LAKE TITICACA, BOLIVIA/PERU
HIGH RESOLUTION SINGLE CHANNEL SEISMIC SURVEY
CRUISE ON LAKE TITICACA ON THE M/V YAKUZA
15 APRIL TO 29 APRIL 1996

Cruise participant: David A. Mucciarone from Rice University, Scott Cross from Duke University, and Co-PI Geoffrey Seltzer from Syracuse University.

The following is a technical summary for the Lake Titicaca cruise aboard the M/V *Yakuza* beginning on 4/15 and ending on 4/29/96. The Lake Titicaca single channel high resolution survey was a joint project between the Syracuse, Duke, and Rice Universities. The cruise involved single channel seismic using a sub-bottom profiler (chirper).

Seismic acquisition was digital using the Edge Tech (EG&G) X-Star acquisition system and SB-216S tow fish. Seismic data collected in SEGY format and stored on 2.3 GB Exabyte tapes. Analog seismic was collected using the EPC1086 thermal plotter. Navigation was GPS acquired every 5 seconds in standard NMEA183 format and input directly to the X-Star system through the RS232 serial port. Energy source was the Edge Tech SB-216S tow fish with a bandwidth of 2 to 12 KHz.

There were two seismic cruise legs on the M/V *Yakuza* with a total of 49 lines were shot capturing an overview of the lake sediments. Leg 1 was from 4/12 to 4/14 with only Scott Cross and Geoffrey Seltzer participating and only 5 seismic lines collected (LINE01 - LINE05). Leg 2 was from 4/18 to 4/27 with Scott Cross, Geoffrey Seltzer, and David Mucciarone participating and consisted of 45 seismic lines (LINE06 - LINE49).

Seismic acquisition:

Parameters	S-15/B-5/B-20(ci)
Shooting Interval =	8 pulses/sec.
Sampling Frequency =	8 KHz
Recording Length =	125 ms
Source distance from ship =	9 m
Source depth =	3 m

Leg 1: Seismic File Statistics for single channel lines using Edge Tech SB-216S sub-bottom profiler:

Line name	Dist. nm	Time	Heading	Rate kts	Coordinates	Date
LINE01	7.00	1:41	330	2.7	16°12.70'S 068°51.40'W	4/12/96
					16°07.79'S 068°56.47'W	
LINE02	10.50	2:23	180	3.6	16°07.70'S 069°11.65'W	4/13/96
					16°15.53'S 069°15.85'W	
LINE03	11.25	2:45	355	4.3	16°14.50'S 069°15.80'W	4/13/96
					16°02.79'S 069°15.68'W	
LINE04	7.00	1:56	315	4.5	16°13.69'S 069°06.97'W	4/14/96
					16°08.39'S 069°13.24'W	
LINE05	15.50	4:29	045	4.2	16°08.32'S 069°13.16'W	4/14/96
					15°57.59'S 069°01.82'W	

Leg 2: Seismic File Statistics for single channel lines using Edge Tech SB-216S sub-bottom profiler:

Line name	Dist. nm	Time	Heading	Rate kts	Coordinates	Date
LINE06	24.50	5:17	315	4.0	16°02.65'S 068°52.63'W	4/18/96
					15°45.47'S 069°10.48'W	
LINE07	7.75	1:54	255	4.2	15°47.55'S 069°14.49'W	4/19/96
			315		15°45.67'S 069°22.22'W	C/C
					15°35.32'S 069°38.40'W	

Leg 2: Seismic File Statistics for single channel lines using Edge Tech SB-216S sub-bottom profiler: (continued)

Line name	Dist. nm	Time	Heading	Rate kts	Coordinates	Date
LINE08	16.75	3:49	315	4.1	15°35.13'S 069°35.55'W	4/19/96
					15°24.39'S 069°48.40'W	
LINE09	7.25	1:39	077	4.5	15°22.63'S 069°48.53'W	4/20/96
					15°19.89'S 069°41.71'W	
LINE10	8.75	1:55	197	4.5	15°19.82'S 069°41.73'W	4/20/96
			220		15°20.54'S 069°42.63'W	C/C
					15°26.77'S 069°48.60'W	
LINE11	6.75	1:26	060	4.2	15°25.54'S 069°48.59'W	4/20/96
			082		15°25.46'S 069°48.37'W	C/C
					15°22.41'S 069°42.54'W	
LINE12	5.60	1:17	230	4.3	15°22.35'S 069°42.62'W	4/20/96
					15°26.70'S 069°46.19'W	
LINE13	6.70	1:34	010	4.1	15°26.56'S 069°46.27'W	4/20/96
					15°20.08'S 069°44.43'W	
LINE14	5.25	1:08	057	4.5	15°47.39S 069°50.38'W	4/21/96
					15°43.84'S 069°46.39'W	
LINE15	5.25	1:13	180	4.5	15°43.92'S 069°46.37'W	4/21/96
					15°49.61'S 069°46.02'W	
LINE16	6.50	1:28	080	4.5	15°49.69'S 069°50.38'W	4/21/96
					15°47.72'S 069°39.72'W	
LINE17	9.00	2:26	079	3.8	15°47.84'S 069°39.99'W	4/22/96
					15°45.16'S 069°31.44'W	
LINE18	13.00	3:14	125	4.1	15°45.26'S 069°31.30'W	4/22/96
					15°54.15'S 069°21.50'W	
LINE19	4.25	1:09	078	4.2	15°54.13'S 069°21.44'W	4/22/96
					15°52.48'S 069°17.32'W	
LINE20	5.75	1:23	110	3.9	15°52.52'S 069°17.26'W	4/22/96
					15°55.08'S 069°12.04'W	
LINE21	9.90	2:09	123	4.1	15°55.18'S 069°11.86'W	4/22/96
					16°00.25'S 069°03.97'W	
LINE22	5.50	1:19	235	4.5	16°00.34'S 069°03.99'W	4/22/96
			xxx		16°03.34'S 069°08.48'W	C/C
					16°03.11'S 069°09.18'W	
LINE23	15.25	3:18	180	4.3	16°00.35'S 069°12.91'W	4/23/96
					16°15.51'S 069°11.98'W	
LINE24	5.75	1:28	315	4.2	16°15.48'S 069°12.05'W	4/23/96
					16°11.08'S 069°16.02'W	
LINE25	1.25	0:15	180	5.0	16°11.07'S 069°16.07'W	4/23/96
					16°12.21'S 069°15.94'W	
LINE26	7.25	1:30	090	4.5	16°12.22'S 069°15.91'W	4/23/96
					16°11.98'S 069°08.71'W	
LINE27	6.50	1:27	345	4.5	16°11.92'S 069°08.69'W	4/23/96
					16°06.05'S 069°10.07'W	
LINE28	24.00	5:19	305	5.0	16°09.68'S 069°06.06'W	4/24/96
					15°58.53'S 069°28.20'W	
LINE29	7.25	1:41	028	4.5	15°58.39'S 069°28.10'W	4/24/96
					15°52.33'S 069°24.15'W	
LINE30	11.30	2:44	010	4.0	15°52.15'S 069°24.03'W	4/24/96
					15°41.91'S 069°18.75'W	
LINE31	3.75	0:48	125	4.5	15°51.92'S 069°18.75'W	4/24/96
					15°43.97'S 069°15.59'W	

Leg 2: Seismic File Statistics for single channel lines using Edge Tech SB-216S sub-bottom profiler: (continued)

Line name	Dist. nm	Time	Heading	Rate kts	Coordinates	Date
LINE32	15.00	3:51	104	4.0	15°58.14'S 069°05.87'W	4/25/96
					16°01.09'S 068°50.93'W	
LINE33	3.75	1:01	000	4.0	16°01.05'S 068°50.89'W	4/25/96
					15°57.45'S 068°50.88'W	
LINE34	1.25	0:18	200	5.0	15°57.32'S 068°51.08'W	4/25/96
					15°58.50'S 068°51.27'W	
LINE35	1.75	0:25	007	4.5	15°58.57'S 068°51.35'W	4/25/96
					15°56.98'S 068°51.50'W	
LINE36	3.50	0:41	197	4.5	15°57.00'S 068°51.55'W	4/25/96
					16°00.28'S 068°51.83'W	
LINE37	6.25	1:17	230	4.5	16°03.51'S 068°54.55'W	4/26/96
					16°07.43'S 068°59.69'W	
LINE38	5.50	1:17	080	4.0	16°07.45'S 068°59.62'W	4/26/96
					16°06.41'S 068°54.14'W	
LINE39	2.75	0:35	200	5.0	16°06.47'S 068°54.20'W	4/26/96
					16°08.71'S 068°55.67'W	
LINE40	6.25	1:21	138	4.5	16°09.66'S 068°54.97'W	4/26/96
					16°13.69'S 068°50.33'W	
LINE41A	1.25	0:20	060	4.5	16°13.79'S 068°50.06'W	4/26/96
					16°13.04'S 068°48.84'W	
LINE41B	1.00	0:18	063	4.0	16°13.96'S 068°50.08'W	4/26/96
					16°13.23'S 068°49.03'W	
LINE42	2.00	0:31	050	4.5	16°12.79'S 068°48.41'W	4/26/96
					16°11.31'S 068°46.61'W	
LINE43	4.00	0:52	130	4.5	16°11.33'S 068°46.55'W	4/26/96
					16°13.72'S 068°43.44'W	
LINE44	1.25	0:19	010	4.0	16°13.72'S 068°43.47'W	4/26/96
					16°12.71'S 068°42.92'W	
LINE45	2.00	0:35	280	4.0	16°17.20'S 068°41.39'W	4/27/96
					16°16.72'S 068°43.16'W	
LINE46	4.25	1:22	270	3.5	16°20.59'S 068°50.71'W	4/27/96
					16°20.60'S 068°57.37'W	
LINE47	2.75	0:56	270	4.0	16°20.90'S 068°57.48'W	4/27/96
					16°20.90'S 069°00.06'W	
LINE48	6.50	1:58	135	3.5	16°20.94'S 069°01.08'W	4/27/96
					16°24.97'S 068°55.30'W	
LINE49	6.75	2:14	345	3.5	16°24.99'S 068°55.23'W	4/27/96
					16°18.47'S 068°55.47'W	

Seismic tape and line statistics for Legs 1 and 2:

Tape number	Line names	Date	Distance. nm	Time on tape (hr)
Tape 01	Line01 - 05	4/12 - 14/96	51.25	13.23
Tape 02	Line06	4/18/96	24.50	5.28
Tape 03	Line07	4/19/96	23.75	5.62
Tape 04	Line08	4/19/96	16.75	3.82
Tape 05	Line09 - 13	4/20/96	35.05	7.85
Tape 06	Line14 - 16	4/21/96	17.00	3.82
Tape 07	Line17 - 20	4/22/96	32.00	8.20
Tape 08	Line21 - 22	4/22/96	15.40	3.47
Tape 09	Line23 - 27	4/23/96	36.00	7.97

Leg 2: Seismic File Statistics for single channel lines using Edge Tech SB-216S sub-bottom profiler: (continued)

Tape number	Line names	Date	Distance. nm	Time on tape (hr)
Tape 10	Line28 - 29	4/24/96	31.25	7.08
Tape 11	Line30 - 31	4/24/96	15.05	3.53
Tape 12	Line32 - 33	4/25/96	18.75	4.87
Tape 13	Line34 - 36	4/25/96	6.50	1.40
Tape 14	Line37 - 39	4/26/96	14.50	3.15
Tape 15	Line40	4/26/96	6.25	1.35
Tape 16	Line41A	4/26/96	1.25	0.33
Tape 17	Line41B	4/26/96	1.00	0.30
Tape 18	Line42 - 44	4/26/96	7.25	1.70
Tape 19	Line45	4/27/96	2.00	0.58
Tape 20	Line46 - 49	4/27/96	20.25	6.50

Statistics for Leg 1 and Leg 2:

20 Tapes	**50 seismic lines**	**10 day cruise**	**375.75 nm**	**90.05 hrs.**

LEG 2 CRUISE OUTLINE: 15 April to 29 April 1996

15 April 1996

1) Departed IAH at 1815 on American Airlines Flt. 1124 to MIA (Miami) arrived at 2120. Departed MIA at 2350 on AA Flt. 923 arrived in La Paz, Bolivia (LPB) at 0630 on 4/16/96.

16 April 1996

1) Met with Geoff Seltzer and Scott Cross at airport
2) Stayed at apartment near downtown La Paz.
3) Problem with checked baggage, floats did not arrive on flight.
4) Collected/purchased supplies for cruise.
5) Reviewed chirper system and began packing equipment.

17 April 1996

1) Picked up more supplies for cruise.
2) Checked on arrival of lost excess baggage with AA, have floats delivered to appartment.
3) Loaded up van at 1700 to transport equipment from La Paz to Huatajata on Lake Titicaca. Departed La Paz at 1830 and arrived in Huatajata at 2100.
4) Off loaded equipment and stowed gear on board the M/V *Yakuza* (10m long boat).
5) Spend night on boat.

18 April 1996

1) Departed dock at 0925 for seismic survey.
2) Set-up 1.8KW Honda generator. Set-up GPS and link to Edge Tech (EG&G) X-Star acquisition system. Assemble and test X-Star system and sub-bottom profiler (SB-216S).
3) Deployed tow fish at 1250 and began shooting seismic at 1257L (1657Z) with Line06 on Tape02. Attempt to average 4.0 kts, shooting rate 125 ms with 15 to 25 cm resolution, recording length 125 ms.
4) Stopped Line06 at 1814L, shut down X-Star system, and pulled tow fish. Anchored just west of Escoma, Bolivia.
5) Collected 24.5 nm and 5 hr 17 min of data.

19 April 1996

1) Pulled anchor and depart at 0650L.
2) Powered up seismic system and deployed tow fish at 0710L. Began shooting with Line07 on Tape03 at 0720L.

LEG 2 CRUISE OUTLINE: 15 April to 29 April 1996 (continued)

3) Began Line08 at 1319L on Tape04. Stopped Line08 at 1708L, shut down X-Star system, and pulled tow fish. Anchored south side of Isla Santiago Mori, Peru toward the north end of Lake Titicaca.
4) Collected 40.5 nm and 9 hr 26 min of data.

20 April 1996

1) Pulled anchor and depart at 0700L.
2) Powered up seismic system and deployed tow fish at 0720L. Begin shooting with Line09 on Tape05 at 0727L.
3) Shot Line09 - 13 all on Tape05. Stopped Line13 at 1535L, shut down X-Star system, and pull tow fish. Head for Puno, Peru at 1543. Anchored on northwest side of lake near Puno, Peru.
4) Collected 35.05 nm and 7 hr 51 min of data.

21 April 1996

1) Pulled anchor and depart at 0700L and head into Puno, Peru to clear customs, gather supplies, and refuel boat.
2) Departed Puno, Peru at 1155L. Powered up seismic system and deployed tow fish at 1348L. Began shooting with Line14 on Tape06 at 1354L.
3) Shot Line14 - 16 all on Tape06. Stopped Line13 at 1535L, shut down X-Star system, and pulled tow fish. Anchored on south side of Isla Taquile near Puno, Peru.
4) Collected 17.0 nm and 3 hr 49 min of data.

22 April 1996

1) Pulled anchor and depart at 0525L.
2) Powered up seismic system and deployed tow fish at 0610L. Began shooting with Line17 on Tape07 at 0613L.
3) Shot Line17 - 20 on Tape07 and Line21 - 22 on Tape08. Stopped Line22 at 1804L, shut down X-Star system, and pulled tow fish. Anchored on west side of Isla del Sol in south center of lake.
4) Collected 47.4 nm and 11 hr 40 min of data.

23 April 1996

1) Pulled anchor and departed at 0700L.
2) Equipment problems with X-Star - skipping trace. Cleaned and greased termination to tow fish. Powered up seismic system and deployed tow fish at 0923L. Began shooting with Line23 on Tape09 at 0927L.
3) Shot Line23 - 27 on Tape09. Stopped Line27 at 1730L, shut down X-Star system, and pull tow fish. Anchor on southwest side of lake at Copacabana, Bolivia.
4) Collected 36.0 nm and 7 hr 58 min of data.

24 April 1996

1) Collected supplies, and refueled boat. Called Cindy Ross to have her change flight from La Paz to the 29th instead of 27th. Pulled anchor and depart at 0835L.
2) Powered up seismic system and deployed tow fish at 0836L. Began shooting Line28 on Tape10 at 0841L.
3) Shot Line28 - 29 on Tape10 and Line30 - 31 on Tape11. Stopped Line31 at 1821L, shut down X-Star system, and pulled tow fish. Anchored on east side of lake at Escoma, Bolivia. Prior to arrival at Escoma the propeller tangled in fish net during transit from end of Line 31 to the Escoma anchorage.
4) Collected 46.3 nm and 10 hr 37 min of data.

25 April 1996

1) Pulled anchor and departed at 0700L. Transit to Isla de la Lana to begin Line32.
2) Powered up seismic system and deployed tow fish at 1035L. Began shooting Line32 on Tape12 at 1039L.

LEG 2 CRUISE OUTLINE: 15 April to 29 April 1996 (continued)

3) Tow fish tangled in fish net at end of Line33 at 1535L. Pulled tow fish to untangle, cleaned and greased termination on tow fish and redeployed at 1550L and began Line34 at 1554L
4) Shot Line32 - 33 on Tape12 and Line34 - 36 on Tape13. Stopped Line36 at 1722L, shut down X-Star system, and pulled tow fish. Anchored near Santiago de Huata, Bolivia at 1820L on southeast side of lake.
5) Collected 25.25 nm and 6 hr 16 min of data.

26 April 1996

1) Pulled anchor and departed at 0715L.
2) Powered up seismic system and deployed tow fish at 0811L. Began shooting Line37 on Tape14 at 0815L. Stopped Line40 at 1217L on Tape15, shut down X-Star system, and pulled tow fish. Headed to Tiquina to refuel boat. Arrived in Tiquina, Bolivia at 1350L and departed at 1455L.
3) Powered up seismic system and deployed tow fish at 1514L. Began shooting Line41A on Tape16 at 1518L. Problem at 1526L with Honda 1.8 KW generator, serviced, and temporarily disconnected oil sensor. Stopped Line41A at 1538L. Began shooting Line41B on Tape17 at 1611L and stopped at 1629L because of problems with X-Star computer system.
4) Began shooting Line42 on Tape18 at 1636L.
5) Shot Line41A on Tape16, Line41B on Tape17, and Line42 - 44 on Tape18. Stopped Line44 at 1820L, shut down X-Star system, and pulled tow fish. Docked at Huatajata, Bolivia.
6) Collected 30.25 nm and 6 hr 50 min of data.

27 April 1996

1) Departed dock at 0710L. Repaired Honda generator and connected oil sensor. Attached F-7 float to SB-216S tow fish in order to work in shallow portion of Lake Titicaca (south end).
2) Powered up seismic system and deployed tow fish at 0750L. Began shooting Line45 on Tape19 at 0755L. Stopped Line45 at 0830L, shut down X-Star system, and pulled tow fish and headed to Laguna Huiñaimarca.
3) Powered up seismic system and deployed tow fish at 1010L. Began shooting Line46 on Tape20 at 1014L. Stopped Line46 at 1136L, problems with carburetor on boat. Began shooting Line47 at 1219L on same Tape20.
4) Shot Line46 on Tape19 and Line47 - 49 on Tape20. Stop Line49 at 1730L, shut down X-Star system, and pulled tow fish to end survey at 1735L/2135Z.
5) While heading back to Huatajata we had problems with Peru customs and had to return to the customs office to work things out. Arrived an docked in Huatajata at 2100L.
6) Collected 22.25 nm and 6 hr 30 min of data.

28 April 1996

1) Off loaded all seismic gear from boat and loaded gear onto van. Departed Huatajata at 0930 for La Paz. Arrived at apartment #200 on Calle 14 and off loaded van and stored equipment in apartment.
2) Discussed mooring set-up and deployment with Geoff Seltzer.
3) Confirm flight reservations for 4/29.

29 April 1996

1) Departed apartment for El Alto airport at 0530 with Geoff Seltzer.
2) Departed LPB at 0745 on AA Flt. 922 through Santa Cruz, arrived at MIA at 1610.
3) Departed MIA at 1920 on AA Flt. 968 to IAH arrived at 2055.