

U.S. DEPARTMENT OF THE INTERIOR  
U.S. GEOLOGICAL SURVEY

ONSHORE-OFFSHORE WIDE-ANGLE SEISMIC RECORDINGS FROM CENTRAL  
OREGON: THE OCEAN BOTTOM SEISMOMETER DATA

By

Anne M. Trehu and Yosio Nakamura

Open-File Report 93-317



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Menlo Park, California

1993

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By

Anne M. Trehu<sup>1</sup> and Yosio Nakamura<sup>2</sup>

Open-File Report 93-317

<sup>1</sup>College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR 97331

<sup>2</sup>Institute for Geophysics, University of Texas, Austin, TX 78759

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## **ABSTRACT**

The University of Texas and Oregon State University deployed eight ocean bottom seismometers (OBS) during marine seismic reflection profiling of the central Oregon margin conducted in September 1989 (figure 1). The OBS's were deployed along the reflection profile to record the shots from a tuned 128 liter (7800 cu. in.) airgun array towed by a commercial seismic ship. This report provides the locations of the OBS's, discusses the preliminary processing procedures, and illustrates the recorded wide-angle seismic data.

## **INTRODUCTION AND OBJECTIVES**

In September, 1989, investigators from Oregon State University (OSU), University of Texas Institute for Geophysics (UTIG), and the U.S. Geological Survey (USGS) collaborated to collect a seismic reflection profile and wide-angle seismic recordings along the reflection line in central, coastal Oregon (Trehu et al., 1990; Lin and Trehu, 1991). This study was followed in 1991 by an onshore seismic refraction profile that overlapped and extended the 1989 profile east to the Cascade foothills. Results from an inversion of the travel times recorded during the 1989 and 1991 experiments were presented by Trehu et al. (1992a,b).

In the following we report on wide-angle data obtained by a deployment of University of Texas at Austin ocean-bottom seismometers during the acquisition of the seismic reflection profile. Complementary data recorded onshore are presented in companion Open-file Reports by Brocher et al. (1993) and Trehu and Azevedo (1993).

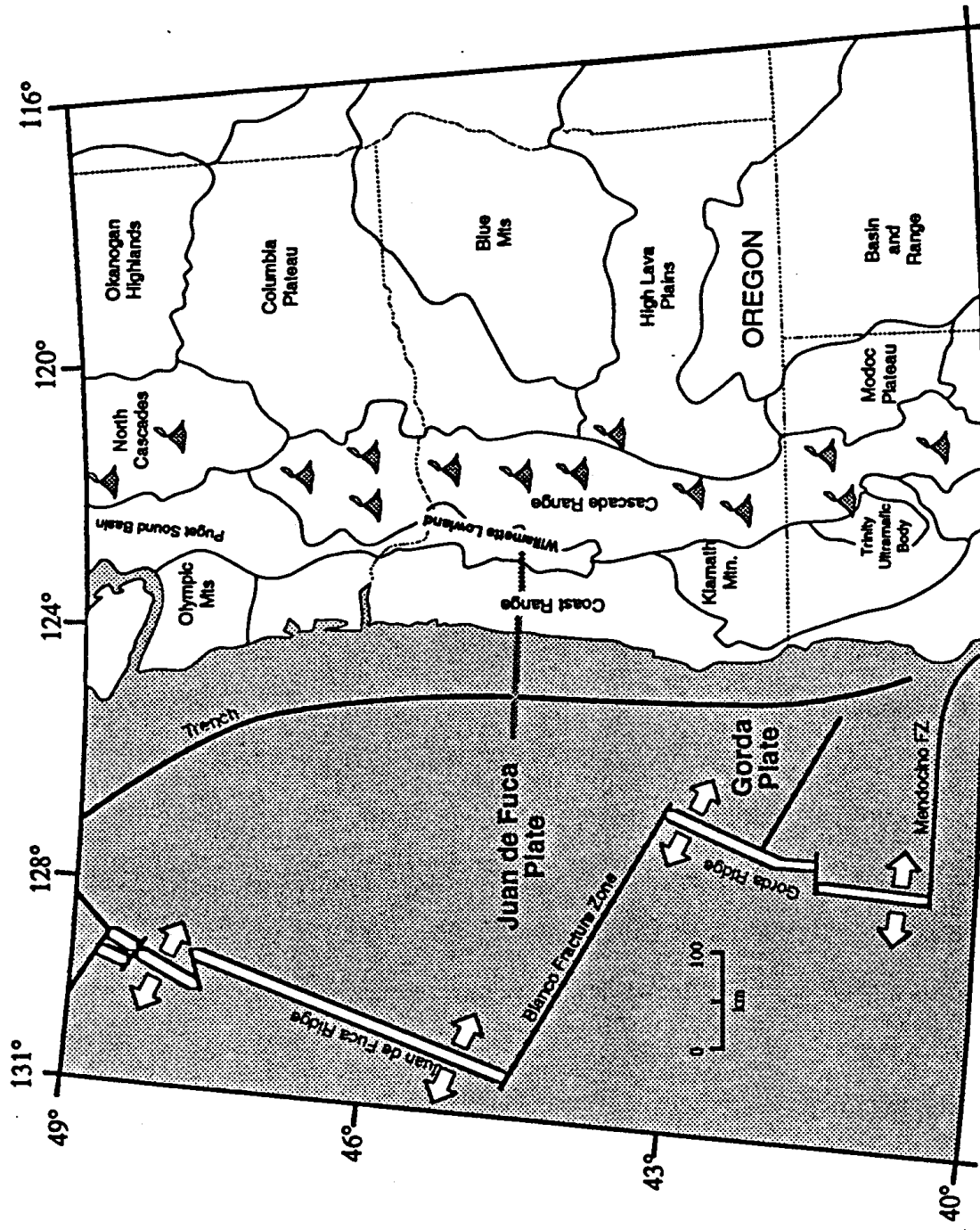


Figure 1. Location map of Pacific Northwest showing the study area and position of 1989 onshore-offshore seismic experiment in central Oregon as a heavy gray line.

## DATA ACQUISITION AND PROCESSING

The tuned airgun array used for marine reflection profiling, which had a total volume of 128 liters (7800 cu. in.), also served as a seismic source for ocean bottom seismometers positioned along the profile on the continental shelf, slope and adjacent abyssal plain (fig. 2a). The locations and origin times of all shot points are listed in Appendix A. A simplified line drawing of the unmigrated seismic reflection profile is shown in figure 2b (Lin and Trehu, 1991; Trehu, A., and G. Lin, A deep crustal seismic profile across the central Oregon continental margin; manuscript in preparation).

The OBS's were prepared for deployment in a laboratory at the Hatfield Marine Science Center in Newport, Oregon. When notice was received that the shooting ship was approaching the beginning of the line, eight OBS's were loaded onto a 72-foot-long fishing boat chartered for the occasion (the F/V Olympic) and deployed along the profile prior to the start of shooting. The large gap in spacing between sites 2 and 3 resulted from the need to avoid water depths in which fishermen were actively dragging for shrimp. The gap in spacing between 5 and 8 results from failure of instrument 6, which was deployed at the base of the slope, just seaward of the deformation front.

Six of the OBS's were of the type described in detail by Nakamura et al. (1987). The data storage capacity of these instruments is 5 MBytes, which is insufficient to record continuously for the time it takes to shoot a 120 km long seismic reflection profile. This presents a significant logistic challenge since it requires that deployment and shooting ships be very well synchronized and that the shooting ship shoot at equal time intervals rather than equal distance intervals in order to maximize the efficiency of data storage. Moreover, only every other shot (ie. one minute, or approximately 132 meter, intervals) could be recorded. One of these instruments, located at the base of the continental slope (OBS 6), failed to record data; the other five each recorded the entire profile. One instrument (OBS 4) had a faulty memory, resulting in intermittent distortion of data.

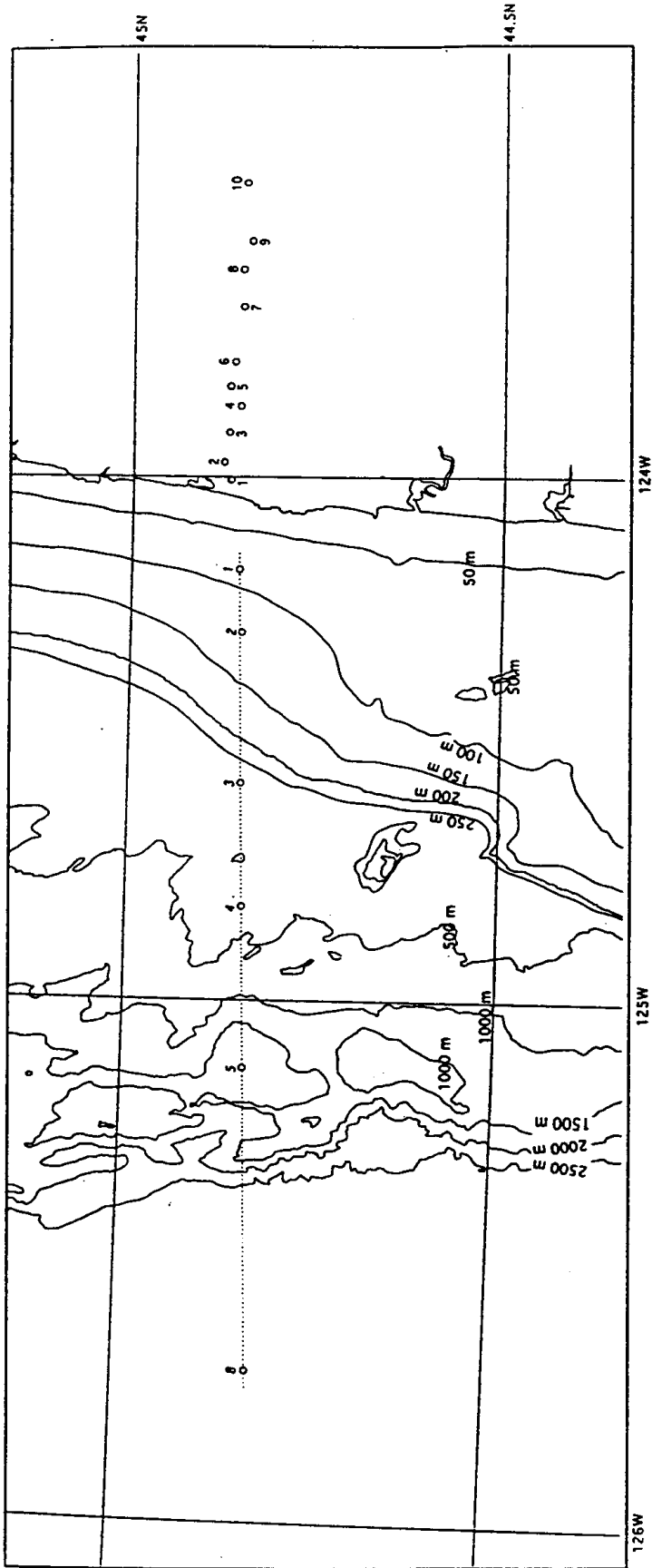


FIGURE 2. (A) Map of central Oregon showing the locations of the marine reflection line (every tenth shot shown as a small dot), temporary seismic recorders (large circles), and offshore bathymetry.

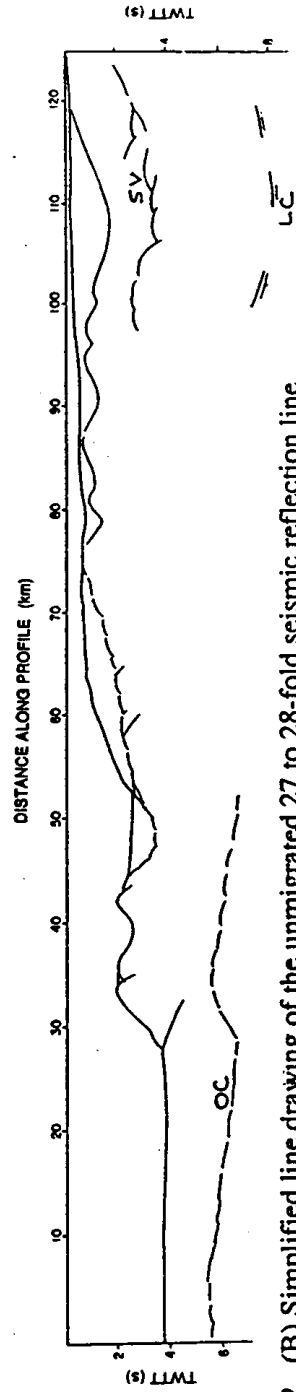


FIGURE 2. (B) Simplified line drawing of the unmigrated 27 to 28-fold seismic reflection line showing the position of Neogene basins. The top of the oceanic crust (OC), the top of the Siletz Volcanics (SV), and a reflection from within the lower crust, interpreted to represent the base of the Siletz Volcanics (LC) are also shown.

Two of the OBS's contained the new large capacity recording system described by Nakamura and Garmany (1991). These instruments recorded three orthogonal geophone components for each shot onto 155 MByte digital cartridge tapes. This experiment represented only the second field deployment for these instruments and was only moderately successful because of a programming error in the internal OBS clock. One instrument recorded a portion of the profile (OBS 2) and released early; it was recovered with the assistance of the local shrimping fleet. The other was not deployed.

Timing for the OBS's was provided by an internal clock that was calibrated with a GOES clock just before deployment and immediately after retrieval. Corrections to the timing to correct for drift were applied during the preliminary processing stage. Because the OBS clock is designed to drift forward, with periodic setbacks to compensate for the positive drift, this procedure is quite complicated and includes several components: a sawtooth function due to the periodic setbacks, a linear long-term drift obtained from comparison with the pre- and post-deployment calibrations, and a constant delay between when the OBS system fetches time from the clock and when it acquires the first sample.

Shot instant times were obtained using a PC-based recorder located on the commercial seismic vessel. A Kinometrics True Time satellite clock receiver (model 468), set for the local time delay to the GOES satellite, and stabilized using a high-precision Cesium oscillator, provided the absolute time base recorded on the commercial vessel. The GOES clock receiver produces time accurate to a millisecond.

Navigation on the deployment ship was by Loran C. This was adequate to place the instruments along the profile and to retrieve them afterwards. For further analysis of the data, instruments positions were calculated using observed first arrivals from shots in the vicinity of the OBS's. For sites 1 and 2, the first arrivals represent waves refracted in the uppermost sediments, and the sediment velocity was treated as an additional variable in the inversion. For sites 3-7, the first arrivals were water waves, and the water velocity obtained from Matthew's tables was used. For site 8, a water velocity of 1500 km/s was assumed. The shot data were also used to orient the



horizontal components at site 2, and the data were rotated to extract the radial and transverse components. These procedures are described in detail by Nakamura et al. (1987). Instruments were relocated independently at UT and at OSU with similar results. The instrument locations are summarized in Table 1. Although two solutions, one on each side of the shot line, are obtained from the inversion (except for site 2, where water wave polarization observations remove this ambiguity), only the preferred solution, chosen by comparison with the position of the ship on deployment as determined from Loran C, is listed. Also listed is the computed delay time of the shots, which represents an estimate of the lag time between the time of the shot trigger recorded on the shooting ship and the actual shot time. A mean shot instant delay of 48 ms is indicated. Instrument depths were estimated from the echo sounder on the F/V Olympic.

Table 1. Location and depth of ocean bottom seismometers. The shots used for each site are also indicated.

Site	Shots used	Latitude (°N)	Longitude (°W)	v, m/s	Dt, ms	s <sub>t</sub> , ms	Dep, m
1	5068-5034	44°51'04.9"	124°10'35.0"	1756	57	4	75
2*	4929-4891	44°50'55.3"	124°17'51.0"	1734	44	3	130
3	4584-4544	44°50'32.8"	124°35'23.2"	1480	39	3	335
4	4302-4262	44°50'18.0"	124°49'24.7"	1480	57	4	385
5	3948-3868	44°50'06.1"	125°07'39.8"	1481	41	5	1840
8	3260-3170	44°48'51.9"	125°42'23.5"	1500	50	4	2890

v = sub-bottom wave speed for sites 1 & 2 (output), water-wave speed for other sites (input)

Dt = computed time delay

s<sub>t</sub> = standard deviation in arrival time readings

\*The orientation of the instrument defined by the direction of +H<sub>1</sub> axis measured clockwise from north = 118.4 ± 1.6° on map (UTM), or 117.5 ± 1.6° from true north

Dep = Depth in meters. Instrument depths were initially determined from the echo sounder on the R/V Olympic. These depths were then compared to depths obtained from the water bottom reflection of the closest shot to each instrument.

Instrument depths were initially determined from the echo sounder on the F/V Olympic.

Shot-receiver offsets were calculated using the navigation data from the shooting ship (obtained

using Starfix), corrected for the offset between the ship's antenna and the center of the airgun array, and the OBS locations obtained from the inversion. The timing corrections, corrected navigation information, and calculated shot-receiver offsets were then merged with the trace headers and reformatted into SEG-Y format tapes (Barry et al., 1975), as interpreted by UTIG (appendix B).

## DESCRIPTION OF THE DATA

Figure 3 illustrates the data recorded at the six OBS's. For display, data were filtered with a minimum phase bandpass filter with a passband of 5 to 25 Hz, reduced using a velocity of 6.5 km/s, and corrected for geometrical spreading by multiplying trace amplitudes by a factor of  $(\text{offset}/10 \text{ km})^{0.75}$ . For offsets less than 10 km, no geometrical spreading was applied. For OBS2, which recorded every shot, two adjacent traces were added together.

The signal to noise ratio of the recorded data is quite variable along the profile. OBS1 (figure 3a), nearest to the coast, is very noisy. In addition to noise generated at the coast line or sea surface at this shallow water site, this station may be affected by cultural noise due to an active quarry onshore, which began operation at 6:30 AM (i.e. offsets greater than 55 km for OBS1). Data on OBS2 (figure 3b-d) are limited to near offsets because of the clock error mentioned above, and there are several significant data gaps. Data on OBS4 (figure 3e) are noisy because of the memory problem mentioned earlier. In addition, data from that station are strongly affected by water-borne energy from the previous shot. Because of the limited storage capacity of the OBS's, requiring recording of shots at about 132 m intervals, our ability to remove this noise through f-k filtering is very limited. The best data were recorded on OBSs 3 (figure 3f) and 5 (figure 3h), where strong arrivals are observed to the maximum offsets recorded. Although interference from water-borne energy is observed, the primary signal is still clearly detected in this region. For reasons not understood, this water-borne energy is strongest at OBS8 (figure 3g), the deep water

site on the abyssal plain, and severely limits the maximum offset to which primary seismic arrivals are observed at this site.

## ACKNOWLEDGEMENTS

Thanks to Terry Thompson, the captain of the F/V Olympic and his crew for their help in deploying the OBS's. John Shay (OSU; now at SIERRA Geophysics) and Gary Lux (UTIG) also assisted with deployment. Guy Cochran was the observer on the shooting ship. Tim Holt helped with initial data processing and display. The Hatfield Marine Science Center provided laboratory space to prepare the OBSs for deployment. Tom Brocher and H.M. Iyer reviewed the manuscript. This work was supported by the National Science Foundation through grants OCE-8900962 and EAR-8905189 and by the USGS NEHRP grant 1408-0001G2072.

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APPENDIX A

Oregon Margin Line 89OR100  
 Digicon, October, 1989  
 Airgun : Starfix  
 WGS-72 : UTM zone 10 : meters

shot no.	origin time	latitude (°N)	longitude (°W)
5097	07:00:31	44.85414	-124.13980
5096	07:01:01	44.85411	-124.14058
5095	07:01:31	44.85408	-124.14139
5094	07:02:01	44.85408	-124.14219
5093	07:02:31	44.85405	-124.14300
5092	07:03:01	44.85405	-124.14378
5091	07:03:31	44.85405	-124.14461
5090	07:04:00	44.85405	-124.14544
5089	07:04:30	44.85403	-124.14622
5088	07:05:00	44.85397	-124.14703
5087	07:05:30	44.85394	-124.14786
5086	07:06:00	44.85394	-124.14864
5085	07:06:30	44.85394	-124.14941
5084	07:07:00	44.85394	-124.15019
5083	07:07:30	44.85397	-124.15100
5082	07:08:00	44.85397	-124.15181
5081	07:08:30	44.85397	-124.15256
5080	07:08:59	44.85397	-124.15337
5079	07:09:29	44.85397	-124.15417
5078	07:09:59	44.85397	-124.15500
5077	07:10:29	44.85397	-124.15581
5076	07:10:59	44.85397	-124.15662
5075	07:11:29	44.85400	-124.15739
5074	07:11:59	44.85400	-124.15823
5073	07:12:29	44.85397	-124.15900
5072	07:12:59	44.85394	-124.15984
5071	07:13:29	44.85389	-124.16061
5070	07:13:59	44.85383	-124.16145
5069	07:14:29	44.85381	-124.16225
5068	07:14:59	44.85381	-124.16311
5067	07:15:29	44.85378	-124.16392
5066	07:15:59	44.85378	-124.16475
5065	07:16:29	44.85375	-124.16553
5064	07:16:59	44.85372	-124.16636
5063	07:17:29	44.85372	-124.16717
5062	07:17:59	44.85369	-124.16797
5061	07:18:29	44.85369	-124.16878
5060	07:18:59	44.85366	-124.16958
5059	07:19:29	44.85355	-124.17036
5058	07:19:59	44.85347	-124.17113
5057	07:20:29	44.85339	-124.17191
5056	07:20:59	44.85333	-124.17272
5055	07:21:29	44.85333	-124.17355
5054	07:21:59	44.85333	-124.17433
5053	07:22:29	44.85336	-124.17516
5052	07:22:59	44.85336	-124.17597
5051	07:23:29	44.85336	-124.17677
5050	07:23:59	44.85336	-124.17755
5049	07:24:29	44.85339	-124.17838
5048	07:24:59	44.85339	-124.17916
5047	07:25:29	44.85336	-124.17994
5046	07:25:59	44.85336	-124.18069
5045	07:26:29	44.85336	-124.18153
5044	07:26:59	44.85339	-124.18236
5043	07:27:29	44.85342	-124.18322
5042	07:27:59	44.85344	-124.18406

5041	07:28:29	44.85347	-124.18494
5040	07:28:59	44.85347	-124.18578
5039	07:29:29	44.85347	-124.18667
5038	07:29:59	44.85347	-124.18750
5037	07:30:29	44.85347	-124.18839
5036	07:31:00	44.85347	-124.18922
5035	07:31:30	44.85344	-124.19009
5034	07:32:00	44.85344	-124.19092
5033	07:32:30	44.85342	-124.19178
5032	07:33:00	44.85339	-124.19258
5031	07:33:30	44.85336	-124.19344
5030	07:34:00	44.85336	-124.19428
5029	07:34:30	44.85333	-124.19514
5028	07:35:00	44.85331	-124.19603
5027	07:35:30	44.85331	-124.19689
5026	07:36:00	44.85328	-124.19778
5025	07:36:30	44.85328	-124.19861
5024	07:37:00	44.85328	-124.19947
5023	07:37:30	44.85328	-124.20036
5022	07:38:00	44.85328	-124.20122
5021	07:38:30	44.85325	-124.20208
5020	07:39:00	44.85322	-124.20294
5019	07:39:30	44.85322	-124.20377
5018	07:40:00	44.85319	-124.20464
5017	07:40:30	44.85314	-124.20544
5016	07:41:00	44.85311	-124.20633
5015	07:41:30	44.85308	-124.20719
5014	07:42:00	44.85305	-124.20805
5013	07:42:30	44.85303	-124.20892
5012	07:43:00	44.85300	-124.20978
5011	07:43:30	44.85297	-124.21063
5010	07:44:00	44.85294	-124.21149
5009	07:44:30	44.85289	-124.21233
5008	07:45:00	44.85283	-124.21317
5007	07:45:30	44.85280	-124.21400
5006	07:46:00	44.85278	-124.21489
5005	07:46:30	44.85280	-124.21572
5004	07:47:00	44.85280	-124.21661
5003	07:47:30	44.85278	-124.21741
5002	07:48:00	44.85278	-124.21831
5001	07:48:30	44.85278	-124.21914
5000	07:49:00	44.85278	-124.22003
4999	07:49:30	44.85278	-124.22092
4998	07:50:00	44.85278	-124.22181
4997	07:50:30	44.85278	-124.22272
4996	07:51:00	44.85278	-124.22359
4995	07:51:30	44.85278	-124.22447
4994	07:52:00	44.85278	-124.22536
4993	07:52:30	44.85278	-124.22625
4992	07:53:00	44.85272	-124.22708
4991	07:53:30	44.85264	-124.22797
4990	07:54:00	44.85258	-124.22881
4989	07:54:30	44.85253	-124.22964
4988	07:55:00	44.85253	-124.23048
4987	07:55:30	44.85250	-124.23136
4986	07:56:00	44.85250	-124.23217
4985	07:56:30	44.85247	-124.23300
4984	07:57:00	44.85244	-124.23383
4983	07:57:30	44.85244	-124.23469
4982	07:58:00	44.85244	-124.23553
4981	07:58:30	44.85244	-124.23644
4980	07:59:00	44.85244	-124.23730
4979	07:59:30	44.85244	-124.23822
4978	08:00:00	44.85244	-124.23911
4977	08:00:30	44.85244	-124.24000

4976	08:01:00	44.85247	-124.24083	4911	08:33:30	44.85133	-124.29725
4975	08:01:30	44.85247	-124.24166	4910	08:34:00	44.85130	-124.29808
4974	08:02:00	44.85247	-124.24249	4909	08:34:30	44.85130	-124.29894
4973	08:02:30	44.85250	-124.24333	4908	08:35:00	44.85128	-124.29977
4972	08:03:00	44.85253	-124.24422	4907	08:35:30	44.85125	-124.30064
4971	08:03:30	44.85253	-124.24513	4906	08:36:00	44.85125	-124.30148
4970	08:04:00	44.85253	-124.24603	4905	08:36:30	44.85122	-124.30234
4969	08:04:30	44.85250	-124.24691	4904	08:37:00	44.85119	-124.30317
4968	08:05:00	44.85244	-124.24780	4903	08:37:30	44.85119	-124.30403
4967	08:05:30	44.85239	-124.24863	4902	08:38:00	44.85117	-124.30486
4966	08:06:00	44.85233	-124.24950	4901	08:38:30	44.85114	-124.30569
4965	08:06:30	44.85228	-124.25036	4900	08:39:00	44.85114	-124.30650
4964	08:07:00	44.85219	-124.25122	4899	08:39:30	44.85111	-124.30737
4963	08:07:30	44.85214	-124.25203	4898	08:40:00	44.85111	-124.30820
4962	08:08:00	44.85208	-124.25289	4897	08:40:30	44.85108	-124.30903
4961	08:08:30	44.85208	-124.25375	4896	08:41:00	44.85106	-124.30987
4960	08:09:00	44.85208	-124.25464	4895	08:41:30	44.85102	-124.31070
4959	08:09:30	44.85208	-124.25553	4894	08:42:00	44.85097	-124.31156
4958	08:10:00	44.85208	-124.25639	4893	08:42:30	44.85094	-124.31242
4957	08:10:30	44.85208	-124.25725	4892	08:43:00	44.85091	-124.31328
4956	08:11:00	44.85208	-124.25814	4891	08:43:30	44.85089	-124.31417
4955	08:11:30	44.85208	-124.25900	4890	08:44:00	44.85086	-124.31500
4954	08:12:00	44.85208	-124.25986	4889	08:44:30	44.85086	-124.31590
4953	08:12:30	44.85208	-124.26075	4888	08:45:00	44.85083	-124.31672
4952	08:13:00	44.85211	-124.26164	4887	08:45:30	44.85083	-124.31761
4951	08:13:30	44.85211	-124.26256	4886	08:46:00	44.85083	-124.31844
4950	08:14:00	44.85211	-124.26344	4885	08:46:30	44.85083	-124.31934
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3402	21:08:00	44.82211	-125.53953	3337	21:40:30	44.82036	-125.59795
3401	21:08:30	44.82206	-125.54039	3336	21:41:00	44.82030	-125.59881
3400	21:09:00	44.82200	-125.54131	3335	21:41:30	44.82025	-125.59972
3399	21:09:30	44.82197	-125.54219	3334	21:42:00	44.82022	-125.60064
3398	21:10:00	44.82197	-125.54308	3333	21:42:30	44.82019	-125.60161
3397	21:10:30	44.82195	-125.54397	3332	21:43:00	44.82017	-125.60255
3396	21:11:00	44.82191	-125.54486	3331	21:43:30	44.82011	-125.60350
3395	21:11:30	44.82191	-125.54575	3330	21:44:00	44.82005	-125.60442
3394	21:12:00	44.82189	-125.54664	3329	21:44:30	44.81997	-125.60533
3393	21:12:30	44.82186	-125.54752	3328	21:45:00	44.81992	-125.60628
3392	21:13:00	44.82180	-125.54842	3327	21:45:30	44.81989	-125.60716
3391	21:13:30	44.82175	-125.54931	3326	21:46:00	44.81986	-125.60811
3390	21:14:00	44.82172	-125.55017	3325	21:46:30	44.81983	-125.60900
3389	21:14:30	44.82172	-125.55109	3324	21:47:00	44.81981	-125.60997
3388	21:15:00	44.82169	-125.55200	3323	21:47:30	44.81978	-125.61086
3387	21:15:30	44.82167	-125.55286	3322	21:48:00	44.81972	-125.61175
3386	21:16:00	44.82167	-125.55376	3321	21:48:30	44.81969	-125.61269
3385	21:16:30	44.82164	-125.55467	3320	21:49:00	44.81966	-125.61364
3384	21:17:00	44.82164	-125.55556	3319	21:49:30	44.81966	-125.61458
3383	21:17:30	44.82164	-125.55645	3318	21:50:00	44.81969	-125.61547
3382	21:18:00	44.82158	-125.55731	3317	21:50:30	44.81966	-125.61642
3381	21:18:30	44.82153	-125.55820	3316	21:51:00	44.81964	-125.61731
3380	21:19:00	44.82147	-125.55911	3315	21:51:30	44.81961	-125.61826
3379	21:19:30	44.82144	-125.56001	3314	21:52:00	44.81961	-125.61917
3378	21:20:00	44.82144	-125.56095	3313	21:52:30	44.81961	-125.62009
3377	21:20:30	44.82141	-125.56187	3312	21:53:00	44.81961	-125.62106
3376	21:21:00	44.82141	-125.56275	3311	21:53:30	44.81961	-125.62197
3375	21:21:30	44.82139	-125.56364	3310	21:54:00	44.81958	-125.62292
3374	21:22:00	44.82139	-125.56458	3309	21:54:30	44.81955	-125.62381
3373	21:22:30	44.82136	-125.56548	3308	21:55:00	44.81950	-125.62475
3372	21:23:00	44.82133	-125.56639	3307	21:55:30	44.81950	-125.62567
3371	21:23:30	44.82130	-125.56731	3306	21:56:00	44.81947	-125.62659
3370	21:24:00	44.82128	-125.56825	3305	21:56:30	44.81944	-125.62750
3369	21:24:30	44.82122	-125.56914	3304	21:57:00	44.81942	-125.62842
3368	21:25:00	44.82119	-125.57003	3303	21:57:30	44.81936	-125.62933
3367	21:25:30	44.82117	-125.57092	3302	21:58:00	44.81931	-125.63023
3366	21:26:00	44.82114	-125.57181	3301	21:58:30	44.81927	-125.63117
3365	21:26:30	44.82111	-125.57272	3300	21:59:00	44.81925	-125.63203
3364	21:27:00	44.82108	-125.57359	3299	21:59:30	44.81919	-125.63295
3363	21:27:30	44.82106	-125.57447	3298	22:00:00	44.81916	-125.63383
3362	21:28:00	44.82100	-125.57536	3297	22:00:30	44.81914	-125.63472
3361	21:28:30	44.82097	-125.57628	3296	22:01:00	44.81905	-125.63564
3360	21:29:00	44.82097	-125.57719	3295	22:01:30	44.81903	-125.63655
3359	21:29:30	44.82092	-125.57811	3294	22:02:00	44.81900	-125.63747
3358	21:30:00	44.82086	-125.57892	3293	22:02:30	44.81897	-125.63839
3357	21:30:30	44.82080	-125.57977	3292	22:03:00	44.81894	-125.63931
3356	21:31:00	44.82075	-125.58064	3291	22:03:30	44.81892	-125.64022
3355	21:31:30	44.82072	-125.58156	3290	22:04:00	44.81889	-125.64114
3354	21:32:00	44.82069	-125.58241	3289	22:04:30	44.81889	-125.64205
3353	21:32:30	44.82067	-125.58327	3288	22:05:00	44.81886	-125.64300
3352	21:33:00	44.82067	-125.58420	3287	22:05:30	44.81886	-125.64391

3286	22:06:00	44.81889	-125.64478	3221	22:38:29	44.81747	-125.70211
3285	22:06:30	44.81889	-125.64564	3220	22:39:00	44.81744	-125.70300
3284	22:07:00	44.81886	-125.64647	3219	22:39:29	44.81742	-125.70386
3283	22:07:30	44.81881	-125.64730	3218	22:39:59	44.81739	-125.70475
3282	22:08:00	44.81881	-125.64814	3217	22:40:29	44.81736	-125.70564
3281	22:08:30	44.81881	-125.64897	3216	22:40:59	44.81733	-125.70653
3280	22:09:00	44.81878	-125.64986	3215	22:41:29	44.81730	-125.70741
3279	22:09:30	44.81875	-125.65075	3214	22:41:59	44.81728	-125.70831
3278	22:09:59	44.81875	-125.65164	3213	22:42:29	44.81728	-125.70919
3277	22:10:29	44.81872	-125.65253	3212	22:42:59	44.81725	-125.71008
3276	22:10:59	44.81872	-125.65339	3211	22:43:29	44.81722	-125.71097
3275	22:11:29	44.81870	-125.65428	3210	22:43:59	44.81719	-125.71186
3274	22:11:59	44.81866	-125.65517	3209	22:44:29	44.81717	-125.71275
3273	22:12:29	44.81866	-125.65606	3208	22:44:59	44.81714	-125.71361
3272	22:12:59	44.81864	-125.65694	3207	22:45:29	44.81711	-125.71452
3271	22:13:29	44.81864	-125.65781	3206	22:45:59	44.81708	-125.71539
3270	22:13:59	44.81861	-125.65870	3205	22:46:29	44.81705	-125.71628
3269	22:14:29	44.81861	-125.65958	3204	22:46:59	44.81703	-125.71717
3268	22:14:59	44.81858	-125.66048	3203	22:47:29	44.81700	-125.71806
3267	22:15:29	44.81855	-125.66133	3202	22:47:59	44.81697	-125.71895
3266	22:15:59	44.81855	-125.66222	3201	22:48:29	44.81694	-125.71983
3265	22:16:29	44.81853	-125.66311	3200	22:49:00	44.81692	-125.72073
3264	22:16:59	44.81853	-125.66400	3199	22:49:29	44.81689	-125.72158
3263	22:17:29	44.81850	-125.66489	3198	22:49:59	44.81686	-125.72244
3262	22:17:59	44.81850	-125.66578	3197	22:50:29	44.81683	-125.72334
3261	22:18:29	44.81847	-125.66664	3196	22:50:59	44.81680	-125.72420
3260	22:19:00	44.81847	-125.66753	3195	22:51:29	44.81678	-125.72506
3259	22:19:29	44.81844	-125.66841	3194	22:51:59	44.81672	-125.72591
3258	22:19:59	44.81842	-125.66930	3193	22:52:29	44.81669	-125.72678
3257	22:20:29	44.81842	-125.67019	3192	22:52:59	44.81667	-125.72764
3256	22:20:59	44.81839	-125.67108	3191	22:53:29	44.81664	-125.72853
3255	22:21:29	44.81839	-125.67197	3190	22:53:59	44.81661	-125.72939
3254	22:21:59	44.81836	-125.67283	3189	22:54:29	44.81658	-125.73025
3253	22:22:29	44.81833	-125.67372	3188	22:54:59	44.81653	-125.73111
3252	22:22:59	44.81833	-125.67461	3187	22:55:29	44.81650	-125.73197
3251	22:23:29	44.81831	-125.67550	3186	22:55:59	44.81647	-125.73286
3250	22:23:59	44.81831	-125.67638	3185	22:56:29	44.81644	-125.73372
3249	22:24:29	44.81828	-125.67725	3184	22:56:59	44.81642	-125.73458
3248	22:24:59	44.81825	-125.67814	3183	22:57:29	44.81639	-125.73544
3247	22:25:29	44.81825	-125.67902	3182	22:57:59	44.81633	-125.73631
3246	22:25:59	44.81822	-125.67992	3181	22:58:29	44.81630	-125.73716
3245	22:26:29	44.81822	-125.68080	3180	22:59:00	44.81628	-125.73805
3244	22:26:59	44.81819	-125.68166	3179	22:59:29	44.81622	-125.73891
3243	22:27:29	44.81816	-125.68256	3178	22:59:59	44.81619	-125.73978
3242	22:27:59	44.81816	-125.68345	3177	23:00:29	44.81614	-125.74064
3241	22:28:29	44.81814	-125.68433	3176	23:00:59	44.81608	-125.74149
3240	22:29:00	44.81814	-125.68523	3175	23:01:29	44.81606	-125.74236
3239	22:29:29	44.81808	-125.68611	3174	23:01:59	44.81600	-125.74322
3238	22:29:59	44.81805	-125.68700	3173	23:02:29	44.81594	-125.74408
3237	22:30:29	44.81803	-125.68789	3172	23:02:59	44.81591	-125.74494
3236	22:30:59	44.81800	-125.68878	3171	23:03:29	44.81586	-125.74580
3235	22:31:29	44.81797	-125.68967	3170	23:04:00	44.81580	-125.74669
3234	22:31:59	44.81792	-125.69056				
3233	22:32:29	44.81789	-125.69144				
3232	22:32:59	44.81786	-125.69234				
3231	22:33:29	44.81783	-125.69322				
3230	22:33:59	44.81778	-125.69411				
3229	22:34:29	44.81775	-125.69500				
3228	22:34:59	44.81772	-125.69589				
3227	22:35:29	44.81769	-125.69678				
3226	22:35:59	44.81767	-125.69767				
3225	22:36:29	44.81761	-125.69856				
3224	22:36:59	44.81758	-125.69945				
3223	22:37:29	44.81755	-125.70033				
3222	22:37:59	44.81753	-125.70122				

APPENDIX B  
UTIG OBS SEG-Y Format Tape Trace Header Information

Bytes <sup>1</sup>	Value <sup>2</sup>	Data Description	Unit
1-4, 5-8	v	Trace sequence number	
9-12	v	Field record number <sup>3</sup>	
13-16	v	Component <sup>4</sup>	
17-20	v	Shot number	
29-30	1	Trace identification code = seismic data	
31-32	1	Vertical summing = none	
33-34	1	Horizontal stacking = none	
35-36	1	Data use = production	
37-40	v	Distance from source to OBS	m
41-44	c	OBS depth (negative elevation)	-m
49-52	c	Source depth	m
61-64	v	Water depth at source	m
65-68	c	Water depth at OBS	m
69-70	1	Depth scale factor = 1	
71-72	-10	Coordinate scale factor = 0.1	
73-76	v	Source longitude	0.1"
77-80	v	Source latitude	0.1"
81-84	c	OBS longitude	0.1"
85-88	c	OBS latitude	0.1"
89-90	2	Coordinate units = seconds of arc	
109-110	v	Delay recording time <sup>5</sup>	ms
115-116	c	Number of samples	
117-118	c	Sample interval	μs
119-120	3	Instrument gain type = floating point	
141-142	c	Alias filter frequency	Hz
143-144	24	Alias filter slope	dB/oct
157-158	c	Year data recorded	
159-160	v	Day of year	
161-162	v	Hour of day	
163-164	v	Minute of hour	
165-166	v	Second of minute	
167-168	v	Millisecond of the first sample of the trace <sup>6</sup>	
181-184	v	Shot azimuth <sup>7</sup>	0.01°

<sup>1</sup>Those not listed are all zeroes

<sup>2</sup>v = variable for each trace; c = generally constant for each OBS/line

<sup>3</sup>Usually OBS record number plus a constant offset to give a unique record number to each record

<sup>4</sup>1 = horizontal 1 or radial; 2 = horizontal 2 or transverse, 3 = vertical

<sup>5</sup>Note that this quantity varies for each trace, and usually is negative at close ranges

<sup>6</sup>Note that this a non-SEG-standard entry

<sup>7</sup>Azimuthal angle of shot location as seen from OBS, measured clockwise from north