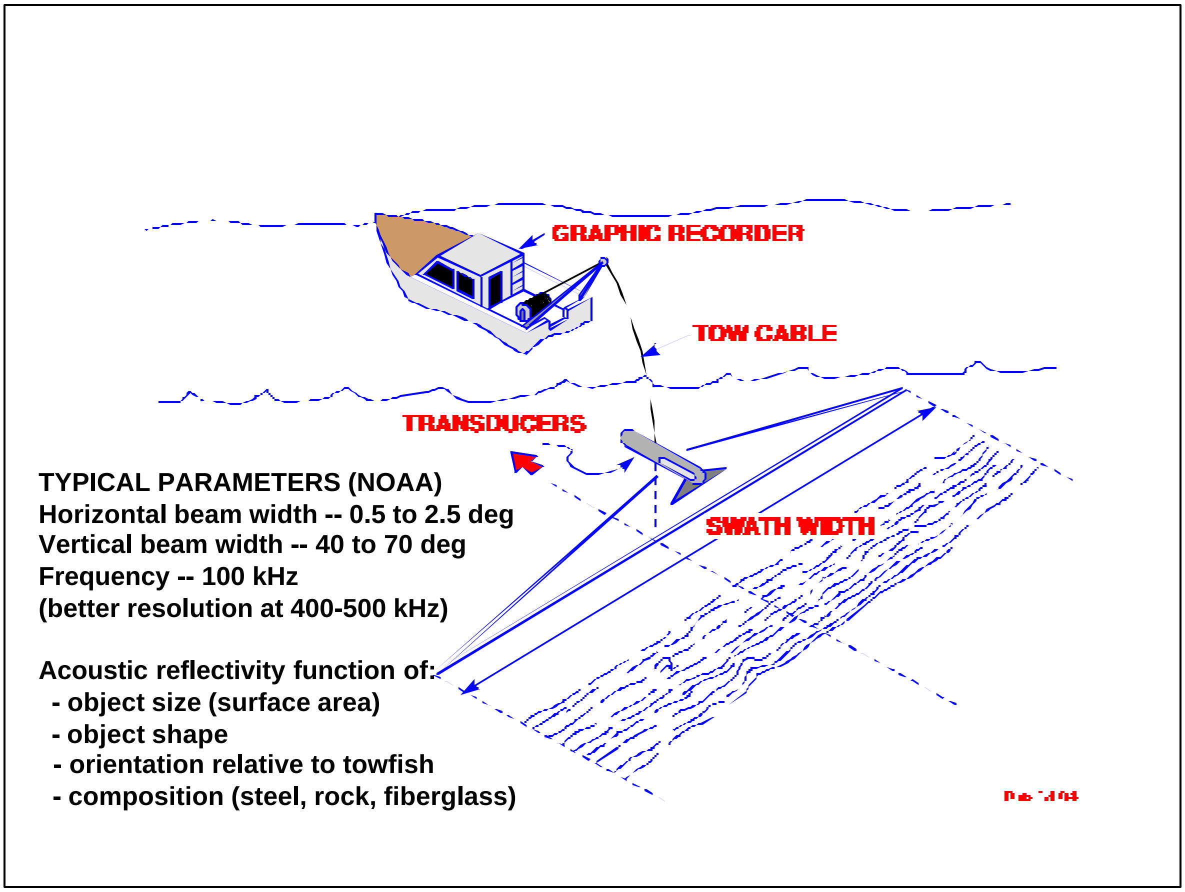


Figure 12-2. Side scan sonar

a. Operating principles. A side scan sonar consists of a recording device, an underwater sensor, and a cable to connect the two. In basic operation, the side scan sonar recorder charges capacitors in the towfish through the tow cable. On command from the recorder this stored power is dumped to the transducers, which emit the acoustic pulse that propagates out through the water. Then over a very short period of time, the returning echoes from the sea floor are received by the transducers, amplified on a time varied gain curve, and transmitted up the tow cable to the recorder. The recorder further processes the signals, digitizes them, calculates the proper position for them in the final record, pixel by pixel, and then prints these echoes on electro-sensitive or thermal paper one scan or line, at a time. The horizontal beam width of side scan sonar is typically between 0.5 and 2.5 degrees. The vertical beam width is between 40 and 70 degrees.

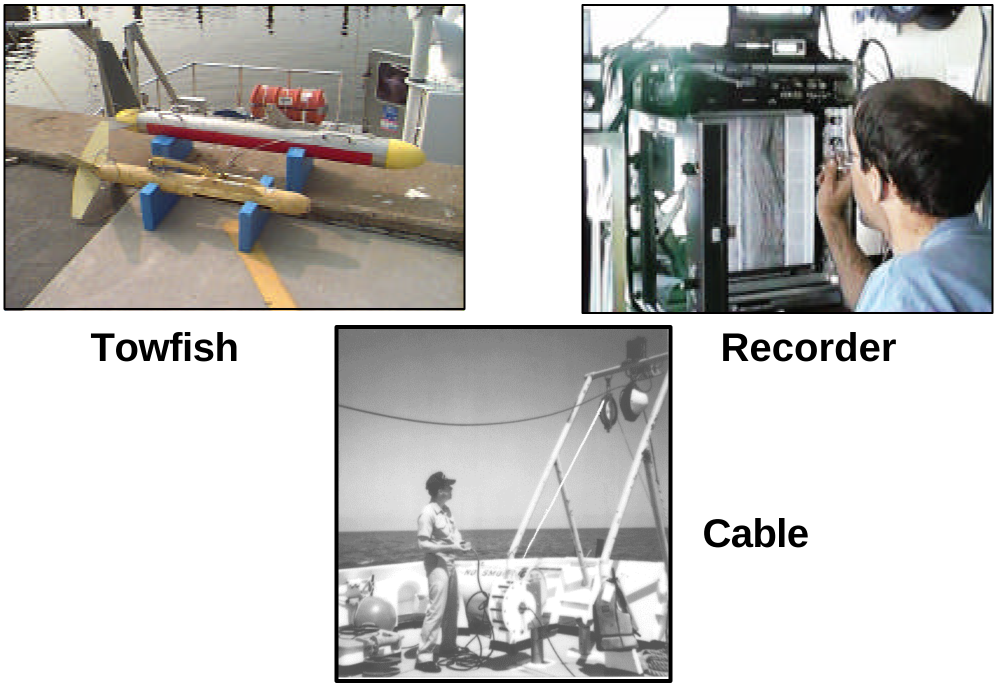


Figure 12-3. Basic components of a side scan sonar (NOAA)

Recording can be analog on a moving paper medium (Figure 12-3), or it can be digital. Digital data collection will permit the application of slant range corrections in order to produce approximate planimetric images, which may be assembled into mosaics to depict large areas of sea floor. Such a system is depicted in Figure 12-4. Digital side scan data files can also be merged with concurrently recorded swath data from a multibeam system.

**EdgeTech Model 272-TD Series
Side Scan Sonar Tow fish**

**OIC GeoDas Seismic Data
Acquisition & Processing System**

Trimble DGPS

**Coastal Oceanographics' "Hypack"
Navigation Software**

Figure 12-4. Digital side scan display system (Sea Systems Corporation)

b. Tow height and speed. The quality of the sonar data is often a function of the height of the towfish above the bottom, or bottom targets during a survey or target imaging. In general, with standard sonar configurations, surveys are performed with the towfish positioned a distance above the bottom approximately equivalent to between 8 percent and 20 percent of the range setting of the sonar. If the transducer array is towed high off the seafloor, shadowing will be lessened and target recognition may be reduced. If towed too low, the reflectivity at outer edges will be reduced limiting the effective range of the system. So when the towfish is towed at less than 8 percent above the bottom, the swath width that is considered achieved is reduced. NOAA's "Rule of Thumb": Below 8%, the achieved range = 12.5 x towfish height (m). The towing speed is adjusted such that 3 acoustical hits (pings) are received on an object.

c. Object imagery. The accuracy or ability of the system to detect a given size object is dependent on a number of factors, including the material type, size, and shape of the object, refraction, noise, biological interference, boat wakes, surface reflections, and towfish stability. On a homogeneous bottom type, shadow zones or lighter areas (or darker areas for digital reverse image display) on the sonar record are typically a function of the amount of ensonification an area receives. A shadow zone in front (towards the towfish) of a strong reflector indicates a depression in the sea floor. A shadow zone behind (away from the towfish) of a strong reflector, indicates a rise in the sea floor.

d. Object height computation. Approximate heights of an object can be estimated from these shadows--see Figure 12-5. Acoustic reflectivity is a function of the size of the object (surface area presented), the shape of the object, its orientation relative to the towfish, and its composition. Steel or rock are good reflectors. Fiberglass, soft pine, plastics, and rubber are poor reflectors. Usually 200% scanning coverage is required with a side scan range scale set at 100 meters. Confidence checks should be conducted daily to ensure the specified size object is being detected.

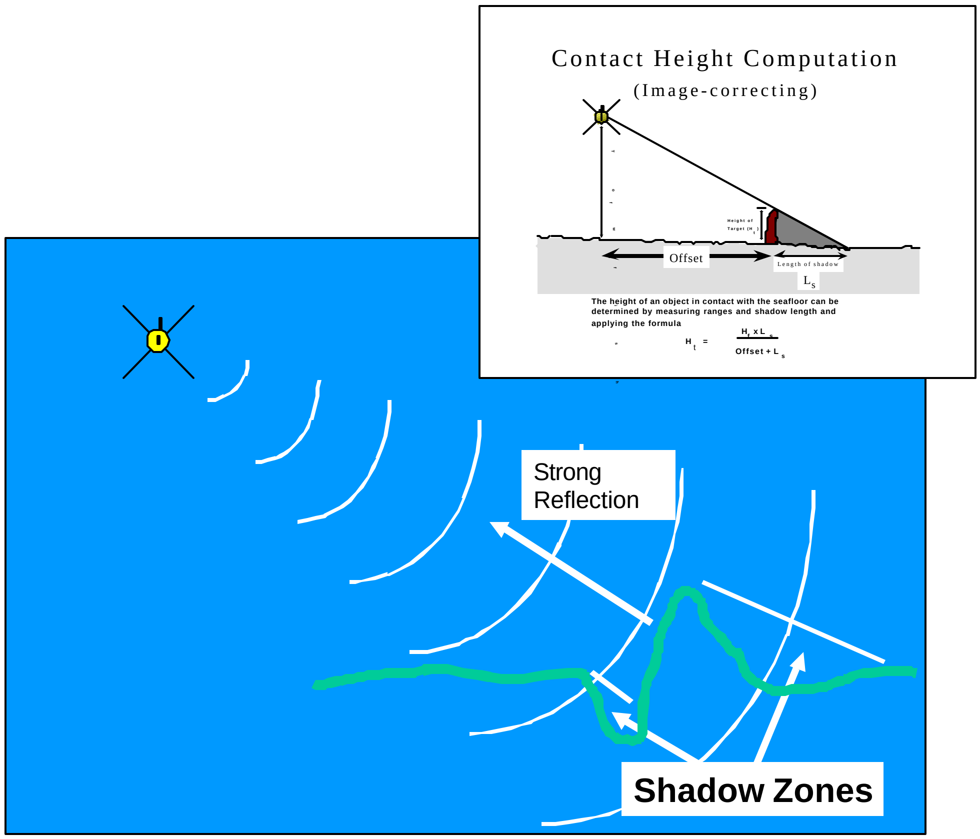


Figure 12-5. Side scan height and contact height computations (NOAA)

e. Object position determination. In order to accurately determine the position of a side scan sonar contact, we need to first determine the position of the vessel, and then translate that position to the towfish. In NOAA, the transducer location is used as the origin for a local coordinate system that is established aboard the vessel. Directions fore and aft are called laybacks, while distances measured from port to starboard (beam to beam) are called offsets. By convention, layback is positive in a direction aft of the transducer, while offsets are positive to starboard (the right). The position of the transducer is computed from the GPS antenna by geometrically combining the antenna's offset and layback coupled with a course-made-good heading of the vessel. Once the position of the towfish is known, the computation for the position of the contact is easy. The contact offset is scaled from the sonar record. In Figure 12-6, the contact has an offset of about 38 meters on a 75-meter range scale--offset is positive to starboard, negative to port. Given the offset from the fish and the vessel's heading, the position of the contact can be computed.

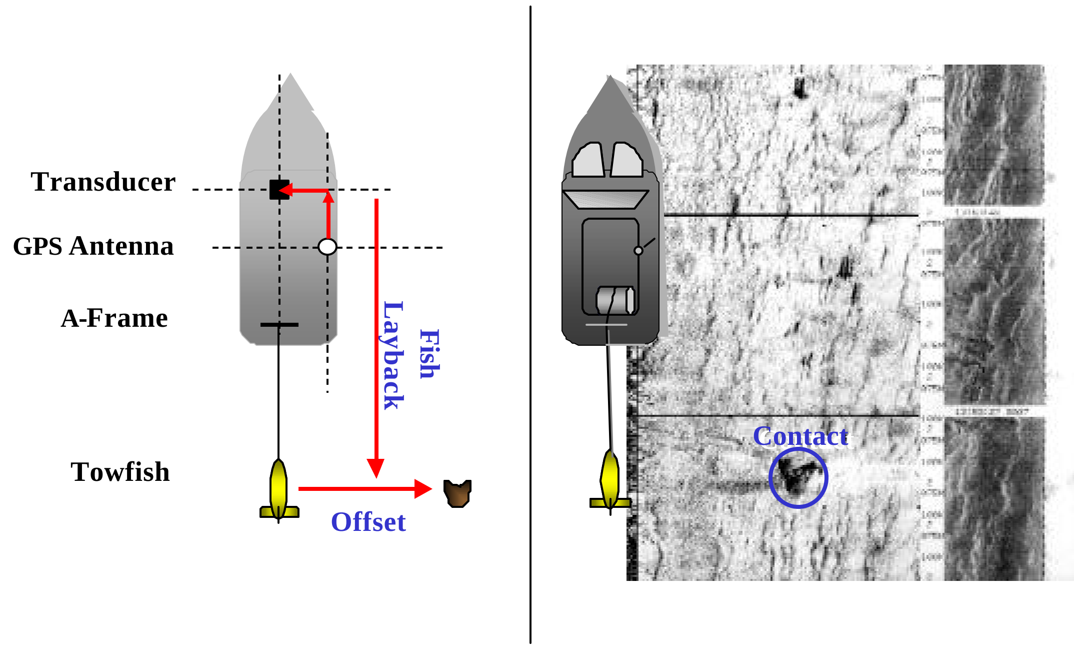


Figure 12-6. Contact position computation (NOAA)

f. Side scan sonar records. In general, there are two types of sonar records. Slant range corrected records show distances as if the bottom were flat as if taken by an aerial photograph. By knowing the fish height above the bottom, the slant range from the fish to the bottom can be rectified. In addition, the recorder paper speed will be adjusted based on the speed of the survey vessel. Therefore, on the paper, 100 meters in the along-track direction will equal 100 meters in the across-track direction. Uncorrected records show the fish height as the first return. True horizontal distances cannot be scaled directly from the sonar record. The image in Figure 12-7 shows small sand waves throughout. These waves rise off the bottom about a meter. A rock is shown with a black mark, signifying a strong return. The white behind the rock is an acoustic shadow. The position of the rock can be determined by scaling the offset (across track distance) off the record. In this case, the rock is about 15 meters to starboard of the towfish track. The shadow height is then scaled in order to determine the height of the object off the bottom. The horizontal black marks across the record are made at a predetermined time interval. This enables the operator to correlate the record with position and depth data. Figure 12-8 depicts computer-generated side scan imagery enhancements that will provide significant detail of bottom objects or sediments.

g. Accuracy. Movement of the fish can cause a degradation of the side scan record. In particular, on a short tow in shallow water, the surface waves affecting the ship can have a coupling effect with the towfish. As it pitches fore and aft, the towfish experiences a similar dampened motion. The rapid accelerations and decelerations of the towfish degrade the sonar record.

- Roll - The rhythmic movement of a ship or tow body along its longitudinal axis.

- Yaw - An instability characterized by the side to side movement of a ship or towed body about its vertical axis

- Heave - The rise and fall of a surface vessel or towfish in a rhythmic movement

- Pitch - An instability in the towfish expressed by the alternate rise and fall of the nose and tail about a horizontal axis.

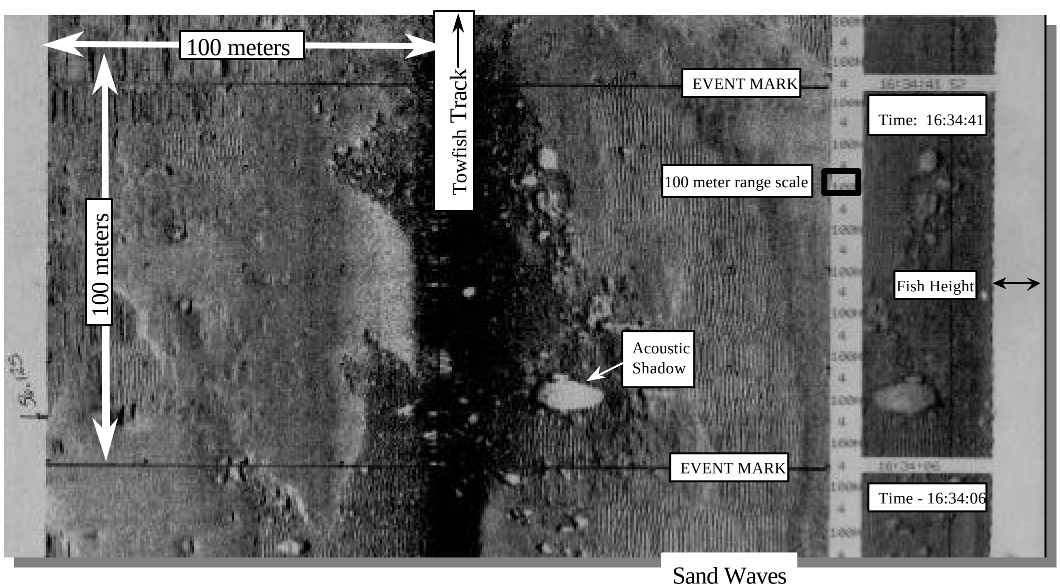


Figure 12-7. Side scan sonar record (NOAA)

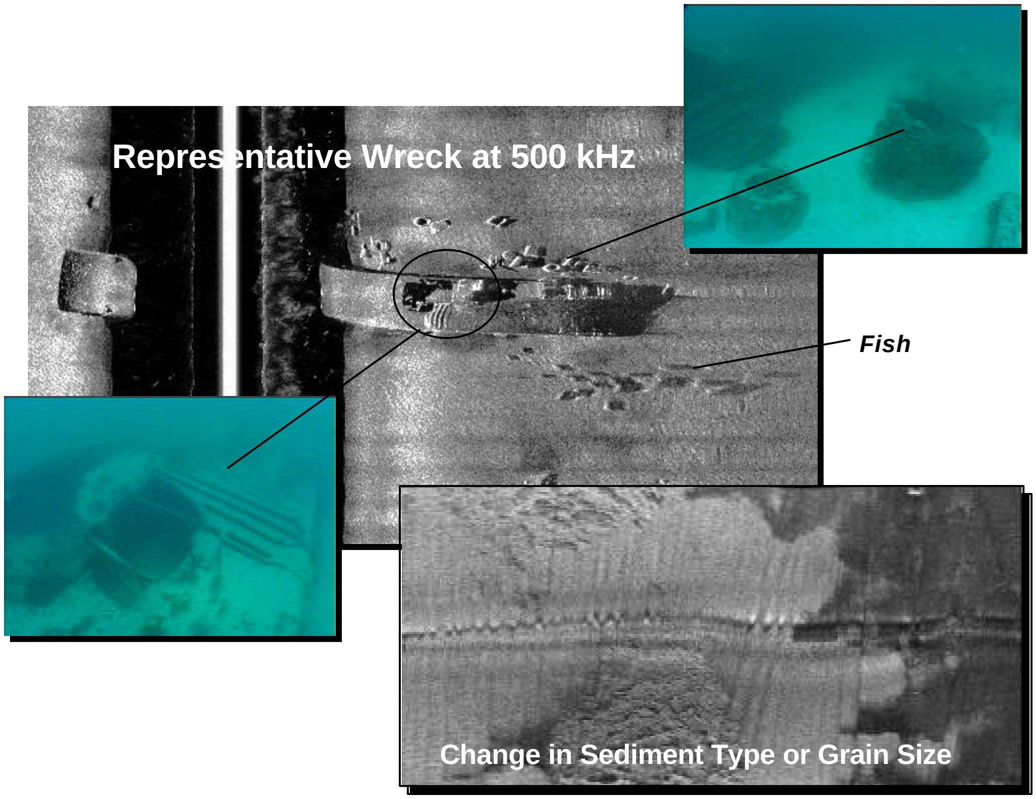
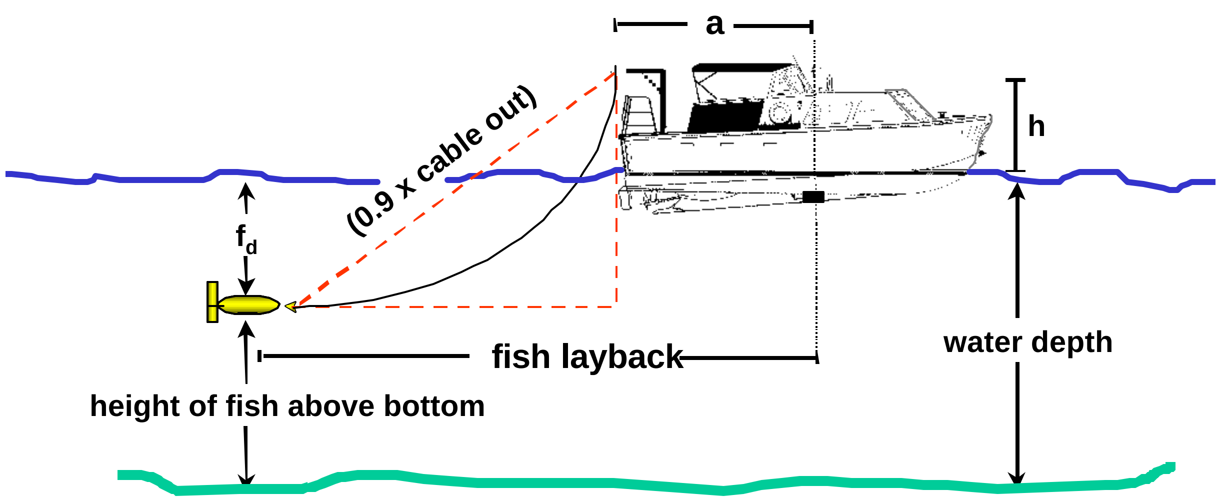


Figure 12-8. Enhanced side scan imagery depicting detailed underwater features (Sea Systems Corporation and OIC GeoDas)

12-4. Side Scan Sonar Survey Specifications (NOAA)

The following paragraphs under this section contain excerpts from side scan specifications developed by NOAA for both internal survey forces and contracted forces. Although they were developed for nautical charting applications, these specifications and standards are directly applicable to side scan survey operations performed by Corps in-house or contract crews on USACE navigation and dredging projects. Bracketed areas relate to project-specific information.

a. General Requirements. Side scan sonar shall be used to locate obstructions and a shallow water multibeam sonar system shall be used to determine the least depth over the obstructions. Side scan sonar data shall be collected over the channel areas indicated on the drawing at [__________], which is identical to that required for multibeam coverage. The Contractor shall acquire digital side scan sonar data using a towed system. The side scan sonar system shall be operated with a maximum range scale of 100 meters and with a towfish height above the bottom of 8% to 20% of the range scale in use--see Figure 12-9. The side scan sonar data shall be horizontally referenced to [NAD 27] [NAD 83].



fish layback = a + sqrt [(0.9 x cable out)^2 - (h + f_d)^2]

$$\text{fish layback} = a + \sqrt{(0.9 \times \text{cable out})^2 - (h + f_d)^2}$$

where a = layback of A-frame from echo sounder transducer
h = height of cable block on A-frame above waterline
f_d = depth of side scan sonar fish = water depth - height of fish above bottom

Figure 12-9. Height and position determination of towfish (NOAA)

b. Accuracy. The side scan sonar system shall be operated in such a manner that it is capable of detecting an object that measures [0.5] [1.0] meter cube from shadow length measurements.

c. Towing Speed. Since the sonar is pulsing at a fixed rate based on its range scale, the speed that the towfish is being towed will have an affect on the ability to resolve items. In general, the slower the fish is towed, the more definition is obtained. The side scan sonar shall be towed at a speed such that a detected object in the channel would receive a minimum of three pings per pass. The required towing speed may be computed as shown in Figure 12-10.

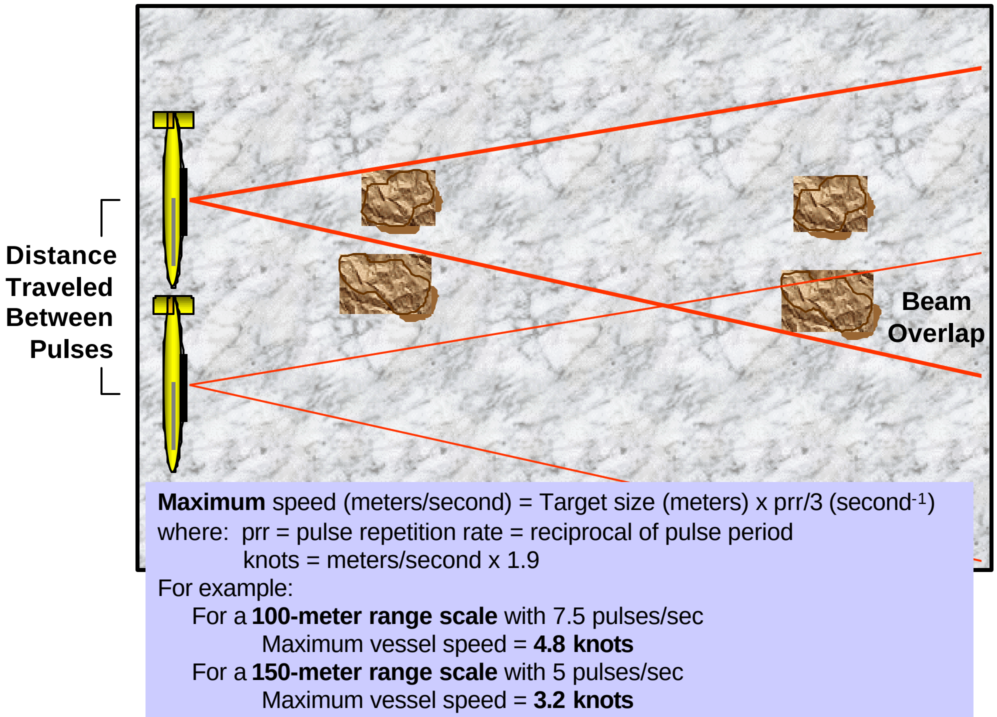


Figure 12-10. Determining towing speed for side scan sonar (NOAA)

d. Coverage. The scanning coverage shall be 200%. "Scanning coverage" is the concept used to describe the extent to which the bottom has been covered by side scan sonar swaths, that is, the band of sea bottom which is ensonified and recorded on the side scan sonar record along a single vessel track line. Trackline spacing shall be reduced from the maximum if the quality of the side scan sonar records deteriorate, i.e., record does not show features in the outer edges of the swath. For hydrographic purposes, scanning coverage of an area is expressed as multiples of 100%, and is cumulative. One-hundred percent coverage causes an area to be ensonified once, with a small overlapping area between adjacent swaths that is ensonified twice. For example, if a region of the bottom is ensonified twice, coverage of that region is said to be 200%. Approved 200% coverage techniques are as follows:

(1) Technique 1. Conduct a single survey wherein the vessel track lines are separated by one-half the distance required for 100% coverage.

(2) Technique 2. Conduct two separate 100% coverages wherein the vessel track lines during the second coverage split the distance between the track lines of the first coverage. Final track line spacing using this technique is essentially the same as Technique 1. The advantage of this method is that areas are viewed at different parts of the range scale for each run. (The ability to distinguish targets directly under the fish and at short ranges is difficult. This method ensures an area is covered other than directly under the fish.) The disadvantage is that an obstruction with a narrow east/west aspect could be undetected.

(3) Technique 3. Conduct two separate 100% coverages in orthogonal directions. This method allows contacts to be ensonified from two different aspects. Also, depending on weather conditions, a vessel course can be selected to obtain the best return from the sonar. The disadvantage is that some areas have only been ensonified with the fish directly overhead.

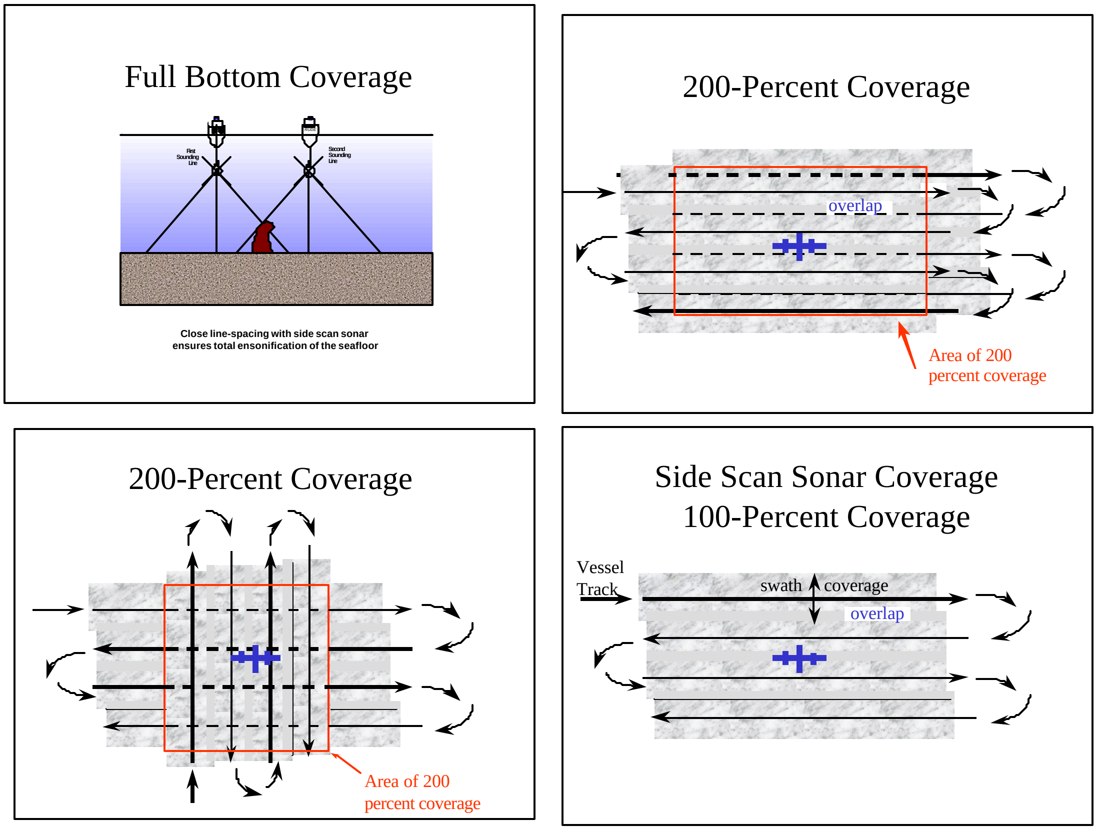


Figure 12-11. Side scan coverage (NOAA)

Figure 12-11 shows a plan view of a side scan sonar search area. The object in the middle is a cartographic symbol signifying the submerged wreck that is being searched for. The dark lines with arrows represent the vessel trackline. On the 100% coverage sketch, the search was conducted by running east-west lines. The side scan sonar ensonifies an area to the north and south of the vessel trackline. The line spacing may be computed as follows:

Image-correcting:
Recommended Line Spacing = (2 x RS) - 40 meters

Non-correcting:
Recommended Line Spacing = (2 x RS) - 40 meters - (0.05 x RS)

where RS = range scale (i.e., 100 or 150 m) *e. Quality Control.*

(1) Confidence Checks. Confidence checks of the side scan sonar system shall be conducted at least once daily. These checks should be accomplished at the outer limits of the range scales being used based on a target near or on the bottom. Each sonar channel (i.e. port and starboard channels) shall be checked to verify proper system tuning and operation. Confidence check can be made on any discrete object, offshore structure, or bottom feature which is convenient or incidental to the survey area. Targets can include wrecks, offshore structures, navigation buoy moorings, distinct trawl scours or sand ripples. Confidence checks can be made during the course of survey operations by noting the check feature on the sonargram. If a convenient or incidental target is not available, a known target may be placed on or near the bottom and used for confidence checks. Confidence checks shall be an integral part of the daily side scan sonar operation and shall be annotated in the side scan sonar data records.

(2) Significant Contacts. Contacts with computed target heights (based on side scan sonar shadow lengths) of at least [0.5] [1.0] meter should be considered "significant." Other contacts without shadows may also be considered "significant" if the sonargram signature (e.g., size, shape, or pattern qualities) is notable.

(3) Correlate with Multibeam Data. The Contractor shall examine the multibeam data and correlate anomalous features or soundings with the side scan sonar data. The contractor shall examine and correlate targets between successive side scan sonar coverages (i.e., compare the first 100% with the second 100% sonar coverage). Anomalous features or targets which appear consistently and correlate in each type of data record provide increased confidence that acquisition systems are working correctly and help to confirm the existence of these features or targets. The Contractor shall cross reference and remark on each target correlation in the Remarks column of the Side Scan Sonar Contact List.

(4) Identification of Potential Field Examinations. The Contractor shall use the sonar contact list, in conjunction with an analysis of multibeam least depths, to identify hydrographic features which may require further examination. The contractor shall make recommendations for additional field examinations which are deemed necessary to establish survey completion.

f. Side Scan Sonar Contact List and Coverage Plot The contractor shall produce a separate sonar coverage plot for each 100% side scan coverage. This provides a graphic means for documenting that the effective scanning swath from each search track sufficiently overlaps the effective scanning swath from adjacent tracks.

(1) Contact List. The Sonar Contact List is compiled manually using a form or as the output of an automated listing device. An acceptable method is described below. The column entries required on the Sonar Contact List are the specific elements of information which the Hydrographer needs to prepare the preliminary Sonar Contact Plot. The various column entries are described below, along with a brief discussion of how each is to be derived.

Column 1. Search Track Number - identifies the particular search track from which the contact was observed.

Column 2. Contact Number - uniquely identifies the contact. An example of a contact number is a number based on the date/time the contact was observed, followed by a letter indicating the port or starboard (P or S) channel; i.e., if a port-side contact is observed on day 181 at 150125, the contact number will be 181/150125P. Using signed (+ or -) contact range in column 4 eliminates the need for the P or S indicator.

Column 3. Towfish Layback - the approximate distance in meters from the positioning system antenna to the towfish. Unless computed by an automated system, the towfish may be assumed to be directly astern of the towing vessel and on the search track.

Column 4. Contact Range - the horizontal distance from the towfish track to the contact, expressed in meters. All ranges scaled from the sonargram are slant ranges for standard sonars, true ranges for image-correcting sonars. True ranges are obtained from slant-range information by geometric corrections using the Pythagorean Theorem.

Column 5. Contact Position - the preliminary position as determined by reconstruction of the vessel position, towfish layback, towfish position, port or starboard channel, and contact range at the time the contact was observed. The Contact Position shall be stated as a latitude/longitude.

Column 6. Estimate of contact height computed from range and shadow length.

Column 7. Remarks - used to denote first impressions of the contact's identity (wreck, rock, etc.), or to make any comments deemed appropriate. If after examining the records and correlating targets from overlapping coverage the Hydrographer determines that a contact does not warrant further investigation, it shall be noted as such. A brief statement of the reasons must be made. This determination should not be made until all numbered contacts are plotted on a preliminary Sonar Contact Plot. Any abbreviations should be defined on the list.

Column 8. Comparison with shallow water multibeam data - used to note the corresponding shallow water multibeam data (day/time, line number, etc.), the results of comparing the side scan sonar data with the multibeam data (e.g., contact did not appear in the multibeam data, SWMB least depth = x.x - SSS least depth = y.y), and the type of multibeam coverage (i.e., center beams or reconnaissance beams).

Column 9. Contact is depicted on a drawing [file] - yes/no.

Once added to the list, a contact should never be removed. If after further processing a contact is deemed not significant by the hydrographer, it shall be labeled as such in column 7. The contact list, and any subsequent field examination lists and records developed from the contact list, shall be included with the data submission in both hard copy and digital forms.

(2) Contact Plot. The Contact Plot will show the position of all significant contacts entered on the Sonar Contact List. Only "significant" contacts, along with the views from adjacent lines, need to be plotted on the Sonar Contact Plot. In some areas, "significant" contacts may be clustered (e.g., debris, boulder fields). Such an area may lend itself to being depicted as a single feature with least depth(s). Only the most significant contact(s) in the group needs least depth(s) and position(s) determined.

g. Sonargrams. If sonargrams are recorded, annotation of the sonargram while on-line is mandatory during all side scan sonar operations. All annotations shall be made in the margins of the sonargram so that no portion of the trace is unduly obscured. Time references shall be made in Coordinated Universal Time (UTC). Additional annotations will be added during contractor processing. Note: If sonar data is supplied in digital format only, the digital data needs to be similarly annotated.

(1) Header Annotations. Header annotations are required to identify the sonar work and for ease of later reference. Header annotations are:

1) Registry number
2) Item number (AWOIS, if applicable)
3) Day of year and calendar date
4) Towing vessel
5) Tow Point

Header annotations shall be made:

1) at the beginning of a new paper roll,

2) at the beginning of each day's work (for 24-hour operations, these annotations shall be made at the beginning of the first complete track of the new day),

3) when there is a change in the towing configuration during a day's operation.

(2) System-Status Annotations. System-status annotations are required to describe the recorder settings and the towing situation. System-status annotations are:

1) mode of tuning (manual or auto)
2) range-scale setting
3) paper-speed setting
4) left and right channel recorder settings
5) operator's initials
6) length of tow-cable deployed (tow point to towfish)
7) depressor in use (yes or no)
8) weather and sea conditions

System-status annotations shall be made:

1) prior to obtaining the first position of the day,

2) prior to obtaining the first position on a new paper roll,

3) at any time the recorder has been switched off and then back on,

4) while on-line, approximately every hour, regardless of any changes made.

(3) First Position/Last Position Annotations. The following annotations shall be made at the first position on each search track:

1) Line begins (LB) or Line Resumes (LR)
2) tow-vessel heading (degrees true or magnetic)
3) towing speed (engine rpm, and pitch if applicable)
4) index number and time (at event mark)

The following annotations shall be made at the last position on each search track:

1) Line turns (LTRA, LTLA), Line breaks (LBKS), or Line ends (LE)

2) index number and time (at event mark)

(4) Special Annotations. The occurrence of any of the following events shall be annotated on the sonargram margin at, or as soon after as possible, the time the event occurs:

1) new index number (at event mark)
2) change in operator (new initials)
3) change in range-scale setting
4) change in paper-speed setting
5) confidence checks
6) individual changes to recorder channel settings
7) change in tow-cable length (tow point to towfish)
8) change in towing speed (engine rpm and pitch) or vessel heading
9) change in tow point
10) significant contact observed (flag using an arrow)
11) surface phenomenon observed (wakes, passing vessels, etc.)
12) passes by buoys or other known features within sonar range
13) interference (state source if known)
14) time corresponding to the index marker.

The Hydrographer shall make any other annotations necessary to note any occurrence which may later serve to reconstruct the operation. Too much information is always better than not enough.

(5) Annotation Methods. Header and system-status annotations may be made using any of the following methods:

1) freehand on the sonargram,
2) by use of a stamp,
3) by use of an automatic annotator, if available.

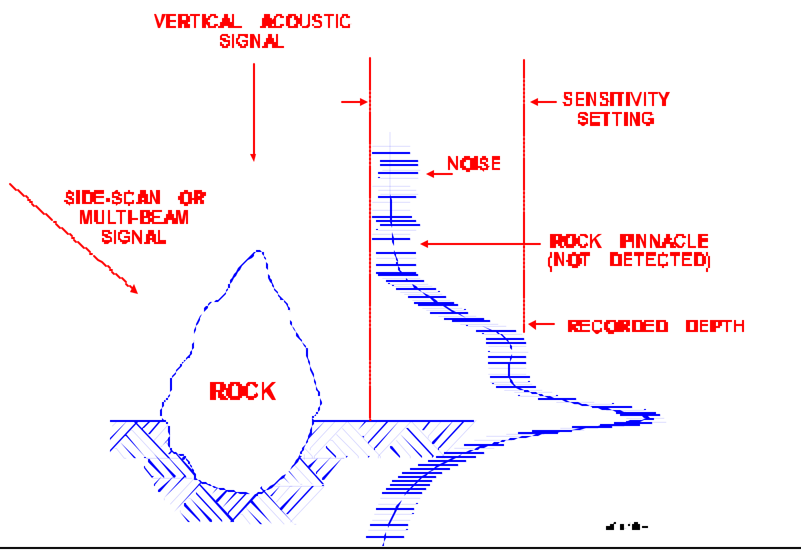
The method is left to the Hydrographer's discretion, but should be used consistently throughout the operation.

h. Side Scan Sonar Data Format and Media. [The Government] will review the side scan data on an Aspen workstation running the Unix version of CARIS SIPS (version 4.2.7, by Universal Systems LTD). Therefore, all side scan data shall be submitted on 4 mm or 8 mm tape, such that, the data can be loaded directly onto the workstation and viewed using CARIS SIPS. The contractor shall include a file listing of each tape, describe the archiving method used, and shall work with the Government to ensure no compatibility problems exist after data submission.

i. Final report of contacts. If a final survey report is required then side scan sonar operations should be included. Identify the manufacturer, model, and serial number of all side scan sonar equipment used. State the vertical beam width used and depression angle, if adjustable. State the frequency used (for example, 100 or 500 kHz). Briefly describe the operations. Include range scales, depths of water, standard line spacing, and point of deployment (bow, stern, or beam). Describe the methods and frequency of confidence checks. The percentage of area coverage (normally 100 or 200) obtained by the swaths should be noted. Where necessary, factors affecting data quality, such as towfish stability, signal interference, degraded returns due to thermoclines, and clutter, should be addressed. A discussion of side scan sonar work devoted exclusively to item investigation is not necessary in this section if the information is included in the Item Investigation Report, or an equivalent form, filed with the survey data. Methods and standards used to examine sonar records should be noted and a brief description of processing procedures should be provided. Two examples of topics include the methods for establishing proof of coverage and the criteria for selecting contacts.

12-5. Channel Obstructions

Once an obstruction is detected from routine hydrographic surveys or other reports, a special survey is performed to determine its precise horizontal and vertical extent. The horizontal detection and mapping can be done by a variety of methods, but perhaps the best technique to help identify an obstruction is side scan sonar coupled with multibeam acoustic swath survey systems. Reciprocal headings past the target can provide average coordinates within 20 ft to 30 ft of the true obstruction location using DGPS code phase positioning. Divers can easily find targets at this accuracy provided a buoy can be deployed this close. Side scan can also locate the diver over the target by observing the trace of the air bubble reflections in the side scan record. The safety of the divers must be ensured with this procedure. Following a positive location, divers usually move the buoy sinker to the target for more precise horizontal positioning by a survey vessel. The new location of the marker buoy may be plumbed over the survey vessel bow and marked with an event from the navigation system. The improved horizontal coordinate is obtained from the vessel heading, magnetic declination, and distance to the bow from the antenna. In the vertical, the pinnacle elevation is most accurately determined by a bar sweep. Further elevations can be obtained by other high-resolution sensing equipment or physical inspection by diver. Targeted obstructions or objects can be removed or cleared by dredging, blasting, or recovery. Stealth-like objects, such as rock shards remaining after blasting, may be difficult to detect with standard, vertically-mounted, single-beam survey echo sounders. The return energy is buried within the noise level and sensitivity adjustments are not capable of distinguishing the object from the noise. See Figure 12-12. Very little of the pinnacled object is capable of reflecting sonic energy back to the transducer. However, there is a greater degree of side reflection if a side scan or multibeam system is used.



- Insufficient Energy Is Returned From Small Pinnacle
- Side-looking Sonar Or Multibeam Will View More Surface Area

Figure 12-12. Acoustic return from a stealth-like object

Multibeam and side scan imagery can be used to enhance the detection of underwater objects. This is illustrated in Figure 12-13 where an object is detected by both the multibeam array and the side scan imagery. The side scan imagery can also be overlayed onto the bathymetric data set, as illustrated in Figure 12-14.

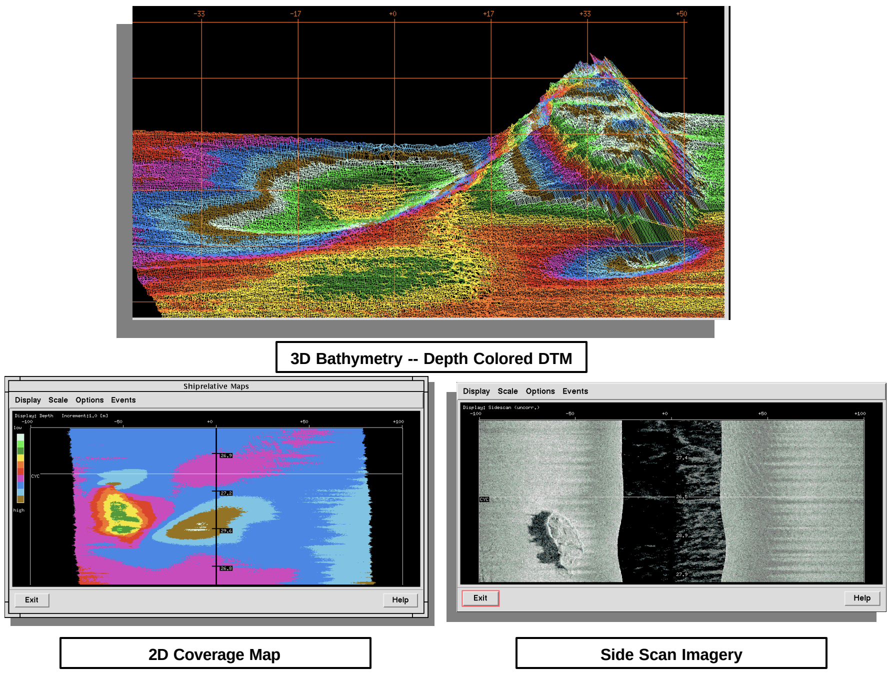


Figure 12-13. Combined Odom Echoscan multibeam and side scan imagery (Odom Hydrographic Systems)

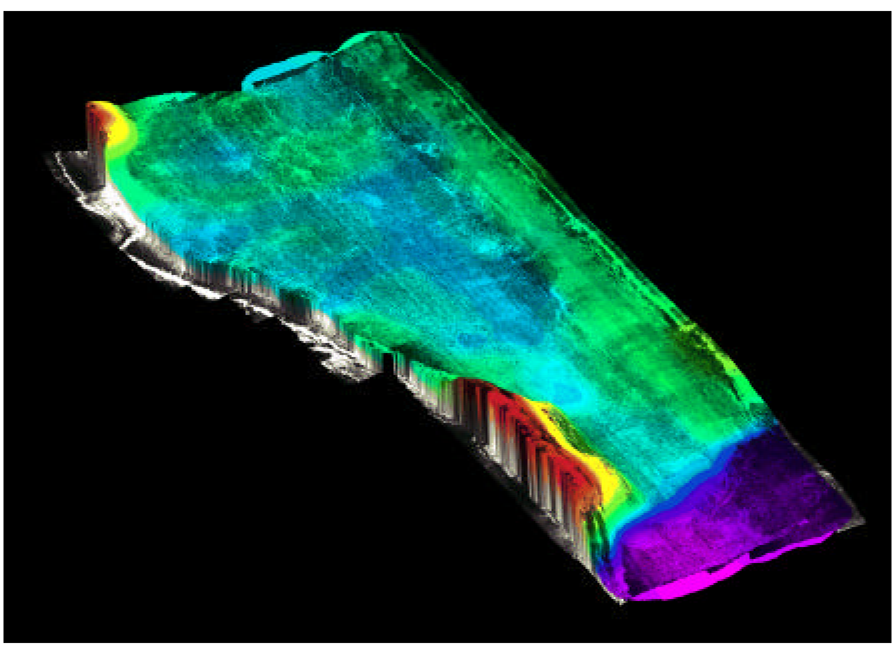


Figure 12-14. 3-D multibeam bathymetry with side scan imagery overlay (Odom Hydrographic Systems)

12-6. Magnetometer Surveys

Detection of ferromagnetic objects near the sea floor is possible through the measurement of magnetic anomalies with a magnetometer. Typical applications include detection of sunken ships, pipelines, communication cables, and other items that could hinder navigation or use of the sea floor.

a. Magnetometers are relatively simple to operate. The sensor head is towed behind the survey vessel at a distance of several boat lengths. If operations are conducted in shallow water, a buoy may be attached to the fish to prevent sinkage and to keep it at a consistent depth. Output on shipboard is real time in the form of a single line scribed on a strip chart. A variation in the line's position is an indication of the nearby presence of ferrous objects.

b. Magnetometers may be operated in towed pairs, termed gradiometers, which will measure the rate of change of magnetic lines, permitting approximate positioning of magnetic features on the bottom. Tow cables should be long enough to place the survey ship at sufficient distance so it will not affect readings.

12-7. Quality Control and Quality Assurance Criteria

Table 12-1. Quality Control and Quality Assurance Criteria for Side Scan Surveys

	PROJECT CLASSIFICATION		
	Navigation & Dredging Support Surveys Bottom Material Classification		Other General Surveys & Studies
	Hard	Soft	(Recommended)
RECOMMENDED COVERAGE	200%	100%	100%
REQUIRED ACOUSTIC HITS	3 minimum	3	3
QA PERFORMANCE TEST	1/day	1/day	1/day

12-8. Mandatory Requirements

The criteria in Table 12-1 are considered mandatory.