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M E M O R A N D U M

DATE: June 8, 1988

TO: Dr. Arthur E. Maxwell

FROM: Yosio Nakamura YM

SUBJECT: Cruise Report, R/V *Pelican* Cruise No. 88-27

R/V *Pelican* Cruise No. 88-27 took place from May 25 through 31, 1988, in the northern Gulf of Mexico. The purpose of the cruise was to collect large-offset seismic data from air-gun sources using ocean-bottom seismographs. The shooting was done from GECO *My* using an array of air guns as they conducted an industry-standard multichannel reflection survey. Our participation in the survey was strictly passive; i.e., we recorded data while GECO *My* performed a regular reflection survey without regard to our presence.

The cruise was a part of a seismic study in the northern Gulf of Mexico by the Louisiana State University, Department of Geology, with Drs. Rex Pilger and Vindell Hsu as co-principal investigators. R/V *Pelican* is operated by the Louisiana Universities Marine Consortium (LUMCON), based in Cocodrie, Louisiana. The scientific party consisted of the following: Yosio Nakamura (UTIG, Chief Scientist), Donald Stevenson (Louisiana Geological Survey), Paul MacPherson (UTIG) and Phillip Roper (UTIG).

Relevant technical details of the experiment are as follows:

Seismic line: from 29°12'N, 92°54'W to 25°48'N, 93°12'W; 378 km

Signal source: GECO point source array VI consisting of 6 air-gun subarrays of 1254 in^3 each (500, 290, 195, 125, 90 and 54 in^3), total 7524 in^3; 50 m shot spacing

Detectors: 4 UTIG OBSs, each with a 4.5 Hz vertical geophone

Recording: 20.4 second recording every minute for approximately 20 hours each OBS

OBS locations: Table 1

Site	OBS	Deployment Location		Recovery Location		Depth, m
A	81-2	28°44.88'N	92°56.62'W	28°44.95'N	92°57.04'W	32
B'	81-3	28°02.09'N	93°00.13'W	28°02.24'N	93°00.48'W	94
C"	81-4	27°07.95'N	93°05.18'W	27°08.19'N	93°05.56'W	~1200
E	83-4	27°32.32'N	93°02.96'W	27°32.48'N	93°03.19'W	673

Locations are from the display on the Northstar 800 Loran-C unit on board. The depths are from the readings on the Furuno FE-881 echo sounder plus 3 m added for the depth of transducer, except for site C" depth, which is estimated from a navigation chart.

This was the first time we ever attempted to record seismic signals from air-gun array sources during an industrial-type multichannel reflection survey. This was in contrast to all of our earlier air-gun/OBS surveys, where shots were fired primarily for the recording by OBSs, with the multichannel reflection recording as an ancillary operation.

Because of the subordinate nature of the OBS experiment, we did encounter many difficulties not common with our earlier studies. The most difficult was to manage the limited time available for the OBS operation when faced with the highly unpredictable shooting schedule. Although this was more of less expected, a delay of more than 50 hours between the earliest predicted time of shooting and the actual commencement of shooting resulted in long idle time on the OBS ship with limited time left for the actual operation.

Despite these difficulties, we did deploy four OBSs, one more than originally planned, and collected excellent seismic data on three of them. An unusual equipment malfunction (see below) on the fourth OBS prevented acquisition of data on that unit.

The cruise generally went very smoothly. A part of the credit for the success of the cruise should go to the competent crew of R/V *Pelican* under Bob Cutting, the captain of the ship.

In the following chronological narrative, all times are local (CDT) and all coordinates are from the Northstar 800 Loran-C unit on board R/V *Pelican*.

Wednesday, May 25

17:00 Sailed from Cenac refueling dock in Houma, La. The latest message from GECO indicated that the earliest possible start of shooting would be noon Thursday.

18:30 Safely instruction and fire drill.

Thursday, May 26

09:40 Arrived at Phillips platform EC-195 at 28°45.63'N, 92°48.47'W, 8 miles east of site A. Waited for further word from GECO *My*.

11:20 Radio contact with GECO *My* (Wiederspahn). Test shots expected at around 18:00.

14:30 Radio contact with GECO *My*. Expected to start test shots in about 4 hours. Best estimate for start of line between 22:00 and 04:00.

18:30 Radio contact with GECO *My*. Expected shooting start between 02:00 and 03:00; further delay possible.

Friday, May 27

03:00 Radio contact with GECO *My*. Expected time of start between 10:00 and 12:00.

08:00 Radio contact with GECO *My*. Expected shooting start around dinner time (18:00?).

09:20 Moved to platform APC-EC-222A at 28°39.12'N, 92°47.75'W.

12:00 Radio contact with GECO *My*. Earliest estimated start of shooting around 21:00. Since it was clear that we would not have time to deploy OBSs unless we had an additional day of ship time, we requested it through LUMCON, and obtained a permission. (This was the second request for an additional ship time. The first request was made and granted on the day of sailing upon discovering that not enough ship time had been allocated to do what we planned even if there were no delays.)

16:00 Radio contact with GECO *My*. Estimated start of line around midnight.

19:00 Moved to platform SONAT EC-232-D at 28°37.17'N, 92°46.48'W.

19:05 Radio contact with GECO *My*. No change of status.

21:00 Radio contact with GECO *My*. Further delay possible.

21:40 Moved to a buoy near platform APC-EC-222-A at 28°39.08'N, 92°48.14'W.

Saturday, May 28

00:00 Radio contact with GECO *My*. Earliest shooting in 6 to 8 hours.

04:00 Radio contact with GECO *My*. Expected to start shooting in 7 to 8 hours.

08:00 Radio contact with GECO *My*. Expected shooting start between 15:00 and 15:30.

12:00 Radio contact with GECO *My*. All systems operational; GECO *My* expected to be at the beginning of the line at 15:00 or shortly thereafter.

12:56:05 Deployed OBS #1 at site A.

15:16 GECO *My* started the line.

18:08:12 Deployed OBS #2 at site B'.

18:45 Because of the strong head wind, it was apparent that we would not be able to go back to site A in time for recovery of OBS #1 if we went down to site C' for deployment of OBS #3 as planned. Therefore, it was decided that we deploy OBS #3 at a site 15 km north of the planned site.

Sunday, May 29

01:00 Cali from GECO *My*. Having problems with air guns and plan to shut down guns for 2 hours starting 02:00. Because the cruise had already been extended two days beyond what the LSU people originally planned for and because of dwindling food supply on board, we decided not to request any additional ship time. Since the available ship time was now very severely limited, we also decided not to delay the recording on the remaining OBSs to accommodate the shooting delay.

01:38:40 Deployed OBS #3 at site C".

04:36:40 Deployed OBS #4 (spare OBS) at site E.

12:49 Returned to about 1 mile of site A. OBS #1 sighted.

12:56 OBS #1 recovered on board. Good data on all 4 tracks.

18:58 OBS #2 recovered on board. Good data on all 4 tracks.

23:00 OBS #4 recovered on board. Good data on all 4 tracks.

Monday, May 30

03:06 OBS #3 recovered on board. No data on tape. It was discovered that two of the circuit boards (data acquisition and memory) had come off the baseboard connectors. This unusual failure probably happened at deployment because of the rough sea.

Tuesday, May 31

03:45 Returned to Cocodrie, La.

05:12 GECO *My* completed the line.

The cruise has taught us many lessons on using commercial reflection shooting for OBS observation. First of all, the mode of shooting, with many unpredictable delays and interruptions, adds a significant amount of time both to the required coverage in time for each OBS and to the total time required for the OBS operation. The lengthened time requirement for each OBS cannot be handled well with instruments of limited data storage capacity such as our current OBS. We clearly need a higher data storage capacity to overcome this difficulty.

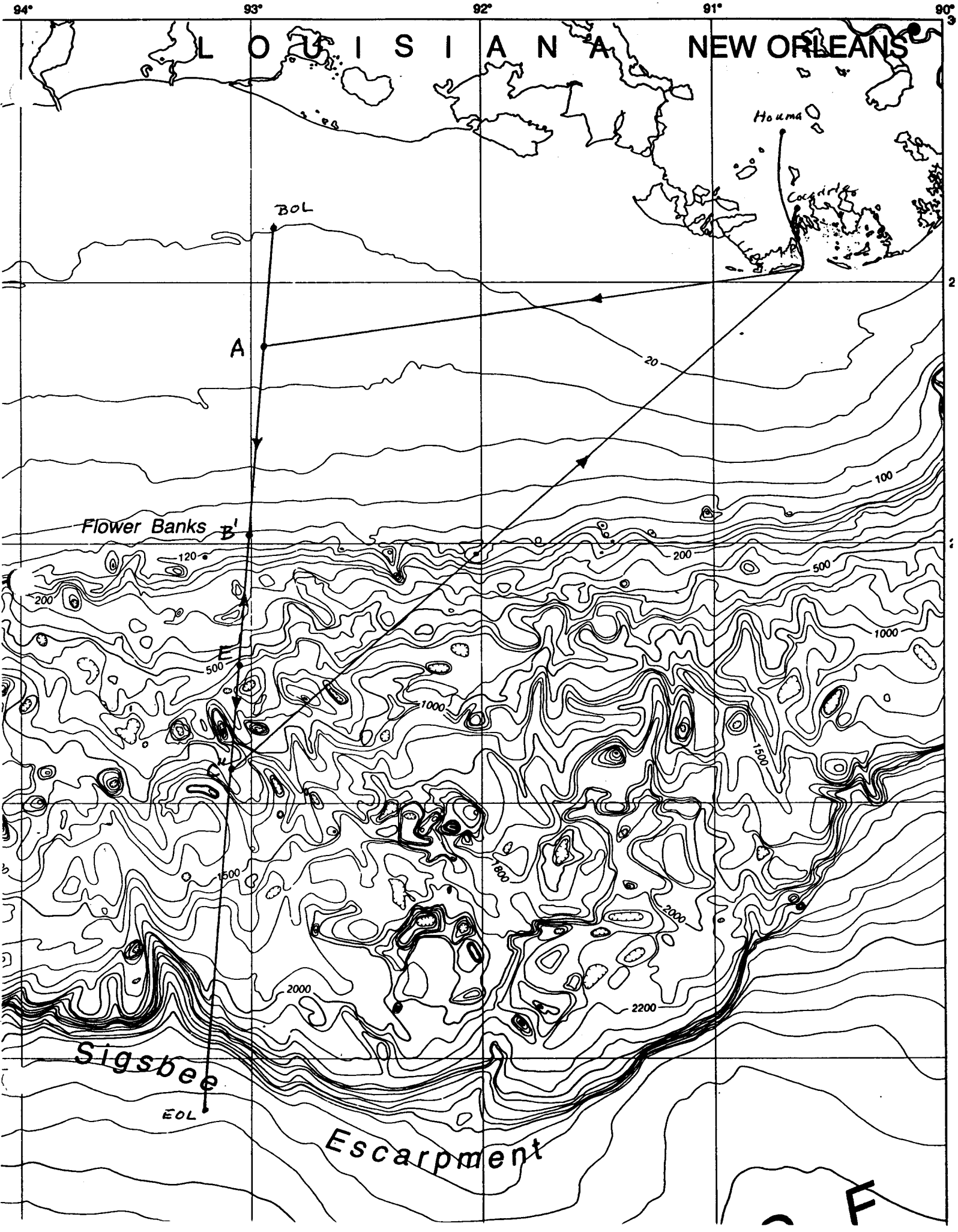
The extended time requirement for the entire operation increases the OBS ship cost. We spent nearly 4 days, exclusive of the transit to and from the area, to deploy and retrieve 4 OBSs along a 180 km spread, and we had to retrieve the OBSs long time before the shooting was actually completed. This was about twice the time needed if we had control over shooting. If we are to use a ship to deploy and retrieve OBSs, we must reserve sufficient time to cover all possible delays. An alternative would be to use a helicopter based on the

shooting ship to handle the OBS deployment and possibly recovery too. This might be more economical than using a ship to do the job.

Another problem caused by the unpredictable interruption of shooting is the difficulty in scheduling the recovery ship to be on site at a given time. With instruments that release on preset times such as ours, the times of recovery add very severe constraints to the scheduling of ship when shooting is unpredictable. Acoustic release would be an extremely useful alternative in this situation.

R/V *Pelican* was nearly ideal vessel for OBS deployment and recovery. She has ample lab and deck spaces for the operation. Having a bow thruster and a skillful crew very significantly reduced the time we spent in retrieving OBSs. The recovery never took more than a few minutes. The time saved in quick recovery of OBSs helped to offset the time lost in transit, which took longer than expected. The only deficiency of the ship was the limited depth range of the echo sounder on board. We could not operate it beyond about 700 m of water depth.

cc: Dr. Vindell Hsu - LSU
Mr. Steve Rabalais - LUMCON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Escarpment
EOL

Summary of Navigation Data Reduction
LSU Line B OBS Experiment

Data Sets

Navigation data set A: Post-cruise processed navigation data on tape (Tape No. 35, dated 8/3/88) provided by GECO and obtained through LSU. The tape contains (a) TRANSIT satellite based latitude and longitude in 0.1" precision with a 138 m setback added for the source offset, (b) UTM easting and northing in feet based on the Clarke 1866 spheroid, (c) bathymetric depth in m, and (d) approximate shot time, of each shot.

Navigation data set B: Second navigation data tape (Tape No. NAV438, dated 9/12/88) provided by GECO and received through LSU. This tape contains shot-point coordinates derived from Loran-C. [This data set was not used.]

Navigation data set C: Print-out listing of Loran-C time differences (TD's) computed for each shot in 0.0001 μs precision as received from GECO on 9/22/88. No setback has been added.

Navigation data set D: Loran-C TD's and coordinates read on Northstar 800 on board *R/V Pelican* at each OBS deployment.

Navigation data set E: Coordinates based on Loran-C read on Furuno LC-80 on board *R/V Pelican* at each OBS recovery.

Shot-time data: GOES satellite clock time of the shot-time signal provided by GECO on board *GECO My* at each shot and recorded on a Macintosh.

Near-OBS first-arrival data: Times and polarities of first arrivals from near-OBS shots as recorded on OBS's.

OBS Location

Objective: To locate each OBS in the same coordinate reference used for the navigation data set A(a) above.

Deployment location: From the navigation data sets A(a) and C above, estimate the Loran-C TD correction factors (ASF's) to be applied before computing the latitude and longitude from Loran-C TD's. Apply these corrections to the observed TD's of navigation data set D above and compute the coordinates.

Recovery location: From a set of Loran-C TD's and coordinates as read on Furuno LC-80 before the shooting, it was determined that Furuno LC-80 uses TD values for slave stations w and x for the chain 7980 with no additional corrections to compute the coordinates. The procedure, then, is to estimate the TD's for stations w and x from the navigation data set E above, apply the ASF corrections as determined above, and recompute the coordinates.

Location from seismic data: The OBS location can be estimated from the times of first arrivals from near-OBS shots. This is done by a linearized least-squares inversion of a set of arrival times to minimize the sum of squared deviations (observed - theoretical) of arrival times to determine simultaneously the OBS coordinates, the wave velocity and the shot-time delay (or clock correction).

Results:

OBS 1	Deployment:	28°44'39.9" N, 92°56'33.3" W
	Recovery:	28°44'37.4" N, 92°56'40.8" W
	Computed:	28°44'37.8" N, 92°56'30.7" W *
		28°44'37.4" N, 92°56'24.3" W
OBS 2	Deployment:	28°02'05.3" N, 93°00'01.2" W *
	Recovery:	28°02'06.4" N, 93°00'17.1" W
	Computed:	28°02'05.3" N, 93°00'01.2" W
OBS 4	Deployment:	27°32'18.4" N, 93°02'59.4" W *
	Recovery:	27°32'21.2" N, 93°02'57.6" W
	Computed:	27°32'23.5" N, 93°03'19.9" W
		27°32'19.9" N, 93°02'18.7" W

Generally there are two solutions to the computed location when only single-component data are available.

An asterisk indicates the location used for the subsequent computations.

For OBS 1, one of the computed locations is clearly the best one to use because excellent water-wave arrival data from close shots are available. The first of the two computed locations is chosen because it is closer to the deployment location (less than 100 m) than the other (more than 250 m).

For OBS's 2 and 4, the computed locations are not accurate because the shooting stopped about 1.4 km and 2.3 km, respectively, short of reaching the instrument and no closer shots were recorded. For each of these instruments, the deployment location is the better choice.

The recovery location was 220 m, 140 m, and 100 m from the deployment locations of OBS's 1, 2, and 4, respectively.

Shot Time Delay

The water-wave arrival times indicate that there was a delay of 72 ms from the shot time as recorded on board to the actual time of each shot.

Distance and Azimuth of Shots from OBS

The shot-to-OBS distances and the azimuths of shots as seen from each OBS have been computed from the OBS location coordinates as given above and the shot coordinates as given in the navigation data set A(a) above. The reference spheroid used is the WGS-72.

Description of OBS SEG-Y Tape SLSU

The tape SLSU contains the OBS data from LSU Line B in SEG-Y format. There are three files on the tape for OBS 1, 2, and 4.

File	1	2	3
OBS	1	2	4
No. Traces	1712	1291	1420
Shots	8558-6021	7892-5993	6873-4910
Time, GMT	149/20:17-150/15:14	150/00:00-150/15:23	150/10:30-151/01:35
Distance, km	50.8(N)-76.0(S)	96.3(N)-1.4(N)	100.5(N)-2.3(N)

Only those records from the original OBS data tape for which shots of known location occurred within ±20 s of the reference time are included, where the reference time is defined as the recording start time plus the smaller of the distance divided by 6 km/s and 12 s. Since for each record there usually were two shots that satisfied this criterion when shots were fired approximately every 20 s, there usually are two traces of identical data except for different delay times in the trace header referring to two consecutive shots.

Data Gaps

OBS	Shots	Time	Distance, km	Reason
1	7927-7924	149/23:48	19.2-19.1	not recorded
	7767-7758	150/00:44-00:46	11.2-10.8	tape rewind
	6953-6942	150/05:33-05:35	29.5-29.9	tape rewind
2	7092-7083	150/04:43-04:45	55.4-55.6	tape rewind
	6178-6169	150/14:22-14:24	10.6-10.2	tape rewind
4	6662-6659	150/11:39	89.9	not recorded
	5812-5803	150/20:35-20:37	47.5-47.2	tape rewind
	5651-5637	150/21:27-21:30	39.5-38.9	bad navigation data
	5040-5034	151/00:51-00:52	8.8-8.6	tape rewind

Data Overlaps

OBS	Shots	Time	Distance, km	Remarks
1	6920-6892	150/05:45-05:55 150/10:14-10:23	31.2-32.6	
	6881-6858	150/06:00-06:07 150/10:28-10:34	33.2-34.2	tape rewind from 10:24 to 10:27
2	6920-6858	150/05-45-06:07 150/10:14-10:34	44.6-47.6	
4	6047-5993	150/15:06-15:23 150/19:18-19:35	56.6-59.3	

Trace Header Information

Bytes	Data Description	Unit
1-4, 5-8	Trace sequence number	
9-12	Field record No.[1]	
13-16	Component[2]	
17-20	Shot number	
37-40	Distance from source to OBS	m
41-44	OBS depth	-m
49-52	Source depth	m
61-64	Water depth at source	m
65-68	Water depth at OBS	m
73-76	Source longitude	0.1"
77-80	Source latitude	0.1"
81-84	OBS longitude	0.1"
85-88	OBS latitude	0.1"
109-110	Delay recording time	ms
115-116	Number of samples	
117-118	sample interval	μs
157-158	Year of recording	
159-160	Day or recording	
161-162	Hour of recording	
163-164	Minute of recording start	
165-166	Second of recording start	
167-168	Millisecond of recording start[3]	
181-184	Shot azimuth[3,4]	0.01°

[1] $\log_2$(OBS No.)x10000 + Record No.x5 +1 for each additional shot for the same record.
[2] 1 = horizontal 1 or radial; 2 = horizontal 2 or tangential; 3 = vertical
[3] Non-standard entry
[4] Azimuthal angle of shot location as seen from OBS, measured clockwise from north