Preliminary Version

SOUTHAMPTON OCEANOGRAPHY CENTRE
CRUISE REPORT No. 22

R. V. COLONEL TEMPLER CRUISES 01 AND 02/98
Leg 1 : 22nd April - 18th May, 1998
Leg 2 : 20th May - 18th June, 1998

TOBI surveys of the continental slope north and west of Scotland

Principal Scientist
Leg 1 : D. G. Masson
Leg 2 : C. L. Jacobs

1998

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ACKNOWLEDGEMENTS

All data and survey results presented herein were acquired during a wide area survey project undertaken in 1998 on behalf of the Atlantic Frontier Environmental Network (AFEN). AFEN comprises: Agip (UK) Ltd., Amerada Hess Ltd., Amoco (UK) Exploration Company Limited, ARCO British Ltd., BG E&P Ltd., BP Exploration Operating Company Ltd., Chevron U.K. Ltd., Conoco (U.K.) Ltd., Deminex UK Oil and Gas Limited, Elf Exploration UK plc., Enterprise Oil plc., Esso Exploration and Production UK Ltd., Fina Exploration Ltd., Marathon Oil UK Ltd., Mobil North Sea Ltd., Phillips Petroleum Company U.K. Ltd., Saga Petroleum Ltd., Shell U.K. Exploration and Production , Statoil Ltd., Texaco Britain Ltd., Total Oil Marine plc., Joint Nature Conservation Committee, Fisheries Research Services, and the Department of Trade and Industry.

The survey project was scoped and agreed between the Department of Trade and Industry, SOAEFD, GEOTEK, the University of Southampton and the AFEN Consortium, and was commissioned and funded by the AFEN Consortium.

FOR FURTHER INFORMATION

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1. SCIENTIFIC PERSONNEL

	Leg 1	Leg 2	
MASSON, D. G. (Principal Scientist)	x		Southampton Oceanography Centre
JACOBS, C. L. (Principal Scientist)		x	Southampton Oceanography Centre
EVANS, J. M.	x	x	Southampton Oceanography Centre
FLEWELLEN, C. G.	x		Southampton Oceanography Centre
GRANT, K. M.	x		Southampton Oceanography Centre
HÜHNERBACH, V.		x	Southampton Oceanography Centre
KIRK, R.		x	Southampton Oceanography Centre
LE BAS, T. P.	x		Southampton Oceanography Centre
MATTHEW, D.		x	Southampton Oceanography Centre
ROUSE, I. P.	x		Southampton Oceanography Centre
WHITTLE, S. P.	x	x	Southampton Oceanography Centre
YULE, B.		x	Southampton Oceanography Centre
ROBERTS, J. A.	x		GEOTEK Ltd.
ANDERSON, S		x	GEOTEK Ltd.

2. SHIPS PERSONNEL

	Leg 1	Leg 2
Master	BURDETT, D.	BURDETT, D.
Chief Officer	HENSER, K.	ROSE, M.
2nd Officer	BAKER, M.	BAKER, M.
Chief Engineer	NICHOLSON, J.	DESILVA, C.
2nd Engineer	HOCKENHULL, B.	HOCKENHULL, B.
3rd Engineer	DAYKIN, G.	DAYKIN, G.
Bosun	ADIE, K	HONNOR, P.
Seaman	DRYDEN, W	
Seaman	CASEY, A.	CASEY, A.
Seaman	HOPKINS, M.	HOPKINS, M.
Seaman	WILD, K.	MCPHAIL, A.
Seaman	DOLLERY, P.	DOLLERY, P.
Motorman	MILLS, W.	MILLS, W.
Cook	MORGAN, T.	MORGAN, T.
Steward		BARKER, R.

3. ITINERARY

Leg 1

Sailed Southampton	22nd April, 1998
Arrived Stornoway	18th May, 1998

Leg 2

Sailed Stornoway	20th May, 1998
Arrived Southampton	18th June, 1998

4. CRUISE OBJECTIVES

4.1. TOBI survey plan

The objective of the cruise was to undertake comprehensive TOBI 30 kHz sidescan sonar and 7.5 kHz profiler surveys of several blocks of seafloor to the north and west of the UK which were released for hydrocarbon exploration in 1997 (Fig. 1). All of the license areas with water depth >200 m was to be surveyed. Surface towed 3.5 kHz high resolution profiles were also to be collected along all survey lines. The Research Vessel *Colonel Templer* was chartered by Geotek Ltd. to undertake the survey work. Although TOBI has a nominal swath width of 6 km, survey lines were typically spaced 4 to 5 km apart to allow for overlap between adjacent swaths, and for some reduction in range in the shallower water areas (typically < 1000 m waterdepth) in the northern survey blocks. This range reduction occurs because of severe temperature stratification in the water column, where warm North Atlantic Water (typically 8-9°C) immediately overlies cold water originating in the Norwegian Sea (typically < 0°C), causing refraction and reflection of the sonar energy.

4.2. Processing of data and interpretation of results

It was planned that a preliminary interpretation of the data would be undertaken during the survey, so that results could be transmitted to a related sampling cruise being carried out on the *RRS Charles Darwin*. This sampling cruise partly overlapped the sidescan surveys in time, necessitating a rapid turn round in data processing and interpretation. To this end, preliminary image processing was carried out on board, producing sidescan mosaics at a scale of 1:50,000. Sidescan and profile data were then combined into an integrated interpretation which was transmitted in digital form either to Geotek Ltd. or directly to the *RRS Charles Darwin*.

4.3. Data annotation

All data were recorded with reference to GMT and Julian day numbers.

5. NARRATIVE

Monday 20th April (Day 110)

Commenced mobilisation alongside Southampton Oceanography Centre.

Tuesday 21st April (Day 111)

Continued mobilisation.

Wednesday 22nd April (Day 112)

Completed mobilisation. *R. V. Colonel Templer* sailed from Southampton at 0700 GMT (0800 local time) on passage to the working area. Prior to sailing, the ship's Captain and First Officer instructed the scientific party on basic safety at sea. Fire and boat drill practice was completed immediately after sailing.

Thursday 23rd April (Day 113)

Continued on passage to the working area.

0955-1015 Vessel slowed to 1 kt for a test of the USBL system.

Friday 24th April (Day 114)

Continued on passage to the working area.

Saturday 25th April (Day 115)

Weather excellent, light winds from S/SE, calm seas.

0000-1355 Completed passage to initial working area (Tranche 65-67).

1355-1405 3.5 kHz fish deployed.

1410- 1445 USBL system deployed in moonpool.

1500- 1545 TOBI deployed.

1545-1821 Run up to start of line 1.

1821 Start of line 1 (Tranche 65-67).

Sunday 26th April (Day 116)

Weather excellent, light winds from S/SE, calm seas.

0750 End of line 1.

0951 Start of line 2.

2305 End of line 2.

Problems with 3.5 kHz logging system when logging in shallowest depth range. Logging system locks and system has to be rebooted.

Monday 27th April (Day 117)

Weather excellent, light winds from S/SE, calm seas.

0030 Start of line 3.

1247 End of line 3.

1424 Start of line 4.

Tuesday 28th April (Day 118)

Weather excellent, light winds from S, calm seas.

0129 End of line 4.

0230 Start of line 5.

1200 End of line 5.

1336 Start of line 6.

2340 End of line 6.

Wednesday 29th April (Day 119)

Weather excellent, light winds from S, calm seas.

0042 Start of line 7.

1120 End line 7 (Completion of Tranche 65-67).

1142 3.5 kHz fish and USBL recovered.

1319 TOBI inboard. Start passage to Tranche 60-63.

2030 Complete passage to Tranche 60-63.

2030-2125 Complete deployment of 3.5 kHz, USBL and TOBI.

2300 Start of line 8 (Start Tranche 60-63 survey).

Thursday 30th April (Day 120)

Weather excellent, light winds from N and NW, calm seas.

1138-1200 Problems with USBL dropout at ranges of >2500 m.

1904 End of line 8.

2155 Start of line 9.

2300-2315 Problems with USBL dropout.

Friday 1st May (Day 121)

Weather excellent, light winds from SW, calm seas.

1830 End of line 9.

2028 Start of line 10.

2223 TOBI logging system failure.

Saturday 2nd May (Day 122)

0421 TOBI logging system restarted. Six hours of digital data lost, although paper records recovered.

Weather deteriorated overnight, with 30-35 kt winds from the north. Making slow progress on northward survey line. USBL frequently missing fixes, probably due to combination of vessel motion and reaching maximum range of the system (approximately 3000 m).

1530 End of line 10.

1830 Start of line 11.

2000 Weather now much improved with light northerly winds.

Sunday 3rd May (Day 123)

Wind direction changed to southwest and slowly increasing (20 kt at 0800).

1350 End of line 11.

1620 Start of line 12.

Monday 4th May (Day 124)

Wind moderate from west, moderate seas.

0130-0230 USBL fixes intermittent.

0310 End of line 12.

0500 Start of line 13.

1450 End of line 13.

1705 Start of line 14.

Tuesday 5th May (Day 125)

Weather excellent, almost no wind, moderate swell from the west.

0015 End of line 14.

0221 Start of line 15.

1114 End of line 15.

1243 Start of line 16.

1948 End of line 16.

2228 Start of line 17.

Wednesday 6th May (Day 126)

Weather excellent, almost no wind, moderate swell from the west.

0645 End of line 17.

0824 Start of line 18.

1633 End of line 18. End of survey of Tranche 60-63.

1633-1820 Haul TOBI wire.

1820-1910 Recover USBL, 3.5 kHz and TOBI.

1910-2359 Passage to Block 204/14-15.

Thursday 7th May (Day 127)

Weather excellent, almost no wind, moderate swell from the north, ship rolling nicely.

0000-0600 Complete passage to Block 204/14-15.

0600-0720 Deploy TOBI, 3.5 kHz and USBL.

0830 Start line 19.

0730-0905 Poor performance of USBL system, with few usable fixes. Found that lowering the hydrophone by about 6 inches resulted in dramatic improvement. Good fixes from 0905 (fix number 9060).

1208 End of line 19.

1414 Start of line 20.

2115 End of line 20.

2253 Start of line 21.

Friday 8th May (Day 128)

Squally showers with winds gusting up to 40 kt overnight, but decreasing to 10-15 kt by morning. Still a moderate swell from the north, still rolling.

0215 End of line 21.

0430 Start of line 22.

1200 End of line 22.

1215 Start of line 23.

Saturday 9th May (Day 129)

Weather still good, moderate westerly wind.

0003 End of line 23, start of line 24.

0700 End of line 24.

0700-0830 Recovered 3.5 kHz, TOBI and USBL. On recovery it was discovered that some 6-8 strands of the armouring of the main TOBI tow cable had broken at the termination. This required a re-termination of the wire, for which 24 hours needs to be allowed.

0830 Start passage to start of Tranche 36-53.

Sunday May 10th (Day 130)

Weather excellent, light SW winds, calm sea.

0700 On station at the start of Tranche 36-53. New cable termination completed.

0710-0800 Deployed 3.5 kHz, TOBI and USBL.

0832 Start of line 25.

1500 End of line 25. Start of line 26.

1845 End of line 26. Start of line 27.

0828 - 2300 Several crashes of 3.5 kHz system on shallowest depth setting.

2318 End of line 27.

Monday May 11th (Day 131)

Weather excellent, no wind, calm sea.

0039 Start of line 28.

0500 End of line 28. Start of line 29.

0646 End of line 29.

0724 Start of line 30.

0830-0940 Deviation from planned line to avoid long lines.

1500 End of line 30.

1627 Start of line 31.

1650-1750 Problems with losing DGPS signal.

Tuesday May 12th (Day 132)

Moderate wind from SE, slight sea.

0500-0530 Deviation from planned line to avoid long line buoys.

0657 End of line 31.

0904 Start of line 32.

1130-1230 Deviation from planned line to avoid long line buoys.

Wednesday May 13th (Day 133)

Excellent weather, almost no wind, calm sea.

0308 End of line 32.

0516 Start of line 33.

Thursday May 14th (Day 134)

Excellent weather, almost no wind, calm sea.

0350 End of line 33.

0550 Start of line 34.

Friday May 15th (Day 135)

Excellent weather, almost no wind, calm sea but moderate swell from west.

0806 End of line 34.

1038 Start of line 35.

Saturday May 16th (Day 136)

Light wind from SW, moderate swell from west, little sea.

1302 End of line 35.

1522 Start of line 36.

Sunday May 17th (Day 137)

Light wind from SW, moderate swell from west, little sea.

2048 End of line 36, start of line 36A.

Monday May 18th (Day 138)

Light wind, calm sea.

0039 End of line 36A.

0207 Start of line 36B.

0540 End of line 36B, end of Leg 1 survey.

0615 USBL and 3.5 kHz fish recovered.

0643 TOBI recovered.

0700 Begin passage to Stornoway.

1700 Ship Docked in Stornoway.

Tuesday May 19th (Day 139)

0000 - 2400 Port Call.

Wednesday May 20th (Day 140)

Light wind, calm sea, overcast skies.

0800 - 2000 Ship Sailed from Stornoway, completed passage to resume survey of Tranche 36-53. Before the vessel cleared the harbour, the ship's Captain and First Officer instructed the scientific party on safety procedures at sea, followed by fire and boat drill practice.

2005 3.5 kHz fish launched and logging commenced.

2030 USBL deployed, tested and aligned.

2136 TOBI deployment completed, logging commenced, passage to start point of line 37.

2330 Navigation logging begins.

2347 Start of Line 37.

Thursday May 21st (Day 141)

Light wind, calm seas and sunny then becoming overcast.

0000 Logging of USBL stopped to update line numbers.

0008 Logging of USBL re-started.

Friday 22nd May (Day 142)

Moderate wind, calm seas and overcast.

0827 End of Line 37

1026 Start of Line 38

The TOBI data obtained so far was processed and replayed. It appeared to be very noisy in the far ranges, with apparently very little signal (compared to the same area on Leg 1) across the whole swath. The quality was so poor that after carrying out several laboratory based diagnostics and re-booting the vehicle from both the software and power supplies, it was decided to terminate the survey, recover the vehicle and investigate the problem. The USBL was left deployed as was the 3.5 kHz fish.

1300 TOBI survey terminated, 3.5 kHz data logging stopped.

1340 TOBI depressor weight recovered.

1410 TOBI vehicle recovered and secured.

The TOBI electronics were checked after removal of pressure housings from the vehicle and after re-fitting it was found that the profiler would not fire, so the electronics pressure tubes were again removed to the laboratory for further inspection.

Saturday 23rd May (Day 143)

Overcast and breezy, swell from southwest.

0100 TOBI electronics re-fitted to vehicle and the system left powered up on deck overnight.

0654 3.5 kHz logging re-started.

0710 TOBI re-launched, all systems OK.

0740 Logging of sidescan data started.

0837 Start of Line 38.

Sunday 24th May (Day 144)

Overcast, steady 20-25 kt winds.

0408 Break off Line 38 to avoid seismic survey vessel *MV Geco Diamond*, hauling TOBI cable and circling back onto track.

0641 Ship back on Line 38.

0700 TOBI vehicle back on line.

1200 Gradually moved off-line by about 300 m to the northwest to avoid *MV Geco Diamond*.

1300 Passed *MV Geco Diamond* 0.6 n miles to port, then moved gradually back onto line.

2313 End of Line 38.

Monday 25th May (Day 145)

Mostly cloudy, steady 30-40 kt winds from northwest.

0045 -0107 USBL navigation locked. Stopped logging to re-boot system and adjust tie-line input to be curved rather than straight.

0207 Start of Line 39.

1000 SUN workstation had problems reading a 3.5 kHz CD-ROM. The CD had a small scratch which seemed to lock the system such that it kept trying to read the CD even when it was not in the drive. After several attempted re-boots, including power-offs, the problem persisted.

1130 Processed USBL navigation data appeared suspect, with a sinusoidal wave along the TOBI tracks. This was eventually traced to incorrect processing of the data.

1300 SUN CD-drive appears to be OK to read other disks but two of the system hard disks are now inaccessible. We are able to produce good navigation and run the image processing software however.

2207 Loss of output from sidescan and profiler. System apparently functional from laboratory diagnostics.

2237 Begin to haul in for recovery of TOBI.

2319 Depressor weight on deck, begin hauling in umbilical. Conditions for recovery are marginal with winds steady at 30 kt and gusting to 40 kt and a sharp 3-4 m swell.

2345 TOBI vehicle brought to the stern of the vessel but conditions judged to be too dangerous to attempt recovery. Umbilical paid out.

Tuesday 26th (Day 146)

0015 Depressor weight re-connected and 100 m of tow cable deployed to take vehicle below the wave base until conditions improve.

1200 Conditions still too severe (3-4 m swell, 30-35 kt wind, 40 kt gusts) to attempt safe recovery of vehicle, will look at conditions later although forecast is for only very slow improvement from northwest.

1800 Weather conditions as above.

2300 Weather conditions as above.

Wednesday 27th May (Day 147)

0800 Conditions showing a very slight improvement, wind down to 20 kt steady, gusting to 25, but the large swell persists.

1330 Began TOBI recovery, depressor weight on deck at 1335.

1400 TOBI on deck. Upon recovery a number of mechanical items were noted to be damaged and in need of repair as well as the investigation of the electrical/electronic fault(s). These included: the top “bumper bar” where the recovery ropes are stored was virtually ripped off and the bottom bumper was also bent, towing strut movement restrictor bolts were sheared, the main towing bolt was bent, three aluminium studs that hold the syntactic foam buoyancy in place were sheared. Examination of the electronics revealed the fault to be some power switching components that had failed (see TOBI report) leading to a loss of triggering on both the sidescan and profiler.

Thursday 28th May (Day 148)

Weather improved dramatically overnight, wind down to < 10 kt, with virtually no swell.

1030 TOBI repaired and tested, gyro’s spun up and ship proceeding along a steady course to align gyros.

1127 3.5 kHz logging re-start.

1330 TOBI launched all systems OK, return to Line 39.

1445 Back on Line 39 where previous TOBI run ceased.

Friday 29th May (Day 149)

Wind 12 kt from northeast, swell < 1 m, overcast.

0235 End of Line 39.

0452 Start of Line 40.

1430 3.5 kHz turned off to investigate noisy records. On lifting the fish it was found that the cow-tail had come adrift and the towing strut had cut through the plastic coating and into the cable armouring. The cable was replaced.

1908 3.5 kHz system back on-line.

Saturday 30th May (Day 150)

Overcast, wind 10 - 15 kt, no swell.

0242 End of Line 40.

0536 Start of Line 41.

1723 Lost DGPS.

1910 DGPS Back on-line.

Sunday 31st May (Day 151)

Overcast, wind increasing in speed from 25 kt in morning to steady 30- 40, gusting 45 kt in afternoon, from the northeast, swell rising to 3 m.

0004 End of Line 41.

0230 Start of Line 42.

1322 End of Line 42.

1553 Start of Line 43.

1733 TOBI sidescan and profiler stopped triggering, symptoms very similar to the previous failure of the MOSFET power switching components. Haul in to give only 300 m of wire out while waiting on the weather to improve for recovery. Heading slowly for start of Line 37R.

Monday 1st June (Day 152)

Mostly clear skies, winds 25-30 kt, swell about 2 m.

Still waiting for conditions to calm down prior to recovery.

1410 Wind down to 20 kt, swell 1-2 m, recovering TOBI.

1600 TOBI on-deck. System checked and MOSFET power switches found to be faulty. After repair the system was powered up on deck for final checks prior to deployment, but the profiler had stopped receiving or sending received signals to the logger. The system was dismantled for further tests.

Tuesday 2nd June (Day 153)

Cloudy, wind 20-25 kt, swell 1-2 m.

1730 TOBI re-deployed.

1754 Depressor weight connected, all systems checked out OK, logging begins, deploying depressor and paying out.

1805 Turn to head for Line 37R.

1921 Start of Line 37R.

Wednesday 3rd June (Day 154)

Partly cloudy with sunshine, < 1 m swell, wind 10 kt from NNE.

Thursday 4th June (Day 155)

Very sunny, no wind, no swell.

0716 End of Line 37R, alter course for area T30.

0820 During replay of the TOBI M-O disks it was noticed that on day 153/154 the internal clock did not advance the date on the logger. System re-set and logging resumed at 0826.

1928 Start Line 44, area T30. On instructions from Geotek, survey lines planned at 50% coverage for T30, to allow time for a return to the northwestern corner of T36-53 and for work to be undertaken in optional area T19-22. Only if seafloor proves to be of great interest will coverage of T30 be increased to 100%

2017 Deviating from line to avoid moored buoy.

2100 During processing of Line 37R, it was noted that some of the TOBI data has been logged with erroneous times (going backwards). Data was edited manually.

Friday 5th June (Day 156)

Wind 25 kt from East, swell around 1 m and building.

0753 End of Line 44

1005 Start of Line 45

2234 End of Line 45.

Saturday 6th June (Day 157)

0020 Total loss of Uninterruptable Power Supplies (UPS) in laboratory, all systems down.

0226 Power to laboratory cannot be maintained through UPS. Surveying suspended.

0308 TOBI short-hauled to an estimated 300m.

0707 All gear recovered, steaming for Kyle of Lochalsh for electrical repairs to vessel. Problem diagnosed as blow circuit board in ships main UPS.

Sunday 7th June (Day 158)

0800 Docked at Kyle of Lochalsh. Awaiting arrival of electrical engineer and portable UPS systems to run equipment through ship's "dirty" electrical supply. Engine room modifications made to power TOBI winch from the main engine transformer and thus relieve load through generators. Awaiting delivery of sufficient portable UPS systems.

Monday 8th June (Day 159)

1700 UPS systems delivered.

2100 All UPS systems attached to laboratory equipment and gear run up for electrical load testing prior to sailing. Processing of TOBI data from area T36-53 resumed. Bands of noise on TOBI sonar are the only difference detected since power diverted through portable UPSs. However, the source of these cannot be pinpointed.

2235 Decision made to sail and try and diagnose problem during passage, though it will be possible to interpret the geology through the noise.

2238 Sailed from Kyle of Lochalsh, heading for resumption of survey area T36-53, Line 43 at full speed.

Tuesday 9th June (Day 160)

Wind 35 kt, gusting 40-45 from northeast, swell 2-3 m.

1530 Arrived at area T36-53 start point, waiting on weather.

Wednesday 10th June (Day 161)

Wind 30-35 kt from northeast in morning, swell 2-3 m, moving round to north, 25 kt, gusting 35, swell 3-4 m in afternoon to evening.

Thursday 11th June (Day 162)

Wind 15-20 kt from northeast, swell 2-3 m.

0926 Begin deployment of 3.5 kHz fish and USBL.

1010 TOBI deployed, connecting depressor.

1042 Logging started, wire-out meter failed, but continued with deployment and run in to start of Line 43B. CTD keeps "hanging", hard system re-boots seem to cure the problem but only for a time, no signals from magnetometer. The approximate power requirements of the survey systems are estimated (from UPS units) as:-

TOBI deck unit and logging system............. 1,100 watts
TOBI replay system.. 700 watts
3.5 kHz & logger.. 700 watts

1116 Start of Line 43B.

1200 Magnetometer back on-line.

1947 End of Line 43B.

2214 Start of Line 46.

Friday 12th June (Day 163)

Very sunny, no swell, wind < 5 kt

0448 Transmission on TOBI sidescan and profiler failed, possibly MOSFET trouble again. Recovering TOBI. End of Line 46.

0608 TOBI inboard. Blown MOSFET confirmed as culprit and replaced.

0805 TOBI re-launched.

0825 TOBI logging, lowering to operating depth, moving to Line 47.

0859 Start of Line 47.

1447 End of Line 47.

1645 Start of Line 48.

2048 End of Line 48, end of area T36-53 survey, hauling survey gear.

2141 All gear inboard, begin steaming for area T19-22.

Saturday 13th June (Day 164)

Some clouds and sunshine, wind 10 kt, little swell.

1400 Begin equipment deployment.

1530 All equipment deployed, holding TOBI at 100 m depth to manoeuvre to Line 49 run-in.

1730 Start of Line 49.

2355 End of Line 49.

Sunday 14th June (Day 165)

Clouds and sunshine, wind 10 - 15 kt from northeast.

0128 Start of Line 50.

0200 Problems with quality of USBL fixes.

0744 End of Line 50.

0922 Start of Line 51.

1612 End of Line 51.

1733 Start of Line 52.

Monday 15th June (Day 166)

Sunny, no swell, wind < 5 kt

0223 End of Line 52.

0250 Start of Line 53.

0536 End of Line 53.

0630 Start of Line 54.

1130 End of Line 54.

1150 Start of Line 55.

1500   End of Line 55.

1530 Start of Line 56.

1845 End of Line 56, survey Ends, begin recovery of survey equipment.

2048 All gear recovered, begin steaming for Southampton.

Upon recovery of the USBL transponder from the moon-pool, the transponder head was found to be hanging loose from its mounting. Of the six stainless steel bolts holding the head in place, five had become unscrewed from their retaining bolts virtually to the end of each bolt and the sixth had become loosened to allow a gap of about 5 mm between the transponder and the mounting joint. This means that the transponder head was free to skew approximately 10° in the horizontal plane and 15° in the vertical and may explain why some of the later USBL data is apparently of poor quality, especially at the longer ranges.

Tuesday 16th June (Day 167)

Sunny, no swell, wind < 5 kt

Passage to Southampton.

Wednesday 17th June (Day 168)

Overcast and raining in morning, wind 30 kt from SSW, little swell.

Passage to Southampton.

Thursday 18th June (Day 169)

Overcast, wind 10 kt from SW, little swell.

On passage to Southampton.

1455 Docked at Southampton Oceanography Centre, begin demobilisation.

Friday 19th June (Day 170)

1700 Demobilisation completed.

TOBI OPERATIONS

6.1 System Description

TOBI - Towed Ocean Bottom Instrument - is Southampton Oceanography Centre's deep towed vehicle. It is capable of operating in 6000 m of water although during this survey the depth requirement was only down to 2000 m, with most of the area under investigation significantly shallower than this.

Although TOBI is primarily a sidescan sonar vehicle a number of other instruments are fitted to make use of the stable platform provided by TOBI. For this survey the instrument compliment was:

1. 30 kHz sidescan sonar (Built by SOC)
2. 7.5 kHz profiler (Built by SOC)
3. Three axis fluxgate magnetometer. (Ultra Electronics Magnetics Division MB5L)
4. CTD (Falmouth Scientific Instruments Micro-CTD)
5. Gyrocompass (S. G. Brown SGB 1000U)
6. Pitch & Roll sensor (G + G Technics ag SSY0091)

An AutoHelm ST50 GPS receiver provides the TOBI logging system with navigational data. An MPD 1604 9-tonne instrumented sheave provides wire out, load and wire rate information both to its own instrument box and wire out count signals to the logging system. For this cruise the TOBI vehicle was fitted with a Nautronix transponder beacon to give vehicle positions relative to the ship. The ship-mounted Nautronix Ultra Short Base Line (USBL) navigation package was mounted in the moonpool of the *R. V. Colonel Templer*.

The TOBI system uses a two bodied tow system to provide a highly stable platform. The vehicle weighs 2.5 tonnes in air but is made neutrally buoyant in water by using syntactic foam blocks. A neutrally buoyant umbilical connects the vehicle to a 600 kg depressor weight. This in turn is connected via a conducting swivel to the main armoured coaxial tow cable. All signals and power pass through this single conductor.

For this cruise the SOC TOBI winch system was utilised. This system combines tow, launch and umbilical winches onto one container-sized baseplate enabling one driver to control all operations. The winch was secured to the aft deck using a mounting bed frame designed and manufactured by Shiptech, Hull. The frame was designed so that the winch was mounted at a slight angle to the transverse to allow a straight line pull for the main winch to the towing block. During the surveys the winch was controlled by a remote station in the main laboratory.

6.2. Operations

The *R.V. Colonel Templer* is equipped with a stern mounted 5 tonne hydraulic 'A' frame. The frame has two locations for towing blocks. An upper point, used on this cruise for deploying and recovering the TOBI vehicle, and a lower site used for towing and for the deployment and recovery of the depressor weight. The main sheave was hung from a short strop from the lower point and a smaller ships' block used on the upper point.

For the first deployment and recovery a normal sideways method was tried for the TOBI vehicle. This was not easy as the distance between the 'A' frame legs is too narrow to allow the TOBI vehicle through sideways without turning it slightly. This proved difficult to achieve without reducing handling control of the vehicle. For the remainder of the cruise the vehicle was re-rigged with four recovery lines and a fore/aft deployment and recovery scheme adopted. This was a much simpler and safer method. The TOBI team would like to thank the Bosun and his crew for their help and ideas during the cruise.

TOBI watchkeeping was split into three four hour watches repeating every 12 hours. Watchkeepers kept the TOBI vehicle flying at a height of between 350 to 400 m above the seabed by varying wire out and/or ship speed. Ship speed was usually kept between 2.0 and 3.0 kt and fine adjustments carried out by using the winch. As well as flying the vehicle and monitoring the instruments watchkeepers also kept track of disk changes and course alterations.

Launch and recovery times of TOBI deployments are summarised in Table 1 (below). Full details of all survey lines are given in Figures 2-7 and in Tables A2.1 to A2.6 (Appendix 2). Data disks and their times are listed in Table A3.1 (Appendix 3). A total of 3617 line km of data (excluding turns between survey lines) was collected, resulting in coverage of 16200 km^2 of seafloor.

Table 1. Summary of TOBI deployments

Run	Start Time	End Time	Survey time	Length	Comments
1	1604/115	1241/119	3.8 days	210 miles	T65-67
2	2206/119	1825/126	6.7 days	375 miles	T60-63
3	0825/127	0716/129	1.9 days	95 miles	Block 240/14-15
4	0701/130	0643/137	7.0 days	480 miles	T36-53
5	2126/140	1300/142	1.65 days	89 miles	T36- 53 (repeat line 37)
6	0837/143	2207/145	2.6 days	154 miles	T36- 53
7	1430/148	1733/151	3.1 Days	143 miles	T36- 53

8	1754/153	0020/157	3.27 Days	195 miles	T36- 53 & T30
9	1042/162	0448/163	0.75 Days	51 miles	T36- 53
10	0825/163	2048/163	0.5 Days	31.5 miles	T36- 53
11	1530/164	1845/166	2.1 Days	129 miles	T19-22

Instrument Performance : Leg 1

During the passage to the first deployment site two electronic problems and one software problem were tackled.

Firstly, the wire out signals from the new MPD 1604 sheave were interfaced into the TOBI logging system: the sheave had arrived only the day before sailing. The quadrature signals were brought out to a 9-way 'D' type connector on the side of the MPD instrument display box, level shifted down to 5V level and passed to an up/down counter. The output of the counter is read by the logging computer and scaled to give an accurate metre reading.

Secondly, the profiler power amplifier blew a MOSFET output transistor on powering up on deck for the first time. The causes for this were eventually traced to pick-up from the sidescan transmission in the driver circuitry and a faulty MOSFET driver chip. The driver circuitry was redesigned using opto-isolators for good noise immunity and the driver chip replaced. This new design seems to have cured the reliability problems this circuit experienced in the past.

Thirdly, the logging computer clock was synchronised to the GPS system clock instead of its own internal DOS-based one which suffered from drift. This was accomplished by re-setting the internal clock to the GPS satellite time every hour. This method kept the logging system accurate to GMT to within 2 seconds, the minimum step under DOS.

During the survey the sidescan sonar performed well given the generally low backscatter levels of the seafloor. A number of probable man-made targets were observed during the cruise. At least two may be wreckage of some description and another is probably a partially buried cable or pipe some 15 km long. Noise on the sidescan record was mainly due to the USBL beacon and shipping noise, mostly from trawlers. An unidentified low amplitude pulse was observed with a repetition rate of about 1 second but not synchronous to the vehicle transmit pulse. There were three occasions of long bursts of modulated noise during run 4. Again these could not be attributed to any identifiable source.

The profiler performed well throughout the cruise. Again the USBL beacon and shipping were the main causes of interference. Penetration of up to 40 m was achieved in the softer sediments during run 2. This rather deep penetration seemed to make the bottom tracking algorithm give false readings, although this can be processed out post-survey if required.

The magnetometer data was solid throughout all the runs. Prior to the first deployment an axis change in data display software was required to correct for the 180 degree rotation that occurred during the repair to the unit after the last cruise.

The CTD functioned correctly throughout the first Leg.

The winch system functioned well throughout, with the only problem being one of blowing the phase monitoring module in the winch control box. This was put down to harmonics on the main three phase supply. The unit was bypassed after the second failure as its use is only for setting up the supply phase and sequence at the start of a cruise.

The new sheave unit performed well mechanically and electrically in the dry. However in the wet, noise appeared on the quadrature signal lines which gave wildly false readings on the MPD instrument display. Luckily the TOBI logging system counter could reject the high frequency spikes and remained unaffected. The load sensor gave believable readings throughout. The rate indicator needs a longer time constant over which to count to give reliable readings. The original rate meter was used to give an indication of winch speed.

After recovering the vehicle on run 1 it was noticed that one of the armouring strands on the main towing cable had broken at the termination module. This was acceptable and the cable was used for runs 2 and 3. On recovery from run 3 six more strands had broken and the termination had to be re-made before launch for run 4. The swivel was also changed for run 4, and a brand new unit used for the first time. The old swivel was in good condition and was serviced ready for future use.

It was hoped to test the swath bathymetry system during the first leg of the survey. However an instability in the swath receiver pre-amp which was affecting the sidescan signal meant that it was too risky use on the first run. Between the first and second runs tests were carried out and a solution was thought to have been reached by limiting the swing of the port swath FM telemetry channel. However after initial hopes, just before launch for run 2 the instability returned and the system was blanked off again. Prior to the third run tests confirmed that the instability was in the swath pre-amp tube. The tube was removed and a long term soak test carried out in the laboratory during the run with no problems occurring. The tube was re-inserted prior to the fourth run but again instability occurred. The pre-amp tube and the hydro tube were brought into the laboratory for tests and a solution was thought to have been found by limiting the range of TVG gain in the pre-amps. Re-installing into the vehicle again proved disappointing and the system had to be blanked off for the final run and was not used again during the survey.

Instrument Performance : Leg 2

In total there were 7 vehicle deployments and recoveries. Three forced recoveries resulted from the loss of the profiler and sidescan transmission on the TOBI vehicle and one further recovery was made because of poor quality of sidescan data. An additional recovery had to be made as a result of the failure of ship's laboratory power supply. In addition, a proportion of time was lost due to adverse weather conditions, hindering recovery and deployment (Tables A1.1 and A1.2).

Leg 2 suffered a higher proportion of vehicle downtime than in leg 1. The primary reason for the downtime was the repeated failure of the Profiler PPA (Pulse Power Amplifier). In each case, one of the MOSFET power switching transistors failed. This resulted in the power line, which supplies the profiler and sidescan driver systems, to be dragged down to ground. The vehicle is then not transmitting on either profiler or sidescan sonars.

The other source of downtime was the poor quality of sidescan data during the first run, run 5, where the return signals were low and obscured by noise. The source of this degradation was the sidescan chassis, housing the profiler and sidescan transmitter/receiver systems, becoming improperly isolated from it's pressure casing. This provided a signal return loop into the sea which is highly undesirable. Insulation modifications were carried out to the chassis and the problem of poor sidescan data did not re-occur.

A minor, although not critical, problem occurred due to the locking of the CTD, magnetometer and gyrocompass data streams from the vehicle to laboratory logging system. In all, this occurred three times, immediately after deployment, while the vehicle was in transit down to it's working depth. This did not result in any TOBI downtime. It only resulted in a few minutes of data logging downtime as the vehicle was powered down, then back up. This was required in order to reset the communications link between one of the TOBI microcontrollers (K4II) and the CTD/gyro subsystem.

At the end of the survey the hydro tube was opened up for inspection. This tube had not been touched during the whole of the second survey leg. On inspection the chassis was found to have moved and was loose. This could have caused the locking problems through a potential earth path to the sea. Insulation modifications, similar to the sidescan tube, were carried out to the chassis and the vehicle was tested on deck. A future deployment, at sea, will have to monitor for any re-occurrence of this problem.

The winch system functioned well throughout the second leg. With the failure of the ship's laboratory power supply, the winch was switched over to run off a spare transformer from the ship's main engine. This allowed an alternative laboratory supply to be provided with clean power through stand alone Uninterrupted Power Supplies (UPSs) placed strategically throughout the main lab. This did not affect the winch's performance for the rest of the leg.

The new sheave performed well mechanically and electrically, at first. However, while the vessel was hove to, in heavy seas, it broke loose from is anchor rope. Later inspection, at the end of the survey, revealed that a number of signal wires had chaffed. This was repaired and tested out satisfactory, on deck. Mechanically the sheave showed signs of sticking towards the end of the survey. A re-greasing of the sheave's bearings has successfully loosened up its movement.

The newer swivel was used on this leg and functioned with no problems. An oil change was carried out mid-cruise and another oil change at the end of the survey.

6.4. Data Recording and Replay

Data from the TOBI vehicle is recorded onto 1.2 Gbyte or 1.3 Gbyte magneto-optical (M-O) disks. One side of each disk gives approximately 16 hours 10 minutes or 17 hours 41 minutes of recording time respectively, depending on the disk type used. All data from the vehicle is recorded along with wire out and ship position taken from the GPS receiver. Data was recorded using TOBI programme LOG.C. The profiler data was corrected for the depth of the vehicle and replayed in programme PROFRAY.C. CTD data was copied off the M-O disks and onto floppy disk in ASCII format for importation into a spreadsheet using programme CTDCOPY.C. BLOWUP.C was used to generate large images of areas of interest. Data from the M-O disks were copied onto CD-ROM's for archive and for importation into the image processing system.

7. TOBI LAUNCH AND RECOVERY PROCEDURE

7.1. Overview

TOBI is equipped with sidescan sonar and sub-bottom profiler sonars and a range of other scientific instruments (see section 6.1 for details of instruments carried during this survey).

The vehicle itself measures 4.5 m long by 1.5 m high by 1.5 m wide and weighs approximately 2.5 tonnes in air. When deployed the vehicle is towed from a 200 m neutrally buoyant umbilical which is in turn attached to a 600 kg depressor weight. The weight is connected to the main conducting cable via a swivel unit. The use of this two bodied tow system gives a very stable towing arrangement but has the disadvantage of being more complicated to deploy and recover.

Since its first scientific cruise TOBI has been used on 8 different ships. The detailed method of deployment and recovery varies from ship to ship but the overall tactics remain the same. This document is based on the procedure used on the *R.V. Colonel Templer*.

7.2. Deck Equipment

Deck equipment used for TOBI operations on the *R.V. Colonel Templer* consisted of the following:

- Moving 'A' frame 3.7 m in width. This is less than the ideal width (> 4.5 m), necessitating that the vehicle was launched in a ‘fore and aft’ orientation and turned through 90° during launch
- Integrated winch system consisting of :
  - The main towing winch carrying 10 km of conducting tow cable.
  - A launch winch used for vehicle deployment
  - A umbilical winch used for deploying the 200 m long rope umbilical.
- Two capstans, one either side of the 'A' frame, for steadying and manoeuvring the vehicle during launch and recovery.
- A towing block with sheave mounted centrally on the 'A' frame.
- A lifting block mounted centrally on the 'A' frame.
- A 3-tonne deck crane for manoeuvring the vehicle.

7.3. Pre-launch Vehicle Rigging

In order to be able to safely recover the vehicle, recovery lines must be stowed on the vehicle. Lines are attached to the port side forward and aft quarters of the vehicle and a recovery hoisting line attached to the central lifting bridle. The aft line is attached along the port side towards the front using thin cable ties. The forward line and the hoisting line are then coiled with the aft line into a cradle at the front of the vehicle. The forward and aft lines are shorter than the hoisting line and are taped to it at their ends. Care must be taken not to twist the lines as this could impair recovery. Once coiled the lines are tied to the forward frame using thin cable ties.

The final procedure is the attachment of the recovery hoop. A thin rope running through the hoop is attached at both ends to the loop in the end of the hoisting line. The loop is tied to the front of the vehicle using cable ties so that it forms a target that can be easily grappled.

7.4. Vehicle Launch

The umbilical is attached to the vehicle and both electrical and mechanical connections are completed. The vehicle is then placed into the launch position under the 'A' frame. Stay lines are tied to fixing points on the outside of each 'A' frame leg, passed outboard around each 'A' frame leg, around the nearest inboard TOBI vehicle frame leg, then back around the 'A' frame before being coiled around their respective capstans. These stay lines must be long enough to allow the vehicle to be placed into the water under their control.

Two more stay lines are used inside the 'A' frame. These are made fast to a suitable eye, run around the nearest vehicle frame leg and back through another eye or cleat. These lines are hand held and are used to control the vehicle before the outside lines take control. They need to be long enough to enable this.

The launch winch cable is paid out through the launch block and attached to a large shackle. The two loops in the lifting bridle strops are passed through the shackle and held in place by a greased spike. The spike is attached to a rope such that it can be pulled out of the lifting bridle strops when the vehicle is in the water, so detaching the launch cable.

Once the vehicle is in position, with the stay lines and launch cable attached and the 'A' frame inboard, the ship is slowed to 0.5 kt and brought into the wind. About 10 m of umbilical cable is paid off the winch and laid out on deck, so that the vehicle can be launched without straining the umbilical. A minimum of seven people are required for the TOBI launch - four to man the stay lines, one each to operate the 'A' frame, the launch winch and the main winch.

With the stay lines manned the tension is taken up - the outer ones using the capstans and the inner ones by hand. The launch winch lifts the vehicle off the deck and the 'A' frame is paid out. Once clear of the stern the vehicle is turned through 90° and the winch pays out and the inner stay lines loosed off the vehicle. The outer lines are now in control and it is imperative that they remain tight to prevent unwanted movement of the vehicle. Once in the water the outer lines are loosed and the spike pulled, freeing the vehicle. The 'A' frame is then brought in.

The umbilical is then paid out and the ship's speed increased to 1.0 kt to stream the vehicle.

7.5. Depressor Weight Launch

Whilst the umbilical is being paid out the depressor weight can be brought into position (with the tail facing aft) underneath the 'A' frame using the crane. A cradle is used to hold the weight. The main cable is fed over the towing sheave and connected to the swivel unit on the depressor weight.

The umbilical is paid out until the tie loop is reached, stopping briefly before this to free the electrical connection from the inside of the winch. The umbilical is made off temporarily to an eye or cleat using the loop. The remainder is taken off by hand and the terminated end taken over to the tail of the depressor weight. The ship should now be slowed to 0.5 kt

The umbilical is terminated mechanically to the depressor weight tail and electrically to the swivel unit. At this point the vehicle can be turned on and tested. If tests are successful then the depressor can be launched by hauling on the main cable, paying out on the 'A' frame, then paying out on the main winch. Hand held stay lines may be used to steady the weight as it is deployed.

Once deployed the ship can be brought up to towing speed and the main cable paid out to working depth.

7.6. Depressor Weight Recovery

The recovery process is essentially the reverse of the deployment. The weight is brought to the surface using the main winch, ship speed brought down to 0.5 kt (into the wind) and the 'A' frame brought in. The launch winch cable is paid out to hook onto the nose of the weight when it comes aboard. A stay line may be slipped down the cable to restrict movement of the weight.

The weight is lifted from the water using the main winch under the control of the stay line. As soon as possible another line can be attached and the launch cable attached to the nose of the weight using a shackle or karabiner clip. The weight is then hauled up the deck using the launch winch and onto the cradle. The recovery loop on the umbilical is made off to an eye or cleat. The mechanical and electrical connections to the weight/swivel can then be disconnected. The mechanical connection is tied off to the umbilical winch and the electrical connection fed inside the winch for protection. The umbilical can then be hauled in whilst the depressor weight is stowed.

The ship may be sped up to 1.0 kt to keep the vehicle directly behind the ship.

The weight may be stowed with the main cable attached if no maintenance is required on the swivel unit.

7.7. Vehicle Recovery

The same personnel are needed for recovery as for launch.

As the umbilical is being recovered a long boathook equipped with a carribiner clip is readied. The inner stay lines, as used for deployment, are also made ready. The launch cable is fed through the launch block to accept the hoist line. As the vehicle approaches the ship the rate of umbilical recovery is reduced. When in range of the boathook the umbilical winch is stopped and the hoop on the vehicle grabbed by the carribiner. A pull on this will release the hoisting line and stay lines from the coil on the front of the vehicle.

This is the most dangerous part of the operation as the vehicle could get caught under the ship and damaged. It is good policy to pay out about 10 m on the umbilical as soon as the recovery hoop is grabbed. In severe conditions the ship speed can be increased to prevent the vehicle from surging under the stern.

Once the hoist line has been grabbed and uncoiled from the vehicle then the two stay lines are passed around their respective 'A' frame legs and fed over their capstan. The hoist line is attached to the launch cable and the slack taken up. The vehicle is then brought under the control to the stay lines to the stern of the ship and the 'A' frame brought half-way in. The vehicle is then lifted out of the water using the launch winch pulling on the hoisting line. The outer stay lines must be kept taut at this point to prevent unwanted motion of the vehicle. As soon as possible the inner stay lines are fed around the vehicle frame legs and passed through an eye or cleat to increase purchase. The 'A' frame is then brought fully in with the vehicle under the control of the four stay lines and the launch winch, the vehicle is turned through 90° and placed onto the deck underneath the 'A' frame.

8. 3.5 KHZ OPERATIONS

High-resolution sub-bottom profiles were routinely collected along all survey and passage lines using a standard SOC 3.5 kHz digital profiling system supplied by the Ocean Technology Division of SOC. The profiler was deployed over the bows of the vessel using a small crane which was then fixed in a cradle attached to the ship's rail. Approximately 4000 line km of data were collected during the survey. Minor problems were experienced with system crashes during the first leg.

The 3.5 kHz profiler data was archived digitally on a PC in addition to paper records being printed in real time. Initially the data was recorded onto 100 Mb Zip disks but a drive hardware fault made some of these disks unreadable and thus data was subsequently logged directly onto the hard disk. Download of data was achieved during the end of survey lines. The data consists of hourly binary files which were transferred to the main processing system via a CD-ROM archive. Each ping (or more accurately each received ping) consists of 4980 data points over a 1 second period, thus giving a vertical pixel resolution of approximately 15 cm. As the data rate was considerable a second smaller archive was also created. This archive reduced the pings to a regular 4 second period and 1000 samples (by averaging) thus improving the signal-to-noise ratio. Consecutive data files were then concatenated to make larger files as listed in Table A3.4.

For the second survey leg, a new PC controller was installed and logging went as originally planned, initially onto 100 Mb Zip disks before archival onto CD-ROM.

9. NAVIGATION

9.1. Vessel Navigation

During all survey periods DGPS was used to position the vessel. This comprised a Trimble GPS antenna and receiver for GPS and the Racal Skyfix system for DGPS. The data was logged directly from the ship's navigation computer onto a logging PC in the main laboratory using serial communications. Data were logged at 30 second intervals. This PC used Trimble HYDROnav software to log the data. The USBL system was linked to the navigation logging PC via a serial link.

The data logged were transferred over an Ethernet network to a second PC used for extracting the relevant data from the HYDROnav files into ASCII files (using Trimble processing software) for transfer onto the TOBI processing workstation. The data output from the Trimble processing software required manipulation in Microsoft Excel to edit poor quality data and to provide the data in a format usable by the TOBI data processors.

The ship's navigation data were of a very high quality, with the exception of several periods during leg 2 when differential correction signal was lost, due to onshore problems experienced by Racal. The ship's navigation data required little or no subsequent filtering or editing. However, during the first deployment the positions generated for TOBI appeared to be inaccurate and scattered about the ship's track. Investigation showed that this was caused by the Trimble HYDROnav software using the ship's course over the ground (COG) to calculate the TOBI positions. To correct these errors the ship's heading data (recorded by the ship's navigation computer) was used to restore the TOBI positions and a two-stage filter applied over periods of 5 and 10 minutes respectively. The resultant data (in the form of range, bearing and depth) proved to be very satisfactory and only where the USBL system had difficulties in acquiring good fixes did any data have to be discarded. The depth data that were manually entered by watchkeepers were also filtered to ensure any watchkeeping errors were removed.

The fully processed data were transferred to the UNIX workstation used for TOBI processing in the following format : Fix #-Date-Time-Ship's Latitude-Ship's Longitude-Ship's COG-TOBI Range-TOBI Bearing-TOBI Depth.

Ultra-short baseline navigation system

A Nautronix Acoustic Tracking System (ATS) II USBL system was installed prior to the cruise and comprised a data logger, a hydrophone mounted in the ship's moonpool and a high power directional beacon mounted on TOBI. The USBL hydrophone was lowered through the moonpool before each TOBI deployment and the mounting probe secured using four arms forced against the side of the moonpool using compressed air.

Prior to TOBI deployment the USBL system was calibrated; the hydrophone was lowered in the moonpool and positioned below the ship's hull. The beacon was lowered directly over the stern of the ship to ascertain the alignment of the hydrophone in the moonpool with the ship's centre line. Any discrepancies were corrected in the data logging software. During the course of Leg 1 the hydrophone had rotated by 17°. It is believed this was caused either by the rough handling required to lower the hydrophone through the moonpool or by buffeting that may have occurred during transit. This variation did not vary during deployments and was corrected for in the data logging software. During Leg 2, the hydrophone was carefully oriented using the centre line beacon, and no subsequent change in alignment was evident.

The USBL system was connected to the navigation logging PC, via a serial link, where the range and bearing data were used to calculate the position of TOBI. This position had to be corrected for ship's heading during subsequent processing (see above).

The USBL system was in general very easy to use. Although the system is capable of calculating xyz positions, it was operated in manual depth entry mode throughout the surveys. Since TOBI carries an accurate depth sensor this could be used to improve the quality of the xy positions by providing the z variable that would otherwise have to be calculated. This required that watchkeepers were vigilant of significant changes in the depth of TOBI.

During veering and hauling of TOBI, where horizontal range exceeded 2500 m, and in areas of complicated water structure the system found it difficult to acquire accurate positions or to receive a response from the beacon. Watchkeepers were required to monitor the system closely during these periods (and when wildly inaccurate fixes were generated) and attempt to re-acquire position by changing filter width and entering the approximate beacon position manually. In some cases this was not possible, and TOBI position data was interpolated for those periods during the navigation data processing stage.

10. SUMMARY OF PRELIMINARY RESULTS

10.1. Operations

All of the major objectives of the cruise were achieved despite the loss of 4 days of survey time to bad weather, 3.5 days to survey equipment failure and 3.5 days to ship problems. A full breakdown of the cruise operations is give in Tables A1.1 and A1.2 (Appendix 1).

Track charts for the areas surveyed are presented in Figs 2-7. Line spacing of between 4 and 5 km ensures 100% sidescan sonar coverage of the seabed in all areas except T30, where the contractor decided that 50% coverage would be acceptable.

10.2. Interpretation

A brief summary of the preliminary sidescan sonar interpretation undertaken during the cruise is presented below. Note that information based on the seabed sampling undertaken as a follow up to the sidescan survey was not available at the time of preparation of this part of the cruise report.

<u>Tranche 65-67 (Fig. 8)</u>

Sidescan images from this area shows strong variations in backscatter with depth, with a general decrease in backscatter downslope. Iceberg ploughmarks are ubiquitous from the southern edge of the area in about 300 m waterdepth to about 500 m waterdepth on the upper slope. A twofold subdivision of the ploughmark zone can be made, based on the style and density of ploughmarks. Above 400 m waterdepth, relatively small ploughmarks entirely cover the seabed (Fig. 9). Below 400 m, ploughmarks are rarer and larger. One individual ploughmark can be traced for about 20 km across the area. Only a few ploughmarks have any signature on either 3.5 kHz or deep-tow 7 kHz profiles, indicating that most have been filled by post-glacial sediments. They remain visible on the sidescan images because of acoustic contrasts between the sediments which fill the ploughmarks and those which the ploughmarks are cut into. Open ploughmarks are rarely more than 5 m deep. Across most of the area, the mid-slope between 500 and 700 m is marked by smooth high backscatter with few morphological features. By analogy with the west Shetland slope, this indicates an area of current swept seafloor with a sand and sandy gravel substrate. A decrease in backscatter between 700 and 850 m waterdepth indicates a decease in the coarse grain-size sediment and an increase in the mud content. In the northeastern part of the area, backscatter is more variable and a variety of weak downslope trending lineations are seen. Profiles show the subsurface sediments to consist of irregular layers and lenses, suggesting a chaotic structure. This area is interpreted as the southern edge of the North Sea Fan, a large body of glacial sediments deposited at the mouth of the Norwegian Trench. These sediments have a clear onlapping relationship with the slope sediments to the southwest (Fig. 10). In the northwest of area T65-67, this onlap appears to become a subsurface feature, buried beneath a thin sediment body characterised by very low backscatter. Again by analogy with the west Shetland area, this is interpreted as a sandy contourite body of Holocene age, apparently deposited by southward flowing Norwegian Sea water. In the extreme north of the area, backscatter levels increase slightly, indicating the muddy sediments of the basin floor. A possible shipwreck at 62°16'N, 00° 07' 25"E is a feature of note.

<u>Tranche 60-63 (Fig. 11)</u>

This area is mainly located in the deeper part of the Faeroe-Shetland Channel, in waterdepths from 800 to 1700 m. Except for small areas in the extreme northwest and southeast, the entire area is characterised by an even low backscatter sidescan return, interpreted to result from muddy basin floor sediments. A few very weak northwest trending lineaments within this area may be evidence for a relict downslope sediment transport system, possibly associated with the Miller Slide, the headwall of which lies upslope to the east. A slight increase in backscatter levels towards the base of the Faeroes slope may indicate some coarsening of grain size in this direction. Towards the southeast of the area, at the base of the slope between 900 and 1400 m, a band of ultra-low backscatter is interpreted as a sandy contourite deposit. Above 900 m, in the extreme southeast, a small area of high backscatter slope sediments (?sands and gravels) are seen. Profiles crossing this area show large-scale bedforms or slump folds trending alongslope. Pronounced grooves in the troughs between these structures are interpreted as scour by alongslope currents.

<u>Block 204/14-15 (Fig. 12)</u>

This area is located on the lower eastern slope of the Faeroe-Shetland Channel. It is mainly characterised by moderate backscatter largely featureless seafloor, a signature typical of the sandy muds which characterise the lower slope in this area. In the southeast corner of the block, a dense field of erosional furrows or grooves is seen. A few scattered poorly defined furrows also occur throughout the block. In the northeast quadrant of the block, an elongate band of lower backscatter at about 700 m waterdepth may indicate a sandy contourite body. A seafloor depression, up to 30 m deep, is seen near the western edge of the block. Although this feature has relatively steep sides, the backscatter contrasts associated with it are subdued, suggesting an old feature now largely mantled with younger sediments. The origin of this feature is unknown.

A single survey line run to the southwest of block 204-14/15 crossed a group of some 25 shallow channels immediately adjacent to block 204-14/15 (Fig. 12). Profiles indicate a relief of up to 5 m (10 m in one instance). These channels are probably relict features. Further southwest (and at shallower waterdepth) the smooth high-backscatter seafloor is typical of the sands and gravels which characterise the upper slope in the west of Shetland area.

Tranche T36-38, 43, 44, 47, 48, 52, 53 (Fig. 13)

This area is located on the northwest Hebrides continental slope and extends downslope to approximately 1,600 m waterdepth. The northwest limit of the study area is the lower slope of the Ymir Ridge, just to the south of the Wyville-Thompson Ridge. The upper parts of the slope are characterised by two regions of iceberg scours. The area of denser ploughmarks occur on the uppermost slope, down to depths in excess of 400 m, below which the ploughmarks are far fewer, though generally larger and tend to be parallel or sub-parallel to the contours. Only occasionally are ploughmarks noted below the 500 m contour (Note: these apparent depths may be due to poor quality bathymetry). Other characteristics of the ploughmarks are the same as those described in area T65-67. Downslope from the ploughmark zone is a region of high acoustic backscatter, interpreted as an upper-slope facies of probably sands and muddy sands. There are a number of contour-parallel lineations on the southeastern part of the slope, which is otherwise largely featureless, whereas to the northwest, between about 500 - 1,000 m, the slope is characterised by numerous small channels or gullies and lobes or “streams” of relatively high acoustic backscatter suggesting downslope sediment transport paths. Active channels are usually bounded by steep scarps and show well developed depositional lobes (again marked by discrete areas of high acoustic backscattering) at the foot of the slope. The downslope “streams” and channels cut across an area of low backscatter that runs along the base of the slope and extends just onto the basin floor. This is interpreted as a region of probably sandy contourite deposition, similar to area T60-63. The rest of the basin floor is characterised by a low-medium level of acoustic backscatter indicating probable mud and sandy mud deposition with occasional discreet areas of higher backscatter. Within the centre of the basin, there are a few discrete areas worthy of the further description (below).

In the southwest of the area, lying sub-parallel to the 1,400 and 1,500 m contour is a very distinct 10 m high scarp which can be traced for over 30 km. The throw of this scarp is in toward the centre of the basin, and it is probably related to some deeper structural feature; the high resolution profilers used for this study do not have the penetration to determine this. In the centre of the basin a field of sediment waves was mapped. Individual waves varied in size from a few metres to over 30 m from peak to trough. It was possible to map the trend of many (though not all) of the waves from their signature on the sidescan records. The waves trend 145°, and many are > 5 km in length. Those waves in the northeastern part of the field usually showed a higher level of acoustic backscatter on their southwest faces (suggesting coarser sediments and a current direction from the northeast), whereas other waves (apparently regardless of size) had no significant signature on the sidescan images and the crests and trough were mapped from the profiles. The 3.5 kHz profiles show that the original migration direction was to the northeast, confirming that they formed under a current flowing from the northeast. However, all the waves are now covered in a uniformly thick transparent layer, presumably Holocene cover, with no evidence of present (or Holocene) activity.

Adjacent to this sediment wave field is an area of pockmarks. These are circular to sub-circular features with diameters apparently up to 100 m and depths (from the TOBI profiler) of 1-3 m. Just outside of the pockmark area are individual targets that have a slightly higher level of backscatter and a different appearance to the pockmarks; the profiler shows them to be positive relief features of 2-5 m in height and around 200 m in diameters. They occur at about 1,000 m waterdepth. Our preliminary interpretation is that they are likely to be biogenic mounds or small mud volcanoes. The parallel sub-bottom reflectors seen on profiler records in this area disappear beneath the majority of those few mounds crossed with the profiler. This suggests either disrupted reflectors or acoustic blanking.

To the north of the pockmark area the general level of acoustic backscatter from the seafloor is very low, indicative of basin-fill sediments such as muds and muddy sands. However, this low backscatter region is punctuated by a large number of discrete high backscatter targets, centred approximately on 59°42.0'N 07°26.0'W; most are a few to tens of metres in diameter. The very low backscatter of the surrounding sediments makes it difficult to see acoustic shadows to determine whether these features have any relief. However, the strength of the backscatter suggests that they are some form of hard material and may be biogenic mounds.

In the extreme north of the area, we mapped a number of "Haloed" features - circular to sub-circular areas of high acoustic backscatter with areas of moderately high backscatter forming ellipses in an apparent down-current (alongslope) direction (Fig. 14). The central part of each target show small shadows on their far sides indicating that they have some relief. Just to the west of these is an unusual area of medium-high backscatter, with an irregular, but well-defined shape. The backscatter levels here are similar to the "haloes" described above, however, there is no evidence for any relief, and the area in question is very much larger (approximately 1.4 km^2) than other presumed biogenic mounds in the area. The shape of this feature does not suggest an origin through normal sedimentary or bottom current processes, and it may be biological in origin.

<u>Tranche T30 (Fig. 15)</u>

This area is located between the southern flank of Rosemary Bank and the western extremity of the mid and lower west Hebrides continental slope. The sidescan survey (two north-south lines) shows three major acoustic backscatter provinces. The first of these is an area of very high acoustic backscatter located within the scour trench around the base of the seamount. It is interpreted as due to current-winnowing of the seafloor sediments, leaving a lag deposit of coarse material. The second province covers the vast majority of the Tranche and consists of medium strength backscattering sediments with no indication of surface ornamentation. High resolution profiles show this part of the Tranche to consist of well-layered sediments that gently onlap the sediments to the south. The third backscatter province is located at the base of the Hebrides continental slope. Although the sidescan backscatter levels here are significantly higher than those across the majority of the survey area, the only noticeable difference is that on the profile data, the sub-bottom layers are thicker and slightly less coherent, especially higher up the slope, becoming more numerous (thinner beds) and better defined with depth. At the very southern edge of the survey area the surface sediments are draped over a 30 m high raised block at the base of the continental slope.

<u>Tranche T19-22 (Fig. 16)</u>

This area is located on the Malin/west Hebrides continental slope and encompasses the upper regions of the Barra Fan. Overall, the area is characterised by a medium-high levels of acoustic backscatter, due largely to the coarse sediments (produced by current winnowing ?) on this part of the slope. The ENE-WSW trending northernmost survey loop was undertaken to cover a sampling transect taken by the *RRS Charles Darwin*. Here the most striking features were the very high backscatter returns above the 950 m contour, which is interpreted as indicating a current-swept steep upper slope, and on the lower slope, a well defined channel, which at 1750 m waterdepth is 12-15 m deep. The main (central) part of the survey is again characterised by a medium-high level of acoustic backscatter. The two survey lines above the 1300 m contour show few features on the sonographs, and there is considerable water column refraction at ranges over 1 km. The differences in acoustic backscatter in the deeper water can be attributed to coarse debris-flow deposits. The profiler data reveal that the debris flow(s) are mostly very near to the seabed surface and in one area the top of the debris flow outcrops. The southern half of the main survey is a generally featureless slope, though in the extreme south a series of small slope terraces can be mapped. Profile data show that the substrate is composed of draped sediments that smooth the slope, covering debris flow material. The last part of the survey was the single swath running downslope to the WSW. Here again the slope is mostly smooth drape, 2-3 m thick over debris material, with medium-high backscatter levels on the sonographs. Toward the end of this run, several small (10's of metres across), high backscatter targets were mapped, but their origin and relief are at present uncertain.

APPENDIX 1 - SUMMARY OF OPERATIONS

Table A1.1 : Summary

	Mobilisation & Port Call	Passage	Survey	Weather Downtime	Survey Downtime	Ship Downtime
Total (Hr)	113	224.2	842.7	94.5	87.1	87.5
Total (Days)	4.71	9.34	35.1	3.94	3.63	3.65
Total (%)	7.8	15.5	58.2	6.5	6.0	6.0

Total working time **49.16 Days** **(81.43 %)**

Total down time **11.21 Days** **(18.57 %)**

Table A1.2. Detail of operations (hours)

Date	Julian Day	Mobilisation & Port Call	Passage	Survey	Weather Downtime	Survey Downtime	Ship Downtime
April 20	110	16					
21	111	24					
22	112	8	16				
23	113		24				
24	114		24				
25	115		14	10			
26	116			24			
27	117			24			
28	118			24			
29	119		7	17			
30	120			24			
May 1	121			24			
2	122			24			
3	123			24			
4	124			24			
5	125			24			
6	126		5	19			
7	127		6	18			
8	128			24			
9	129		8	7		9	
10	130			17		7	
11	131			24			
12	132			24			
13	133			24			
14	134			24			
15	135			24			

16	136			24			
17	137			24			

Table A1.2 (contd.)

Date	Julian Day	Mobilisation & Port Call	Passage	Survey	Weather Downtime	Survey Downtime	Ship Downtime
18	138	7	10	7			
19	139	24					
20	140	8	15	1			
21	141			24			
22	142			13		11	
23	143			17		7	
24	144			24			
25	145			22		2	
26	146				24		
27	147			9.5	14.5		
28	148			10.5		13.5	
29	149			24			
30	150			24			
31	151			17.5		6.5	
June 1	152				14	10	
2	153			6.5		17.5	
3	154			24			
4	155		12	12			
5	156			24			
6	157						24
7	158						24
8	159						24
9	160				8.5		15.5
10	161				24		
11	162			14.5	9.5		
12	163		3.2	17.2		3.6	
13	164		14	10			
14	165			24			
15	166		3	21			
16	167		24				
17	168		24				
18	169	9	15				
June 19	170	17					

APPENDIX 2 - SURVEY LINE LOCATIONS

Table A2.1. List of TOBI survey line waypoints for Tranche 65-67

Line no	Start			End			Length (n.m.)
	Latitude	Longitude	Time	Latitude	Longitude	Time	
1	61° 59.95'N	00° 33.40'E	1821/115	62° 29.90'N	00° 33.70'E	0750/116	30
2	62° 29.66'N	00° 29.66'E	0951/116	61° 59.74'N	00° 28.32'E	2305/116	30
3	62° 00.13'N	00° 23.18'E	0030/117	62° 30.54'N	00° 23.16'E	1247/117	30
4	62° 30.00'N	00° 17.81'E	1424/117	61°59.84'N	00° 18.00'E	0129/118	30
5	61° 59.91'N	00° 12.92'E	0230/118	62° 30.69'N	00° 12.88'E	1200/118	30
6	62° 29.95'N	00° 07.81'E	1336/118	61° 59.71'N	00° 07.81'E	2340/118	30
7	61° 59.99'N	00° 02.69'E	0042/119	62° 30.82'N	00° 02.69'E	1120/119	30

Table A2.2. List of TOBI survey line waypoints for Tranche 60-63

Line no	Start			End			Length (n.m.)
	Latitude	Longitude	Time	Latitude	Longitude	Time	
8	61° 39.95'N	01° 38.90'W	2300/119	62° 31.37'N	01° 39.00'W	1904/120	50
9	62° 30.00'N	01° 44.80'W	2155/120	61° 39.28'N	01° 44.80'W	1830/121	50
10	61° 40.00'N	01° 50.50'W	2028/121	62° 31.59'N	01° 50.56'W	1530/122	50
11	62° 29.14'N	01° 56.30'W	1825/122	61° 38.99'N	01° 56.29'W	1350/123	50
12	61° 41.60'N	01° 58.00'W	1620/123	61° 41.60'N	03° 00.00'W	0310/124	29.3
13	61° 44.31'N	02° 57.52'W	0500/124	61° 44.28'N	01° 55.87'W	1450/124	29.3
14	61° 47.10'N	01° 59.00'W	1705/124	61° 47.08'N	02° 49.34'W	0015/125	23.2
15	61° 49.91'N	02° 44.59'W	0221/125	61° 49.89'N	01° 56.55'W	1114/125	23.2
16	61° 52.48'N	01° 58.71'W	1243/125	61° 52.47'N	02° 50.83'W	1948/125	23.2
17	61° 55.20'N	02° 44.56'W	2228/125	61° 55.20'N	01° 57.41'W	0645/126	23.2
18	61° 57.99'N	01° 59.02'W	0824/126	61° 59.99'N	02° 50.00'W	1633/126	23.2

Table A2.3. List of TOBI survey line waypoints for Block 204/14-15

Line no	Start			End			Length (n.m.)
	Latitude	Longitude	Time	Latitude	Longitude	Time	
19	60° 38.80'N	04° 24.02'W	0830/127	60° 38.79'N	03° 58.84'W	1208/127	12
20	60° 36.20'N	04° 00.05'W	1414/127	60° 36.06'N	04° 25.04'W	2115/127	12
21	60° 33.69'N	04° 23.95'W	2253/127	60° 33.69'N	03° 59.04'W	0215/128	12
22	60° 31.01'N	04° 00.26'W	0430/128	60° 31.09'N	04° 24.86'W	1200/128	12
23	60° 31.00'N	04° 25.61'W	1215/128	60° 10.00'N	05° 00.00'W	0003/129	25
24	60° 10.00'N	05° 00.00'W	0003/129	59° 25.02'N	05° 29.96'W	0700/129	22

Table A2.4. List of TOBI survey line waypoints for Tranche 36-53

Line no	Start			End			Length (n.m.)
	Latitude	Longitude	Time	Latitude	Longitude	Time	
25	59° 08.82’N	07° 11.94’W	0832/130	58° 57.22’N	07° 33.95’W	1500/130	17
26	58° 57.22’N	07° 33.95’W	1500/130	58° 49.08’N	07° 38.45’W	1845/130	8
27	58° 49.08’N	07° 38.45’W	1845/130	58° 39.71’N	07° 55.34’W	2318/130	12
28	58° 40.00’N	08° 00.61’W	0039/131	58° 50.65’N	07° 40.89’W	0505/131	15
29	58° 50.65’N	07° 40.89’W	0505/131	58° 56.00’N	07° 37.34’W	0646/131	5
30	58° 56.13’N	07° 39.04’W	0724/131	58° 39.93’N	08° 06.84’W	1500/131	22
31	58° 40.33’N	08° 12.17’W	1627/131	59° 12.06’N	07° 11.87’W	0657/131	45
32	59° 15.06’N	07° 12.06’W	0904/132	58° 40.28’N	08° 18.40’W	0308/133	54
33	58° 40.00’N	08° 25.10’W	0516/133	59°.31.81’N	06° 47.18’W	1350/134	72
34	59° 34.87’N	06° 46.62’W	0550/134	58° 40.01’N	08° 32.39’W	0806/135	77
35	58° 40.00’N	08° 39.00’W	1038/135	59° 38.96’N	06° 47.08’W	1302/136	82
36	59° 42.20’N	06° 48.00’W	1522/136	58° 39.96’N	08° 46.58’W	2048/137	87
36A	58° 39.96’N	08° 46.58’W	2048/137	58° 32.73’N	09° 03.37’W	0039/138	10
36B	58° 31.24’N	08° 58.62’W	0039/137	58° 37.57’N	08° 43.94’W	0530/138	11
37[a]	58° 43.12’N	08° 47.95’W	2347/140	59° 49.72’N	06° 41.28’W	0827/142	93
38	59° 49.99’N	06° 47.95’W	0837/143	58° 46.59’N	08° 50.05’W	2313/144	89
39	58° 50.98’N	08° 48.03’W	0207/145	59° 50.68’N	06° 54.33’W	0235/149	83
40	59° 50.00’N	07° 02.70’W	0452/149	59° 07.80’N	08° 24.00’W	0242/150	60
41	59° 11.50’N	08° 24.00’W	0536/150	59° 50.69’N	07° 08.81’W	0004/151	54
42	59° 50.01’N	07° 17.59’W	0230/151	59° 27.54’N	08° 01.22’W	1322/151	32
43	59° 32.00’N	07° 59.98’W	1553/151	59° 34.18’N	07° 56.20’W	1733/151	7.8
37R	59° 46.24’N	06°48.03’W	1921/153	58° 42.21’N	08° 49.59’W	0716/155	88.5
43[b]	59° 33.84’N	07°57.53’W	1116/162	59° 50.39’N	07°24.22’W	1947/162	22.5
46	59° 50.01’N	07°32.59’W	2214/162	59° 50.00’N	07°32.50’W	0448/163	20
47	59° 39.65’N	08°00.00’W	0859/163	59° 50.26’N	07°39.69’W	1447/163	14.5
48	59° 50.09’N	07°47.11’W	1645/163	59° 43.22’N	08°00.54’W	2048/163	9

a Line 37 repeated (37R) due to poor data quality.

b Continuation of partially completed Line 43.

Table A2.5. List of TOBI survey line waypoints for Tranche 30

Line no	Start			End			Length (n.m.)
	Latitude	Longitude	Time	Latitude	Longitude	Time	
44	59° 00.00’N	09° 38.49’W	1928/155	58° 28.47’N	09° 38.74’W	0753/156	30
45	58° 30.00’N	09° 48.49’W	1005/156	59° 00.00’N	09° 48.48’W	0020/157	30

Table A2.6. List of TOBI survey line waypoints for Tranche 19-22

Line no	Start			End			Length (n.m.)
	Latitude	Longitude	Time	Latitude	Longitude	Time	
49	56° 56.05’N	09° 14.50’N	1730/164	56° 38.97’N	09° 14.52’N	2355/164	16
50	56° 40.01’N	09° 19.49’W	0128/165	56° 57.27’N	09° 19.45’W	0744/165	16
51	56° 56.00’N	09° 24.51’W	0922/165	56° 38.74.N	09° 24.63’W	1612/165	16
52	56° 39.81’N	09° 29.48’W	1733/165	57° 02.32’N	09° 29.50’W	0223/166	23
53	57° 03.26’N	09° 28.58’W	0250/166	57° 06.81’N	09°16.64’W	0536/164	8
54	57° 04.99’N	09 °16.15’W	0630/166	56° 59.31’N	09° 33.52W	1130/166	12.5
55	56° 58.53’N	09° 34.49’W	1150/166	56° 49.88’N	09° 34.52’W	1500/166	10
56	56° 48.78’N	09° 36.01’W	1530/166	56° 46.67’N	09° 50.27’W	1845/166	7.5

APPENDIX 3 - DATA SUMMARY

Table A3.1. TOBI data disks and profile rolls

TOBI disk no.	Profiler roll number	Area	Start	End
550	1	T65-67	1604/115	0813/116
551	2	T65-67	0814/116	0023/117
552	3	T65-67	0023/117	1632/117
553	4	T65-67	1632/117	0841/118
554	5	T65-67	0841/118	0050/119
555	6	T65-67	0050/119	1241/119
556	7	T60-63	2206/119	1415/120
557	8	T60-63	1415/120	0624/121
558	9	T60-63	0624/121	2223/121
559	10A	T60-63	2234/121	0334/122
	10B	T60-63	0421/122	1655/122
560	11	T60-63	1655/122	0300/123
	12	T60-63	0302/123	1039/123
561	13	T60-63	1039/123	0420/124
562	14	T60-63	0420/124	2201/124
563	15	T60-63	2202/124	1543/125
564	16	T60-63	1543/125	0924/126
565	17	T60-63	0924/126	1825/126
	18	204/14-15	0825/127	1706/127
566	19	204/14-15	1706/127	1047/128
567	20	204/14-15	1047/128	0428/129
568	21	204/14-15	0428/129	0716/129
	22	T36-53	0801/130	2143/130
569	23	T36-53	2143/130	1352/131
570	24	T36-53	1352/131	0601/132
571	25	T36-53	0601/132	2210/132
572	26	T36-53	2210/132	1419/133
573	27	T36-53	1419/133	0628/134
574	28	T36-53	0629/134	2237/134
575	29	T36-53	2238/134	1447/135
576	30	T36-53	1447/135	0656/136
577	31	T36-53	0656/136	2305/136

Table A3.1. (contd.)

TOBI disk no.	Profiler roll number	Area	Start	End
578	32	T36-53	2305/136	1514/137
579	33	T36-53	1514/137	0602/138
580	34	T36-53	2122/140	1505/141
581	35	T36-53	1505/141	0848/142
582	36	T36-53	0849/142	1133/142
	36A	T36-53	1142/142	1338/142
	37	T36-53	0738/143	2039/143
583	38	T36-53	2039/143	1421/144
584	39	T36-53	1421/144	0803/145
585	40	T36-53	0803/145	2237/145
586	41	T36-53	1332/148	0622/149
587	42	T36-53	0622/149	0004/150
588	43	T36-53	0004/150	1746/150
589	44	T36-53	1746/150	0955/151
590	45	T36-53	0955/151	1836/151
591	46	T36-53	1753/153	1004/154
592	47	T36-53	1004/154	0215/155*
593	48	T36-53	0216/155	0825/155*
	49	Passage to T30	0830/155	1832/155
594	50	T30	1832/155	1043/156
595	51	T30	1044/156	0020/157
596	Not used	------	------	------
597	52	T36-53	1042/162	0255/163
598A	53	T36-53	0255/163	0715/163
	54	T36-53	0822/163	2105/163
599	55	T19-22	1528/164	0738/165*
600	56	T19-22	0739/165	1622/165*
601	57	T19-22	1628/165	0837/166
602	58	T19-22	0837/166	1846/166

* Day number did not advance automatically, system had to be re-set.

Table A3.2. TOBI raw sidescan rolls

Roll number	Area	Start	End
1	T65-67	1600/115	1050/117
2	T65-67	1050/117	1241/119
3	T60-63	2205/119	1825/126
4	204/14-15	0825/127	0720/129
5	T36-53	0801/130	0130/136
6	T36-53	0130/136	0603/138
7	T36-53	2122/140	1131/148
8	T36-53	1332/148	1700/151
9	T36-53	1727/153	1859/155
10	T30	1859/155	0020/157
11	T36-53	1042/162	0752/163
12	T36-53	0821/163	2106/163
13	T19-22	1527/164	1846/166

Table A3.3. 3.5 kHz paper rolls

Roll number	Area	Start	End
1	T65-67	1600/115	1130/119
2A	T60-63	2100/119	0300/120
2B	T60-63	0300/120	1720/122
2C	T60-63	1720/122	1739/126
3	204/14-15	0623/127	0700/129
4A	T36-53	0712/130	1402/130
4B	T36-53	1405/130	0815/135
4C	T36-53	0920/135	0546/138
4D	T36-53	2005/140	2353/141
4E	T36-53	2354/141	2354/145
4F	T36-53	1127/148	1322/151
4G	T36-53	1322/151	1312/155
4H	T36-53	1312/155	1858/155
5A	T30	1858/155	0324/157
4I	T36-53	1000/162	2049/163
6A	T19-22	1544/164	1845/166

Table A3.4. 3.5 kHz data disks

Area	Paper Roll	Disk no	File no	No of lines	Start	End
T65-67	1	1	ctem0198p1.3k5	2280	1728/115	2000/115
T65-67	1	1	ctem0198p2.3k5	19907	2012/115	1939/116
T65-67	1	1	ctem0198p3.3k5	1319	2032/116	2159/116
T65-67	1	1	ctem0198p4.3k5	299	2240/116	2259/116
T65-67	1	1	ctem0198p5.3k5	187	2347/116	2359/116
T65-67	1	2	ctem0198p6.3k5	711	0112/117	0159/117
T65-67	1	2	ctem0198p7.3k5	1704	0206/117	0359/117
T65-67	1	2	ctem0198p8.3k5	7429	0444/117	1259/117
T65-67	1	2	ctem0198p9.3k5	8857	1309/117	2259/117
T65-67	1	2	ctem0198p10.3k5	946	2356/117	0059/118
T65-67	1	2	ctem0198p11.3k5	535	0124/118	0159/118
T65-67	1	2/3	ctem0198p12.3k5	21364	0214/118	0159/119
T65-67	1	3	ctem0198p13.3k5	8208	0220/119	1128/119
T60-63	2A/2B	4	ctem0198p14.3k5	12780	2036/119	1049/120
T60-63	2B	4	ctem0198p15.3k5	21565	1053/120	1052/121
T60-63	2B	4	ctem0198p16.3k5	7000	1057/121	1844/121
T60-63	2B	5	ctem0198p17.3k5	14507	1937/121	1145/122
T60-63	2B/2C	5	ctem0198p18.3k5	21527	1150/122	1146/123
T60-63	2C	5	ctem0198p19.3k5	1822	1151/123	1352/123
T60-63	2C	6	ctem0198p20.3k5	17874	1500/123	1053/124
T60-63	2C	6/7	ctem0198p21.3k5	21677	1057/124	1103/125
T60-63	2C	7	ctem0198p22.3k5	21317	1108/125	1051/126
T60-63	2C	7	ctem0198p23.3k5	6017	1055/126	1737/126
204/14-15	3	8	ctem0198p24.3k5	1367	0623/127	0754/127
204/14-15	3	8	ctem0198p25.3k5	2698	0802/127	1102/127
204/14-15	3	8	ctem0198p26.3k5	11061	1107/127	2054/127
204/14-15	3	8	ctem0198p27.3k5	4423	2204/127	0259/128
204/14-15	3	8/9	ctem0198p28.3k5	6659	0331/128	1055/128
204/14-15	3	9	ctem0198p29.3k5	17954	1101/128	0659/129
T36-53	4A	10	ctem0198p30.3k5	153	0749/130	0759/130
T36-53	4A	10	ctem0198p31.3k5	1153	0830/130	1104/130
T36-53	4A/4B	10	ctem0198p32.3k5	2447	1123/130	1459/130
T36-53	4B	10	ctem0198p33.3k5	108	1552/130	1559/130

Table A3.4. (contd.)

Area	Paper Roll	Disk no	File no	No of lines	Start	End
T36-53	4B	10	ctem0198p34.3k5	7	1659/130	1659/130
T36-53	4B	10	ctem0198p35.3k5	490	1754/130	1859/130
T36-53	4B	10	ctem0198p36.3k5	157	1939/130	2000/130
T36-53	4B	10	ctem0198p37.3k5	4026	2046/130	0359/131
T36-53	4B	10	ctem0198p38.3k5	9150	0451/131	1502/131
T36-53	4B	11	ctem0198p39.3k5	13832	1536/131	0659/132
T36-53	4B	11	ctem0198p40.3k5	15610	0738/132	0100/133
T36-53	4B	11	ctem0198p41.3k5	1348	0138/133	0308/133
T36-53	4B	12	ctem0198p42.3k5	23555	0348/133	0559/134
T36-53	4B	13	ctem0198p43.3k5	23752	0600/134	0825/135
T36-53	4C	14	ctem0198p44.3k5	24866	0920/135	1300/136
T36-53	4C	15	ctem0198p45.3k5	18323	1337/136	0959/137
T36-53	4C	15	ctem0198p46.3k5	17769	1000/137	0545/138
T36-53	4D/4E	16	ctem0298p47.3k5	36781	2005/140	1259/142
T36-53	4E	17	ctem0298p48.3k5	36928	0655/143	0000/145
T36-53	4E	18	ctem0298p49.3k5	21523	0000/145	2356/145
T36-53	4F	18	ctem0298p50.3k5	11285	1126/148	2359/148
T36-53	4F	19	ctem0298p51.3k5	10362	0000/149	1131/149
T36-53	4F	19	ctem0298p52.3k5	2522	1141/149	1430/149
T36-53	4F	19	ctem0298p53.3k5	22351	1908/149	1959/150
T36-53	4F/4G	20	ctem0298p54.3k5	20170	2000/150	1826/151
T36-53	4G	20	ctem0298p55.3k5	13673	1747/153	0859/154
T36-53	4G/4H	21	ctem0298p56.3k5	30564	0900/154	1859/155
T30	5A	22	ctem0298p57.3k5	26071	1900/155	0000/157
T30	5A	22	ctem0298p58.3k5	895	0224/157	0324/157
T36-53	4I	23	ctem0298p59.3k5	31431	0951/162	2048/163
T36-53/ T19-22	4I/6A	24	ctem0298p60.3k5	24523	1443/163	1800/165
T19-22	6A	25	ctem0298p61.3k5	22229	1800/165	1844/166

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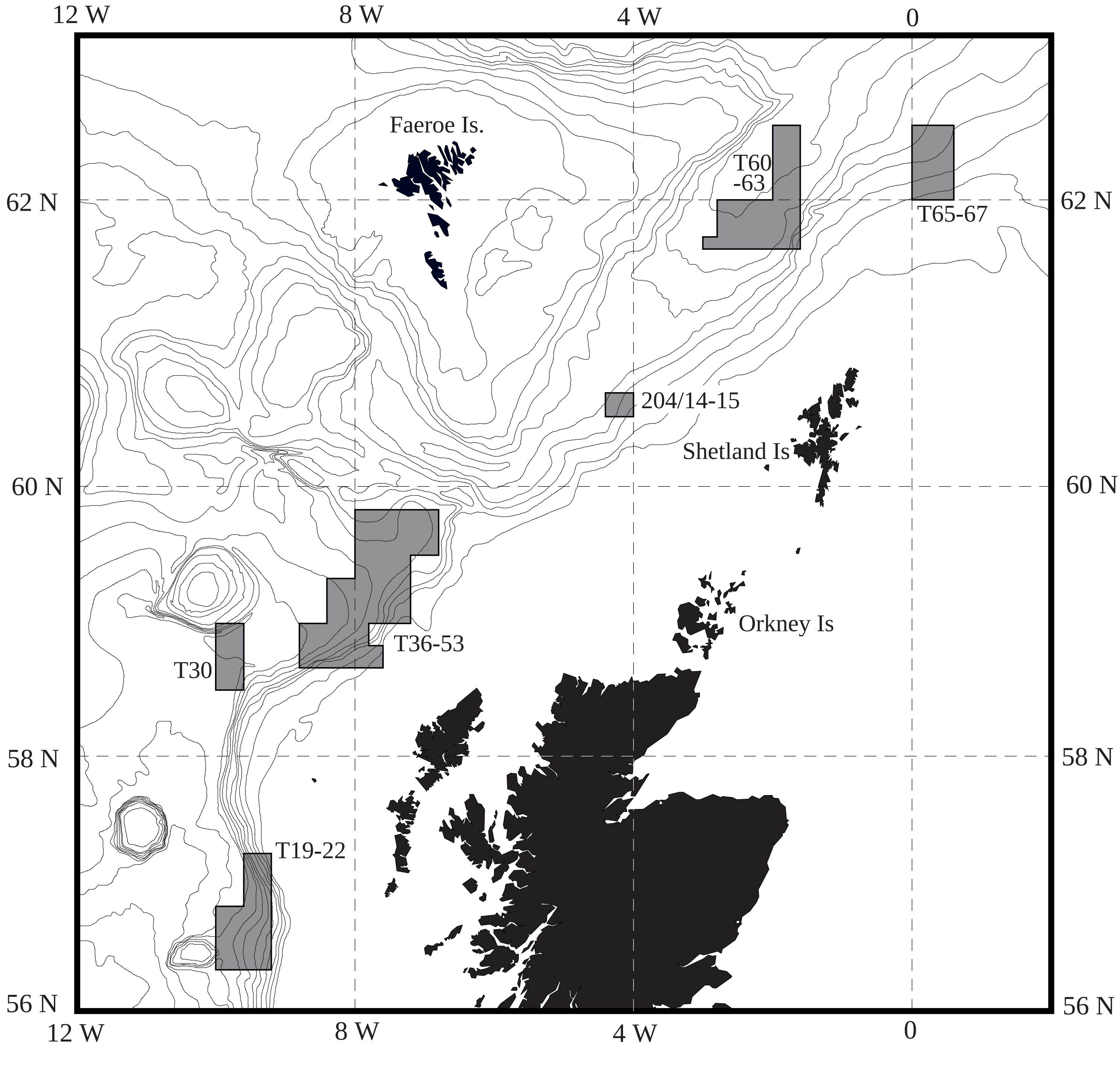

Figure 1. Location of survey areas

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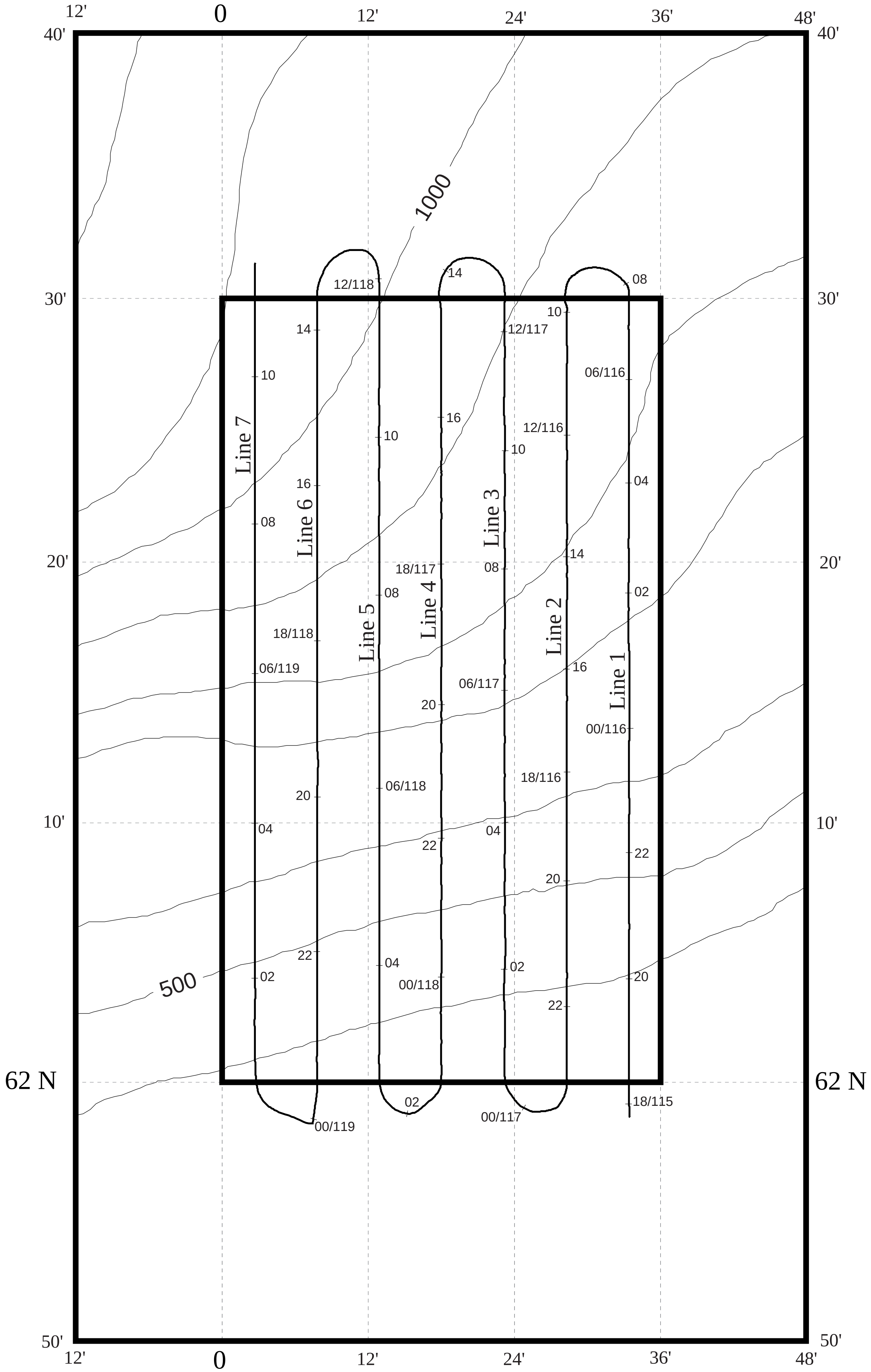

Figure 2. Survey tracks for area T65-67.

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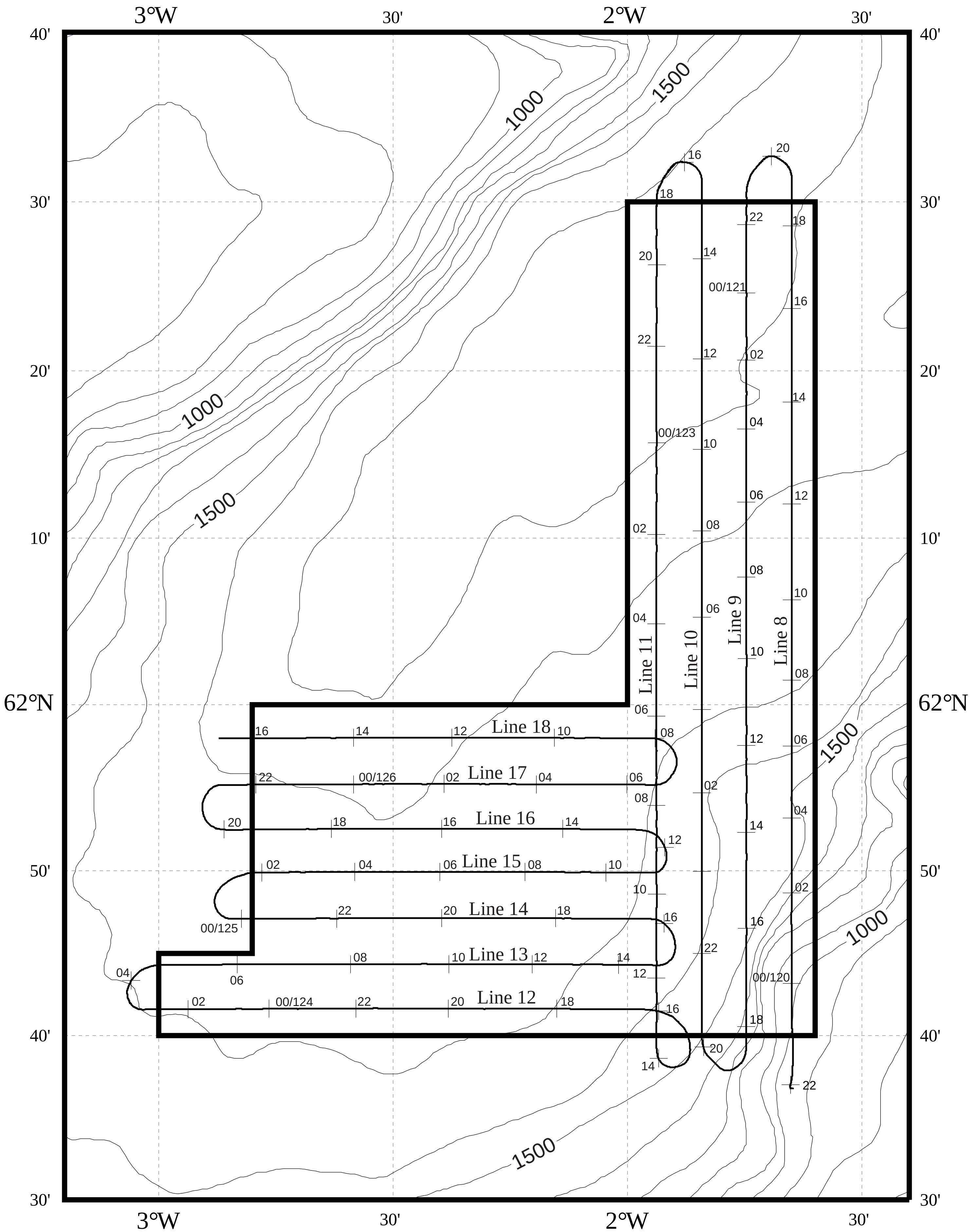

Figure 3. Survey tracks for area T60-63.

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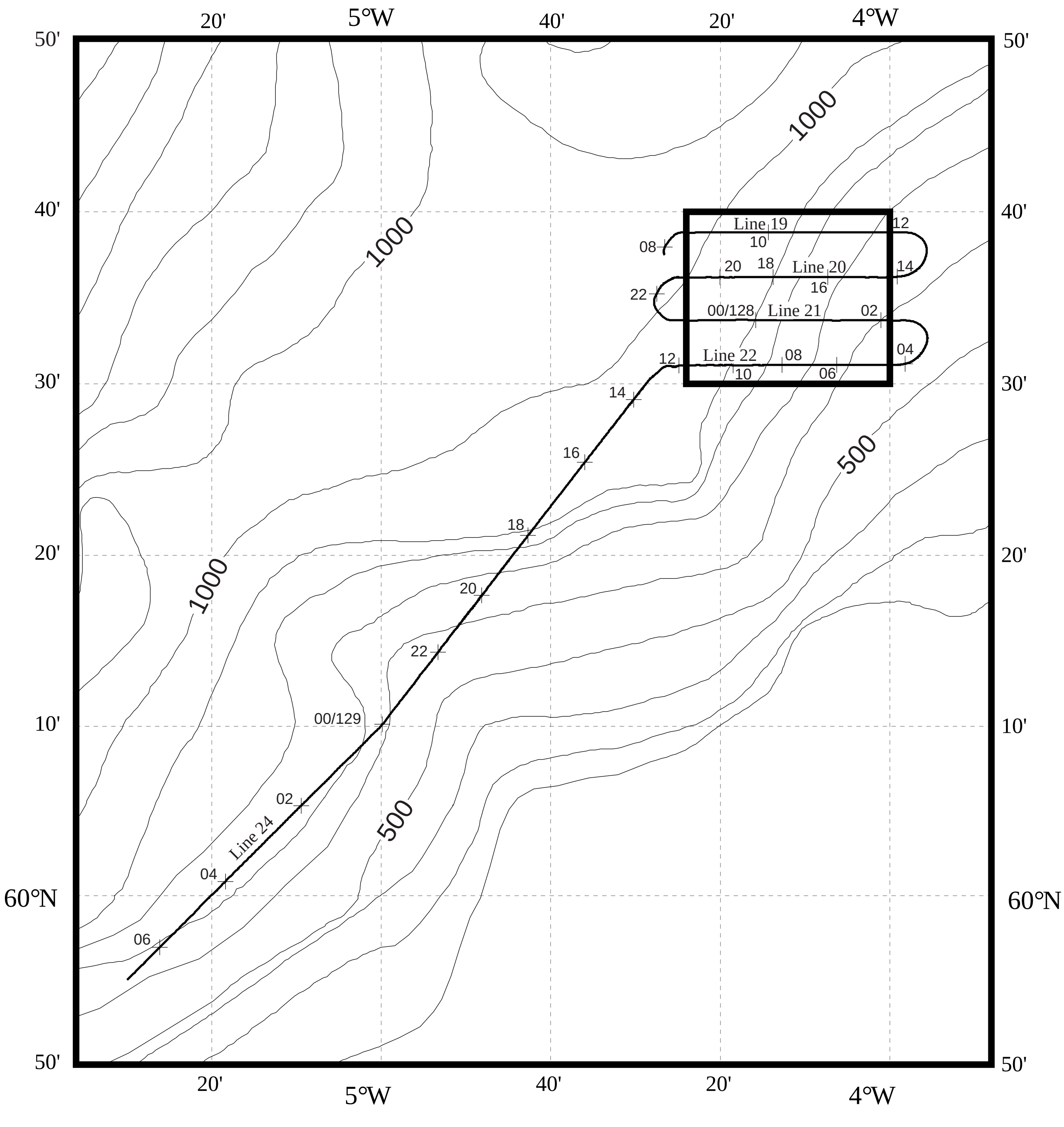

Figure 4. Survey tracks for block 204/14-15

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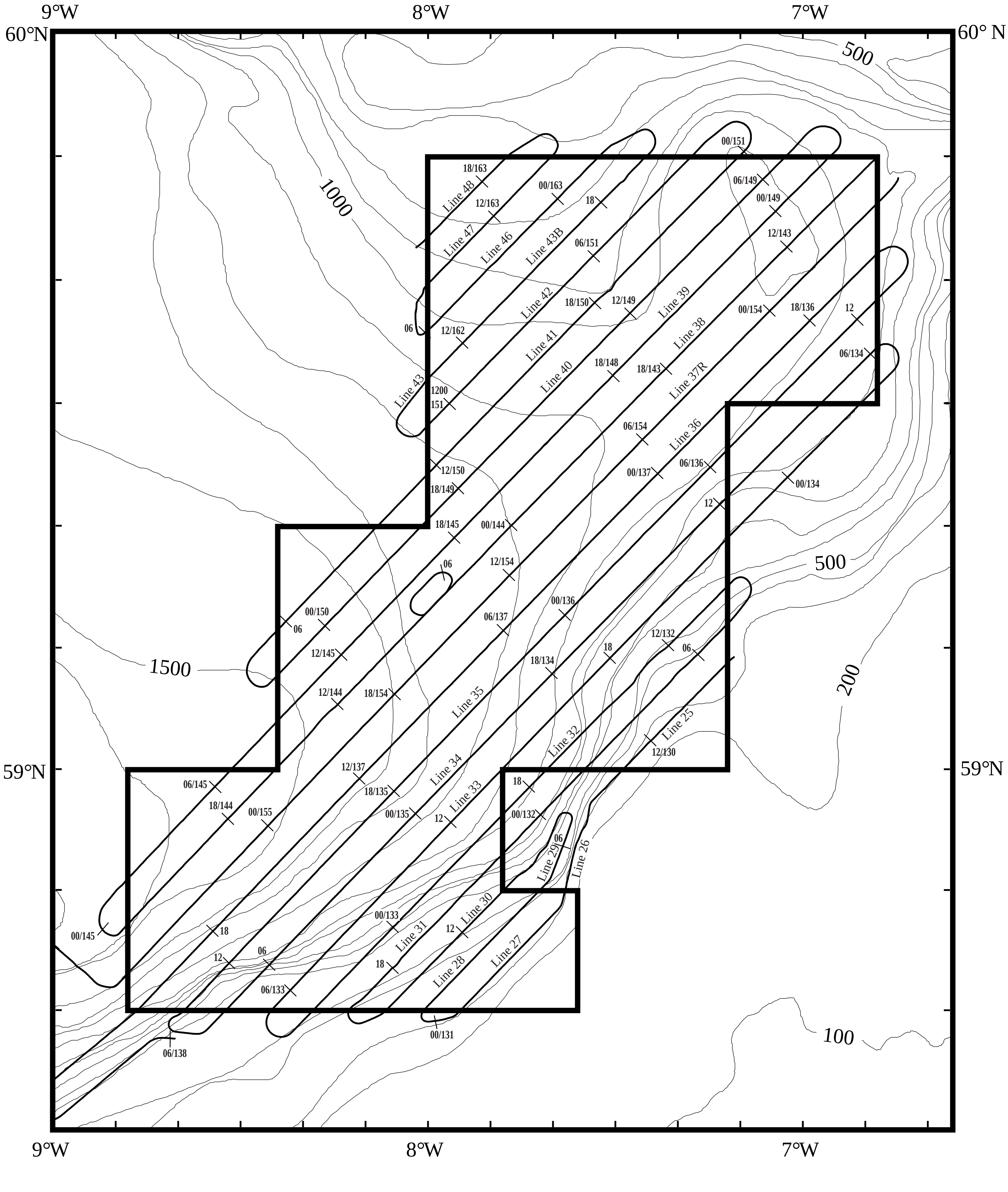

Figure 5. Survey tracks for area T36-53.

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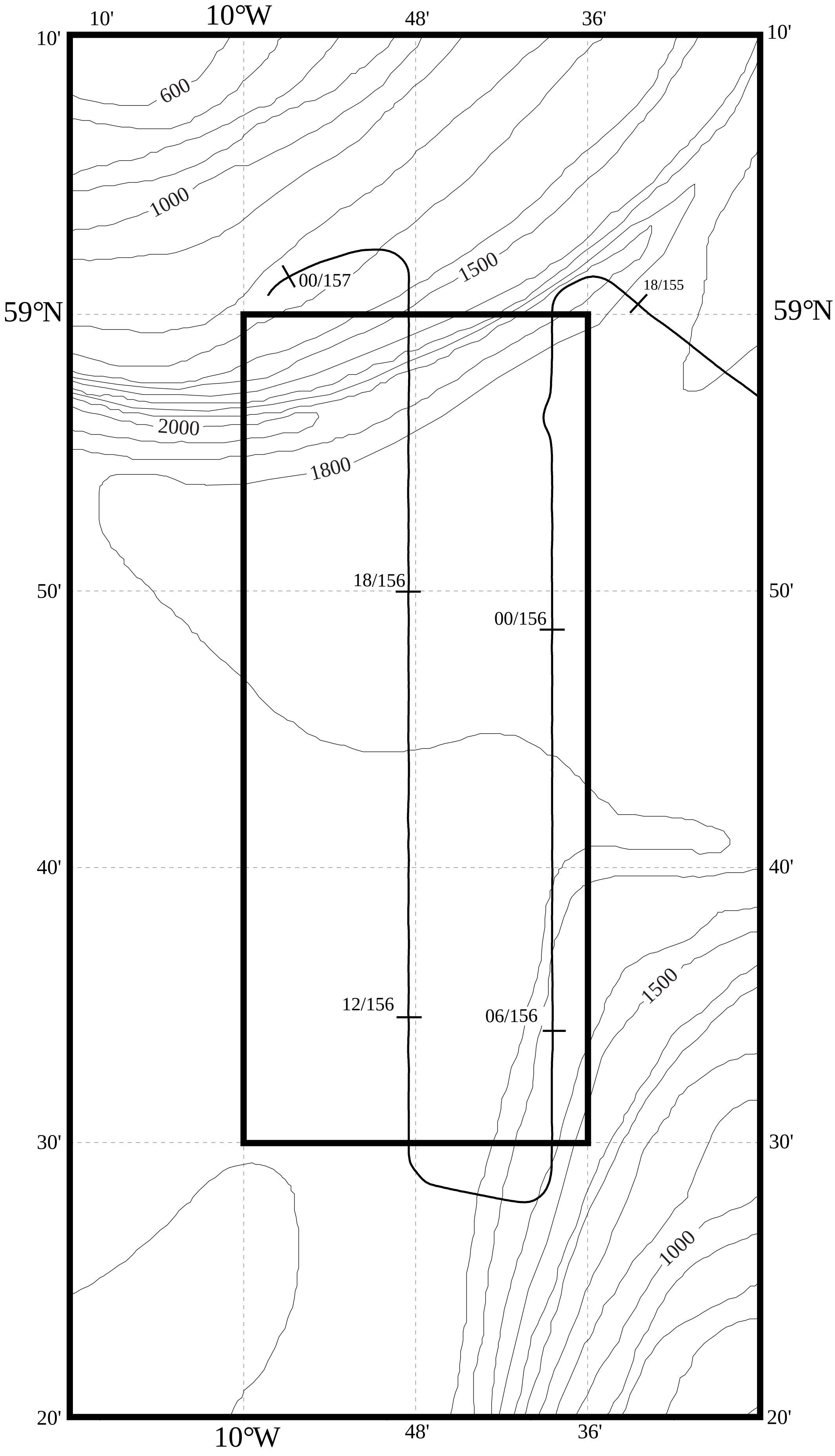

Figure 6. Survey tracks for area T30

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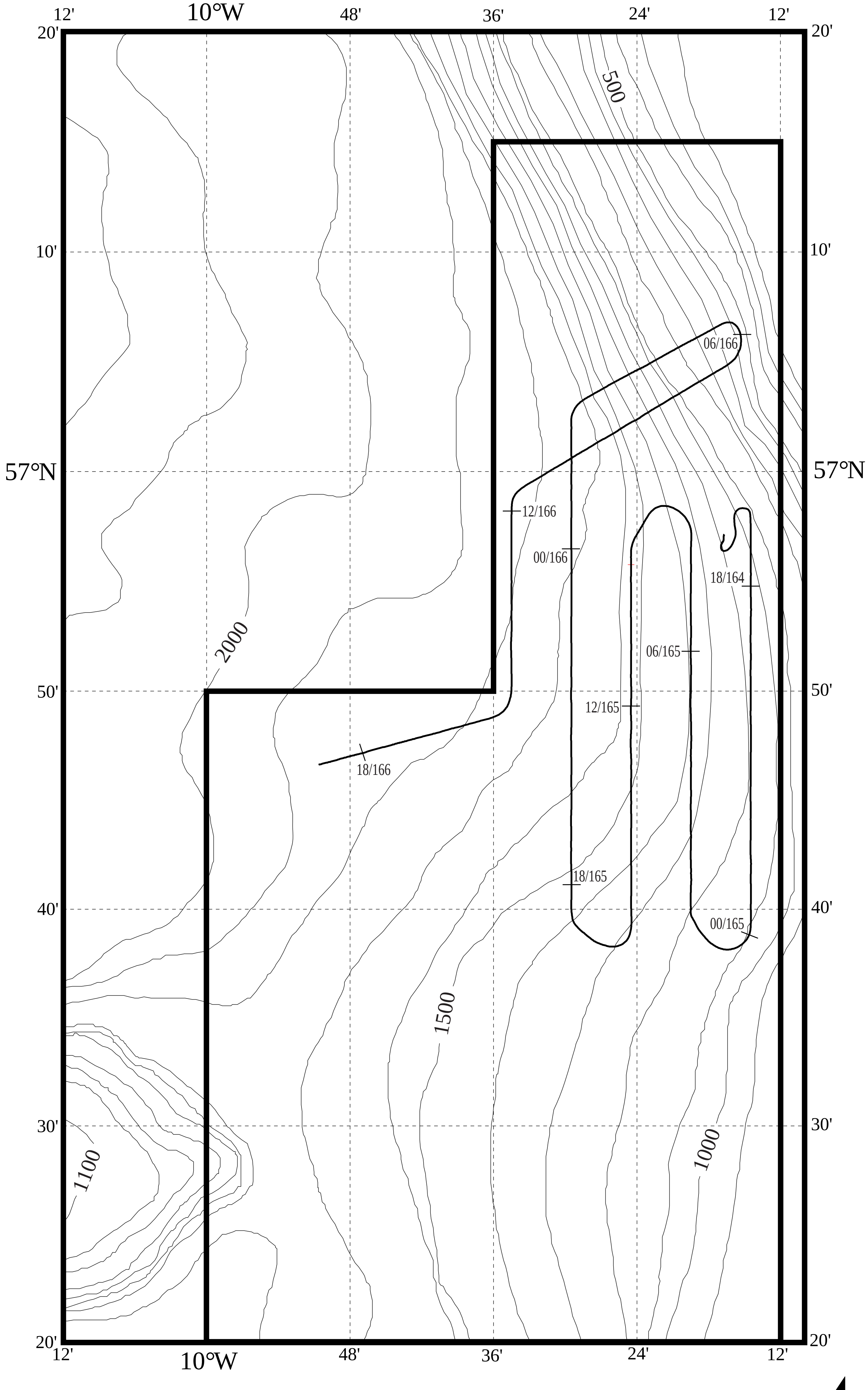

Figure 7. Survey tracks for area T19-22.

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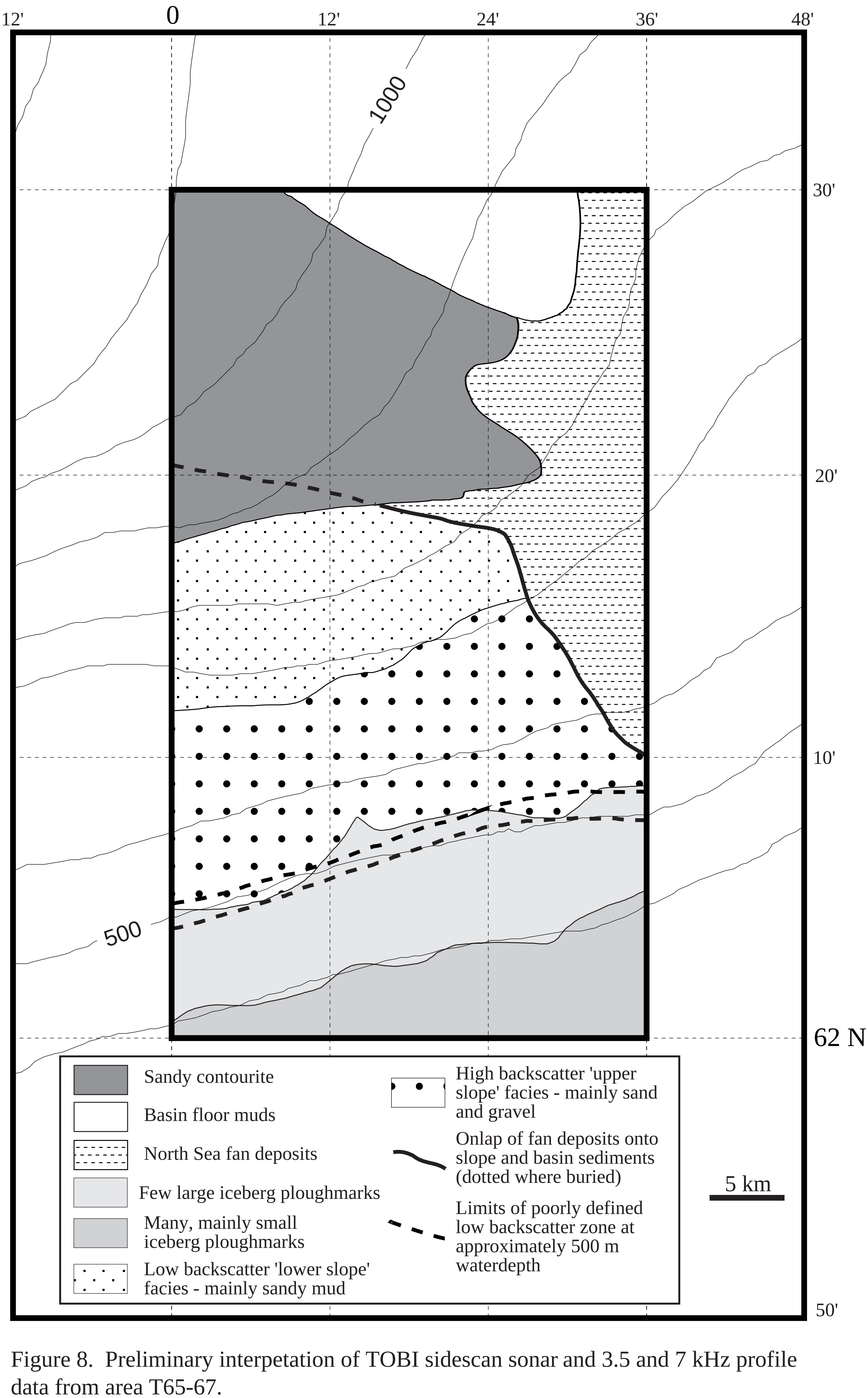

Figure 8. Preliminary interpetation of TOBI sidescan sonar and 3.5 and 7 kHz profile data from area T65-67.

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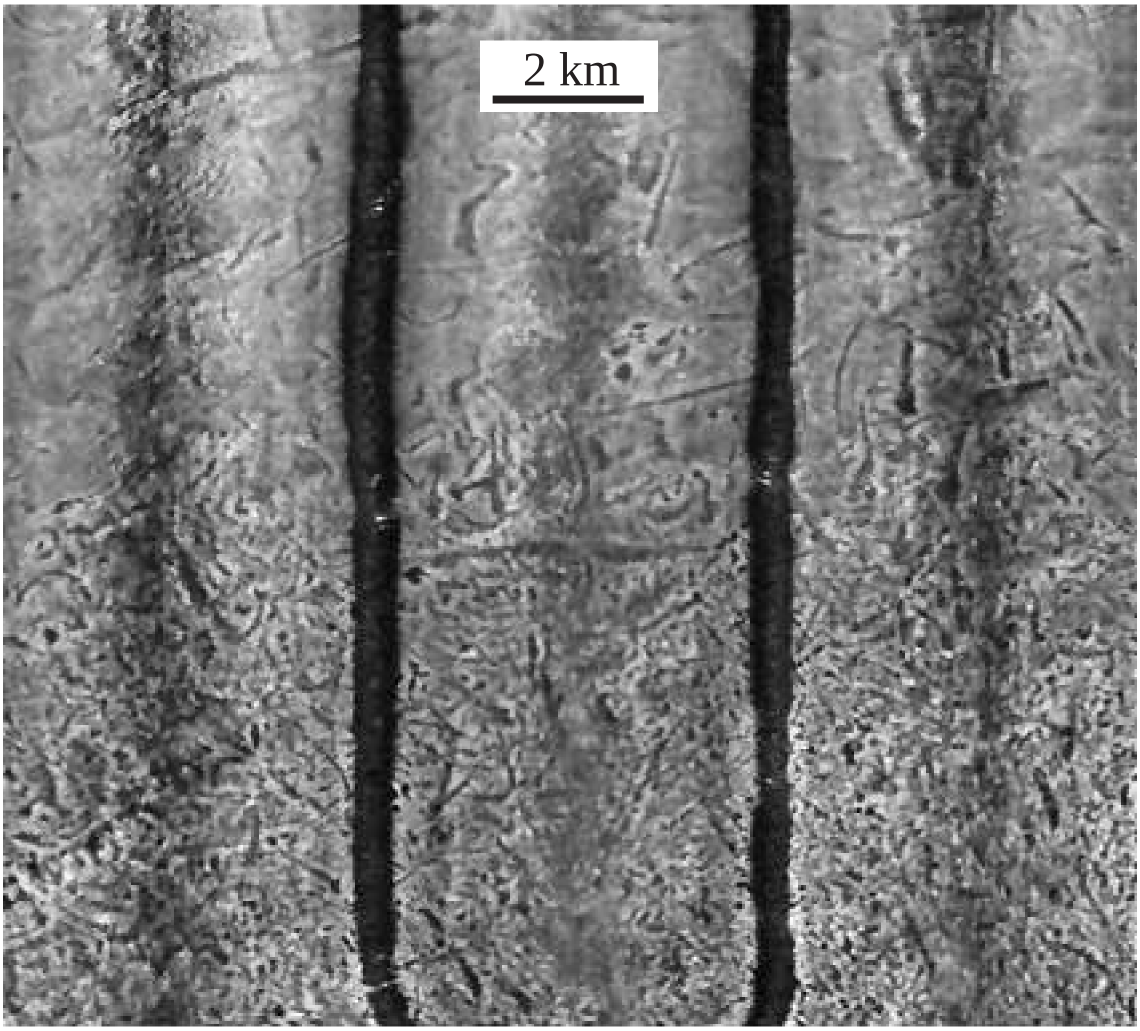

Figure 9. Example of TOBI sidescan sonar data showing iceberg ploughmarks. Area T65-67; waterdepth 300 m (bottom) to 450 m (top). Typical ploughmarks have a low backscatter (dark) stripe surrounded by a rim of higher backscatter. The low backscatter corresponds to relatively fine-grained sediments infilling the central furrow of the ploughmark, the high backscatter to ridges of coarser material pushed aside by the iceberg.

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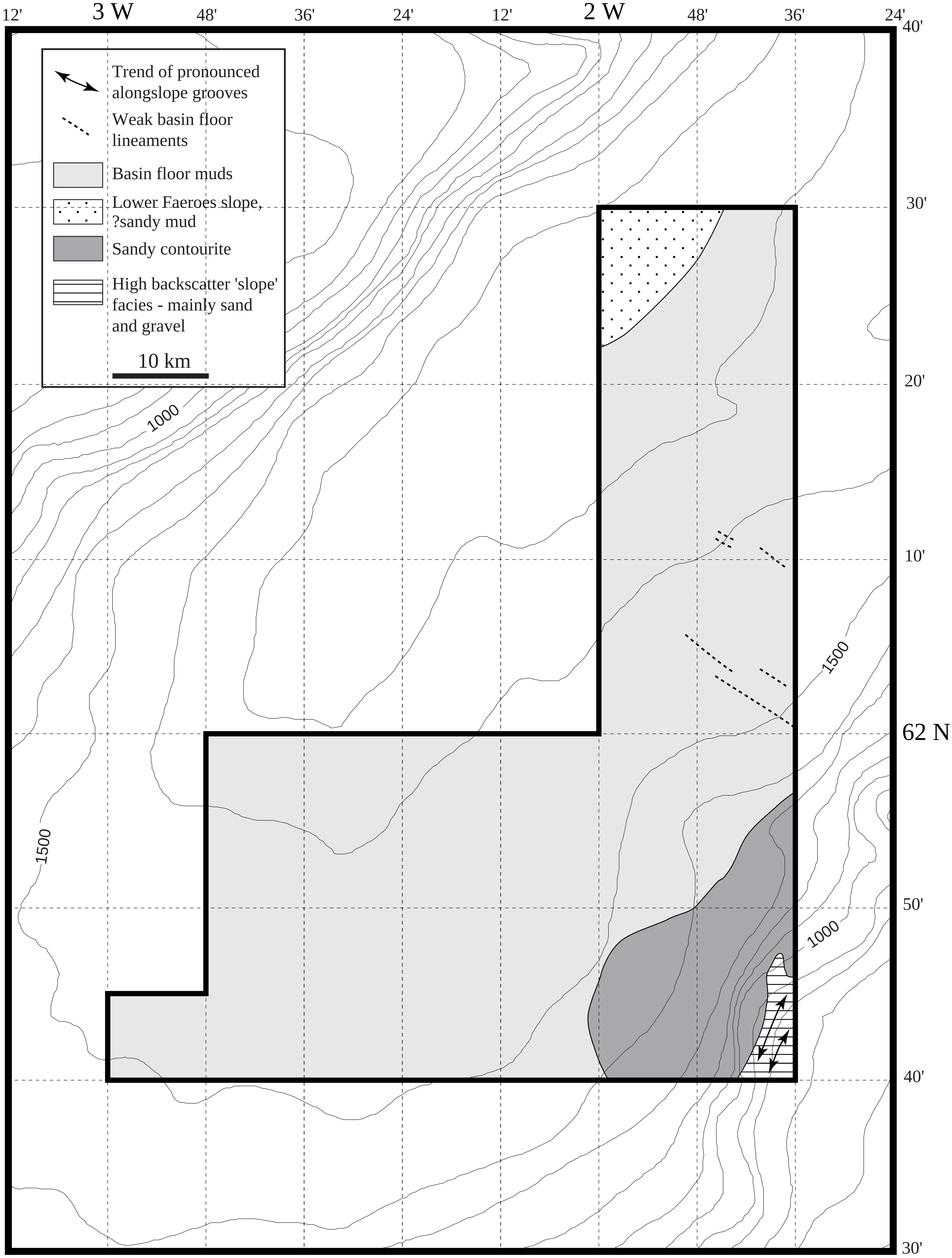

Figure 10. Preliminary interpetation of TOBI sidescan sonar and 3.5 and 7 kHz profile data from Area T60-63.

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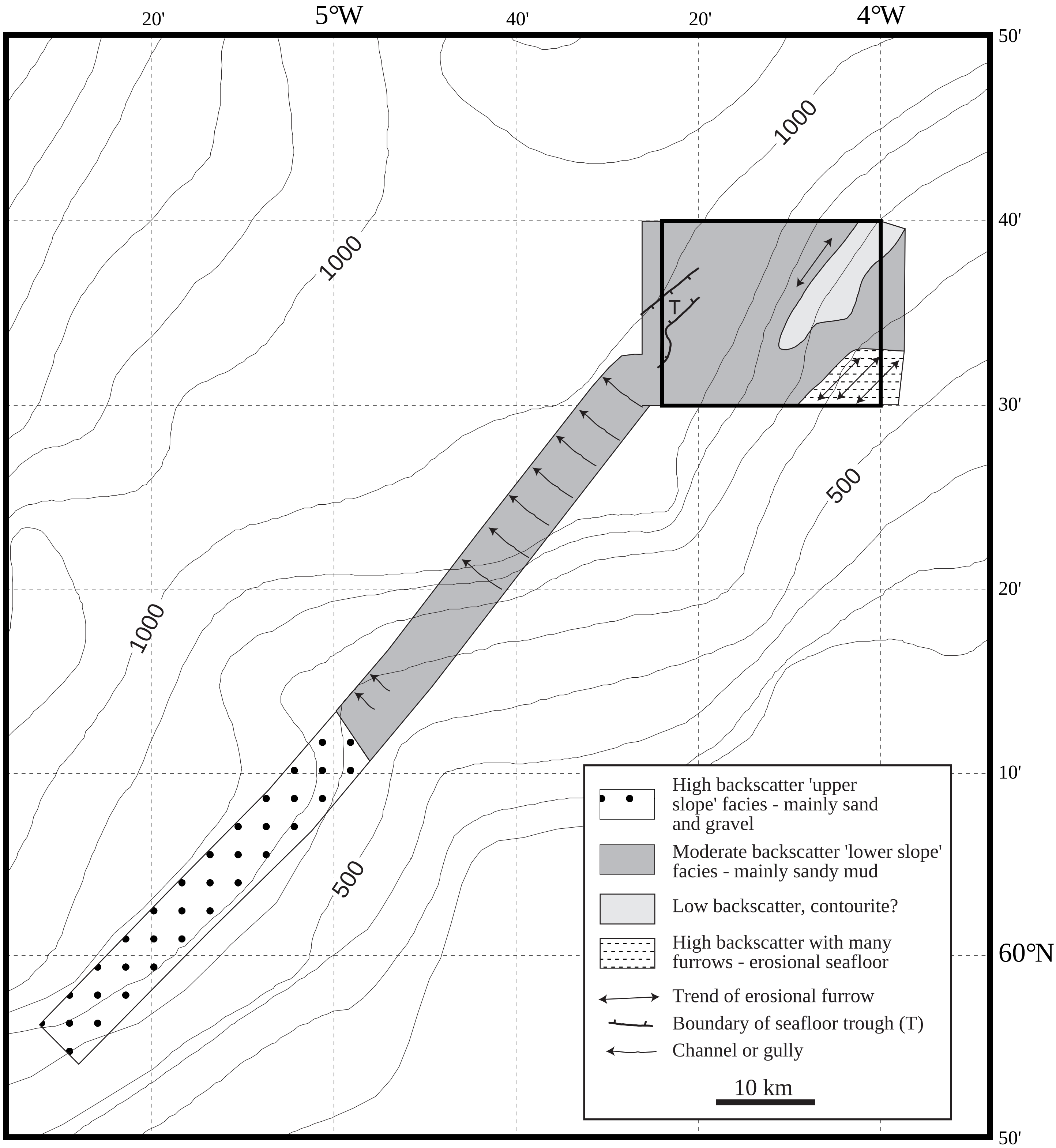

Figure 11. Preliminary interpetation of TOBI sidescan sonar and 3.5 and 7 kHz profile data from Block 205/14-15

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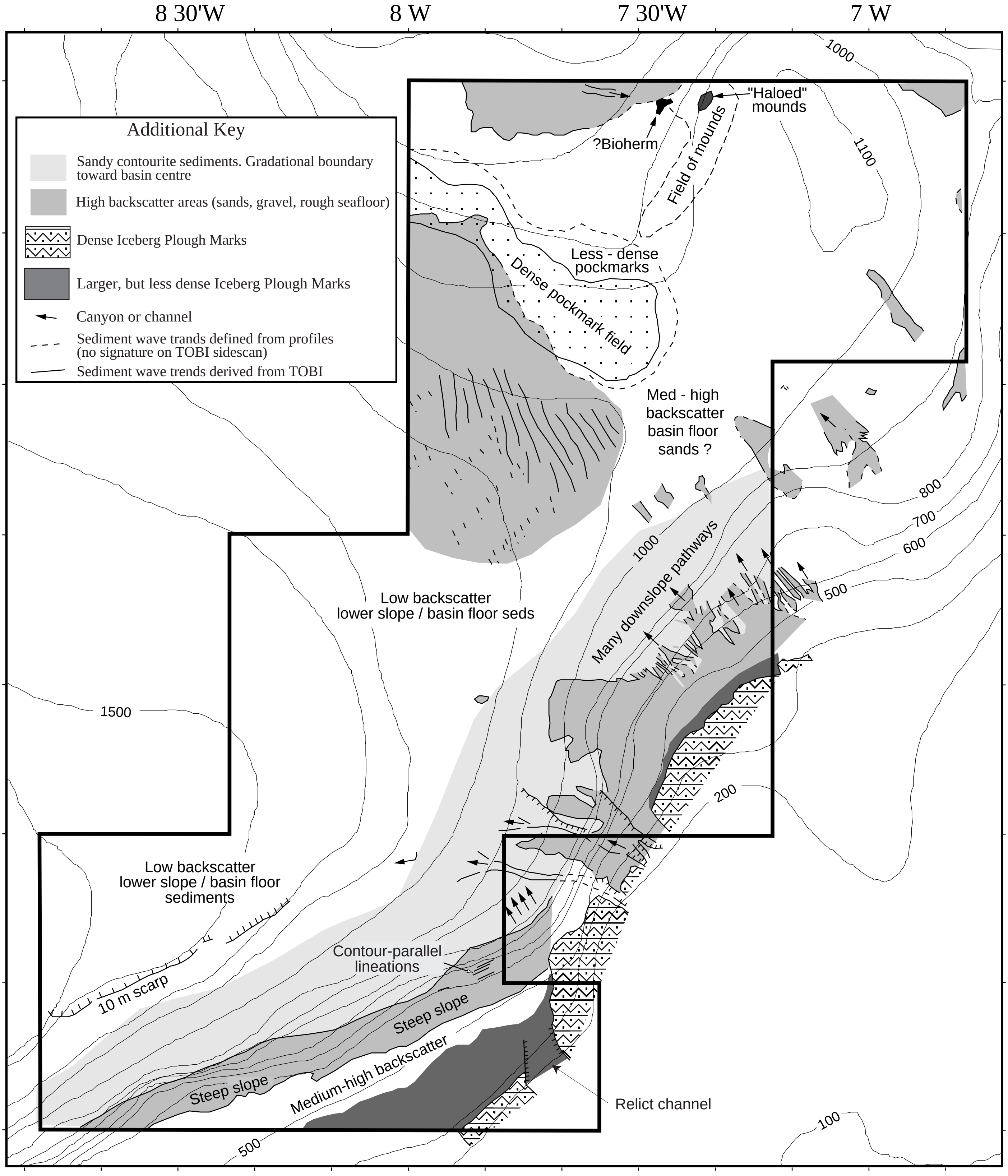

Figure 12. Preliminary interpetation of TOBI sidescan sonar and 3.5 and 7 kHz profile data from Area T36-53.

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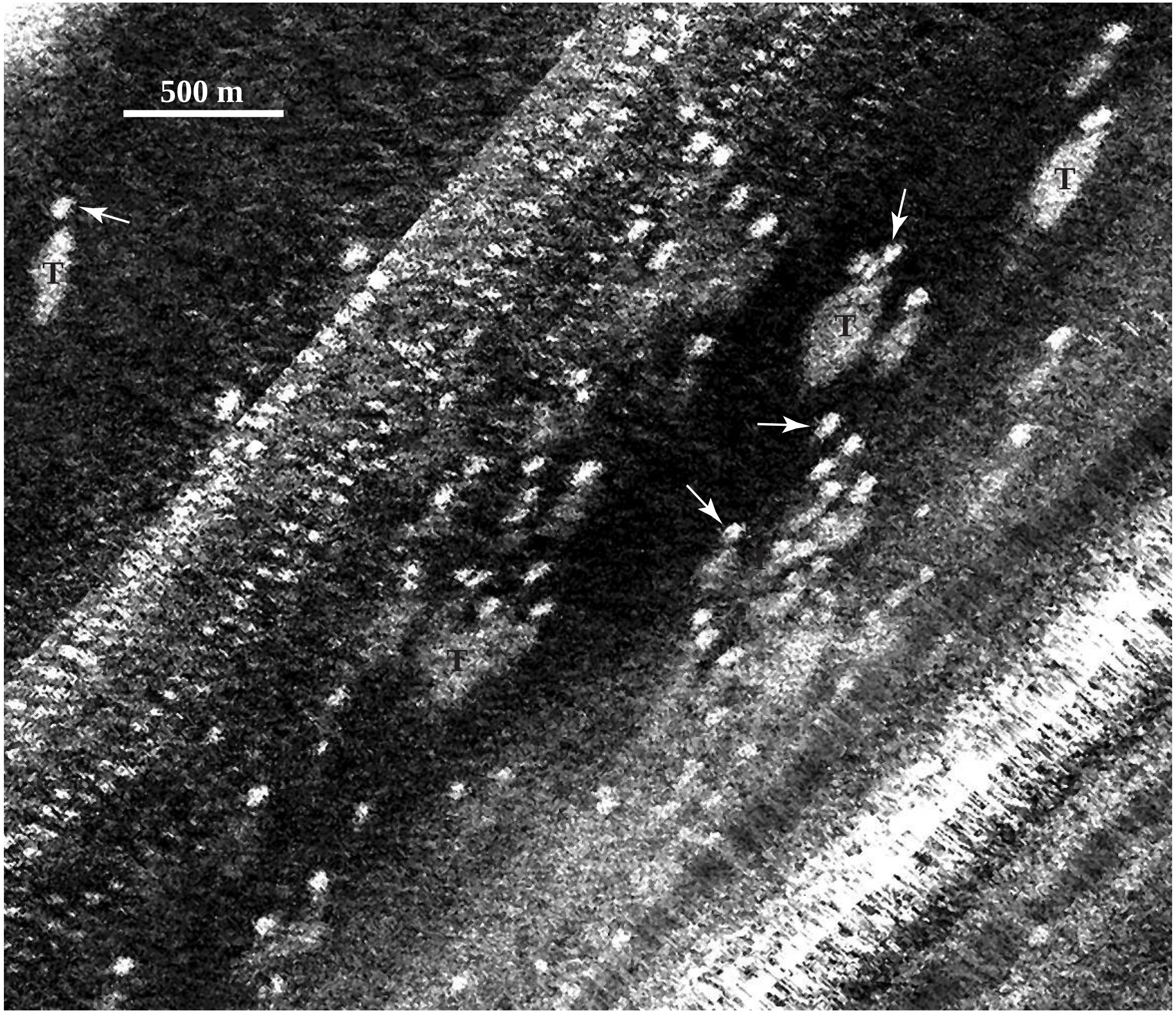

Figure 13. Example of TOBI sidescan sonar image showing small high-backscatter mounds (e.g. arrows) believed to be related to fluid escape from the seafloor. Note that some mounds are associated with a 'tail' of moderate high backscatter material (T) which extends towards the southwest and which appears to have formed as a result of interaction between the fluid escape feature and a southwesterly flowing bottom current.

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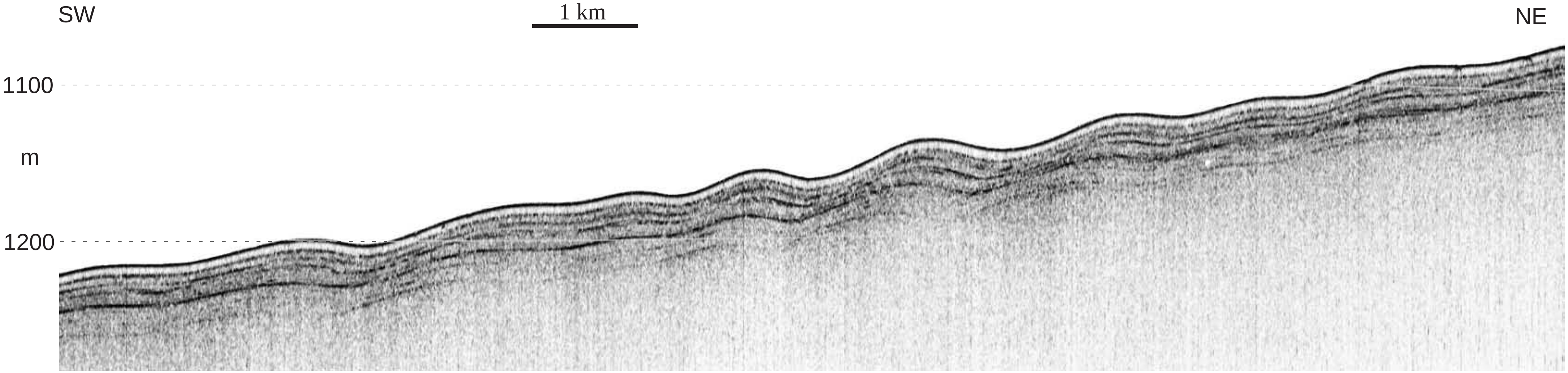

Figure 14. Example of 3.5 kHz profile showing sediment waves in area T36-53. Internal structure of waves indicates that they were formed under a current directed towards the SW. Note that waves are draped by a uniform transparent layer approximately 5 m in thickness

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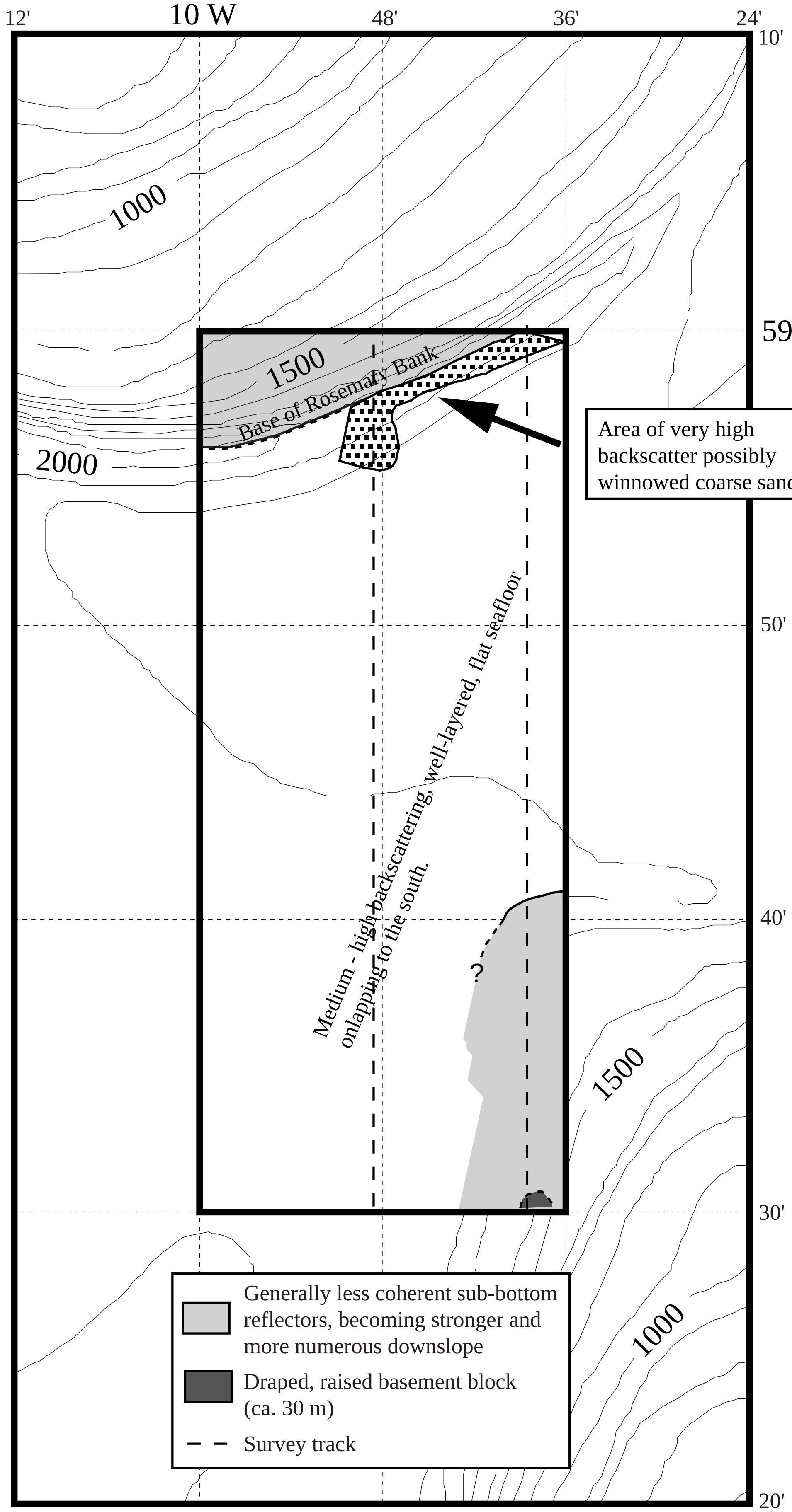

Figure 15. Preliminary interpetation of TOBI sidescan sonar and 3.5 and 7 kHz profile data from Area T30.

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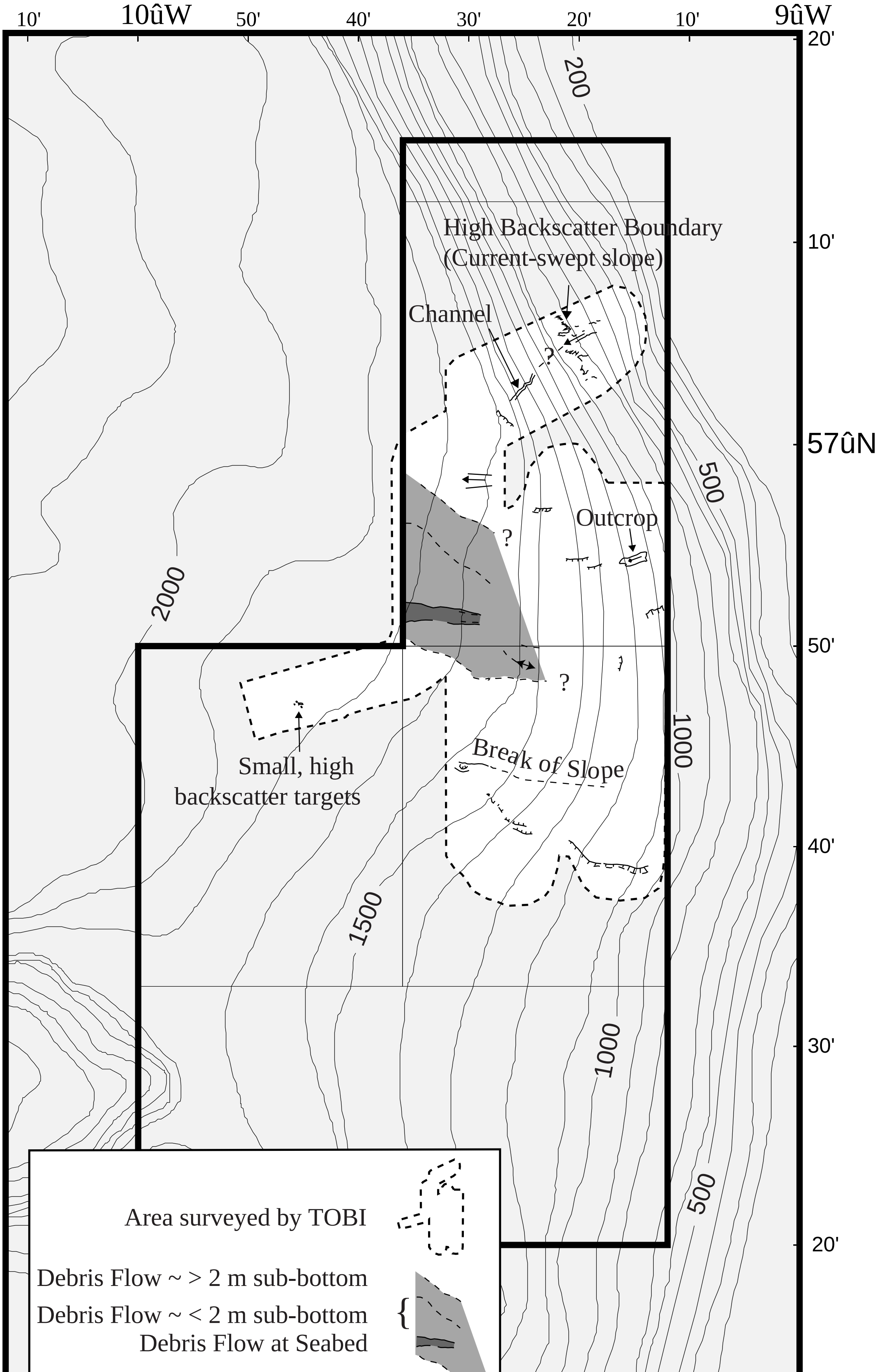

Figure 16. Preliminary interpetation of TOBI sidescan sonar and 3.5 and 7 kHz profile data from area T19-22

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