2 DATA ACQUISITION

2.1 GENERAL

The instruments utilized for this survey are listed in Table 1, and Figures 2 and 3 illustrate the towing geometry of the various sensors relative to the survey vessel and navigation antenna for the surveys. Pelagos Corporation personnel mobilized and conducted the field survey under the direct supervision of DMG and USGS personnel. A roster of all personnel and their responsibilities is given in Table 2. A summary of the data acquisition lines run is provided in Section 4, data inventory.

Table 1
Summary of Instruments

Navigation Equipment	
Positioning System	Differential Global Positioning System (DGPS) NovAtel 3951R GPSCard receiver DCI (1 meter) RTCM source NovAtel 3951 w/PC RTCM base station (2)
Software	WinFrog integrated navigation system
Computer	Pentium-133 computer
Single Channel Shallow Penetration Survey	
Source	Ferranti ORE Geopulse
Receiver	Ferranti ORE MESH
Recording/Control	Elics Delph 2
Printing	Atlantek 2400R thermal plotter
Note: Same equipment used for data processing	
Multichannel Medium Penetration System (Field)	
Source	GSI 14 cu. In. sleeve air gun
Source Controller	Sureshot
Receiver	24-channel 3.125 m ITI model ST5 array
Digital Recorder	OYO DAS-1A
Plotter	Internal thermal
Multichannel Medium Penetration Near Trace Record (Field)	
Receiver	Ferranti ORE MESH
Digital Recorder	Elics Delph 2
Multichannel Medium Penetration Survey Data Processing	
Processing Hardware	IBM 370
Processing Software	Advance Geophysical ProMAX v 5.01
Plotter	OYO GS 624
Acoustic Core Logging	
Source	ORE model 140/136 3.5-kHz system
Receivers:	a. Reson single channel reference hydrophone b. ORE Model 136
Acquisition Hardware:	Pentium PC w/Caulfield Engineering DSP
Processing Hardware:	Pentium PC
Processing Software:	Caulfield Engineering

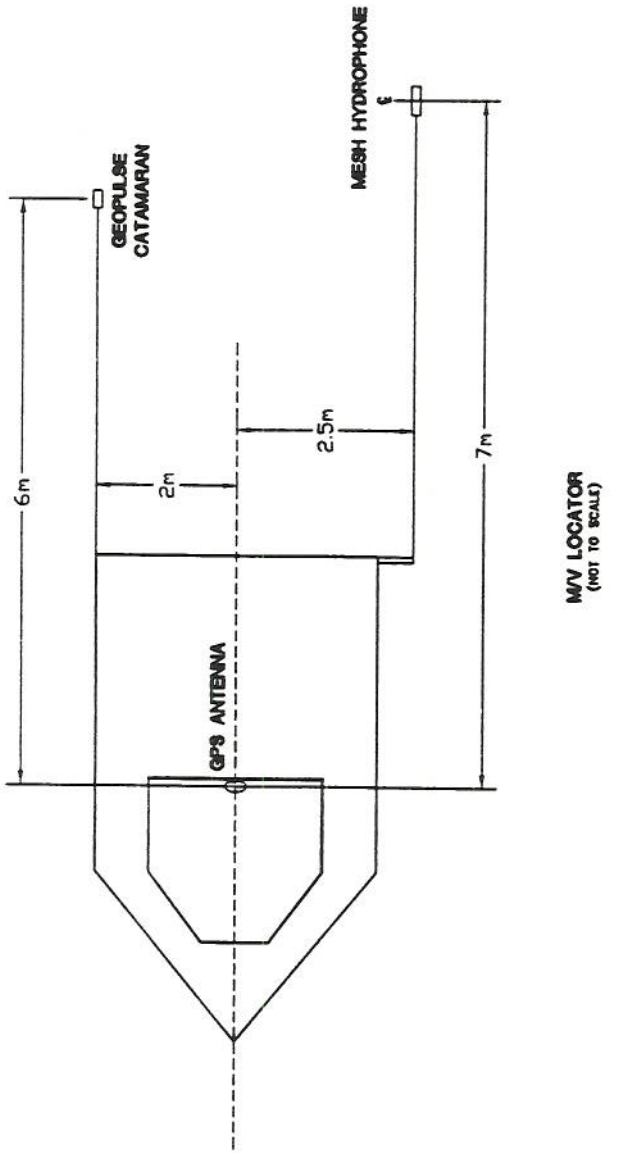

Figure 2. M/V LOCATOR Towing Geometry for Single Channel Very High Resolution System

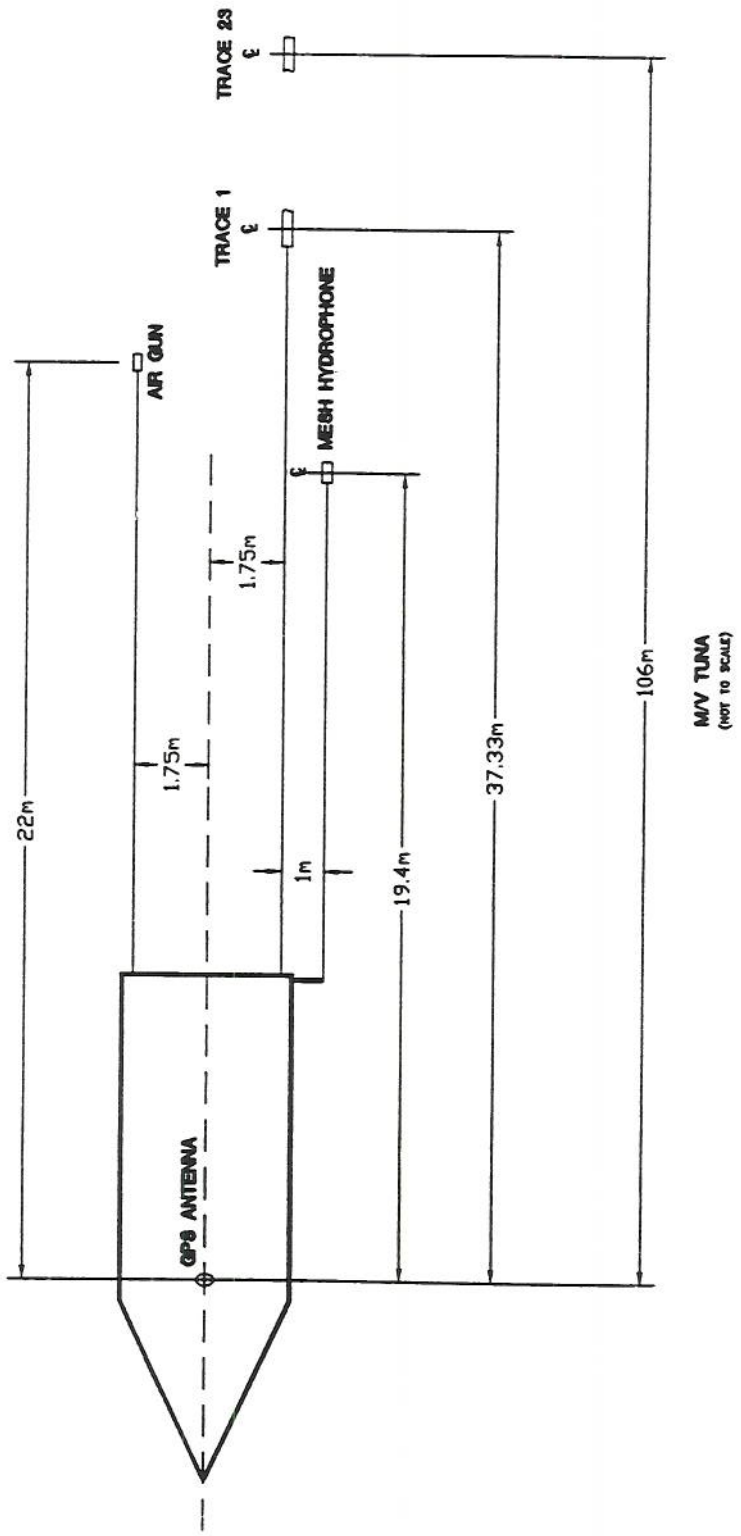

Figure 3. M/V TUNA Towing Geometry for High Resolution Multichannel System

Table 2
List Of Personnel And Responsibilities

Geophysical Field Operations		
Office		
Logistics	F. McFarlane	Pelagos Corporation
Project Manager	J. Wilson	Pelagos Corporation
Field Work		
Party Manager	C. Moody	Pelagos Corporation
Navigator/Surveyor	R. Hansen	Pelagos Corporation
Technician	J. Roth	Pelagos Corporation
Technician	R. Ito	Pelagos Corporation
Client Representative	M. Kennedy	DMG
Client Representative	S. Clarke	USGS
Office Analysis		
Data Processing	R. Hansen	Pelagos Corporation
	C. Moody	Pelagos Corporation
Report	J. Wilson	Pelagos Corporation
	C. Moody	Pelagos Corporation
Drafting/AutoCAD	E. King	Pelagos Corporation
	R. Hansen	Pelagos Corporation
	A. Slaughter	Pelagos Corporation

2.2 VERY HIGH RESOLUTION SHALLOW PENETRATION SURVEY

2.2.1 Vessel

Pelagos used their vessel M/V Locator for the shallow penetration survey. The Locator is a twenty-five-foot-long fiberglass workboat built by Parker. It has been extensively fitted out by Pelagos staff for this type of survey, including permanent antenna and transducer mounts. In accordance with the terms of the contract, the Locator was equipped with all the safety equipment and signals necessary for the number of personnel and type of operations.

2.2.2 Navigation and Positioning

Prior to commencement of survey operations, Pelagos surveyors established two base stations on the roofs of warehouses on San Diego Bay. Accurate control points were established by means of standard GPS translocation techniques. Base stations consisting of a NovAtel 3951 GPSCard installed in a 486 PC computer and a UHF transmitter were installed at both the known locations and configured to transmit RTCM format corrections to the survey vessel every two seconds.

Survey navigation on-board the survey vessel was performed using Pelagos' WinFrog, a Windows-based integrated navigation system developed specifically for surveys of this type. The WinFrog software provided real-time vessel tracking, data logging and a variety of display functions, including line-tracking and real-time QA/QC displays. The vessel operator was provided with a course-steering monitor display to ensure accurate following of the predetermined survey lines. The WinFrog system updated and displayed vessel speed, direction, distance-off-line, event number and other relevant information every second. All raw navigation data were recorded on disk as often as four times per second.

During the course of the survey, position fixes were taken along preplotted lines. Preplots of vessel tracks were used by the navigator to direct the vessel along the desired course and to insure compliance with survey specifications. All raw data from the GPS receiver and the digital echo sounder were time-tagged and recorded directly on disk. At every position fix, both raw and processed data were recorded and printed on the paper recording charts. Position fixes were marked every 50 meters along the predetermined survey lines.

Pelagos employed differential GPS (DGPS) techniques to fulfill the positioning requirements of the survey. A NovAtel 3951R GPSCard differential GPS receiver, installed in the on-board WinFrog integrated navigation computer, was used for all positioning. Pseudo-range corrections were delivered to the WinFrog system from two UHF receivers collecting information from the two shore stations established by Pelagos (see above) and a DCI commercial RTCM receiver. In addition to quality control and other relevant information, these units provide pseudo-range corrections used to correct the information delivered by the NovAtel card. In this configuration, five solutions for the vessel were calculated and logged as follows:

1. Primary

One operator-selected set of RTCM differential corrections were supplied to the NovAtel card which, in turn, supplied a position to the WinFrog system that was used to derive the vessel locations used during the survey. This position was also used to calculate the 50-meter-spaced event marks.

2. Secondary

WinFrog used the pseudo-ranges from the NovAtel card and all three sources of differential corrections to calculate three positions based upon the respective corrections. These three positions were used to create a fourth position based upon a weighted average of the individual positions. The system then calculated the residuals of the individual solutions to the average position, thus allowing the operator to judge the system performance quickly.

2.2.3 Source

A "boomer" type source consisting of a ORE Model 5420A power supply, a Model 5813A plate and a model 5812A catamaran were used to provide the source pulse for the Shallow Penetration profiling system. The ORE power supply system generates a high-energy electrical pulse for the plate which is towed behind the vessel, suspended from the catamaran. The 220 VAC supply power is converted to 4,000 VDC by the power transformer and high-voltage diode bridge in the power supply module. This energy is stored in a bank of high-voltage capacitors. The unit can be configured for various levels of output power ranging from 105 joules to 455 joules. An isolated trigger pulse from the (Delph 2) recording system is used to initiate the discharge of the stored energy into the towed array. After the stored energy has been dumped into the array in a very short time (approx. 1 millisecond), the energy flow is halted and the storage capacitors are recharged prior to the next shot. The energy from the power source is discharged into a coil in the boomer plate. The resulting magnetic field violently repels a plate suspended from a diaphragm close to the coil, creating an acoustic pulse that radiates from the catamaran. Energy traveling downward within a 15-degree cone about the vertical is used for the reflection profile.

2.2.4 Receiver

A combination of a Delph 2 acquisition system and a Benthos, model MESH, hydrophone were used to receive and record the sub-bottom profile data. The system consisted of a Pentium PC computer, custom hardware and software for acquisition, a MESH single channel hydrophone and a custom Pelagos power supply. This receiver package may be used with any high resolution source and is capable of recording data from 4 Hz to 10 kHz.

The Delph 2 system provided all system timing and digital acquisition of the resulting profile data. Data reflected from the seafloor and sub-seafloor features were received by the pressure sensitive elements in the hydrophone and pre-amplified for transmission through the towing cable. The Delph 2 system filtered, digitized and stored, the incoming analog signal. In addition it provided signal processing and display functions. It is important to note that the storage of data in digital form occurred prior to the processing functions, such that true representations of the analog signals entering the system were stored. The incoming analog signal was passed through a pre-amplifier of operator adjustable gain, and an anti-aliasing filter based on the final sample rate to the digitizing circuitry. The Delph 2 used 24 bit sigma-delta digitizing techniques utilizing a primary sample rate of 1 MHz to produce the digital data. Once the primary task of recording and storing the data had been accomplished, the Delph system provided processing, display and "hard copy" of the profile data. Delph 2 provides a multitude of filtering, amplifying and other data enhancement techniques and a complete description of the various options is beyond the scope of this brief overview. Results of the processing and the parameters used were displayed on the system CRT in the form of a "waterfall". The same data were available in similar form on a 24-inch-wide thermal plotter. Navigation data supplied by the WinFrog navigation system via a RS-

232 serial link were recorded with the profile data. Navigation fixes were displayed on both the CRT and plotter displays as dark lines across the record with fix number and time annotated.

2.3 HIGH RESOLUTION MULTICHANNEL SURVEY

2.3.1 Vessel

Pelagos sub-contracted the provision of the survey vessel to San Diego Boat Charters who provided the vessel M/V Tuna for this portion of the survey. The sub-contract included a licensed Captain, deck hand and a "chase" vessel, needed to patrol the immediate vicinity to prevent other vessels running over the hydrophone array. The Tuna is a fifty-foot-long aluminum vessel that has been used many times by Pelagos for this type of operation.

2.3.2 Navigation and Positioning

Navigation hardware both onshore and offshore was the same as that used for the shallow penetration survey detailed in section 2.2.1. above. However, due to the requirement to accurately shoot 3.125-meter shots, Pelagos employed a multi-threaded, multi-tasking version of WinFrog, running under Windows NT to control shot timing and provide for data recording. This version of WinFrog took advantage of the recently available technologies to dedicate one thread to the timing of shots, thus producing very accurate shot intervals based upon distance traveled.

2.3.3 Source

Pelagos provided a fourteen-cubic-inch "sleeve" type airgun as the source for this portion of the survey. Gun timing was provided by a Sureshot system that ensured that the guns fired fifty milliseconds after the shot pulse provided by the navigation system. Shots were timed to an accuracy of less than one millisecond or were rejected. Air for the gun was provided by an American Compressor Co. compressor of 35 SCFM capacity, which was provided under sub-contract.

The Sureshot timer provided an energizing pulse to the firing solenoid of the airgun via the firing lines. Actuation of the firing solenoid causes the airgun to release the air stored in its fourteen cubic inch storage chamber via the sleeve opening. The resulting "bubble" of air expands and contracts rapidly, resulting in a short pulse of acoustic energy that spreads equally in all directions. The downward traveling energy, including that which is reflected from the sea surface, is used for the profile.

2.3.4 Receiver

The recording system was provided by CALTRANS through DMG and consisted of a modern digital recording system and a state-of-the-art kerosene-free hydrophone array. The hydrophone array comprises of twenty-four single-element piezo-electric hydrophones spaced at equal intervals of 3.125 meters. The hydrophone elements

generate a voltage proportional to the pressure applied to them which was transmitted in analog form, via twenty-four twisted wire pairs, to the vessel recording room for processing and storage by the OYO recording system. The OYO recording system processed the data from each channel in the same manner via a sequencing multiplexer. After application of a simple low pass filter to remove any frequencies capable of causing aliasing in the DSP, the signal was converted to digital form by means of a sigma-delta digitizer operating at a one megahertz frequency. Data were temporarily stored in memory, rearranged into SEGD format and transferred to the systems internal 4mm DAT tape drive for more permanent storage. In addition, the data were further filtered and digitally amplified for display on the systems LCD display so that the operator could judge the systems' operation and data quality.

For purposes of quality control, a combination of Delph2 and MESH were also used to collect data during the medium penetration survey. This system worked in the same manner as detailed in section 2.2.4 above to provide a "near trace" equivalent record. As the OYO system does not provide this type of record in "real time", this display was used in the field to assess the shot-to-shot performance of the system. It also proved to be very useful in determining the location of additional lines to be run.

2.4 ACOUSTIC CORE LOG SURVEY

2.4.1 Vessel

The M/V Locator was used for this portion of the survey efforts and is described in section 2.2.1 above.

2.4.2 Navigation and Positioning

The navigation systems used were the same as for the shallow penetration survey described in section 2.2.2 above.

2.4.3 Sources

Two source were used for this survey. The secondary source was the Geopulse system as described in section 2.2.3 above, which was used for the final runs on each of the lines. The majority of the acquisition was conducted using an ORE profiling source consisting of a piezo-electric transducer array and a model 140 transceiver. The transducer and transceiver form a tuned circuit that produce a very narrow bandwidth pulse. For this survey the system was tuned to frequencies of three and a half and seven kilohertz for the primary and secondary runs respectively.

2.4.4 Receiver

In addition to requiring accurately calibrated instrumentation amplifiers, the Caulfield acoustic core logging technique require that the response of the receivers be accurately known. In order to provide continuity, Pelagos elected to provide their own calibration hydrophone that was first compared to Caulfield's calibration hydrophone. The

calibration hydrophone was then used to determine the responses of the piezo-electric transducer array and the MESH hydrophone prior to their deployment.

Regardless of which receiver was used, the signals generated were passed via Pelagos' fixed gain step amplifier to the PC computer that acquired the data. Data were acquired using a Caulfield digital signal processing board. Data were passed through a low-pass filter to remove aliasing components and digitized using sigma-delta techniques. These data were then stored in a proprietary format on the system's hard disk. In addition, the data were displayed in color on the system's CRT and made available for plotting on a color plotter. At the end of each day of surveying the data were transferred to a magneto-optical disk and Exabyte tape for more permanent storage.