Final Hydrographic Survey Report
For The
Regional Scale Nodes (RSN) component of the Ocean Observatories Initiative (OOI)

Prepared for:

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EXECUTIVE SUMMARY

The fiber optic cable network of the Regional Scale Nodes (RSN) component of the Ocean Observatories Initiative (OOI) is composed of eight segments located off the coast of central Oregon. The configuration of the cable routes is as follows:

- Segment 1: Pacific City Oregon to Primary Node PN1A
- Segment 2: Primary Node PN1A to Primary Node PN1B
- Segment 3: Primary Node PN1B to Primary Node PN1C
- Segment 4: Primary Node PN1C to Primary Node PN1D
- Segment 4NP: Primary Node PN1D to Low Voltage Node LV01D
- Segment 5: Pacific City Oregon to Primary Node PN5A
- Segment 6: Primary Node PN5A to Primary Node PN3A
- Segment 7: Primary Node PN3A to Primary Node PN3B

The following briefly summarizes the findings of the survey interpretation on a segment by segment basis:

Segment 1

- Segment 1 water depths range from 0 m at the landfall to 2920 m at Primary Node PN1A, with slopes on the lower continental slope as high as 22.5° in the survey corridor.
- Seabed sediments in the surveyed area range from soft, unconsolidated sand, silt and clay to bedrock.
- Shelf features include sand/gravel waves, a sand dollar patch, pockmarks, bottom contact fishing scars.
- Slope features include areas of exposed bedrock and strata, mini-basins in-filled with thick sediment deposits, steep slopes, faults, gas features, and buried mud diapirs.
- Five side scan sonar contacts are logged for this segment, none of them closer than 160 meters from the survey route.
- The route crosses the active VSNL Pacific SEG G5 cable twice, but both crossing are in deep water and cross at angles greater than 45 degrees.
- 25 CPTs, 15 gravity cores, and 6 grab samples were taken. CPTs achieved 0.17 to 3.03 meters penetration and gravity cores ranged from 0.28 to 4.7 meters penetration.
- 3 areas of concern were identified that may need special consideration with respect to cable burial.

Segment 2

- Segment 2 water depths range from 2920 m at Primary Node PN1A to 1230 m at Primary Node PN1B, with slopes on the lower continental slope as high as 45.9° in the survey corridor.
- The route does not cross any existing cables.
- Seabed sediments in the surveyed area range from soft, unconsolidated silt and clay to bedrock.

- Geologic features include areas of exposed bedrock and strata, authigenic carbonate (carbonate crust on the seabed), and gas-related features.
- No sonar contacts were found.
- 2 CPTs and 1 gravity core were taken. All CPTs penetrated to 3.0 meters and the gravity core penetrated to 1.58 meters.
- No areas of specific concern were identified.

Segment 3

- Segment 3 water depths range from 1310 m just south of Primary Node PN1B to 616 m at Primary Node PN1C, with slopes as high as 3.1° in the survey corridor.
- The route does not cross any existing cables.
- Seabed sediments in the surveyed area range from unconsolidated silt and clay to older, presumably harder outcropping strata.
- Bottom contact fishing scars were noted.
- Geologic features include areas of exposed strata, authigenic carbonate, and gas-related features.
- One sonar contact was found approximately 2 km north of the Primary Node PN1B.
- 5 CPTs and 2 gravity cores were taken. All CPTs and gravity cores achieved 3 meters or better penetration.
- No areas of specific concern were identified.

Segment 4

- Segment 4 water depths range from 620 m south of Primary Node PN1C to 112 m at Primary Node PN1D, with slopes as high as 5.2° in the survey corridor.
- Seabed sediments in the surveyed area range from soft, unconsolidated sand, silt, clay and gravel to strata of variable hardness and bedrock.
- Bottom contact fishing scars were noted.
- The route does not cross any existing cables.
- Geologic features include faults, turbidity channeling, authigenic carbonate, pockmarks, a relict slump deposit and gas-related features.
- 19 CPTs and 12 gravity cores were taken. All CPTs penetrated to 3 meters and gravity cores penetration varied from 0.52 to 3 meters.
- No sonar contacts were found.
- 2 areas of concern were identified. One of these areas is a concern for burial while the other is a concern for events that could compromise the cable during the system's life.

Segment 4NP

- Segment 4NP water depths range from 112 m at Primary Node PN1D to 79.5 m at Low Voltage Node LV01D, with slopes as high as 3.7% (2.1°).

- Seabed sediments in the surveyed area are sand with possible gravel in the floors of channels.
- The route does not cross any existing cables.
- Bottom contact fishing scars were not noted.
- Geologic features include structurally deformed seabed (ridge-troughs) and minor channeling.
- Two sonar contacts were found. The closest of these contacts come within 74 meters of the route.
- 4 CPTs and 3 gravity cores were taken. The CPTs penetrated from 0.3 to 3.0 meters and the gravity cores had no recovery or penetration to 0.3 meters.
- There are no areas of concern, but the slopes along the edges of the ridge-trough features may present challenges for the plow if crossed directly.

Segment 5

- Segment 5 water depths range from 0 m at the landfall to 2825 m in the Cascadia Channel, with slopes on the lower continental slope as high as 26.6° in the survey corridor.
- Seabed sediments in the surveyed area range from soft, unconsolidated sand, silt and clay to bedrock.
- The route crosses 3 active existing fibre-optic cables (VSNL Pacific Seg G5, Southern Cross Seg F, PC 1 Seg E). All crossings occur in deep water and cross at angles greater than 70 degrees.
- Shelf features include sand/gravel waves, a sand dollar patch, pockmarks and bottom contact fishing scars.
- Slope features include areas of exposed bedrock and strata, mini-basins filled with thick sediment deposits, steep slopes, faults, gas features, and mud diapirs.
- Six side scan sonar contacts are logged for this segment. One of these contacts lies within 103 meters of the survey route.
- 25 CPTs, 9 gravity cores, and 6 grab samples were taken. The CPTs had refusal as shallow as 0.36 meters and penetration to 3 meters, the gravity cores penetration was from 'No recovery' to 3 meters.
- 1 area of concern was identified that may need special consideration with respect to cable burial.

Segment 6

- Segment 6 water depths range from 2615 to 2875 m with slopes as high as 2.8° in the survey corridor.
- The route crosses 1 active fibre-optic cables (AKORN Seg 2-2), One Out-of-Service fibre-optic cable (TPC-4), 2 out of service telegraph cables (Bamfield-Fanning Is , and Bamfield-Fanning Is-1) and one out of service coax cable (Compaq Seg 2). All of these crossing are and an angle of 26° or greater.
- No areas of concern are identified for this route.

Segment 7

- Segment 7 water depths range from 1515 to 2630 m with slopes as high as 15.8° in the survey corridor.
- The route does not cross any existing cables.
- Since one goal of the RSN project is to monitor the active Axial Volcano, it goes without saying that this segment is in jeopardy from volcanic eruption. Beyond this potential hazard, there are no identified areas of concern for this route.
- The cable installer should be made that the terrain in this area is highly irregular, but the slopes do not exceed 18.8% (10.6°) along the route.

Issue and Approval Control Sheet

Copies of this Report have been distributed as follows:

0	Williamson and Associates	1
1	L-3 Communications MariPro	3
2	University of Washington	1

The following versions of this report have been issued:

Rev No.	Date	File Name	Description
1	6/20/2010	RSN Survey Report_1 6-20-10	Preliminary Report
2	10/12/2010	Final RSN Survey Report_2 10-12-10	Final Survey Report
3	10/13/2010	Final RSN Survey Report_2 10-13-10	Final Survey Report
4	1/?/2010	Final RSN Survey Report_3 1-?-11	Final Survey Report

Approval:

Approved for Issue: ________________________ Date: _________

Patrick Harwell

Hydrographic Survey Coordinator

L3-MariPro

ABBREVIATIONS AND ACRONYMS

AoC	Area of Concern
BMH	Beach Manhole
CPT	Cone Penetrometer Test
CTD	Conductivity-Temperature-Depth
DEM	Digital Elevation Model
DGPS	Differential Global Positioning System
DPR	Daily Progress Report
DTS	Desktop Study
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EOB	End of Burial
Fm	Geologic Formation
GC	Gravity Core
GPS	Global Positioning System
HDD	Horizontal Directional Drilling
IS	In-service (cable)
Ka	Kilo-annum (1,000 years)
kHz	Kilohertz (frequency)
	OFCC
KM	Kilometer
KTS	Knots
LP	Landing Point
M	Meter
Ma	Mega-annum (1 million years)
Mb	Geologic Member (of a formation)
MBES	Multibeam Echo Sounder
MCPT	Mini Cone Penetrometer Test
MLLW	Mean Lower Low Water
MMS	Minerals Management Service
NM	Nautical mile
NOAA	National Oceanic and Atmospheric Administration
NOTAM	Notice to All Mariners
NPC	North Pacific Cable
OFCC	Oregon Fisherman's Cable Committee
PLIB	Post Lay Inspection and Burial
SBP	Subbottom Profiler
SSS	Side Scan Sonar

TABLES OF TERMS AND DESCRIPTORS

Gradient Classification:

Classification	***Gradient (degrees)***
Very Gentle	< 1°
Gentle	1° - 4.9°
Moderate	5° - 9.9°
Steep	10° - 14.9°
Very Steep	> 15°

Sediment Classification:

Classification	***Size Range***
Boulder	> 256 mm
Cobble	64 – 256 mm
Gravel	2 – 64 mm
Coarse Sand	0.5 – 2 mm
Medium Sand	0.25 – 0.5 mm
Fine Sand	0.0625 mm – 0.25 mm
Silt	0.004 mm – 0.0625 mm
Clay	< 0.004 mm

Observational Frequency:

Classification	***Frequency of Observation***
Rare	<1 objects per 10,000 m^2
Occasional	1-5 objects per 10,000 m^2
Numerous	5-10 objects per 10,000 m^2
Common	10-20 objects per 10,000m^2
Abundant	>20 objects per 10,000 m^2

Consistency of Cohesive Sediments:

Consistency	***Undrained Shear Strength (tsf)***	***kilo Pascal's***
Very Soft	Less than 0.125	Less than 12
Soft	0.125 - 0.25	12 - 24
Medium Stiff	0.25 - 0.50	24 - 48
Stiff	0.50 - 1.0	48 - 96
Very Stiff	1.0 - 2.0	96 - 192
Hard	Over 2.0	Over 192

Consistency of Non-cohesive Sediments

Consistency	***Relative Density (%)***
Very loose	Less than 15%
Loose	15-35%
Medium	36-65%
Dense	66-85%
Very Dense	Over 85%

SEABED CLASSIFICATION

The following table details the geophysical and geotechnical character of seabed classifications referenced in seabed features discussions and mapped within the accompanying charts.

Seabed Classification	Description	SBP Character	SSS Character	MBES Character	Gravity Cores/CPT's
Silt/Clay	Fine grained seabed sediments with mappable thickness.	Acoustically transparent to acoustically amorphous; sometimes stratified.	Areas low acoustic reflectivity. Sometimes associated with abundant pockmarks and bottom fishing scars.	Generally very flat or gently sloping and frequently pockmarked.	Generally soft to stiff, silty sediments. 3+ meters of penetration.
Sand	Medium to coarse grained deposits	Increased seabed signature relative to fine grained sediments. Signal generally attenuates within 15 milliseconds of the seafloor.	Areas of elevated acoustic reflectivity and scattering. Associated with general absence of pockmarks. Sometimes ripple marks noted	Generally very flat or evenly sloping and featureless	Sample is rarely recovered. Traces of sand are found in the shoe. CPT penetration is reduced. Relative Density commonly maxes out at 100% before end of penetration
Gravel	Very coarse grained, clastic, sediments of terrigenous and or biogenic origin.	Scattering of signal is profound. Little to no penetration is achieved. Heavy seabed signature	Dark patches of seafloor. Very high acoustic reflectivity.	Generally very flat or evenly dipping and featureless.	Traces of pebbles and sand. CPT penetration is reduced. Relative Density commonly maxes out at 100% before end of penetration
Bedrock	Hard Rock	Little to no penetration. When penetration is achieved, reflectors are relatively steeply dipping and commonly folded and faulted.	Very high reflectivity. Acoustic shadows associated with prominences and ridges are evident.	Rugged topographic character sometimes with localized ledges and prominences. Most often outcrops along regional structural features (ridges). In some cases has been eroded flat to conform to the seafloor.	No sample recovered, or hard sediments recovered with less than full penetration
Authigenic Carbonate	Fine grained sediments cemented or partially cemented by carbonate.	Associated with gassy subsurface strata within the Subbottom Profiler record. Sometimes a heavy seabed signature	Higher reflectivity than surrounding seafloor. Often associated but not exclusive with the existence of pockmarks.	Usually flat seafloor or in the floors of large pockmarks. Sometimes atop hillocks	Stiff clays and nodules present in sample. Rotten egg odor commonly described in samples

Seabed Classification	Description	SBP Character	SSS Character	MBES Character	Gravity Cores/CPT's
Coral	Seafloor colonized by Corals	Little to no penetration is achieved.	Areas of elevated acoustic reflectivity and acoustic scattering.	Generally found in shallower waters.	Coral fragments recovered.
Undifferentiated Sediments	Sand, silt, clay, and mixed; often mantled by a mud veneer.	Low angle dipping reflectors truncated at the seafloor.	Reflectivity is often elevated above background. Sometimes faint banding is observed. May or may not have pockmarks	Frequently occurs along the slopes of topographic features.	Generally stiff to very stiff sediments.
Outcropping strata	Gently dipping or folded strata of varying composition outcropping at the seafloor.	Gently dipping of folded reflectors truncated at the seafloor	Highly reflective. Often associated with banding. Occasionally pockmarked.	Occurs along the slopes of regional topographic features.	Generally stiff to hard sediment.

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Figures and Tables

Appendices

Charts

Charts are North Up (NU), and organized by Segment (e.g. S1) and type (e.g. A is bathymetry, B is geology). Alignment Charts are indicated with AL. Scale is indicated (e.g. 10k).

Segment 1 Charts

Chart Name	Scale	Type	Chart Name	Scale	Type
RSN.S1.NU.CHART-001	1:5000	Inshore	RSN.S1.NU.CHART-011A	1:10000	Bathymetry
RSN.S1.NU.CHART-002A	1:10000	Bathymetry	RSN.S1.NU.CHART-011B	1:10000	Geology
RSN.S1.NU.CHART-002B	1:10000	Geology	RSN.S1.NU.CHART-012	1:25000	Bathymetry
RSN.S1.NU.CHART-003A	1:10000	Bathymetry	RSN.S1.NU.CHART-013	1:100000	Bathymetry
RSN.S1.NU.CHART-003B	1:10000	Geology	RSN.S1.NU.CHART-014	1:100000	Bathymetry
RSN.S1.NU.CHART-004A	1:10000	Bathymetry	RSN.S1.AL.CHART-001	1:10000	Alignment
RSN.S1.NU.CHART-004B	1:10000	Geology	RSN.S1.AL.CHART-002	1:10000	Alignment
RSN.S1.NU.CHART-005A	1:10000	Bathymetry	RSN.S1.AL.CHART-003	1:10000	Alignment
RSN.S1.NU.CHART-005B	1:10000	Geology	RSN.S1.AL.CHART-004	1:10000	Alignment
RSN.S1.NU.CHART-006A	1:10000	Bathymetry	RSN.S1.AL.CHART-005	1:10000	Alignment
RSN.S1.NU.CHART-006B	1:10000	Geology	RSN.S1.AL.CHART-006	1:10000	Alignment
RSN.S1.NU.CHART-007A	1:10000	Bathymetry	RSN.S1.AL.CHART-007	1:10000	Alignment
RSN.S1.NU.CHART-007B	1:10000	Geology	RSN.S1.AL.CHART-008	1:10000	Alignment
RSN.S1.NU.CHART-008A	1:10000	Bathymetry	RSN.S1.AL.CHART-009	1:10000	Alignment
RSN.S1.NU.CHART-008B	1:10000	Geology	RSN.S1.AL.CHART-010	1:10000	Alignment
RSN.S1.NU.CHART-009A	1:10000	Bathymetry	RSN.S1.AL.CHART-011	1:10000	Alignment
RSN.S1.NU.CHART-009B	1:10000	Geology	RSN.S1.AL.CHART-012	1:10000	Alignment
RSN.S1.NU.CHART-010A	1:10000	Bathymetry	RSN.S1.AL.CHART-013	1:10000	Alignment
RSN.S1.NU.CHART-010B	1:10000	Geology			

Segment 2 Charts

Chart Name	Scale	Type	Chart Name	Scale	Type
RSN.S2.NU.CHART-001	1:25000	Bathymetry	RSN.S2.AL.CHART-001	1:10000	Alignment
RSN.S2.NU.CHART-002A	1:10000	Bathymetry	RSN.S2.AL.CHART-002	1:10000	Alignment
RSN.S2.NU.CHART-002B	1:10000	Geology			

Segment 3 Charts

Chart Name	Scale	Type	Chart Name	Scale	Type
RSN.S3.NU.CHART-001A	1:10000	Bathymetry	RSN.S3.NU.CHART-004A	1:10000	Bathymetry
RSN.S3.NU.CHART-001B	1:10000	Geology	RSN.S3.NU.CHART-004B	1:10000	Geology
RSN.S3.NU.CHART-002A	1:10000	Bathymetry	RSN.S3.AL.CHART-001	1:10000	Alignment
RSN.S3.NU.CHART-002B	1:10000	Geology	RSN.S3.AL.CHART-002	1:10000	Alignment
RSN.S3.NU.CHART-003A	1:10000	Bathymetry	RSN.S3.AL.CHART-003	1:10000	Alignment
RSN.S3.NU.CHART-003B	1:10000	Geology	RSN.S3.AL.CHART-004	1:10000	Alignment

Segment 4 Charts

Chart Name	Scale	Type	Chart Name	Scale	Type
RSN.S4.NU.CHART-001A	1:10000	Bathymetry	RSN.S4.NU.CHART-009B	1:10000	Geology
RSN.S4.NU.CHART-001B	1:10000	Geology	RSN.S4.NU.CHART-010A	1:10000	Bathymetry
RSN.S4.NU.CHART-002A	1:10000	Bathymetry	RSN.S4.NU.CHART-010B	1:10000	Geology
RSN.S4.NU.CHART-002B	1:10000	Geology	RSN.S4.NU.CHART-011A	1:10000	Bathymetry
RSN.S4.NU.CHART-003A	1:10000	Bathymetry	RSN.S4.NU.CHART-011B	1:10000	Geology
RSN.S4.NU.CHART-003B	1:10000	Geology	RSN.S4.AL.CHART-001	1:10000	Alignment
RSN.S4.NU.CHART-004A	1:10000	Bathymetry	RSN.S4.AL.CHART-002	1:10000	Alignment
RSN.S4.NU.CHART-004B	1:10000	Geology	RSN.S4.AL.CHART-003	1:10000	Alignment
RSN.S4.NU.CHART-005A	1:10000	Bathymetry	RSN.S4.AL.CHART-004	1:10000	Alignment
RSN.S4.NU.CHART-005B	1:10000	Geology	RSN.S4.AL.CHART-005	1:10000	Alignment
RSN.S4.NU.CHART-006A	1:10000	Bathymetry	RSN.S4.AL.CHART-006	1:10000	Alignment
RSN.S4.NU.CHART-006B	1:10000	Geology	RSN.S4.AL.CHART-007	1:10000	Alignment
RSN.S4.NU.CHART-007A	1:10000	Bathymetry	RSN.S4.AL.CHART-008	1:10000	Alignment
RSN.S4.NU.CHART-007B	1:10000	Geology	RSN.S4.AL.CHART-009	1:10000	Alignment
RSN.S4.NU.CHART-008A	1:10000	Bathymetry	RSN.S4.AL.CHART-010	1:10000	Alignment
RSN.S4.NU.CHART-008B	1:10000	Geology	RSN.S4.AL.CHART-011	1:10000	Alignment
RSN.S4.NU.CHART-009A	1:10000	Bathymetry	RSN.S4.AL.CHART-012	1:10000	Alignment

Segment 4NP Charts

Chart Name	Scale	Type	Chart Name	Scale	Type
RSN.S4NP.NU.CHART-001A	1:10000	Bathymetry	RSN.S4NP.NU.CHART-003B	1:10000	Geology
RSN.S4NP.NU.CHART-001B	1:10000	Geology	RSN.S4NP.AL.CHART-001	1:10000	Alignment
RSN.S4NP.NU.CHART-002A	1:10000	Bathymetry	RSN.S4NP.AL.CHART-002	1:10000	Alignment
RSN.S4NP.NU.CHART-002B	1:10000	Geology	RSN.S4NP.AL.CHART-003	1:10000	Alignment
RSN.S4NP.NU.CHART-003A	1:10000	Bathymetry			

Segment 5 Charts

Chart Name	Scale	Type	Chart Name	Scale	Type
RSN.S5.NU.CHART-001	3.51388889	Inshore	RSN.S5.NU.CHART-011A	1:10000	Bathymetry
RSN.S5.NU.CHART-002A	1:10000	Bathymetry	RSN.S5.NU.CHART-011B	1:10000	Geology
RSN.S5.NU.CHART-002B	1:10000	Geology	RSN.S5.NU.CHART-012	1:25000	Bathymetry
RSN.S5.NU.CHART-003A	1:10000	Bathymetry	RSN.S5.NU.CHART-013	1:25000	Bathymetry
RSN.S5.NU.CHART-003B	1:10000	Geology	RSN.S5.NU.CHART-014	1:100000	Bathymetry
RSN.S5.NU.CHART-004A	1:10000	Bathymetry	RSN.S5.NU.CHART-015	1:100000	Bathymetry

Chart Name	Scale	Type	Chart Name	Scale	Type
RSN.S5.NU.CHART-004B	1:10000	Geology	RSN.S5.AL.CHART-001	1:10000	Alignment
RSN.S5.NU.CHART-005A	1:10000	Bathymetry	RSN.S5.AL.CHART-002	1:10000	Alignment
RSN.S5.NU.CHART-005B	1:10000	Geology	RSN.S5.AL.CHART-003	1:10000	Alignment
RSN.S5.NU.CHART-006A	1:10000	Bathymetry	RSN.S5.AL.CHART-004	1:10000	Alignment
RSN.S5.NU.CHART-006B	1:10000	Geology	RSN.S5.AL.CHART-005	1:10000	Alignment
RSN.S5.NU.CHART-007A	1:10000	Bathymetry	RSN.S5.AL.CHART-006	1:10000	Alignment
RSN.S5.NU.CHART-007B	1:10000	Geology	RSN.S5.AL.CHART-007	1:10000	Alignment
RSN.S5.NU.CHART-008A	1:10000	Bathymetry	RSN.S5.AL.CHART-008	1:10000	Alignment
RSN.S5.NU.CHART-008B	1:10000	Geology	RSN.S5.AL.CHART-009	1:10000	Alignment
RSN.S5.NU.CHART-009A	1:10000	Bathymetry	RSN.S5.AL.CHART-010	1:10000	Alignment
RSN.S5.NU.CHART-009B	1:10000	Geology	RSN.S5.AL.CHART-011	1:10000	Alignment
RSN.S5.NU.CHART-010A	1:10000	Bathymetry	RSN.S5.AL.CHART-012	1:10000	Alignment
RSN.S5.NU.CHART-010B	1:10000	Geology	RSN.S5.AL.CHART-013	1:10000	Alignment

Segment 6 Charts

Chart Name	Scale	Type
RSN.S6.NU.CHART-001	1:100000	Bathymetry
RSN.S6.NU.CHART-002	1:100000	Bathymetry
RSN.S6.NU.CHART-003	1:100000	Bathymetry

Segment 7 Charts

Chart Name	Scale	Type
RSN.S7.NU.CHART-001	1:100000	Bathymetry

1 INTRODUCTION

The Regional Scale Nodes (RSN) is a component of the National Science Foundation (NSF) Ocean Observatories Initiative (OOI). The OOI is managed and coordinated by the OOI Project Office at the Consortium for Ocean Leadership (OL) in Washington, D.C. The University of Washington (UW) is the RSN Implementing Organization for OL.

In November of 2009, L-3 Communications MariPro entered into contract with the University of Washington for the design-build and long-term technical support of the RSN Primary Infrastructure. Approximately 876 km of electro-optical cable will provide power and communications from a shore station in Pacific City, Oregon, via seven primary segments and one secondary (optional) segment to seven primary nodes and one secondary (optional) node.

In December of 2009, Williamson & Associates (of Seattle, Washington) was contracted by L-3 Communications MariPro to provide survey services in support of the design and installation of the RSN system. As part of the proposal, Williamson & Associates was tasked with undertaking the RSN Desktop Study, as well as the final survey interpretation and reporting. The RSN Marine Survey kickoff meeting included representatives from L-3 MariPro and Williamson & Associates, and was held on January 6, 2010.

After preliminary review of the RSN Desktop Study, a meeting was held on January 28, 2010 at the Williamson & Associates facility in Seattle, Washington. The meeting included representatives from the University of Washington, L-3 MariPro, TE SubCom – the cable backbone supplier and installer – and Williamson & Associates. At this meeting, all parties provided feedback regarding the proposed cable route. Subsequent to the meeting, written comments and route revisions from the University of Washington, L-3 MariPro, and TE SubCom were provided to Williamson & Associates.

Mobilization of the *R/V Mount Mitchell* commenced in Seattle on the 29th of March, 2010. Survey apparatuses were calibrated between April 4th and May 12th, 2010 near the survey area. Nearshore and deep water survey operations began in earnest on the 5th of April, 2010. Geophysical survey operations were concluded on the 1st of May, and the ship was rigged for geotechnical acquisition. Mini Cone Penetrometer Tests (CPTs) and a sampling program (cores/grabs) were completed by May 12th, 2010. The *R/V Mount Mitchell* arrived at dock in Seattle on the 14th of May, and was demobilized the same day. The *M/V Silver Streak* was mobilized for shallow water (inshore) survey operations between May 24th and May 31st. The Inshore survey commenced on the 26th of May, 2010 and was completed by the 31st of the same month.

The objective of the offshore cable route (Figure 1-1) survey was to confirm or amend the route design by acquiring geophysical, geological and geotechnical data along the proposed cable route in order to ascertain a feasible and safe route for cable system, its deployment, survivability, and subsequent maintenance. The survey results were also to allow decisions to be made concerning the marine installation procedures, the final cable engineering and burial for the entire route.

The data required for the route survey were based in part on the water depth, as well as underwater plant components to be laid. The survey was required to fully characterize the seabed from the Mean Lower Low Water (MLLW) reference out to a depth of 1500 m along the proposed cable routes, as specified in the RPLs provided by L-3 MariPro (Appendix A). Survey data included high-resolution multibeam bathymetry and side scan sonar, plus geophysical and geotechnical data to characterize the upper two meters of the seabed for burial assessment purposes.

The following report details the project's survey parameters (§2); summarizes the route revision history (§3); provides a regional overview of the survey area (§4); makes segment-specific interpretations and isolates Areas of Concern (AoC) based on the survey results (§5); discusses specific route recommendations (§6); outlines survey operations for the nearshore/deep water (§7) and inshore (§8) corridors; evaluates data quality and outlines data processing steps (§9); and assesses burial conditions (§10). All subsections of this report expand on these principal themes as needed to disclose any information relevant to the safe installation of the RSN cable and to its long-term operational success.

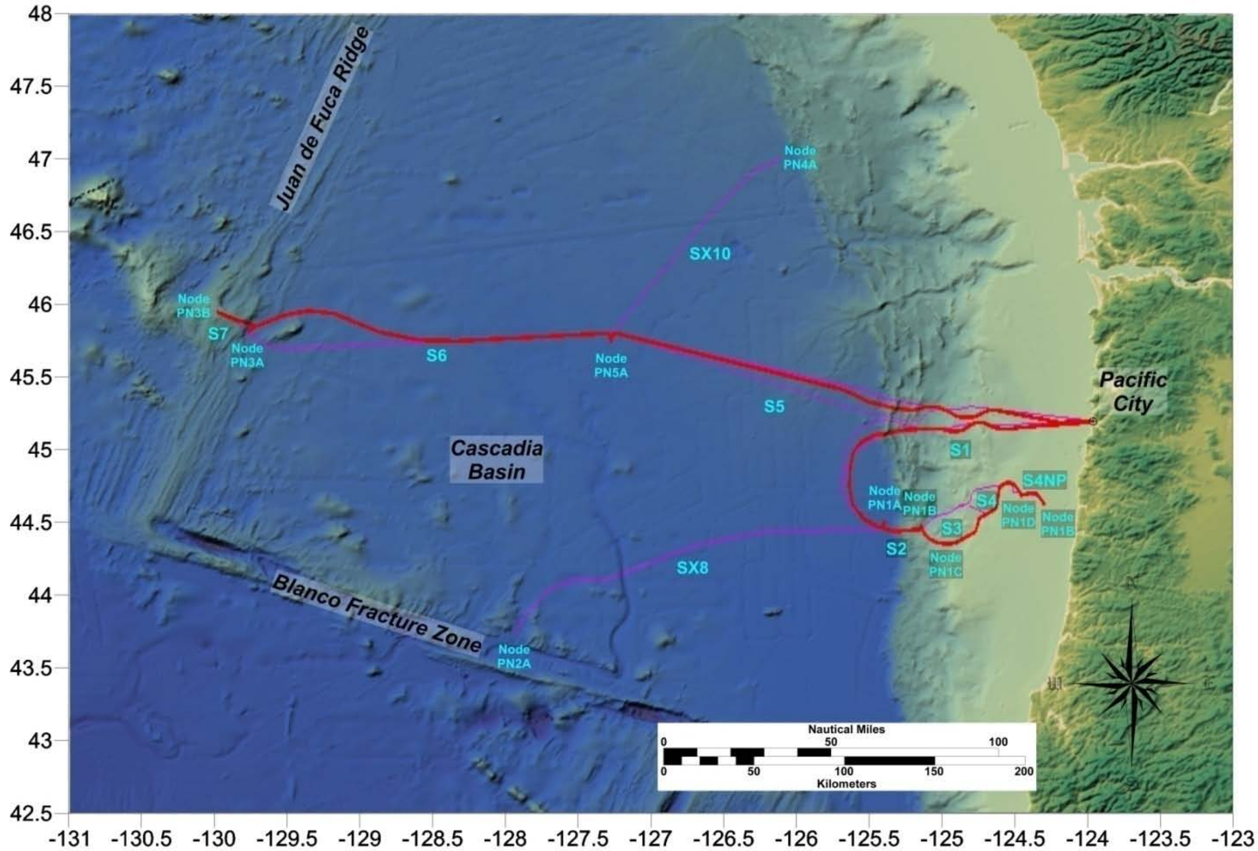


FIGURE 1-1 RSN SURVEY ROUTE OVERVIEW

Original survey route (DTS1-02 Rev 022010) shown in magenta. Survey route (PSR1 060710) is shown in red.

2 SURVEY PARAMETERS

2.1 SCOPE OF WORK

The marine cable route survey comprised the following:

- Inshore work from the 3 m to 20 m bathymetric contours with multibeam echosounder, geophysical spread and sampling.
- Shallow water (Nearshore) work from 20 m to the End of Burial (EOB, nominally 1500 m water depth) with multibeam, geophysical and geotechnical spread and seabed sampling.
- Deep water (beyond the EOB) work in water depths greater than the EOB position, single survey line using multibeam- echosounder only.

The burial assessment survey was carried out using primarily CPT and gravity core equipment to provide geotechnical data for the top 2 m of seabed sediments.

The overall Scope of Work included the following activities:

- Mobilization of a survey vessel(s) with geophysical and geotechnical equipment and personnel sufficient to perform the required work.
- Performance of the marine geophysical route survey.
- Onboard processing and quality control of all acquired geophysical data.
- Assessment of burial in the survey areas where the cable will be buried.
- Issue of preliminary survey report to L-3 MariPro.
- Issue of final report, charts and digital data products to L-3 MariPro.

2.2 PLAN OF WORK

2.2.1 Plan of Work As Designed

The initial Plan of Work (POW) was formulated based on the Scope of Work and RPL (Issue DTS1-02 dated February 20, 2010) provided by L3. In areas shallower than 20 m water depth, Williamson proposed using a C3D light-weight pole mounted system for collection of bathymetric and side scan sonar intensity data, along with a towed subbottom profiler deployed from a shallow draft vessel. Williamson proposed conducting survey operations from the 20 m contour and deeper using the *R/V Mt Mitchell*, with vessel mobilization and demobilization in Seattle, Washington.

Williamson proposed using the Teledyne Benthos C3D towfish with integrated side scan sonar, interferometric bathymetry and subbottom profiler in water depths between 20 and 1500 m, and the hull-mounted Kongsberg EM120 multibeam for deep water bathymetry data acquisition. As a back-up to this primary system, Williamson proposed using their own AMS60 towfish with integrated side scan sonar and subbottom profiler and a hull-mounted Kongsberg EM710 for multibeam bathymetry in water depths between 20 and 1500 m, and the hull-mounted EM120 for deeper water multibeam bathymetry.

Based on the pre-survey RPL total route lengths, 27 cores at a nominal spacing of 10 km and 66 CPTs at a nominal spacing of 4 km were proposed. In anticipation of at least one shallow water cable crossing, a Marine Magnetics SeaSPY magnetometer would be provided if the existing cable could not be located in the geophysical data.

The planned schedule for the cable route survey program broke down roughly as follows:

- R/V Mt Mitchell mobilization and transit to survey area, 5 days.
- Calibration activities, 1 day.
- Geophysical survey activities, 15.75 days.
- Possible personnel transfer at end of geophysical operations, 0.5 day.
- Seabed sampling and CPT operations, 10 days.
- R/V Mt Mitchell transit to Seattle and Demobilization, 4 days.
- Total small boat survey operations, 11 days.

2.2.2 Plan of Work as Carried Out

The POW as carried out was not significantly different than as designed, except for the actual number of calendar days required for the survey. The time spent on route survey was modified due to route revisions before and during survey operations, and route development around significant geologic features. Route development surveys alone added nearly 4 days to the overall survey schedule, while route revisions added about 26 km to the total surveyed centerline lengths. Survey equipment failures and resultant re-runs also contributed to the extended survey schedule by adding another 8.5 days. Weather delays added about 4.0 days to the total schedule.

Significant software issues prevented the initial deployment of the C3D towfish, so the survey operations in burial areas began using the AMS60 towfish. The AMS60 towfish was collecting high-quality data, so the launch of the repaired C3D towfish was delayed until April 12th, when the AMS60 port side sonar transducer array was flooded with seawater and could not be repaired. On April 17th, after deployment of the C3D and several days of data acquisition, the clients formally requested re-deploying the AMS60. The AMS60 was operated in an extended sonar range mode to acquire a full 1000 m swath, and the survey line plan was carefully planned and executed to maintain the appropriate offsets and optimal coverage using only the starboard side array. This modified survey plan also required additional utilization of the hull-mounted EM710 multibeam system.

During the small boat survey, Williamson used a pole-mounted Reson 7125 to acquire multibeam bathymetry data. The small boat survey also utilized an EdgeTech 2000DSS towfish with integrated side scan sonar and subbottom profiler systems to complete the geophysical suite.

After in-field adjustments to the RPLs, 30 cores at a nominal spacing of 10 km and 73 CPTs at a nominal spacing of 4 km were planned. After completion of all survey operations, a total of 31 cores, 73 CPTs and an additional 7 development CPT sites had been sampled.

Significant in-field revisions of S5 on April 2 eliminated the shallow water crossing of existing cable NPC, so no magnetometer survey was conducted.

The actual cable route survey schedule broke down roughly as follows:

- R/V Mt Mitchell mobilization and transit to survey area, 3.04 days
- Calibration activities, 0.4 day
- Geophysical survey activities, 14 days
- Additional transit for personnel and equipment transfers in Yaquina Bay, 0.1 day

- Seabed sampling and CPT operations, 6.8 days
- R/V Mt Mitchell transit to Seattle and Demobilization, 2.5 days
- Total small boat survey operations, 12 days

Additional factors that contributed to an overall increase of the number of calendar days to completion of work included:

- R/V Mt Mitchell weather stand-by, 4.0 days.
- R/V Mt Mitchell equipment maintenance and downtime 7.4 days.
- R/V Mt Mitchell reruns, 1.3 days.
- R/V Mt Mitchell development (includes route development, node area surveys and additional development CPT operations), 3.8 days.
- R/V Mt Mitchell diversion due to fishing activities, 0.3 day.

2.3 AREA OF WORK

The RSN cable comprises eight (8) segments (Figure 1-1). Segment 1 runs westward from Pacific City (45°12.14'N, 123°58.05'W) down the continental slope onto the Cascadia Basin floor, where it curves to the south to terminate at Primary Node PN1A (44°30.56'N, 125° 23.88'W). Segment 2 runs eastward along the continental slope from Primary Node PN1A to Primary Node PN1B (44°29.03'N, 125°08.85'W), south of Hydrate Ridge. From there, Segment 3 climbs the upper continental slope on a southeast bearing and terminates at Primary Node PN1C (44°21.78'N, 124°57.72'W), from which Segment 4 extends north-northeast to Primary Node PN1D (44°01.49'N, 124°27.42'W), near Daisy Bank and around the northern extension of Stonewall Bank. Segment 4NP extends from this node to the secondary node LV01D (44° 37.97'N, 124°18.21'W), just north of Stonewall Bank. Segment 5 extends west-northwestward from Pacific City, down the continental slope, and terminates just beyond the Cascadia Sea Channel at Primary Node PN5A (45°45.22'N, 127°16.72'W). From there, Segment 6 continues westward across the Cascadia Basin to Primary Node PN3A (45°49.22'N, 129°45.40'W), just southwest of the Son of Brown Bear volcano. Finally, from this node, Segment 7 ascends Axial Seamount to terminate near its summit at Primary Node PN3B (45°56.95'N, 129°58.88'W).

The configuration of the cable route survey per RPL RSN PSR3 rev 5 is as follows (route lengths in parentheses):

- Segment 1: Pacific City to Primary Node PN1A (204.733 km)
- Segment 2: Primary Node PN1A to Primary Node PN1B (28.695 km)
- Segment 3: Primary Node PN1B to Primary Node PN1C (23.748 km)
- Segment 4: Primary Node PN1C to Primary Node PN1D (76.260 km)
- Segment 4NP: Primary Node PN1D to Low Voltage Node LV01D (17.563 km)
- Segment 5: Pacific City to Primary Node PN5A (280.496 km)
- Segment 6: Primary Node PN5A to Primary Node PN3A (204.623 km)
- Segment 7: Primary Node PN3A to Primary Node PN3B (25.491 km)

2.4 PROJECT GEODESY

2.4.1 Reference Spheroid

All coordinates are referenced to the World Geodetic System 84 (WGS84) spheroid.

Reference Spheroid	WGS 1984
Semi Major Axis (a)	6378137.000
Semi Minor Axis (b)	6356752.314
Inverse Flattening (f)	298.257223563
Eccentricity (e²)	0.00669438

TABLE 2-1 REFERENCE SPHEROID

2.4.2 Projection

Coordinates are presented in UTM Zone 10N for all Segments of the RSN survey.

Projection – UTM 10N	Universal Transverse Mercator
Central Meridian	123°00.00'W
Latitude Of Origin	0°
False Easting on CM	500,000.00 m
False Northing	0 m
Scale Factor on CM	0.9996

TABLE 2-2 UTM 10 NORTH PROJECTION DETAILS

2.4.3 Vertical datum

The vertical datum utilized for bathymetric measurements was MLLW (Mean Lower Low Water). Tidal reduction was applied to all multibeam echosounder (MBE) data acquired up to a maximum of 2000 meters water depth. Detailed information about each tidal station utilized during the survey is provided below.

2.4.4 Tidal Station

NOAA Station 9437540 (Table 2-3), Garibaldi, Oregon was utilized for tide corrections of bathymetry data collected on the Segments 1 and 5 of the survey route, while NOAA Station 9435380 (Table 2-4), South beach, Yaquina River, OR was used for tide corrections of bathymetry data collected on segments 2,3,4 and 4NP.

Data	Tide Station 9437540
Station Name:	Garibaldi, OR
Location:	45°33.20' N, 123°55.10' W

Data	Tide Station 9437540
Port Type	Standard Harmonic Port
Tide Type	Mixed Diurnal

TABLE 2-3 RSN TIDE STATION 9437540

Data	Tide Station 9435380
Station Name:	South Beach, Yaquina River, OR
Location:	44°37.50’ N, 124°25.00’ W
Port Type	Standard Harmonic Port
Tide Type	Mixed Diurnal

TABLE 2-4 RSN TIDE STATION 9435380

2.4.5 Vertical Datum Conversions

Garibaldi, Oregon *Station 94327540*

- GT 2.537 m
- MHHW 3.743 m
- MHW 3.527 m
- MSL 2.577 m
- MHLW 1.619 m
- MLW 1.207 m
- MN 1.908 m

South Beach, Yaquina River, Oregon *Station 9435380*

- GT 2.543 m
- MHHW 3.990 m
- MHW 3.778 m
- MSL 2.806 m
- MHLW 1.869 m
- MLW 1.448 m
- MN 1.910 m

3 ROUTE REVISION HISTORY

3.1 PRE-SURVEY ROUTE

The RSN Desktop Study recommended changes to the contract route (Rev 011010). Route modification progressed over several iterations, culminating as presented in the final DTS RPL (DTS1-02 Rev 022010). While the node locations remained as placed in the contract route, the recommended "Pre-Survey Route" included seven (7) principle segments with three (3) optional plans, and two (2) optional segments (Figure 3-1). The pre-survey route (Appendix A) was designed to best negotiate the terrain, as anticipated at the resolution of the available bathymetric data (GMRT) as well as potential hazards described in published literature.

3.2 POST-SURVEY ROUTE

The pre-survey RPL provided by the client was revised during the course of the survey to facilitate burial, essentially by avoiding observed or known rock outcrops on the shelf and slope off Oregon. Many of the nodes were relocated during the survey to accommodate the terrain at the resolution provided by the survey data and client preferences. Consequently, all routes except Segments 2 and 7 were significantly modified. The optional Segments SX8 and SX10 were not included in the RSN survey. The "Post-Survey" RPL (PSR1 060710) is provided in Appendix A and displayed in Figure 3-1.

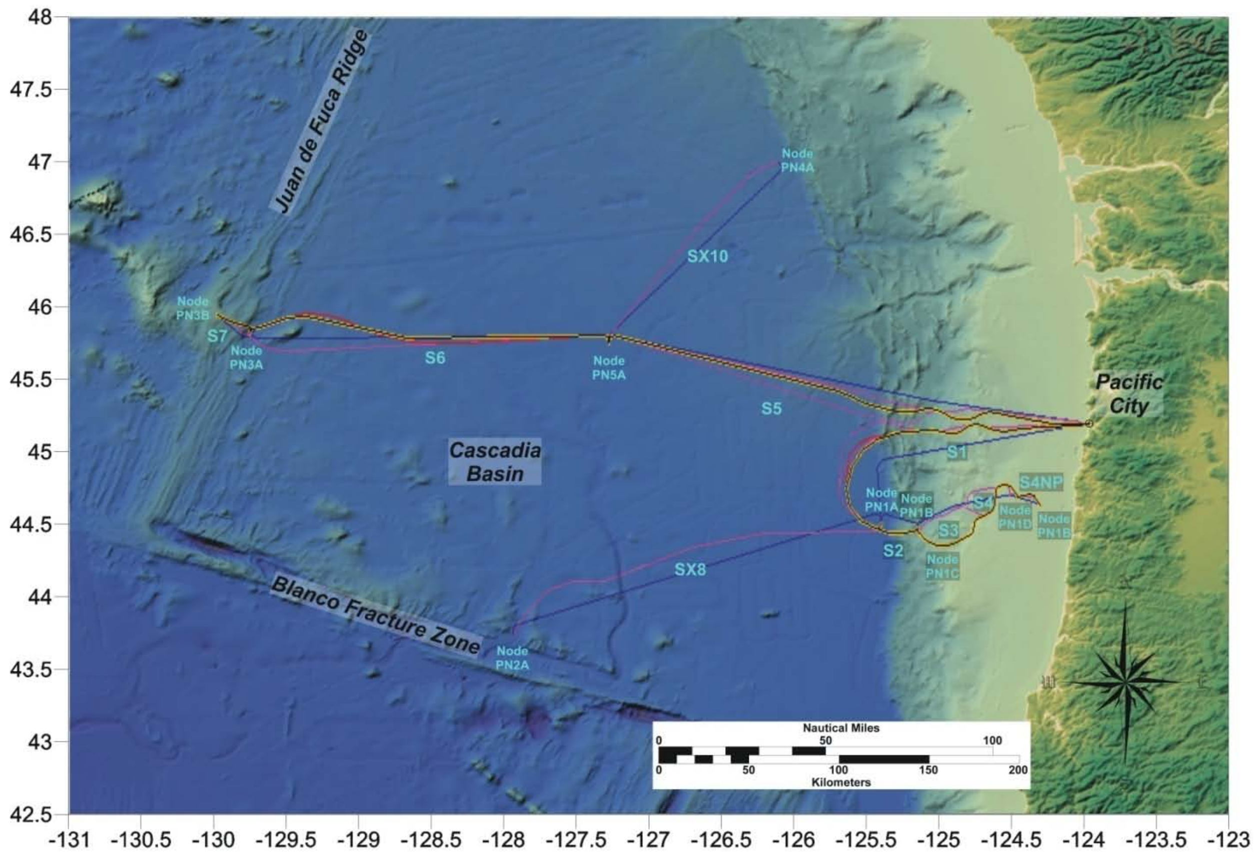


FIGURE 3-1 RSN ROUTE REVISIONS

Blue shows contract route Rev 011010. Solid magenta is pre-survey Route (Rev022010), with Options dashed. Red is post-survey Route (PSR1 060710). The final route (RSN_PSR3_R1) is shown in gold, with revision (RSN_PSR3_R5) in black.

3.3 FINAL ROUTE REVISION 1

A final route was issued subsequent to the submittal and review of the preliminary survey report. The final route (RSN_PSR3_R1) was slightly altered from the post-survey route to avoid potentially hazardous seafloor as well as to better accommodate engineering criteria (Figure 3-1).

Table 3-1 shows the differences in cable lengths, by segment and cable type, between the pre-survey (Issue DTS1_02, dated February 20, 2010) and post-survey (Issue PSR1, dated June 7, 2010) engineered routes. The cable lengths in Table 3-1 do not include any system spares. Cable and route lengths in the RPLs included in this report do not include land cable sections.

3.4 FINAL ROUTES: REVISION 3 AND TRUNK REVISION 3

Following printing and dissemination of the Final Survey Report (Rev 3), additional changes were made to the final route RPL (Issue PSR3_R1) to avoid sonar contacts and authigenic carbonate patches, and to account for the two-phase installation of the cable; first laid will be the "Trunk" with ends temporarily laid away from the node locations, to which they will be moved in the second phase by PLIB. These RPLs (Issue PSR3_R3 and PSR3_trunk_R3) are dated November 19, 2010).

Segment 1					Segment 4NP				
	LWA	SPA	LW	TOTAL		LWA	SPA	LW	TOTAL
DTS1-02	89.296	45.436	78.586	213.318	DTS1-02	19.715	0.000	0.000	19.715
PSR3_R1	93.524	43.630	70.780	207.934	PSR3_R1	17.593	0.000	0.000	17.593
Difference	4.228	-1.806	-7.806	-5.384	Difference	-2.122	N/A	N/A	-2.122
Segment 2					Segment 5				
DTS1-02	9.352	21.320	0.000	30.672	DTS1-02	85.040	47.405	149.995	282.440
PSR3_R1	8.800	20.656	0.000	29.456	PSR3_R1	89.641	45.256	150.556	285.453
Difference	-0.552	-0.664	N/A	-1.216	Difference	4.601	-2.149	0.561	3.013
Segment 3					Segment 6				
DTS1-02	31.167	0.000	0.000	31.167	DTS1-02	0.000	23.786	192.910	216.696
PSR3_R1	23.804	0.000	0.000	23.804	PSR3_R1	0.000	22.166	187.176	209.342
Difference	-7.363	N/A	N/A	-7.363	Difference	N/A	-1.620	-5.734	-7.354
Segment 4					Segment 7				
DTS1-02	42.852	0.000	0.000	42.852	DTS1-02	0.000	30.399	0.000	30.399
PSR3_R1	76.395	0.000	0.000	76.395	PSR3_R1	0.000	26.112	0.000	26.112
Difference	33.543	N/A	N/A	33.543	Difference	N/A	-4.287	N/A	-4.287

TABLE 3-1 COMPARISON OF PRE-SURVEY AND FINAL ROUTE REV1 RPLS

3.5 FINAL ROUTES: REVISION 5 AND TRUNK REVISION 6

Revision 6 of the "Trunk" installation (phase 1) and Revision 5 of the final route RPL (phase 2) altered a section of Segment 5 to avoid a sonar contact, and adjusted the cable end deployment configurations for all Segments except Segment 4NP, which will be laid during node installation. These RPLs – shown in Figure 3-1 – are dated 12/10/2010 and 11/23/2010, respectively.

3.6 FINAL ROUTES: REVISION 7 AND TRUNK REVISION 8

In preparation for installation of the trunk cable route, it was noted that a repeater on Segment 6 would require recovery prior to emplacement of the cable nodes in the second installation phase. The repeater (S6-2) was therefore relocated approximately 6 km to the east of its previous position. All other alignments and cable body locations remain as per RPL Revision 5 and Trunk Revision 6. These Final RPLs – dated January 4, 2011 – are included in Appendix A.

3.7 ONBOARD ROUTE REVISION SUMMARY

Minor modifications to the survey route were made nearly continuously as data were acquired and analyzed. More substantial shipboard route revisions usually resulted from significant development around geological features observed in real-time during survey data acquisition. Revised routes and route deviations that resulted from areas of significant development were informally tracked using the interim route names summarized in Table 3-2. All RPL data were coordinated and provided to Williamson and Associates by L3 MariPro personnel. Significant route revisions and areas of route development included:

- On April 7, route development was conducted along S6 in the vicinity of Primary Node PN3A to accommodate an approach from the northern side of the Son of Brown Bear seamount.

- On April 10, significant route revisions informally referred to as “S5 Dev2” led to abandonment of the Pre-survey S5 route and existing centerline survey, and substantial southward re-route in order to avoid rocky seafloor and steeper seabed gradients near the base of the continental slope. S1 was also re-routed southward as “S1b” to avoid observed rocky/highly reflective seafloor near the base of the continental slope.

- On April 12, 2010, modified survey routes were provided by L3 for S1, S2 and S5. S5 was re-routed to avoid a shallow water crossing of the existing cable NPC, and both S1 and S5 were revised in shallower water for better spacing parallel to the existing cable NPC. S2 was modified primarily to improve the orientation of the route relative to mapped seafloor features.

- On April 15, additional development was done adjacent and further south of the previous S5 Dev2 development area to further increase the survey corridor to allow proper route design around rocky seafloor. Two smaller development areas were referred to as “S5 Dev3” and “S5 Dev4”. The development areas were deviations from the interim route “S5c” dated April 14.

- On April 22, major revisions to the initial routes S3/S4 were made after initial survey found extensive rocky seafloor extending across the corridor west of the Bow Tie, and in an area of steeper terrain near Poggy’s Point. The major revisions moved S3 route (S3 Alt1) well to the south and east around the Southeast Knoll and another SE-trending ridge known locally as Halibut Hill. The new S3 Alt1 also had a generally better angle of approach up the base of the continental slope and ran nearly perpendicular to mapped contours. A revised S4 Alt1 was routed east of Daisy Bank, known locally as Nelson Island, and terminated at a position known locally as Walter’s Wreck that is generally avoided by local fishermen.

- On April 26, a significantly revised S4NP was informally named "S4NPc" and accommodated the revised node location and termination of S4 Alt1 at Walter's Wreck as well as a new location for the OSU buoy, which marks the end of Segment 4NP.

- On May 3, all shipboard route revisions to date were compiled in RPL issue SR1-01.

- On May 14, after completion of the Mt Mitchell survey but before the start of the small boat survey, revisions to the inshore sections of S1 and S5 were made in anticipation of thicker sediment cover to the south of the shipboard routes. Other minor changes in the route were made to avoid specific geologic features and areas where side scan imagery suggested harder seafloor. The RPL was issued as SR1-02.

- On May 18, the beach manhole positions for S1 and S5 were updated in RPL Issue SR1-03 to match the actual position as determined during the excavation and inspection of the vault in May of 2010.

- On June 7, all shipboard revisions to date were compiled and additional route engineering information was added to the RPL (issue PSR1) in preparation for the preliminary survey report and associated charting.

- August 10, revisions were made to accommodate slack rates and avoid features noted in the preliminary survey report and charting (issue PSR2)

- August 27, engineering modifications were made and route was adjusted to avoid geologic features (issue PSR3).

- September 2, minor tweaks and A/C adjustments were made; moved Primary Node PN3B (Issue PSR3 Rev1).

Segment	Received Date	Comments
S1	February 20	Issue DTS1-02, Initial survey route
S1-Opt1	February 20	Issue DTS1-02, Initial survey route
S2	February 20	Issue DTS1-02, Initial survey route
S3	February 20	Issue DTS1-02, Initial survey route
S4	February 20	Issue DTS1-02, Initial survey route
S4-Opt1	February 20	Issue DTS1-02, Initial survey route
S4NP	February 20	Issue DTS1-02, Initial survey route
S5	February 20	Issue DTS1-02, Initial survey route
S5-Opt1	February 20	Issue DTS1-02, Initial survey route
S6	February 20	Issue DTS1-02, Initial survey route

Segment	Received Date	Comments
S7	February 20	Issue DTS1-02, Initial survey route
S1	March 31	Revised initial survey route
S2	March 31	Revised initial survey route
S3	March 31	Revised initial survey route
S6	April 7	Revised in approach to Axial Seamount
S5	April 10	Revised to avoid rocks
S1	April 10	Revised to avoid rocks
S1	April 12	Revised inshore route to provide better separation after S5 changes
S2	April 12	Revised route for better seabed gradients
S5	April 12	Revised inshore route to avoid NPC cable
S1b	April 12	Route revision in areas of rocky seabed near the base of the continental slope; provided as waypoints along the route in development area only
S5 Dev2	April 12	Route revision in areas of rocky seabed near the base of the continental slope; provided as waypoints along the route in development area only
S1c	April 15	Interim revision consolidated changes made in inshore area with additional revisions to improve inshore route separation from S5 and in development area at the base of the continental slope
S5c	April 15	Interim revision consolidated changes made in inshore areas and in development area at the base of the continental slope
S5 Dev4	April 15	Additional development work south of route S5c and at the base of the continental slope; provided as waypoints along the route in development area only
S5 Dev3	April 15	Additional development work south of the route S5c, at the base of the continental slope in an area of steeper topography and rocky bottom; provided as waypoints along the route in development area only
S2b	April 22	Very minor modifications to improve route angles
S3 Alt1	April 22	Major re-route to the south and east prompted by abandonment of S3/S4 after initial survey found rocky seafloor over local bathymetric highs.
S4 Alt1	April 22	Major re-route to the south and east prompted by abandonment of S3/S4 after initial survey found rocky seafloor over local bathymetric highs; route terminates at the node location near Walter's Wreck.
S4NPc	April 26	Major re-route to accommodate changes to S4; route originates at the node location at Walter's Wreck.

Segment	Received Date	Comments
All Segments	May 03	Issue SR1-01.
S1	May 14	Issue SR1-02, minor revisions in inshore areas to move the route into areas with slightly thicker seabed sediments based on CPT results
S5	May 14	Issue SR1-02, Minor revisions in inshore areas to move the route into areas with slightly thicker seabed sediments based on CPT results
S1	May 18	Issue SR1-03, compilation of all shipboard route revisions to date and corrected BMH to actual excavated vault position.
S4	May 18	Issue SR1-03, compilation of all shipboard route revisions to date and corrected BMH to actual excavated vault position.
S1	June 7	Issue PSR1, Post-Survey Route
S2	June 7	Issue PSR1, Post-Survey Route
S3	June 7	Issue PSR1, Post-Survey Route
S4	June 7	Issue PSR1, Post-Survey Route
S4NP	June 7	Issue PSR1, Post-Survey Route
S5	June 7	Issue PSR1, Post-Survey Route
S6	June 7	Issue PSR1, Post-Survey Route
S7	June 7	Issue PSR1, Post-Survey Route
Stub	June 7	Issue PSR1, Post-Survey Route
S1	August-10	Minor route adjustments were made to provide for increased clearance of possible outcropping strata in the vicinity of KP 79.4 and 81.1. The resulting route was moved south between KPs 67 and 79 by less than 200 meters. In some portions of the route through this area the distances between Alter Course points was reduced to about 2.5 times water depth in order to remain within the surveyed corridor.
S1	August-10	The bearing for the lay down leg for Primary Node PN1A was adjusted to provide for an alignment that more approximately bisects the trunk cable alignments.
S1	August-10	Slack rates were changed from initial nominal values of 1% for burial areas and 4% for surface laid areas to recommended values of 0.15% for burial areas and 2.5% for surface laid areas unless otherwise noted.
S1	August-10	Updated repeater locations.
S1	August-10	Moved End of Burial and LWA17 transition to Essential Fish Habitat 700-fm boundary plus 1 km point.

Segment	Received Date	Comments
S2	August-10	The bearing for the lay down legs for Primary Node PN1A and PN1B was adjusted to provide for alignments that more approximately bisect the trunk cable alignments
S2	August-10	Slack rates were changed from initial nominal values of 1% for burial areas and 4% for surface laid areas to recommended values of 0.15% for burial areas and 2.5% for surface laid areas unless otherwise noted.
S2	August-10	Moved End of Burial and LWA17 transition to Essential Fish Habitat 700-fm boundary plus 1 km point.
S3	August-10	The bearing for the laydown legs for Primary Node PN1B and PN1C was adjusted to provide for alignments that more approximately bisect the trunk cable alignments and to accommodate the new location for PN1C established by UW.
S3	August-10	Primary Node PN1C was moved about 420 meters on a bearing of 157 degrees true per UW direction.
S3	August-10	Minor adjustments were made in the cable route to accommodate the Node movement.
S3	August-10	Slack rates were changed from initial nominal values of 1% for burial areas to the recommended value of 0.15% unless otherwise noted.
S4	August-10	Slack rates were changed from initial nominal values of 1% for burial areas to the recommended value of 0.15% unless otherwise noted.
S4	August-10	Between KP 4 and 9 the route was moved about 250 meters north to avoid areas with potentially hard crust.
S4	August-10	Between KP 25 and 39 minor adjustments to the route were made to avoid areas with potentially hard crust.
S4NP	August-10	The route was straightened from KP 9 to 16 at the request of TE Subcom and UW after determination that features originally thought to have potential to affect plow burial of the cable were deemed insignificant.
S4NP	August-10	Slack rates were changed from initial nominal values of 1% for burial areas to the recommended value of 0.15% unless otherwise noted.
S5	August-10	Minor adjustments made in the cable route between KP 54.5 and 82 to achieve better clearance from identified features. Offsets were typically less than 100 meters from the PSR1 route in this area.
S5	August-10	Slack rates were changed from initial nominal values of 1% for burial areas and 4% for surface laid areas to recommended values of 0.15% for burial areas and 2.5% for surface laid areas unless otherwise noted.
S5	August-10	Updated repeater locations.
S5	August-10	Moved End of Burial and LWA17 transition to Essential Fish Habitat 700-fm boundary plus 1 km point.

Segment	Received Date	Comments
S6	August-10	Slack rates were changed from initial nominal value of 4% for surface laid areas to recommended value of 2.5% unless otherwise noted.
S6	August-10	Update repeater locations.
S6	August-10	Moved path point #6 located at KP 110.7 about 3 km NW to reduce overall cable length. This moved the route to the extreme north of the surveyed corridor but was deemed acceptable given the flat featureless nature of the seabed in the vicinity.
S6	August-10	From KP 129.5 to 196.6, deleted one AC and moved the route south to shorten the overall cable route length.
S7	August-10	The bearing for the laydown leg for Primary Node PN3A was adjusted to provide for an alignment that more approximately bisects the trunk cable alignments.
S7	August-10	Slack rates were changed from initial nominal value of 4% for surface laid areas to recommended value of 2.5% unless otherwise noted.
S1	August-10	Extended LWA17 cable an additional 2 water depths past the end of burial per TE Subcom recommendations.
S1	August-10	Altered route between KP 116.7 and 162.8 using reduced alter course point spacing of 4 times WD to tighten radius of turn thus reducing total cable required for lay while maintaining 3xWD distance from existing cables.
S2	August-10	Extended LWA17 cable an additional 2 water depths past the end of burial per TE Subcom recommendations.
S4	August-10	Alter Course established to avoid Authigenic Carbonate area was removed at KP 21.8 after determination that area would have no impact on burial operations.
S4	August-10	Route between KP 56.4 and 63.8 was moved south in order to avoid area where sampling revealed coral fragments which, coupled with imagery analysis, indicated hard bottom.
S5	August-10	From KP 3.4 to 10.5 the route was moved north to avoid passing through area outside surveyed corridor. Maximum movement of route alignment was about 250 meters.
S5	August-10	Between KP 58.6 and 62.3 one AC was removed to allow the route to run just south of an area described as Bedrock.
S5	August-10	Extended LWA17 cable an additional 2 water depths past the end of burial per TE Subcom recommendations.
S5	August-10	From KP 89.5 to 104.7 the route was modified to better accommodate the terrain leading down the continental slope. Route modification involved reducing the spacing of several Alter Course points from 5 x WD to 4 x WD.
S6	August-10	From KP 7 to 156 the route was straightened in order to take a more direct path

Segment	Received Date	Comments
		given the benign nature of the seabed in the area.
S6	August-10	The bearing for the laydown leg for Primary Node PN3A was adjusted to provide for an alignment that more approximately bisects the trunk cable alignments.
S5	September-2	The route was modified by adding AC points to allow the route to follow the original path through the area of additional CPT data showing burial potential and then to arc up to stay within the fully surveyed corridor.
S5	September-2	The route was adjusted to reduce ACs exceeding 15 degrees between KP 58.6 and 62.3. All Alter Course points in the area are now less than 15 degrees.
S7	September-2	The location of Primary Node PN3B was moved about 50 meters west per UW request.
S1	November-22	The route was adjusted to avoid sonar contacts and a large pockmark field, to shorten the crossing distance of two areas of exposed strata, and to increase the northern crossing angle with the VNSL cable.
S4	November-22	The route was adjusted to avoid two patches of authigenic carbonate.
S5	November-22	The route was adjusted to avoid a sonar contact, and to minimize the number of pockmarks during the crossing of a large pockmark field.

TABLE 3-2 SUMMARY OF ROUTE REVISIONS

4 REGIONAL SETTING

4.1 REGIONAL OVERVIEW

The RSN route spans parts of the North American Plate and the Juan de Fuca Plate. Presently, the Juan de Fuca Plate is being subducted beneath the North American Plate at about 4-6 cm/yr at a dip of about 13 to 16 degrees (De Mets *et al*., 1990, Trehu *et al.*, 1994 *in* Roering, 2008). The region's unique tectonic setting has given rise to volcanic, turbidity flow, seismic and shelf-building processes, all contributing to the study area's complex geology. The distribution of the geographic features produced by these processes permits the division of the region into a number of distinct physiographic provinces, as depicted in Figure 4-1.

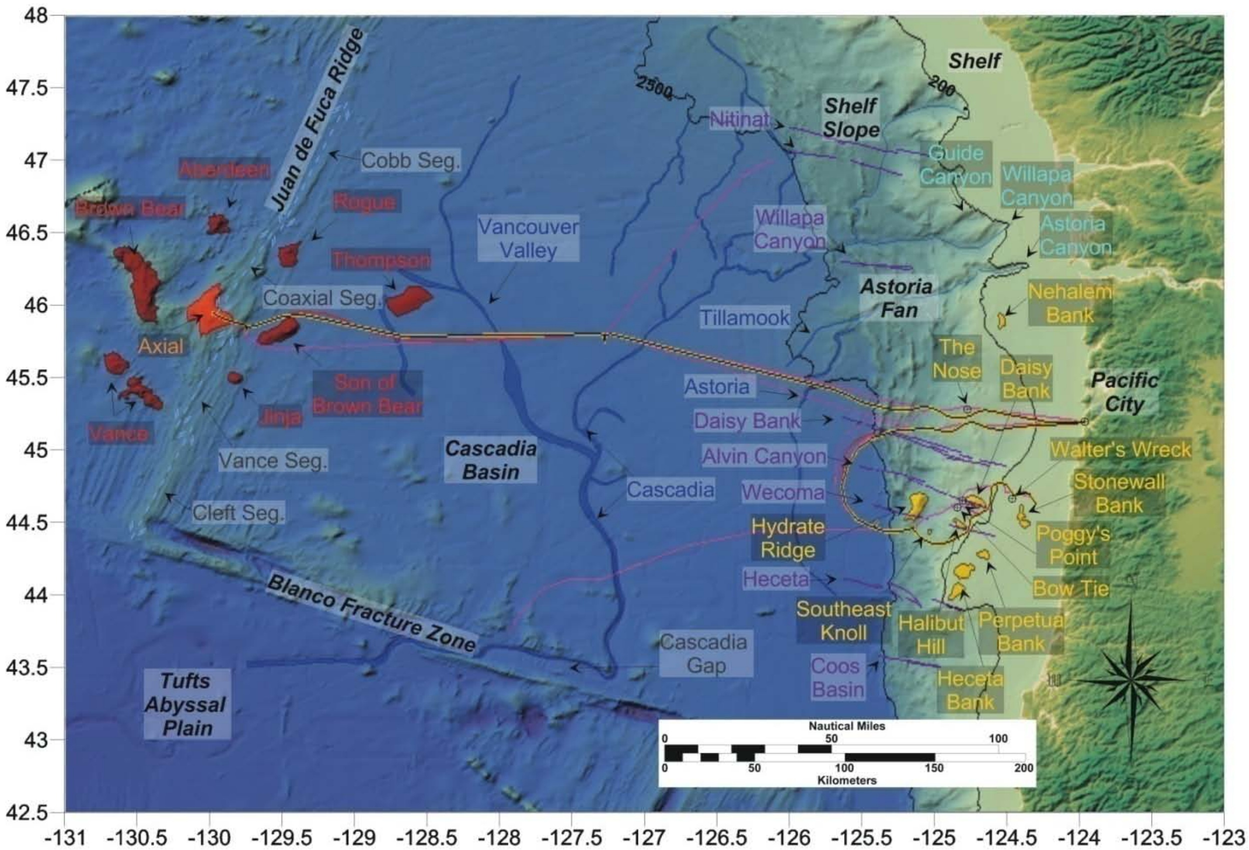


FIGURE 4-1 REGIONAL OVERVIEW

The names of different features are keyed to their type: seamounts are in red; shelf banks, ridges and knolls are in yellow (note Poggy's Point is a cliff edge and the Bow Tie is a narrow valley to the west of Daisy Bank (a.k.a. Nelson's Island)); major fault zones are in purple; shelf canyons are in cyan; sea channels are in blue; active volcanoes are in orange; and physiographic provinces are in black with their sub-provinces in gray. The 200 m and 2500 m isobaths (labeled) approximately divide the shelf slope from the shelf and the Cascadia Basin. The magenta line is the route recommended in the DTS, the red line is the survey route, the gold line is the final route, and the thin black line is revision 5 of the final route (only Segments 1, 4 and 5 are different).

4.1.1 Oregon Shelf

The Oregon shelf nominally extends from the shoreline to about the 200 m isobath. At approximately 24 km, the shelf off of Pacific City is relatively narrow, but outer-shelf; hard-bottom banks extend the shelf to the north and south of Pacific City. The shelf slopes at an even gradient of 0.08% (0.05°) where the final RSN route crosses it. The shelf break along the 200 m isobath informally delineates the transition from the shelf to the shelf-slope. The shelf comprises a thick clastic wedge that overlies deformed and faulted rock layers. Haystack Rock is an extinct volcanic plug that juts up from the seabed about 2 km northwest of the landfall. From this rock, small isolated rock outcrops are reported to dot the seabed in a belt that extends 3 km to the southwest. Sand lies between these small outcrops, and sand predominates past the 120 m isobath, where the surficial sediment transitions to mud that persists beyond the shelf break.

Outer shelf banks form around rock outcrops. To the south of Pacific City (offshore Newport) are Stonewall Bank and Heceta Bank. Daisy Bank is an upper slope bank that lies just below the shelf break. Figure 4-1 shows the relative location of these southern banks. Stonewall Bank formed atop an anticline that was wave-planed during the last eustatic lowstand when the local water depth reached about 40 m. Prior to inundation, a stream channel cut through the southern tip of the bank. Today the 275-400 m-wide channel is filled in with sand. Heceta Bank is an underwater seamount approximately 16 km wide (east-west) and 24 km long (north-south) at a depth of about 55-110 m. Perpetua Bank and Stonewall Bank are less dramatic features of the same large ridge extending southwest from Newport. Daisy Bank is an uplifted block from a major active fault that extends to the northwest. Offset Holocene sediments indicate that this fault has probably shifted in the last couple of hundred years (Goldfinger *et al.*, 1996).

North of Pacific City, the Nehalem Bank fault zone (not shown in Figure 4-1) extends northwest across the shelf, deforming the strata and uplifting rock to the seabed. This activity has resulted in the formation of the Nehalem Bank, which lies about 83 km northwest of Pacific City on the outer continental shelf (45°53.00’ N, 124°32.19’ W).

4.1.2 Shelf-Slope

The shelf-slope (slope), also known as the Cascadia fold and thrust belt, extends from the shelf break to the Cascadia Subduction Zone at a water depth of about 2500 m. The slope is characterized by a series of north-striking ridges that are stacked on top of one another as a result of thrust faulting from the subduction of the Juan de Fuca Plate beneath the North American Plate. As the oceanic plate subducts, slabs are sheared off and accreted onto the western margin of the North American Plate. This complex is known as the Cascadia Accretionary Prism. Between the rocky ridges are numerous intra-slope basins, or topographic lows, filled in with sediment. These basins have flat floors, and the surficial sediment is usually unconsolidated sand, silt and clay.

Most of the ridges are mantled by a thin layer of mud. Rock is exposed in several instances atop the ridges and along their steeper flanks. A number of active (Quaternary) faults have deformed the strata and formed scarps, ridges and valleys. Some of the ridges in the lower slope are currently being studied by research organizations. Perhaps the most notable of these is Hydrate Ridge, situated immediately north of Primary Node PN1B (Figure 1-1). Hydrate Ridge is named for its gas hydrates and hydrate-bearing sediment. This ridge has been drilled in a number of locations as part of the Ocean Drilling Project (ODP), and several oceanographic institutions have ongoing research at this site.

4.1.3 Astoria Fan and Sea Channels

The Columbia River Fan is often referred to as the Astoria Fan; both terms are included here. The present canyon head is 17 km west of the Columbia River mouth. The canyon meanders through apparent structural trends across the continental shelf and slope. At the fan apex, the canyon mouth merges smoothly into the Astoria Channel, which is characterized by a U-shaped profile, uniform lower walls, and levee development. The deep, narrow upper fan valleys break into distributaries on the middle fan where there is the sharpest change in gradient. The main valleys become broader and shallower farther down slope, where the generally concave fan surface grades to nearly a flat seafloor. Bathymetry and seismic refraction data, as well as sediment load of the Columbia River indicate that the cutting of Astoria Canyon and the deposition of the unconsolidated sediment layers forming the Astoria Fan could have been accomplished during Pleistocene time (Nelson *et al.,* 1970). Astoria Canyon forks into two sea channels where it joins the Astoria Fan. The western-most Tillamook Channel heads 27 km from the canyon on a southwest bearing, and then veers south-southwest to cover another 33 km before apparently ending near the proposed route. The Astoria Channel, however, extends south from the Astoria Fan for approximately 175 km.

This channel is floored with sand and gravel, remnants of turbidite deposits moving from the lower fan across the eastern Cascadia Basin. The Cascadia Channel extends southwest across the basin from the confluence of the Willapa and Guide Canyons. It then joins the Vancouver Valley Channel in the middle of the Cascadia Basin before heading south to the Blanco Fracture Zone. This sea channel is more than 2000 km long.

Sea channels are narrow pathways likely carved by turbidity flows; high-density volumes of sediment-laden water that surge over the seafloor, leaving tabular deposits, or *turbidites*, in their wake. Perhaps due to momentum (Muck and Underwood, 1990) or perhaps crustal tilting, the sea channels in the Cascadia Basin appear in some places to flow uphill. The frequency of turbidity flows is difficult to tell, but such events often result from earthquakes that dislodge unconsolidated sediment along canyon margins. Sometimes turbidity flow velocities can approach 100 km/hr (Selley, 1988). While tsunami and storm induced waves and failures of over-steepened or over-loaded slopes can also generate turbidity flows, the depositional record strongly suggests that earthquakes are the predominant trigger along the subduction zone of the Pacific Northwest (PNSN, 2002).

The 1964 Alaska earthquake generated the most destructive tsunami to strike the Oregon-Washington coast in recent times. Although this earthquake was one of the largest seismic events of the 20th century, it did not produce any recorded turbidites. If this large tsunami did not trigger a turbidity flow, it is highly unlikely the turbidite record reflects the occurrence of tsunami. Cascadia Zone earthquakes, on the other hand, have proved to provide enough force and affect a large enough coastal region to cause turbidity flows. Subduction zone earthquakes have long recurrence intervals, as do recorded turbidity flows. Radiocarbon dating of 13 turbidite core samples shows a recurrence interval of about 590 years, closely matching the interval of coastal subsidence observed in coastal Washington (PNSN, 2002).

4.1.4 Cascadia Basin

The Cascadia Basin is generally flat and featureless when compared to other physiographic provinces in the study area. It is bordered to the east by the Cascadia Subduction Zone and Astoria Fan. To the west is the Juan de Fuca Ridge, and to the south is the Blanco Fracture Zone (Figure 4-1). A few small, inactive volcanic seamounts dot the seabed. Terrigenous clastic sediment covers the seabed east of the Vancouver Valley and Cascadia Seachannels. To the west, the sediment is largely pelagic diatomaceous ooze. On approach to the Juan de Fuca Ridge, the concentration of volcanic glass in the sediment increases due to volcanic discharge from the spreading zone.

The oceanic crust of the Juan de Fuca Plate is very young, and the insulating effect of the sediment cover – in places nearly 2 km thick – has resulted in higher than normal crustal temperatures. Heat flow through the region is consequently high as well, and this phenomenon affects the circulation pattern of near-bottom waters.

4.1.5 Juan de Fuca Ridge

The Juan de Fuca Ridge is the volcanic spreading center that separates the Pacific Plate from the Juan de Fuca Plate. Active volcanoes and hydrothermal vents, discussed in more detail later in this section, are widespread on the ridge, which is separated into the Cleft, Vance, CoAxial and Cobb Segments (Figure 4-1). The Cobb Segment is the northernmost, and lies immediately north of the study area. The CoAxial Segment extends northward from Axial Seamount to the Cobb Segment. The Vance and Cleft Segments extend southward from Axial Seamount to the Blanco Fracture Zone. Located at 45°57' N, 130°00' W and coming within 1500 m of the sea surface, Axial Seamount is an active volcano, whose last recorded eruption was in 1998.

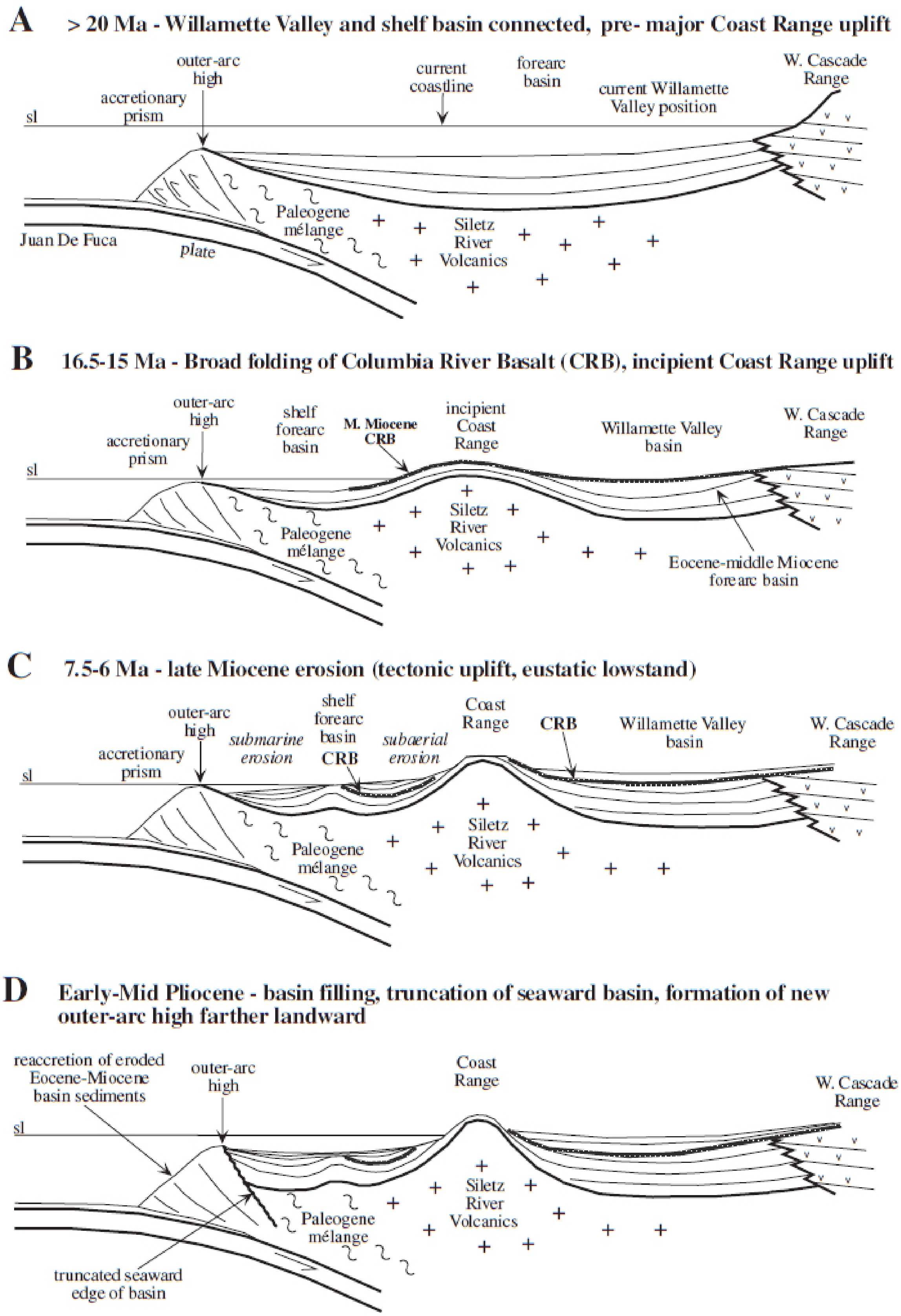
4.2 GEOLOGY

4.2.1 Regional Setting

The interaction of eustatic, tectonic and sedimentologic processes is recorded in the geologic record wherever there is sufficient accommodation space to accumulate a sedimentary package. The rocks and overlying sediments now comprising the Oregon shelf and continental slope were largely deposited in the forearc basin of an island arc system produced by Cretaceous plate convergence and subsequent volcanism in what is now southern Oregon. During Paleocene to Middle Eocene time (~60-45 Ma), submarine volcanoes outboard of Oregon's central and northern coasts contributed the Siletz River pillow basalts to these older rocks and active subduction began accreting the volcanic package to North America's west coast. Peri-synchronous with this development was extensive sand and silt sequences (the Tyee Fm) transported from the rising coastline by turbidity flows.

During Oligocene time (~25 Ma), the forearc basin likely extended as far inland as the early Cascade Range, which formed consequent to plutonic intrusions rising from the subducted Farallon (now Juan de Fuca) Plate that have riddled the region with volcanoes, dikes and sills to the present day. Tuffaceous bathyal mudstones (Smuggler Cove Formation) subsequently accumulated within the basin, and increased continental relief in late Oligocene time (~23Ma) shifted the coastline westward save for the Coos Bay, Newport, Tillamook and Astoria embayments. These contributed delta and turbidite sequences now preserved as volcaniclastic and feldspathic arenites (Yaquina, Alsea and Bewley Creek Fms) that grade upsection to early Miocene (~20 Ma) marine sand and mudstones (Nye and Astoria Fms).

Figure 4-2 depicts the Quaternary history of the western Oregon coastal region. Beginning around 17 Ma, in response to as-yet unresolved processes, some 260,000 km^3 of basalt lava began piling like pancakes in successive flood-basalt events that eventually produced the Columbia Plateau and covered most of the forearc basin out to sea. These layers were subsequently folded by regional compressional stresses that forced the central forearc basin into a broad anticlinorium constituting the incipient Coast Range. This effectively divided the basin into a sub-basin bounded by the Coast and Cascade ranges, and another extending westward from the Coast Range to the accretionary prism. A second anticline subsequently formed in this late Miocene (~7 Ma) forearc basin, and a contemporaneous drop in base level induced erosion over much of its surface, removing much of the Miocene-aged strata in many areas, and producing there an angular unconformity.


A
> 20 Ma - Willamette Valley and shelf basin connected, pre- major Coast Range uplift
outer-arc high
current coastline
forearc basin
W. Cascade Range
accretionary prism
current Willamette Valley position
sl
Paleogene mélange
Siletz River Volcanics
Juan De Fuca plate
B
16.5-15 Ma - Broad folding of Columbia River Basalt (CRB), incipient Coast Range uplift
outer-arc high
shelf forearc basin
M. Miocene CRB
incipient Coast Range
Willamette Valley basin
W. Cascade Range
accretionary prism
sl
Siletz River Volcanics
Paleogene mélange
Eocene-middle Miocene forearc basin
C
7.5-6 Ma - late Miocene erosion (tectonic uplift, eustatic lowstand)
outer-arc high
shelf forearc basin
Coast Range
CRB
Willamette Valley basin
W. Cascade Range
submarine erosion
subaerial erosion
CRB
accretionary prism
sl
Siletz River Volcanics
Paleogene mélange
D
Early-Mid Pliocene - basin filling, truncation of seaward basin, formation of new outer-arc high farther landward
reaccretion of eroded Eocene-Miocene basin sediments
outer-arc high
Coast Range
W. Cascade Range
sl
Siletz River Volcanics
Paleogene mélange
truncated seaward edge of basin

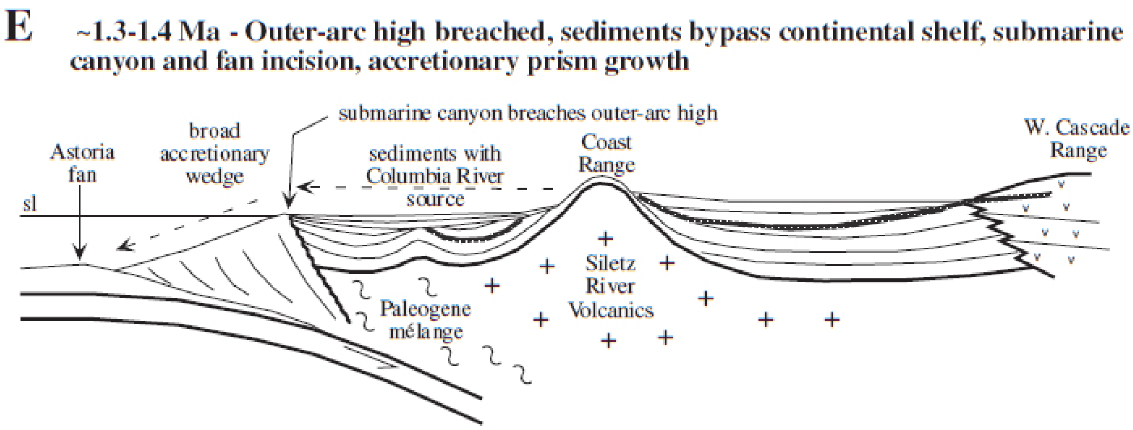
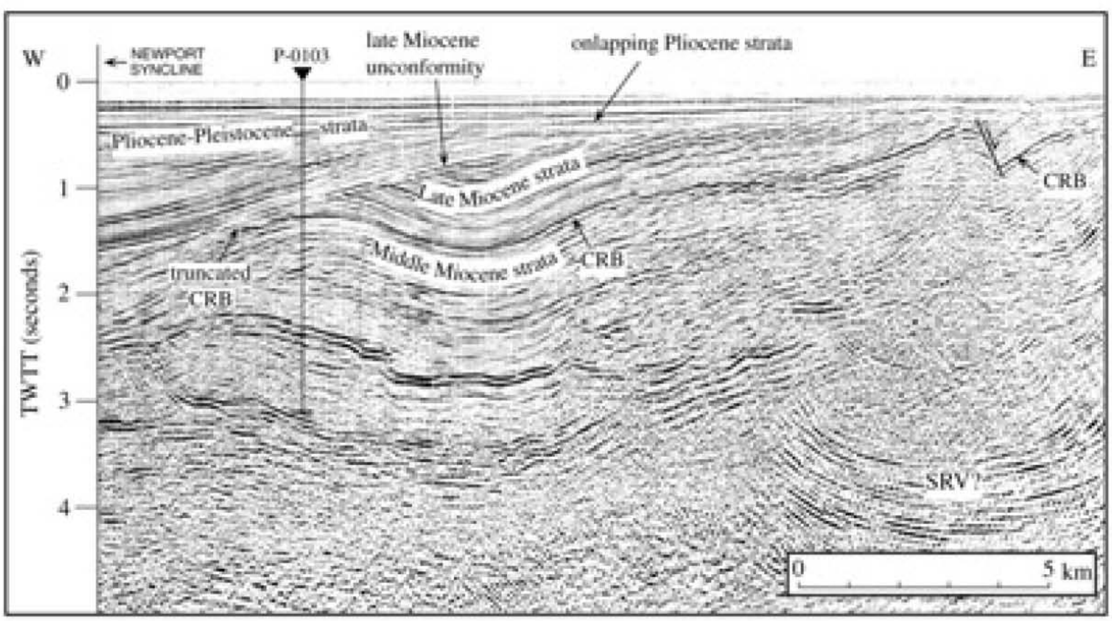


FIGURE 4-2 QUATERNARY TECTONIC SCHEMATIC

Schematic of the Quaternary tectonic history of the Oregon west coast from the western Cascade Range to the Juan de Fuca Plate boundary. Panel E illustrates the general character of the subsurface geology for the continental shelf, shelf slope, and basin floor. Modified from McNeill, Goldfinger, Kulm and Yeats (2000).

In early to middle Pliocene time (~4 Ma), the Eocene-Miocene accretionary prism began truncating the western margin of the forearc basin and new sediments began accumulating in its interior (Figure 4-3). The prism subsequently widened in Pleistocene time (~1.5 Ma), and the Columbia River's vast sediment load overfilled the basin and spilled over the outer arc high of the continental shelf to the abyssal plain, where it began depositing the Astoria Fan. As a result, the general geologic character of the shelf and slope is one of folded and faulted Miocene strata and volcanic deposits unconformably overlain by, and episodically outcropping, seaward-thickening packages of Pliocene and Pleistocene deltaic sequences and turbidites.



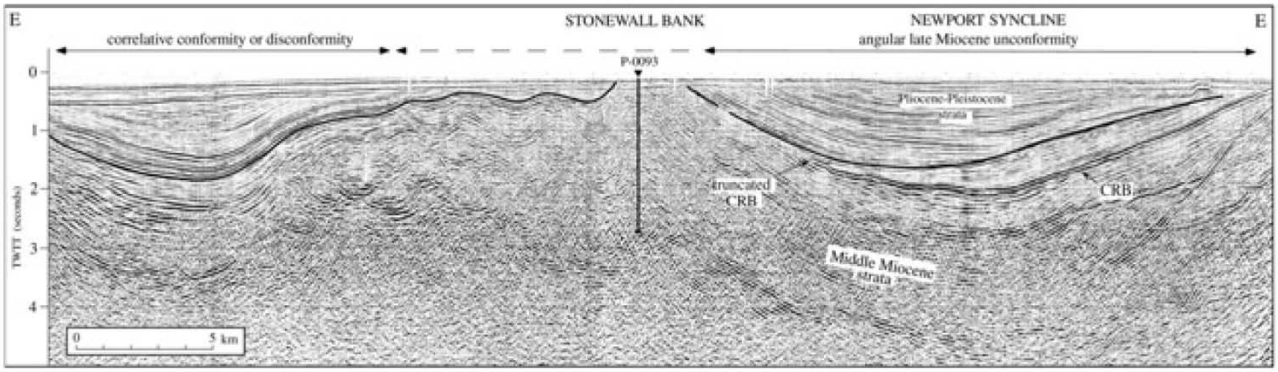


FIGURE 4-3 2D SEISMIC PROFILE OF SHELF

These seismic lines show the general character of the subsurface geology across the continental shelf. From shore (top), the Miocene stratigraphic units are folded and truncated by Plio-Pleistocene strata, which attenuate along into a central anticlinorium dividing two large synclines, with sympathetic folding throughout. These synclines are filled with Plio-Pleistocene strata and the central anticlinorium approaches the seafloor, locally cropping out (bottom). The entire assemblage is planed and overlain by Pleio-Holocene strata, ostensibly from the Columbia River. From McNeill et al (2000). Note the bottom figure is oriented W-E not E-E; the original is mislabeled.

4.2.2 Cape Kiwanda

Near Pacific City, the cliffs of Cape Kiwanda are an exposure of the Angora Peak member of the Astoria formation (Fm), which reportedly rests unconformably on the Smuggler Cove Fm (Parker, 1990). Dark mudstones of the Smuggler Cove Fm are scoured by younger cross-bedded and variably consolidated sandstone deposits. The contact is visible at low tide, and from it the Angora Peak member (Mb) of the Astoria Fm grades to horizontally-laminated and bioturbated carbonaceous sandstone to hummocky cross-stratified sandstone, to massive sandstone interspersed with hematite-cemented cobbles and boulders, then back to bioturbated carbonaceous sandstone. A large and distinctive channel incises the upper layer, one filled by an upward-fining sequence of basalt cobbles and cross-stratified basaltic sandstone. Surmounting the Cape are interbedded mudstone and turbidite deposits of the Cannon Beach Mb of the Astoria Fm.

The base of the Angora Peak Mb (where it contacts the Smugglers Cove Fm), has a noticeable layer of decomposed granite cobbles and boulders believed to have been rafted from the Idaho Batholith to the east during early Miocene time in the roots of trees carried down the ancestral Columbia River. When the tree roots reached the ocean, the boulders eventually dropped out and decomposed over time. The presence of micaceous granite was confirmed during the small boat survey in May, 2010, when members of the survey team visited Cape Kiwanda. Figures 4-4 and 4-5 depict the geology of Cape Kiwanda.

4.2.3 Regional Geology Integration

Published regional geology provides a foundation on which geophysical and geotechnical interpretations are based. Interpretation of survey data is checked against regional models to ensure consistency with known geologic conditions.

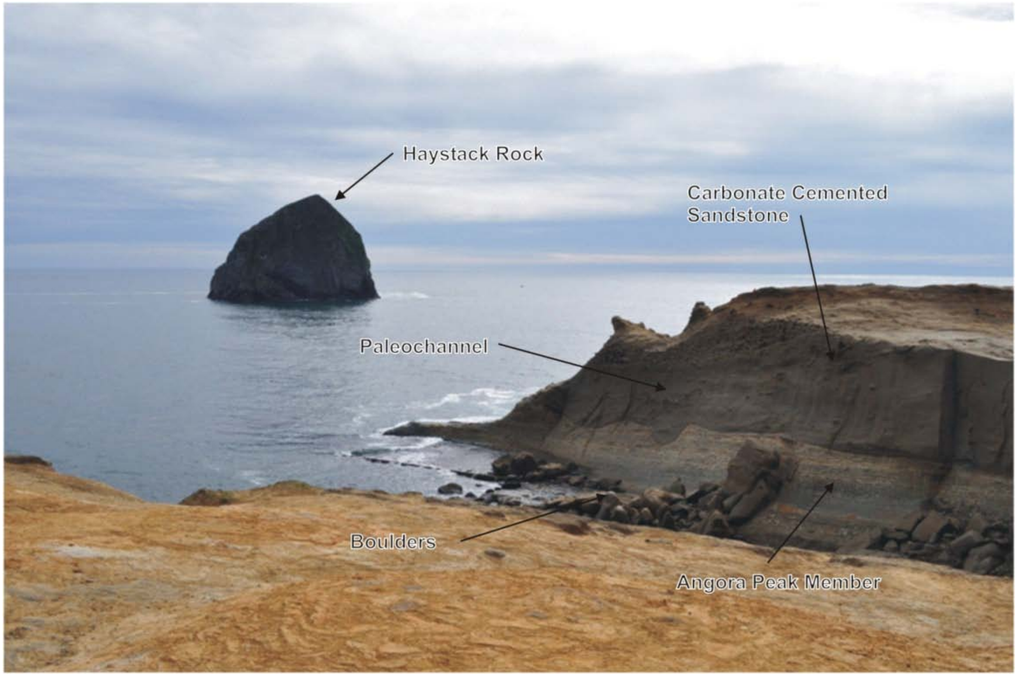


FIGURE 4-4 VIEW OF CAPE KIWANDA SHOWING SANDSTONE

A photograph taken in May, 2010 at Cape Kiwanda. The brown rock is carbonate-cemented Cannon Beach Mb mudstone, and the stratified underlying unit contains partially lithified layers of sandstone, mudstone, and conglomerate of the Angora Peak Mb. A small paleochannel structure is present near the point of the Cape. The rounded boulders are from the overlying sandstone. Haystack Rock is in the background.

FIGURE 4-5 VIEW OF SMUGGLERS COVE AND ASTORIA FORMATIONS AT CAPE KIWANDA

This photograph was taken at Cape Kiwanda looking southwest. Amanda Maness (TE SubCom Field Representative) is standing atop a resistant layer of the Angora Peak member. The Smugglers Cove Fm (mudstone) is at the base of the cliff and extends out into the ocean. An under-consolidated (loose) yellow sand layer is present in the foreground.

5 Survey Results

5.1 Inshore

5.1.1 Bathymetry

There are some 600 m between the shore and the first record of multibeam data. From the 5 m isobath, both segments 1 and 5 cross a low rise (sand bar) before descending westward with seabed gradients decreasing progressively for the remainder of the inshore corridor (i.e. to the 37 m isobath; Figure 5-1, RSN.S1.NU.CHART-001 and RSN.S5.NU.CHART-001).

5.1.2 Seabed Features

Sand dominates the Inshore survey corridor, but beginning approximately 900 m from the BMH, Segments 1 and 5 encounter the first of several gravel patches. The first, extending some 430 m, was blanketed with sand dollars during the survey, and appears as an extremely high reflectivity patch on the side scan recordings. This is not an unusual feature, as sand dollars have been mapped with side scan sonar in other places along the Pacific coast of the United States (e.g. Fenstermacher *et al*., 2001). Sand dollars tend to cluster in areas where food sources and physical environments are favorable. It is therefore difficult to predict whether this patch is stable or transitory. Appearing more like ribbons, the other gravel (or coarse-grained sand) patches are clustered approximately 2550 m from the BMH between the 28 and 34 meter isobaths, none spanning more than 30 m along either route (Figure 5-1, RSN.S1.NU.CHART-001 and RSN.S5.NU.CHART-001).

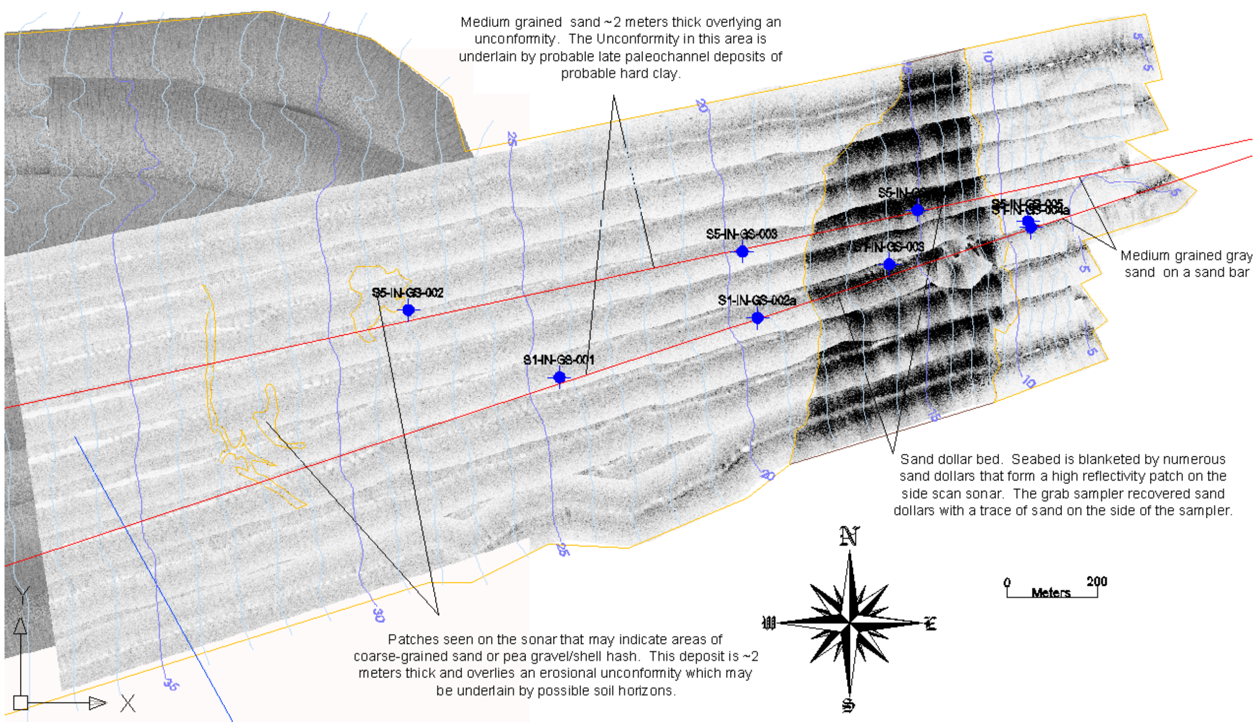


FIGURE 5-1 BATHYMETRY AND INTERPRETED SEABED FEATURES OF THE INSHORE SURVEY CORRIDOR

The solid red lines are Segment 5 (top) and Segment 1 (bottom). Bathymetry is shown in blue. Blue symbols mark the locations of grab samples.

5.1.3 Shallow Geology Routes 1 and 5 Inshore

Although the local members of the Angora Peak Fm and the strata it overlays plunge seaward from the Pacific City region (see §4.2.2), the subbottom profiler data does not reveal them. Instead, the inshore corridor appears to comprise recent beach deposits unconformably overlying older strata and soil horizons with probable paleochanneling. These older sediments probably consist of sand and gravel/shells, and several apparent soil horizons – possibly containing firm to stiff clay, gravel/shells or other compacted sediments – obliquely intersect the unconformity. This interpreted erosional surface is about 1 m below the seabed near the 40 m isobath and 2 m at the 20 m isobath, but does not appear in the subbottom profiles shoreward of the 20 m isobath, possibly due to acoustic scattering from the sand dollars. Figures 5-2 and 5-3 show the interpreted profiles of the centerlines for both Segments 1 and 5.

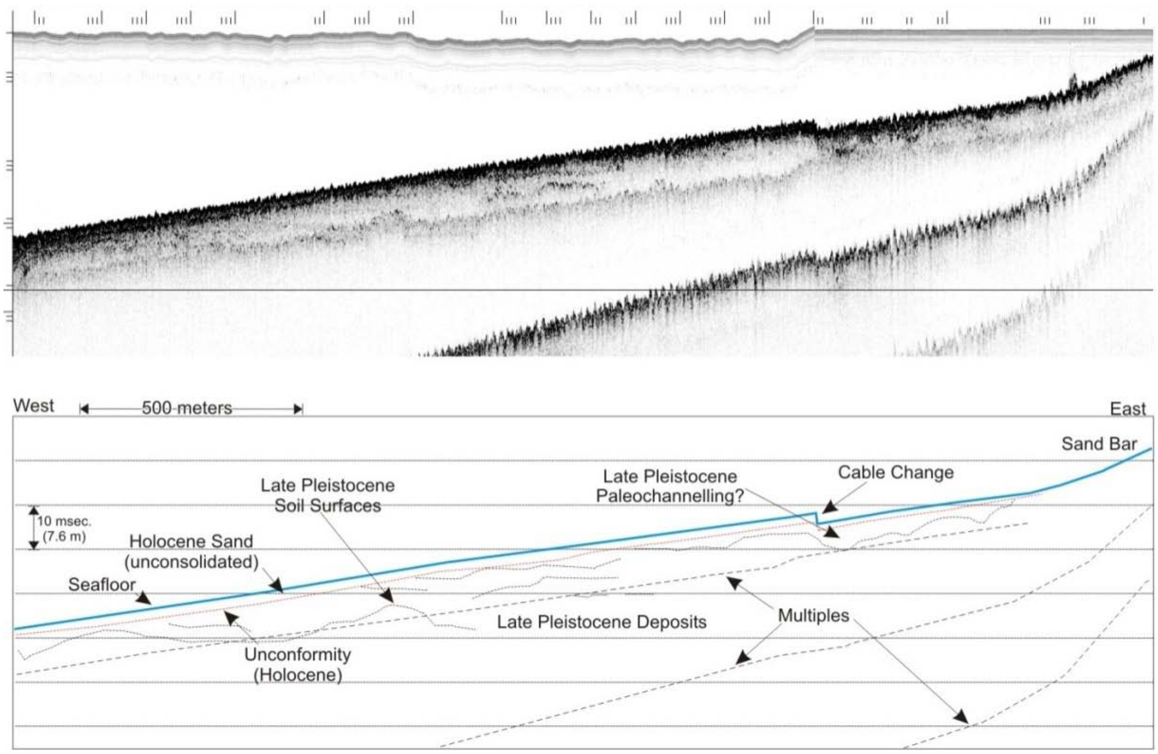


FIGURE 5-2 INTERPRETED SUBBOTTOM PROFILES OF THE INSHORE CENTERLINE OF SEGMENT 1

5.1.4 Hazards and Obstructions

There are no obvious geologic hazards or obstructions along this section of Segments 1 and 5. The interpreted erosional unconformity approaching the seabed near the westernmost extent of the inshore area at 37 meters water depth was not detected farther offshore. It is possible that the erosional surface is exposed at or near the seabed immediately west of the Inshore survey area, where CPT S5-MM-CPT-001-DEV2 recorded medium to very dense sediment (Appendix C). While there is sufficient “soft” sediment for plow burial in the inshore corridor, plow burial may be inhibited farther west.

5.1.5 Seabed Samples

Table 5-1 summarizes the location of seabed samples taken along the inshore portion of the RSN survey. Detailed records of these samples are included in Appendix B.

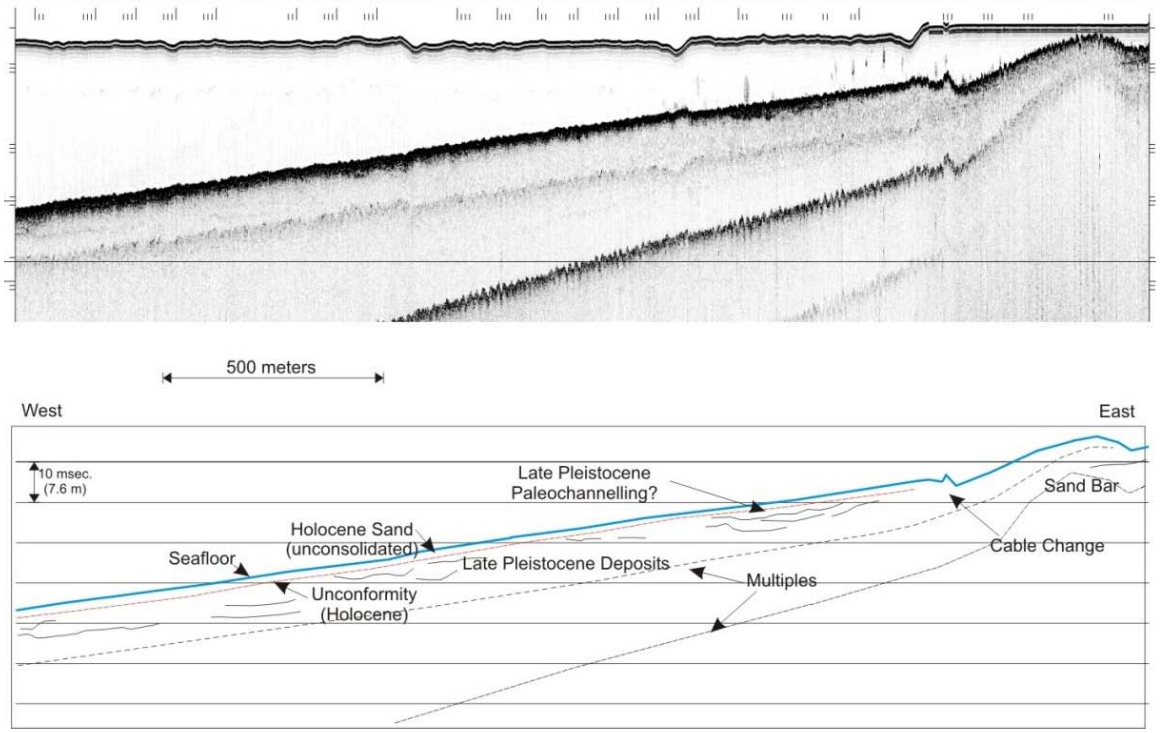


FIGURE 5-3 INTERPRETED SUBBOTTOM PROFILES OF THE INSHORE CENTERLINE OF SEGMENT 5

Name	Location				Depth (m)
	Coordinates		UTM Zone 10N		
	Latitude	Longitude	Northing	Easting	
S5-IN-GS-001	45°11.74’ N	124°0.53’ W	5005174.6	420751.69	40
S1-IN-GS-001	45°11.80’ N	123°59.45’ W	5005279.2	422172.21	26
S5-IN-GS-002	45°11.88’ N	123°59.71’ W	5005427.7	421837.58	28
S1-IN-GS-002a	45°11.87’ N	123°59.12’ W	5005410.8	422611.15	20
S5-IN-GS-003	45°11.95’ N	123°59.14’ W	5005557.5	422577.59	19
S5-IN-GS-004a	45°12.01’ N	123°59.85’ W	5005649.2	422964.95	15
S1-IN-GS-003	45°11.94’ N	123°58.90 W	5005529.5	422903.24	14
S1-IN-GS-004a	45°11.99’ N	123°58.66’ W	5005610.9	423217.11	10
S5-IN-GS-005	45°11.99’ N	123°58.66’ W	5005624	423210.74	10

TABLE 5-1 INSHORE GRAB SAMPLE LOCATIONS

5.2 SEGMENT 1

5.2.1 Bathymetry

The bathymetric summary of the Segment 1 survey corridor runs seaward from the 40 m isobath (seaward terminus of the inshore discussion) to its terminus at the Primary Node PN1A node location. See §5.1 for details regarding the results gathered along the Inshore survey portion of the RSN route.

The overall slope along the route from the 40 m isobath (45°11.54'N, 124°00.52'W) to the 135 m isobath (45°10.68'N, 124°11.29'W) is 0.7% (0.4°), but it increases to 2.9% (1.7°) on the western slopes of a series of north- to northwest-trending linear ridges and ledges (likely gravel, as discussed in §5.2.2) occupying a region approximately 3650 m wide. From the 135 m isobath to the 170 m isobath (45°10.42'N, 124°15.34'W), the slope decreases from 0.9% (0.5°) to 0.5% (0.3°; see charts RSN.S1.NU.CHART-003A and RSN.S1.NU.CHART-004A). The shelf break spans the next seven (7) km or so, and over this distance the slope increases to a maximum of 4.5% (2.6°) near the 280 m isobath (45°10.25'N, 124° 20.58'W; see chart RSN.S1.NU.CHART-005A). For the next five (5) km, the slope decreases to nearly level near the 366 m isobath (45°09.95'N, 124°23.97'W), where the route skirts the southern edge of a local bathymetric low (see charts RSN.S1.NU.CHART-005A and RSN.S1.NU.CHART-006A).

West of the 366 m isobath (45°09.47'N, 124°28.30'W), the slope steadily increases to 2.3% (1.3°) on ascent of a ridge, at the top of which (45°08.87'N, 124°32.81'W) the seabed becomes level (RSN.S1.NU.CHART-006A). West of the small terrace on the ridge's western face (45°08.97'N, 124°35.59'W), the slope increases to 4.8% (2.8°) near the 480 m isobath (45°09.48'N, 124°38.29'W), and decreases again to 0.2% (0.1°) near the 530 m isobath (45°10.32'N, 124°40.53'W; RSN.S1.NU.CHART-008A). Over the next 6 km, the route descends 94 m into a saddle between two bathymetric highs (45°11.41'N, 124°46.38'W) at a slope gradient approaching 2.4% (1.4°; RSN.S1.NU.CHART-009A). From the 624 m isobath, the route traverses the north flanks of the second high before obliquely descending into a shallow basin near the 741 m isobath (45°07.87'N, 124°53.51'W; RSN.S1.NU.CHART-010A). Though variable, the slope during this descent nowhere exceeds 3.7% (2.1°).

West of the 741 m isobath, the route ascends less than 5 m to a low ridge (45°07.79'N, 124°54.10'W) before stair-stepping 115 m down through a narrow canyon onto a relatively featureless slope near the 850 m isobath (45°08.10'N, 124°57.00'W; RSN.S1.NU.CHART-010A). From there, the route descends another 715 m at a gradient no greater than 12.9% (7.4°) before leveling off onto a large, north/south-trending terrace near the 1570 m isobath (45°08.98'N, 125°06.16'W; RSN.S1.NU.CHART-12). For the next 3.8 km or so, the route passes over the terrace's nearly flat terrain, beyond which the slope breaks over two ledges, each 1-2 km wide. The west-facing slopes of these ledges approach 17.5% (9.9°), and beyond them is an undulating plain stretching approximately 6 km (RSN.S1.NU.CHART-12).

The route then ascends 230 m over a narrow (~2 km), north/south-trending ridge (45°08.17'N, 125°17.77'W), whose steep flanks vary between 19.9% (11.24°) and 41.3% (22.5°). The route then levels off on another (~3.5 km) plain before ascending 140 m over the saddle of a second ridge (45°06.75'N, 125°21.60'W), where slope gradients do not exceed 29.2% (16.3°; RSN.S1.NU.CHART-13). Over the following 5 km, the route descends some 530 m at an average slope gradient of 10.6% (6.1°) into a north-northwest trending valley, bounded to the west by a parallel ridge (45°05.20'N, 125°25.65'W), whose slopes average 12.2% (6.9°). This feature constitutes the final obstacle of the continental slope before the route passes onto the Cascadia Basin at a depth of nearly 2700 m (45°03.49'N, 125°28.39'W; RSN.S1.NU.CHART-

13). There, the route turns progressively southward, covering approximately 81.4 km of nearly featureless terrain with an average slope of 0.26% (0.15°) before reaching its terminus at the Primary Node PN1A, where the depth is 2900 meters (RSN.S1.NU.CHART-14).

5.2.2 Seabed Features

Near the 40 m isobath, the predominantly terrigenous sand deposits of the Inshore survey become patchy in a region of north/south-trending, sub-parallel linear features spaced by about 15 m. These features are interpreted as large ripple marks. They are visible in side scan sonar, and extend to a slight slope break near the 62 m isobath (45°11.25'N, 124°03.80'W; Figure 5-4).

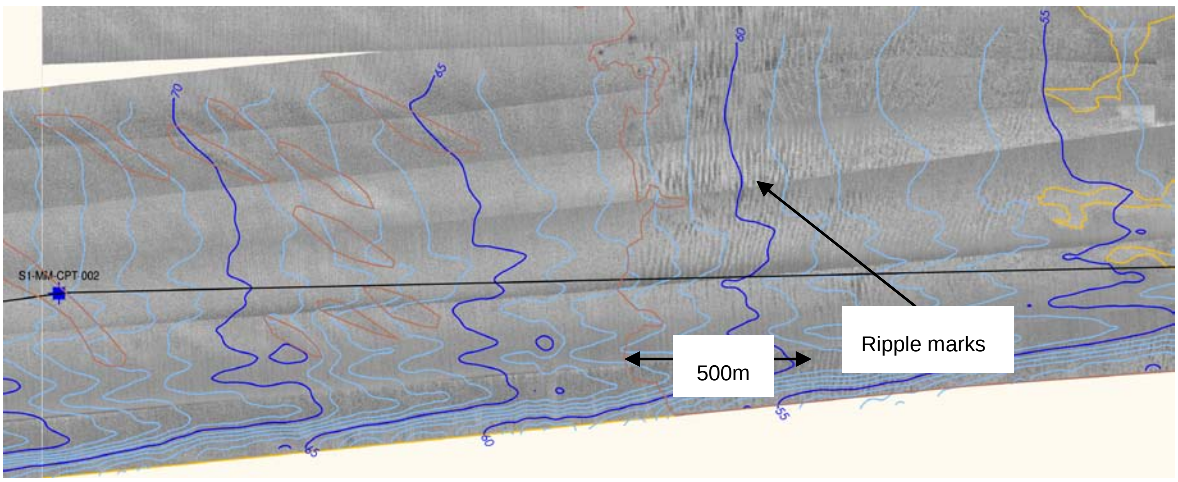


FIGURE 5-4 LINEAR SAND AND GRAVEL FEATURES ON SEGMENT 1

Side scan sonar image of sub-parallel sand/gravel ripples constitute the surface of gravel patch at right; the much larger northwest-trending gravel ridges (brown lines) appear in the sand at left. The jagged, north-south division between these features marks the exposure of an unconformity. The black line shows Segment 1, and bathymetry is indicated in blue. See RSN.S1.NU.CHART-002B for more information.

Immediately west of the ripple patch, the muddy sand returns with scattered patches of gravel, some of which form along the western faces of linear, generally northwest-trending ridges. These ridges are present along the route to about the 90 m isobath (45°11.02'N, 124°06.70'W). West of this point, the seabed slopes evenly to the west and the gravel disappears except for a couple of isolated patches north and south of the route near the 102 m isobath and 120 m isobath (see chart RSN.S1.NU.CHART-003B). The predominant surficial sediment between the 90 m isobath and the 135 m isobath is medium to dense sand, which grades to silt near the 135 m isobath (45°10.68'N, 124°11.29'W). The boundary between the sand and silt is somewhat arbitrary being based on CPTs and gravity cores acquired to either side; there is no clear reflectivity change apparent on the sonar records. The thickness of this surficial deposit is generally 1 to 2 m as deduced from the subbottom profiler records (see isopach contours on chart RSN.S1.NU.CHART-003B).

The shelfbreak begins near the 195 m isobath (45°10.36'N, 124°18.19'W) where the seabed slope increases slightly. Pockmarks dot the seabed beginning at about the 182 m isobath (see chart RSN.S1.NU.CHART-004B), and some are more than 100 m across and may be as deep as 1.5 m. The survey route deviates northward to avoid the largest pockmarks in the vicinity of 45°10.12'N, 124°19.73'W (mapped on chart RSN.S1.NU.CHART-005B; Figure 5-5). These larger pockmarks are floored with dark material on the sonar records tentatively identified as authigenic carbonate, though alternatively it could be lag deposits of gravel.

Pockmarks are usually associated with a clayey sediment type. The surficial layer of sandy silt becomes more clayey and less sandy with distance from shore. A slight apparent unconformity is evident in the subbottom profiler data 2 to 4 m beneath the seabed between the 230 and 360 m isobaths as the route descends a slope. The base of the surficial sediment is shown on chart RSN.S1.NU.CHART-005B as isopach contours. The slope flattens out as the route runs along the 365 m isobath in a shallow north-sloping minibasin (see charts RSN.S1.NU.CHART-005A and RSN.S1.NU.CHART-006A). Numerous small pockmarks dot the seabed in this basin (RSN.S1.NU.CHART-005B and RSN.S1.NU.CHART-006B).

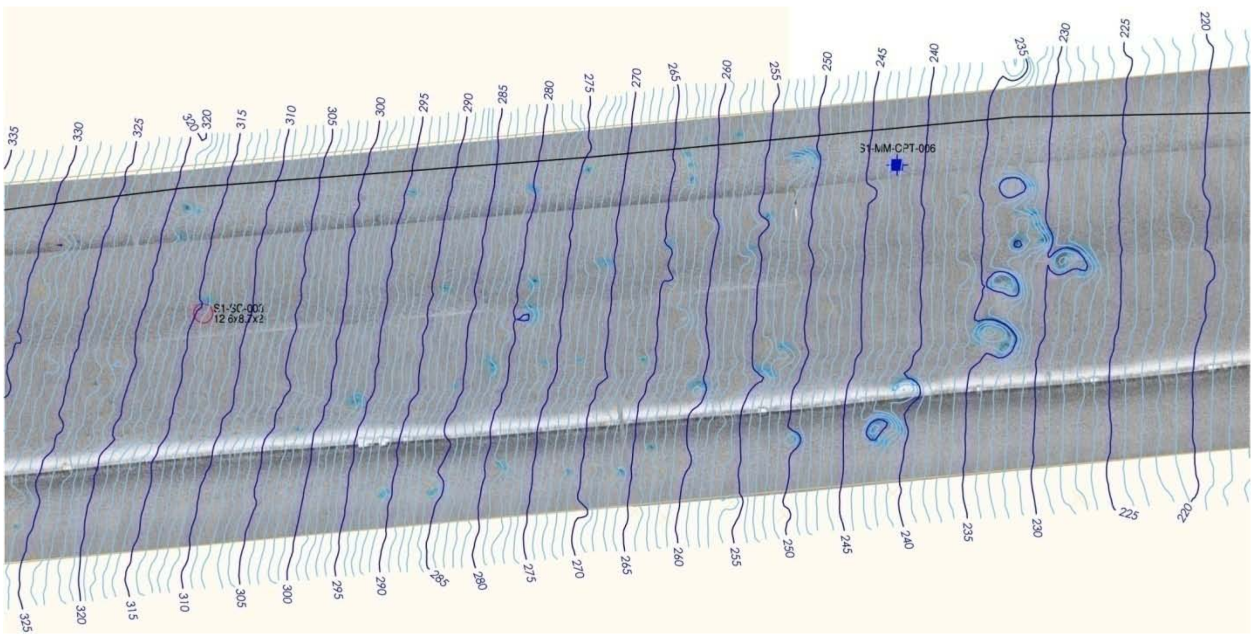


FIGURE 5-5 SIDE SCAN IMAGE OF POCKMARKS ON SEGMENT 1

Side scan sonar mosaic image of route deviating northward of large (~100 m) pockmarks described in text. Silt and clay dominates the surface sediment type, but gravel or authigenic carbonate is present on the pockmark floors. Yellow X's represent pockmarks on sea floor. See Charts for more information.

As the route crosses a low hummock in this basin (45°09.71'N, 124°26.69'W), it threads through patches of authigenic carbonate as evidenced by a slight darkening of the sonar record. Analysis of the subbottom profiler records show indications of shallow gas in this area (see Figure 5-6). More patches of authigenic carbonate occur between the 340 and 345 m isobaths (45°09.0'N, 124°31.20'W; RSN.S1.NU.CHART-006B). Near 45°08.90'N, 124°32.75'W, between the 340 m and 326 m isobaths, the surficial sediments thin to less than 1 m (see charts RSN.S1.NU.CHART-006A, RSN.S1.NU.CHART-006B, RSN.S1.NU.CHART-007A RSN.S1.NU.CHART-007B).

As the route descends westward from this hillock, the surficial silt layer mapped farther to the east disappears, and the underlying undifferentiated sediment is exposed at the seabed, as mapped on RSN.S1.NU.CHART-007B (45°08.87'N, 124°33.48'W). This patch extends 6.2 km to 45°09.42'N, 124°38.12'W. Two CPTs taken in this area indicate the sediment (silt/clay) is stiff to very stiff. Pockmarks appear near the western edge of this patch. As the route continues to drop down the slope, mappable silt (or clay) is again evident and is mapped on as mapped on RSN.S1.NU.CHART-008B. The surficial sediment thickness is one meter at the 526 m isobath (45°09.90'N, 124°39.45'W) and thickens rapidly as the route proceeds towards the northwest. Bottom fishing scars are visible in the pockmarked sedimentary cover over the next 10 km or so, both paralleling and oblique to the slope contours.

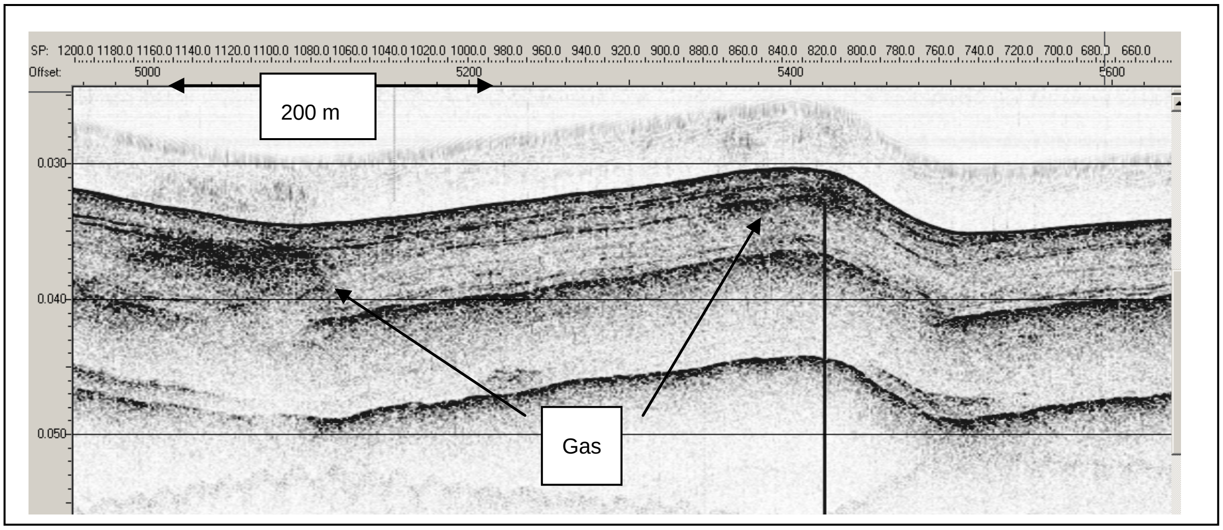


FIGURE 5-6 SUBBOTTOM PROFILER IMAGE OF SHALLOW GAS ON SEGMENT 1

Subbottom image of route as it crosses an authigenic carbonate patch described in text. Vertical scale lines are 10 milliseconds.

Beginning near 45°11.42'N, 124°46.32'W, although the trawling scars and pockmarks remain, the sedimentary cover again thins to nil and undifferentiated sediments are exposed at the seabed. CPT S1-MM-CPT-014 indicates this material is medium to very dense (sand) over very stiff to hard (clay/silt). Strata outcrops the seabed along the route at 45°11.05'N, 124°47.48'W. This patch of outcropping strata extends approximately 72 m along the route, crosses a narrow patch of undifferentiated sediment for another 30 m and again crosses exposed strata for another 26 m, beyond which the undifferentiated sediment cover thickens again (see chart RSN.S1.NU.CHART-009B). CPT S1-MM-CPT-015-DEV1 taken in the mapped patch of outcropping strata recorded medium to very dense (undifferentiated) over very stiff to hard strata (clay?). The outcropping strata are depicted in the sonar mosaic image of Figure 5-7.

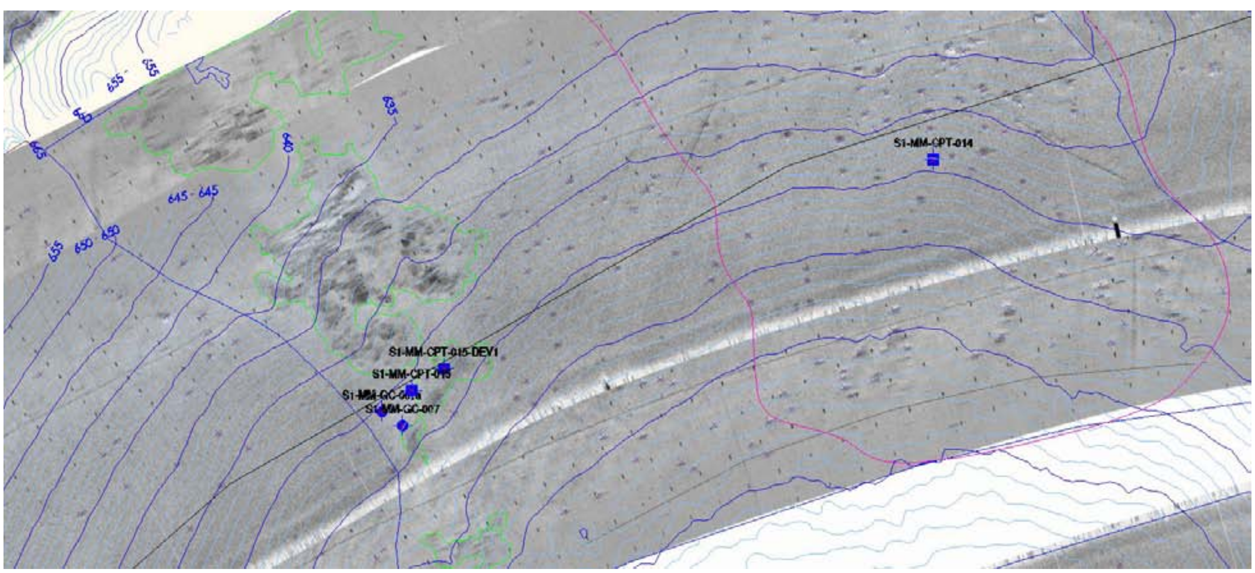


FIGURE 5-7 SIDE SCAN IMAGE OF OUTCROPPING STRATA AND UNDIFFERENTIATED SEDIMENTS

Side scan sonar mosaic image of route passing through a region of thinly covered undifferentiated sediments (blue outline) and outcropping strata (dark patches outlined in green). Segment 1 is the black line, and a patch of abundant pockmarks is outlined in pink. See RSN.S1.NU.CHART-009B for more information.

The route crosses from mapped undifferentiated sediment to silt at 45°10.92'N, 124°47.42'W, where the thickness of the surficial silt (or clay) is barely discernable in the subbottom profiler records. As the route obliquely descends the slope toward the southwest, the silt thickness gradually increases (charts RSN.S1.NU.CHART-009B and RSN.S1.NU.CHART-010B). CPTs taken indicate this silt is stiff between the 655 and 705 m isobaths. As the route curves to the west (45°07.92'N, 124°52.91'W), the silt becomes softer (cf. CPT S1-MM-CPT-018). From 45°11.59'N, 124°45.15'W to 45°08.12'N, 124°57.15'W pockmarks riddle the seabed, and trawling scars are also prevalent, many crossing the route. Beyond this section, and for the remainder of the survey corridor, these features largely disappear. Patches of outcropping bedrock are present north of the route as the route curves to the northwest near 45°07.83'N, 124°55.80'W. The route skirts south of several large outcrops and passes through a gap between outcrops before continuing on to the west. The route clips the edge of an outcropping strata patch at 45°08.03'N, 124°56.71'W. A CPT taken in this patch indicates the strata is very stiff (Figure 5-8 - top). This area is charted on chart RSN.S1.NU.CHART-010B.

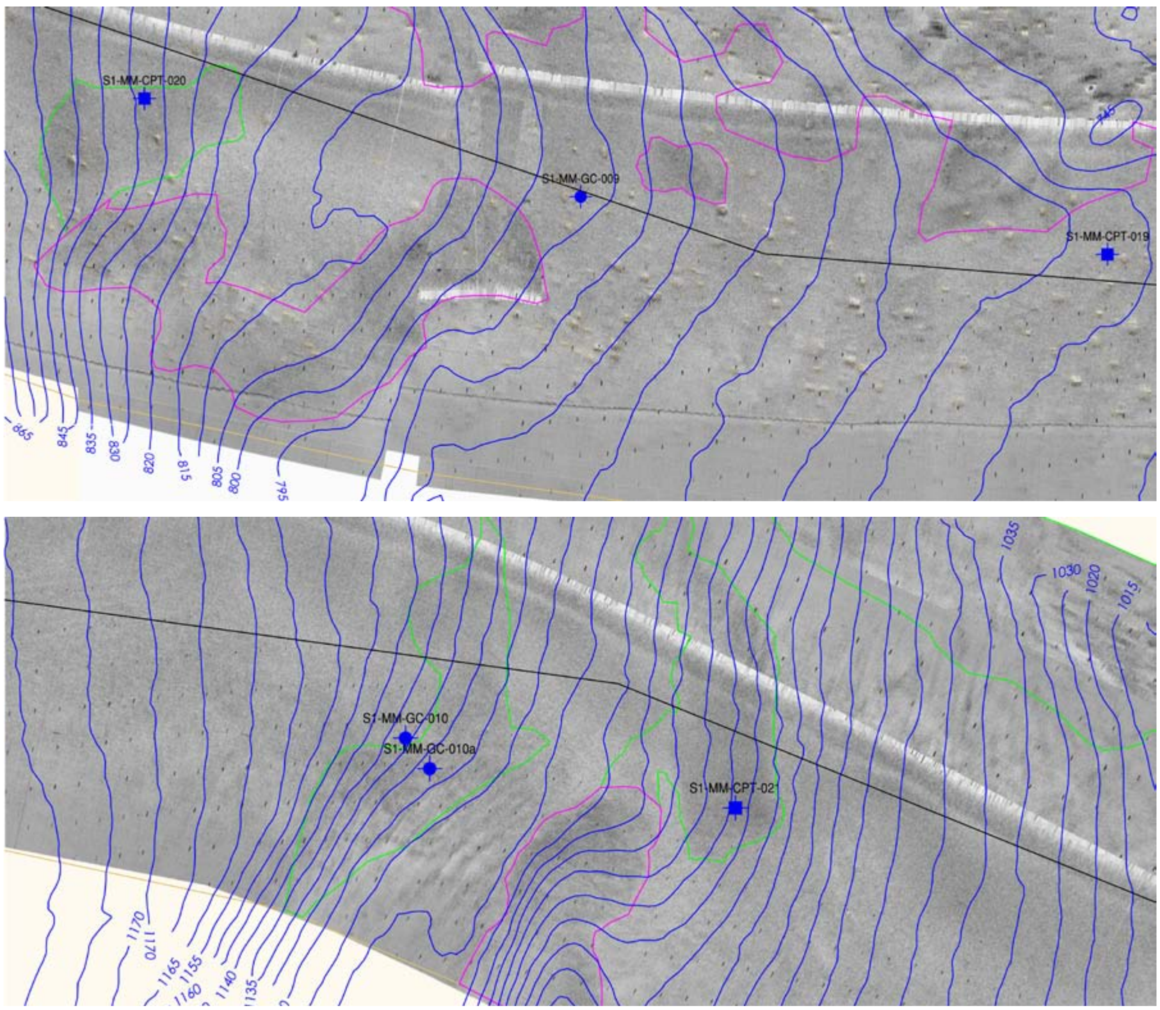


FIGURE 5-8 SIDE SCAN IMAGES OF OUTCROPPING STRATA AND BEDROCK

Areas of outcropping strata (green lines) and bedrock (pink lines) are indicated by patches of higher reflectivity in side scan sonar. The presence of pockmark patches on the surfaces of these features suggests some surficial sediment is present. While the route crosses only the edge of the outcrop near 45°08.03'N, 124°56.71'W (top), it transects two patches beginning near 45°08.80'N, 124°59.80'W (bottom).

The route continues down the slope, and silt again blankets the seabed. Outcropping strata protrude through this silt cover near 45°08.80'N, 124°59.80'W (chart RSN.S1.NU.CHART-011B). Although the seabed appears relatively benign in these outcrop areas (only a slight darkening of the sonar records), the subbottom profiles (depicted in the next section) show tightly folded strata mantled by moderately folded strata, which in turn is mantled by a discernable silt layer away from the outcrops in this area. There is probably a very thin veneer of sediment over the top of these outcrops that helps to smooth the seabed.

5.2.3 Shallow Geology

At approximately 45°11.44'N, 124°00.91'W, the loose sandy surficial sediment identified in the Inshore survey corridor (§5.1.3) onlaps and pinches out against an older layer of sand and gravel that is exposed at the seabed west of this point. Neither the thickness nor hardness of this unit is evident in the geophysical data, but a cone penetrometer taken in a mapped gravel patch (S1-MM-CPT-001) was refused at a depth of 1.55 m at 45°11.56'N, 124°01.02'W. Gravel and sand patches dominate the seabed to near 45°11.26'N, 124°03.79'W. A number of CPTs taken in this area had various penetrations ranging from 0.17 to 3 m; all recorded medium to dense sand/gravel. Superimposed on this surface are the sub-parallel sand waves discussed in §5.2.2. The sandy sedimentary cover resumes west of 45°11.26'N, 124°03.79'W, and is locally interrupted by northwest oriented sand/gravel waves (see §5.2.2; Figure 5-4) that are barely visible in the subbottom profiler data. A faint sub-seabed reflector is evident in the subbottom profiler data at a depth of about 1 m in this area, where CPT S1-MM-CPT-002 recorded medium to dense coarse-grained material. The reflector can be followed to the west as a somewhat discontinuous series of reflections. Figure 5-9 is a profile along the centerline taken across the boundary where the sand transitions to silt at 45°10.63'N, 124°12.15'W (see chart RSN.S1.NU.CHART-003B).

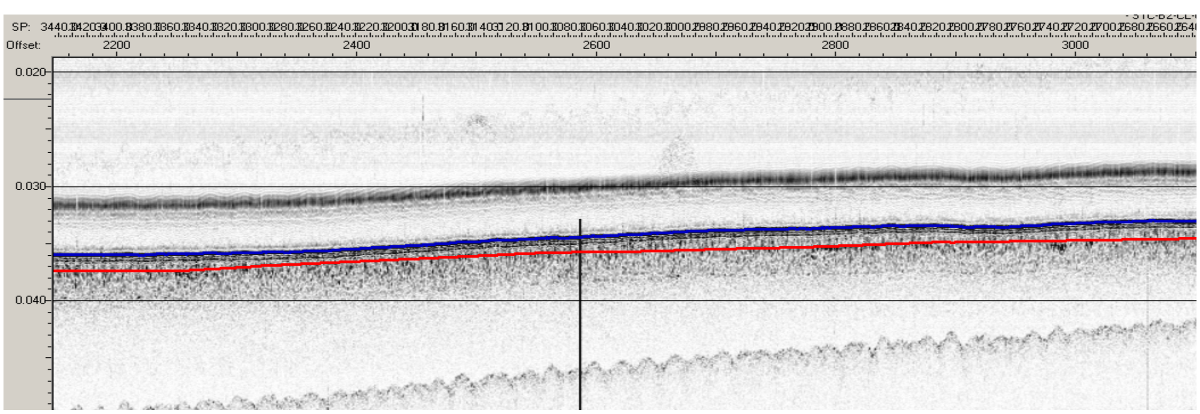


FIGURE 5-9 SUBBOTTOM IMAGES OF SEGMENT 1 (SAND-SILT TRANSITION)

Subbottom profile of Lines S1C-B2-CL-144612 showing base of surficial sediment (red line) across the boundary where the sand to the east transitions to silt to the west. The blue line is the seabed. The base of the surficial sediment is barely discernable as a series of somewhat discontinuous reflectors. Vertical scale lines are 10 msec. (labeled in seconds) 'Offset' indicates horizontal distance in meters.

The reflector identified as the base of the surficial sediment becomes increasingly well-defined as the route proceeds to the west. Faint seabed-parallel, continuous reflectors appear in the uppermost surficial sediment package. Figure 5-10 depicts the seabed as the route deviates to avoid pockmarks near 45°10.25'N, 124°19.13'W (RSN.S1.NU.CHART-004B). It should be noted that this image is taken along the original centerline and not the deviated route.

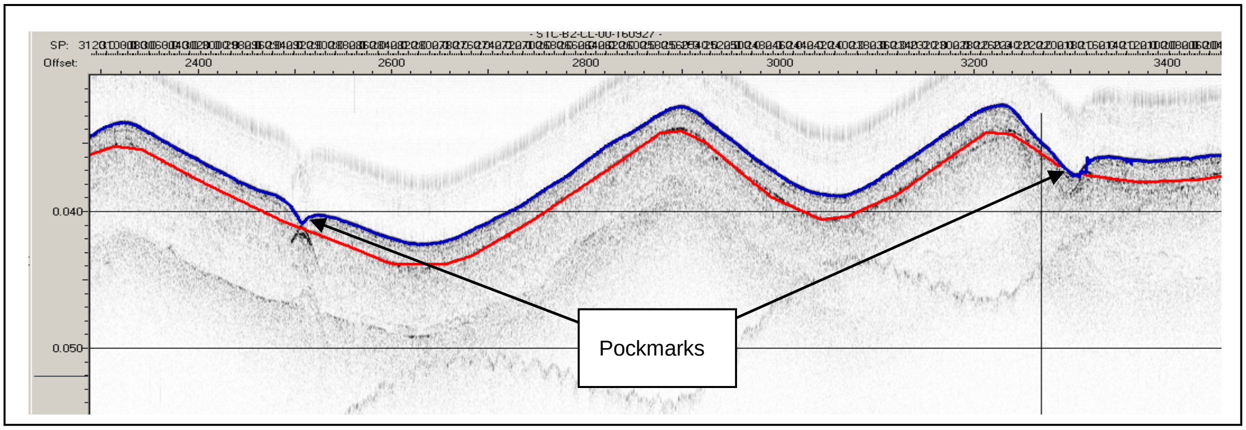


FIGURE 5-10 SUBBOTTOM IMAGES OF SEGMENT 1 (POCKMARKS)

Subbottom profile of Lines S1C-B2-CL-00-160927 showing base of surficial sediment (red line) in the area of a pockmark field. The blue line is the seabed. Vertical scale lines are 10 msec. (labeled in seconds) 'Offset' indicates horizontal distance in meters

As the route descends the slope between the 230 and 350 m isobaths (see RSN.S1.NU.CHART-005A), the horizon defining the base of the surficial sediment becomes increasingly indistinguishable, and the uppermost 4 m of sediment are composed of moderate to low amplitude discontinuous reflectors. CPT S1-MM-CPT-007 taken near the base of the slope at the 362 m isobath recorded stiff clayey silt. As the route proceeds west, it rises gently up a hillock at 49°09.71'N, 124°26.69'W that is covered with several authigenic carbonate patches. The patches are related to gas plumes in the shallow sediment, as depicted in Figure 5-6. Gas is present in several deeper layers across this whole region. These gas-charged layers create prominent subsurface reflectors at depth. Figure 5-11 depicts 6.2 km of the centerline between 45°09.56'N, 124°26.71'W and 45°08.92'N, 124°31.33'W.

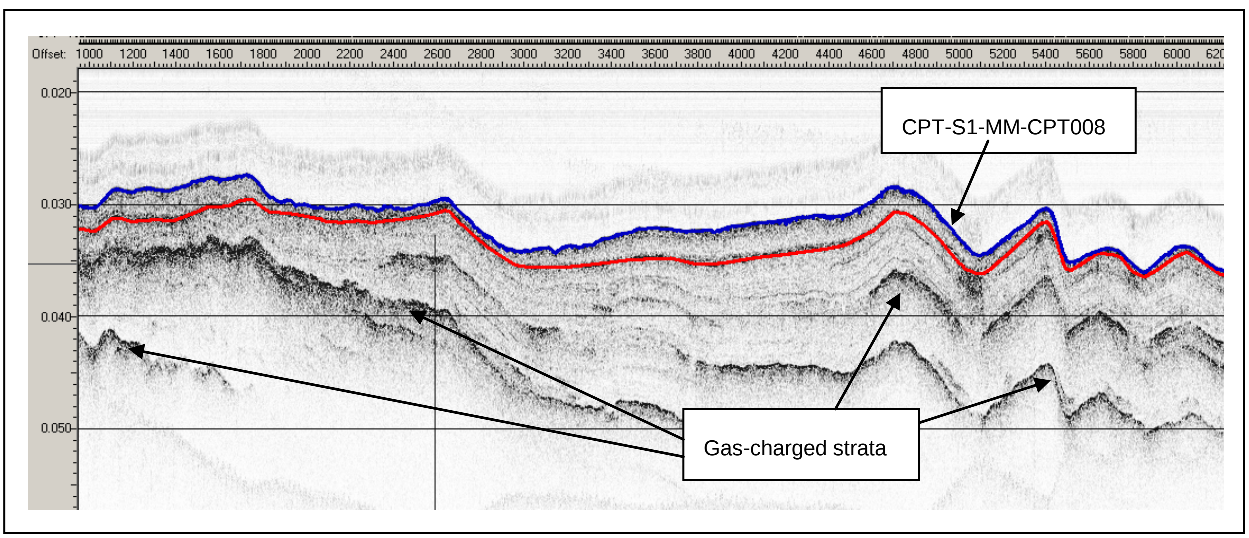


FIGURE 5-11 SUBBOTTOM IMAGES OF SEGMENT 1 (GAS-CHARGED STRATA)

Subbottom profile of Lines S1C-B2-CL-00-173239 showing base of surficial sediment (red line) in the area of a pockmark field. The blue line is the seabed. Vertical scale lines are 10 msec. (labeled in seconds) 'Offset' indicates horizontal distance in meters west is towards the left.

As Figure 5-11 shows, deeper layers rise westward toward the seabed. Near 45°08.93'N, 124°31.46'W (Figure 5-13), strata buried by surficial sediments to the east rise to the seabed and intersect the seafloor as a truncated anticlinal structure, whose internal units are almost totally obscured by bulbous or coalesced parabolic reflectors interpreted as gas. The absence of pockmarks throughout this section is likely due to the absence of soft sedimentary cover and a possible lack of clay content. The extent and location of this structure suggests it is correlative with the large anticlinorium discussed in §4.2.1. Both CPT S1-MM-CPT0009 and S1-MM-CPT-010 taken to either side of the anticline recorded stiff to very stiff sediment.

As the route descends to the northwest off the anticline, the surficial silt layer is absent, replaced by a package of undifferentiated sediment of indeterminate age see RSN.S1.NU.CHART-007B). It is apparent that the gassy strata depicted in Figure 5-12 dip towards the west and extend up to very near the seabed. CPTs and cores taken in this deposit indicate the sediment is stiff to very stiff (clay and silt). The sonar shows an even reflectivity in this patch suggesting that there is an un-mappable thin (veneer) of sediment over these dipping strata.

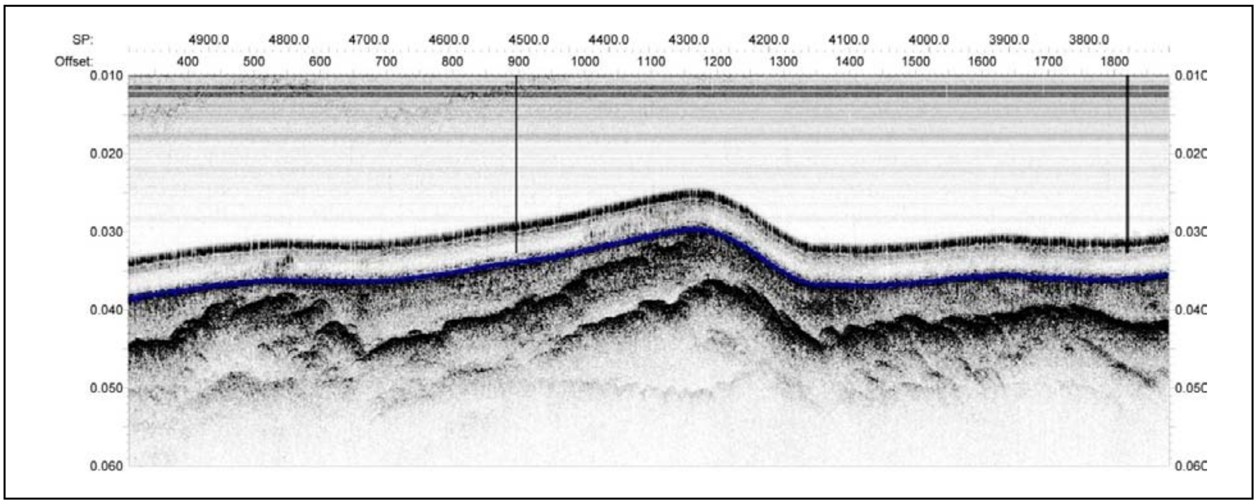


FIGURE 5-12 SUBBOTTOM PROFILE OF LINE S1C-B2-CL-00-181415

Subbottom profile of gas reflectors along line S1C-B2-CL-00-181415. Blue line indicates the seafloor. (Note: this line has not been altitude corrected) Vertical scale lines are 10 msec. (labeled in seconds) 'Offset' indicates horizontal distance in meters west is towards the left.

Near 45°09.41'N, 124°38.07'W the soft sediment layer, whose thickness is presented as isopach contours on chart RSN.S1.NU.CHART-008B, makes its first mappable appearance. This surficial sediment thickens rapidly towards the west as the route parallels to the slope. As the route curves to the west, it crosses a fault and the surficial silt deposit thins abruptly to pinch out against an outcrop of older undifferentiated sediment that has been folded into an anticline (see Figure 5-13).

The route crosses the undifferentiated sediment patch as well as a few exposure of outcropping strata (see RSN.S1.NU.CHART-009B). To the west of this feature the soft sedimentary cover resumes, conformably overlying a sedimentary sequence that is upwarped by the older outcropping sediments. As the route proceeds down the slope to the southwest, surficial silt/clay thickness increases to over 5 meters. This sediment thins as the route curves towards the west near 45°07.75'N, 124°54.25'W. The route passes south of a bedrock outcrop then curves northwest to pass through a gap between 3 other bedrock outcrops. Figure 5-14 shows a profile across the outcropping bedrock south of the route.

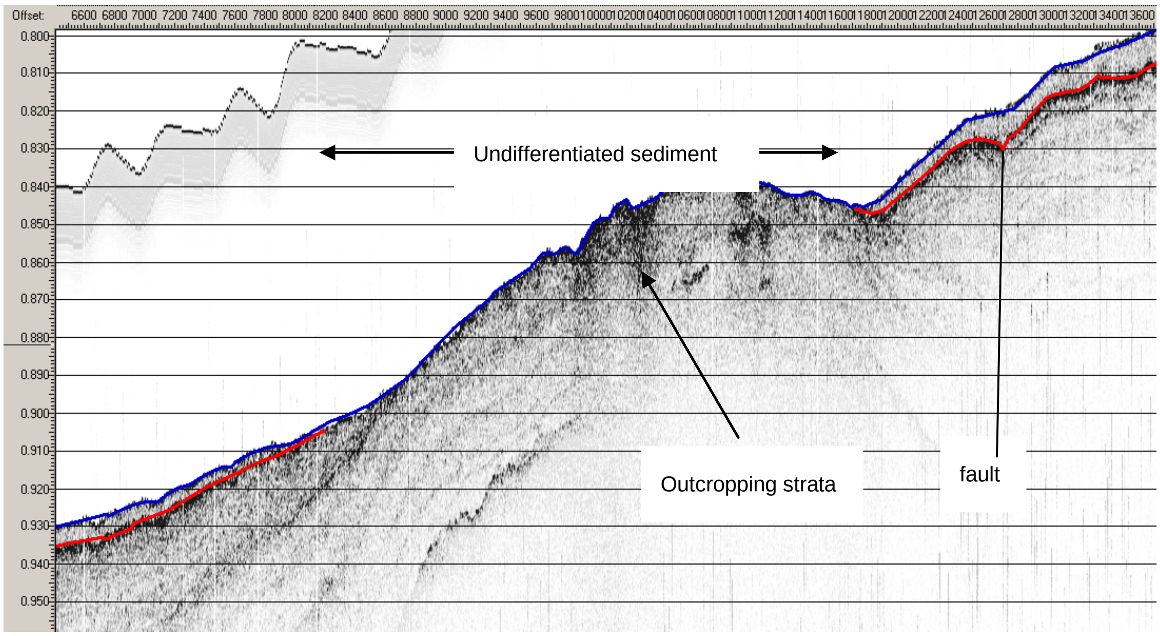


FIGURE 5-13 SUBBOTTOM PROFILE OF LINE S1C-B3-N250-RB-00

Subbottom profile of Line S1C-B3-N250-RB-00 showing exposure of older undifferentiated sediment and strata and overlying sedimentary cover (red line) to either side. A normal fault is visible at right. Vertical scale lines are 10 msec. (labeled in seconds) 'Offset' indicates horizontal distance in meters southwest is towards the left.

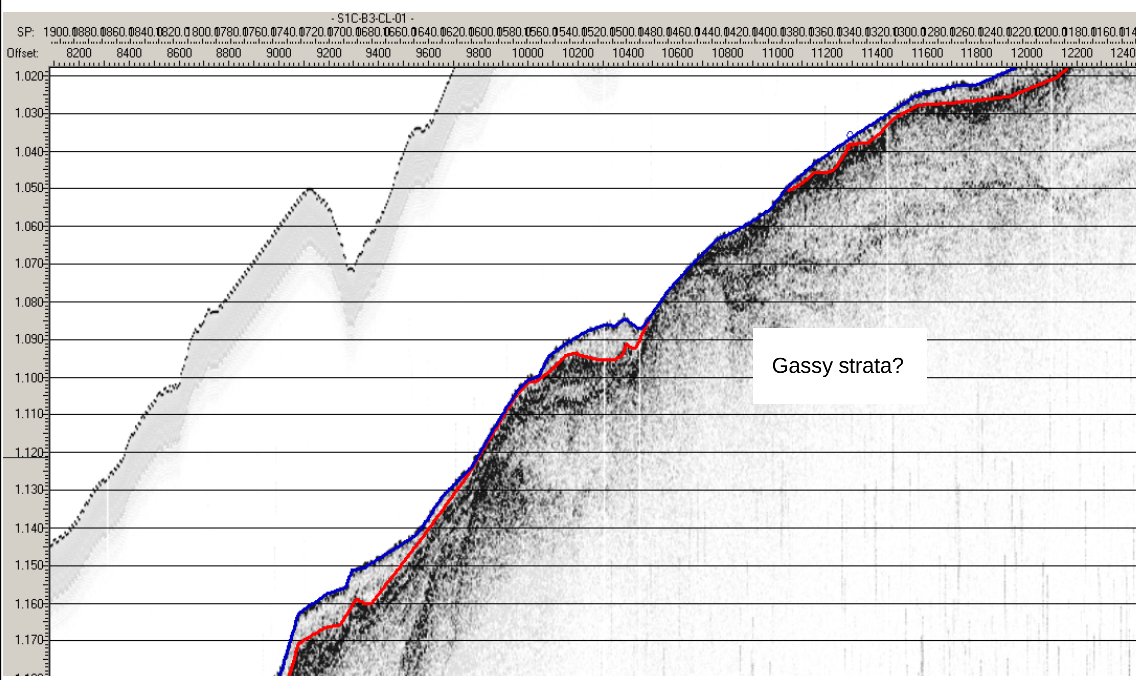


FIGURE 5-14 SUBBOTTOM PROFILE OF LINE S1C-B3-CL-01

Subbottom profile along Line S1C-B3-CL-01 showing the soft sediment cover (red line) onlapping bedrock. Bedrock outcrops where the red line is absent. Vertical scale lines are 10 msec. (labeled in seconds) 'Offset' indicates horizontal distance in meters southwest is towards the left.

The route crosses the northern tip of a patch of exposed older strata at 45°08.17'N, 124°56.72'W before descending the slope where the surficial silt/clay thickness increases rapidly to more than 5 meters. Bedrock again outcrops the surface near 45°08.71'N, 125°1.72'W, where the soft sedimentary cover and the sedimentary package it overlays pinch out. Exposed strata patches are crossed by the route in this area (see RSN.S1.NU.CHART-011B). Very few pockmarks appear in this region. The same is true of the seaward-thickening surficial sedimentary package visible to the western edge of the nearshore survey corridor.

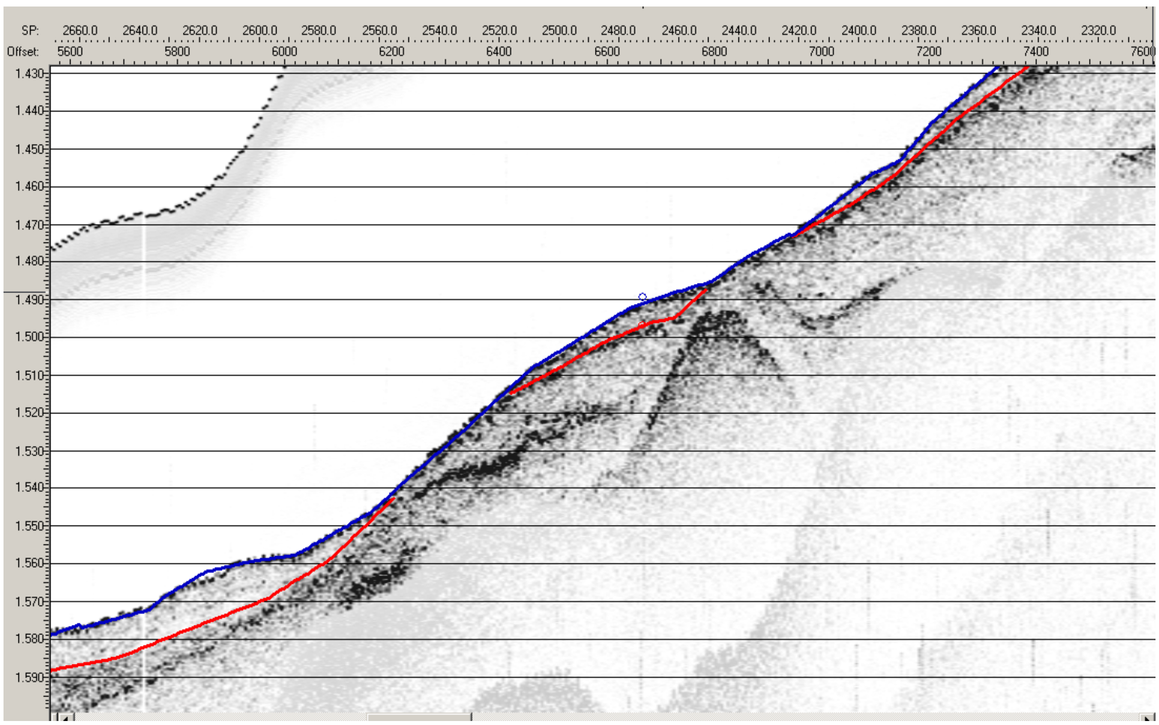


FIGURE 5-15 SUBBOTTOM PROFILE OF LINE S1C-B3-CL-01TO02SNP

Subbottom profile along Line S1C-B3-CL-01to02snp showing the soft sediment cover (red line) onlapping strata. Strata outcrops where the red line is absent. Vertical scale lines are 10 msec. (labeled in seconds) 'Offset' indicates horizontal distance in meters west is towards the left.

5.2.4 Hazards and Obstructions

5.2.4.1 Wrecks and Sonar Contacts

Five (5) sonar contacts were located within the survey corridor, four are unidentified and one is the reported lost core barrel from gravity coring operations (not visible in the sonar data). One contact lies within 6 m of the survey route, as summarized in the following table. For complete details, see Appendix E.

Contact ID	Latitude	Longitude	Dimensions (LxWxH) (m)	Distance from Route (m)	Description
S1-SC-001	45°11.51'N	124°01.13'W	11.2 x 0.8 x 0.5	224	Unidentified linear object protruding slightly from the seafloor

Contact ID	Latitude	Longitude	Dimensions (LxWxH) (m)	Distance from Route (m)	Description
S1-SC-002	45°11.01'N	124°07.60'W	7.3 x 3.2 x 0.6	162	Angular object lying on seafloor
S1-SC-003	45°10.04'N	124°21.20W	12.6 x 8.7 x 2	306	Nondescript object probable rock
S1-SC-010	45°08.49'N	124°52.68W	39.6 x 4 x 1	739	Linear object lying atop the seabed
S1-SC-013	45°08.80'N	125°00.37'W	3	169	Core barrel lost from S1-MM-GC-010

TABLE 5-2 SONAR CONTACT SUMMARY FOR SEGMENT 1

5.2.4.2 Existing and Planned Cables

Segment G5 of the VSNL Pacific is the only in-service fiber optic cable to cross the Segment 1 survey route and it does so at two locations:

Cable Name	Latitude	Longitude	Water Depth (m)	Crossing Angle	Remarks
VSNL Pacific Seg G5	45°06.60'N	125°21.87'W	1855	46°	Not found
VSNL Pacific Seg G5	44°30.76'N	125°30.81'W	2910	56°	Not found

TABLE 5-3 CABLE CROSSINGS FOR SEGMENT 1

5.2.4.3 Fishing Activities

Bottom contact fishing scars are ubiquitous where the survey route bends northward around a feature locally called Little Hat. There, as discussed in §5.2.2, the scars range from parallel to perpendicular to the slope. The number of scars mapped is likely smaller than the number of scars actually present in the area, and since such scars are likely temporary it is prudent to exercise caution across this entire region, as delineated in Table 5-4. Fishing scars over areas of soft sediments are less of a concern than those over areas where the cover is either thin or absent, since burial may not achieved to full burial depth (see §5.2.5). The following table summarizes observations made with regard to fishing activities within the Segment 1 survey corridor. These observations were primarily related to crabbing activities.

Segment	Date	Time	Comments
1	4/15/2010		OFCC credits the F/V Pacific Rebel for an outstanding job clearing pots. However, a few pots surfaced subsequent to their departure. Surface current eased up causing pots to be visible. Ship has done a great job of avoiding the remnant pots. OFCC believes no pots were cut off.

Segment	Date	Time	Comments
1	4/17/2010	7:00	OFCC just sent out today (07:00) a message to fishermen to inform them they could now go back to fishing in 0-70 fathoms area along the route. A couple fish traps were entangled in the depressor and screw. OFCC (Scott) working to identify owner.
1	4/17/2010		Three crab pot buoys surfaced in 20-100 m area of S1. Mt Mitchell mates did a good job of avoiding gear. Crabber Lady Laura contacted to retrieve them but the pots, though similar in buoy color, were not the Lady Laura's gear. Further offshore several shrimp boats were contacted; they were cooperative and altered course & speed to give additional clearance to survey operations.

TABLE 5-4 OBSERVED FISHING ACTIVITY FOR SEGMENT 1

5.2.4.4 Dumping and Dredging

There were no recorded observations of dumping and dredging activities during the Segment 1 portion of the RSN survey. No activities are expected in these areas per the DTS.

5.2.4.5 Hydrocarbon Exploration

There were no recorded observations of hydrocarbon exploration activities during the Segment 1 portion of the RSN survey.

5.2.4.6 Military Activities

There were no recorded observations of military activities during the Segment 1 portion of the RSN survey.

5.2.5 Seabed Samples

Table 5-5 summarizes the location of seabed samples along Segment 1. Gravity cores (GC) were taken at 10 km intervals, and cone penetrometer (CPT) readings taken at approximately 4-5 km intervals. In areas where gravity cores were not successful, grab samples were attempted. Penetration depths, if recorded, are measured from a core barrel's "catcher" (opening) to its "mud line." Therefore clay, being the principal component of mud, is present, likely in abundance, even though many of the seabed samples do not specifically mention it. Detailed records of these samples are included in Appendix B.

Name	Location				Water Depth (m)	Penetration Depth (m)
	Coordinates		UTM Zone 10N			
	Latitude	Longitude	Northing	Easting		
S1-MM-CPT-001	45°11.56'N	124°1.02'W	5004858	420145.7	45	1.55
S1-MM-CPT-001-DEV2	45°11.36'N	124°01.22'W	419852	5004485	47	3.00
S1-MM-CPT-001-DEV3	45°11.22'N	124°01.64'W	419297	5004236	48	0.17

Name	Location				Water Depth (m)	Penetration Depth (m)
	Coordinates		UTM Zone 10N			
	Latitude	Longitude	Northing	Easting		
S1-MM-CPT-002	45°11.23'N	124°04.80'W	5004301	415162	74	3.02
S1-MM-CPT-003	45°10.93'N	124°8.58'W	5003819	410161.6	108	3.00
S1-MM-CPT-004	45°10.64'N	124°12.36'W	5003366	405222.4	146	3.00
S1-MM-CPT-005	45°10.36'N	124°16.20'W	5002910	400223.6	175	3.00
S1-MM-CPT-006	45°10.25'N	124°19.92'W	5002797	395329.9	243	3.03
S1-MM-CPT-007	45°09.76'N	124°23.70'W	5001959	390378.4	362	2.77
S1-MM-CPT-008	45°09.47'N	124°27.48'W	5001528	385392.3	364	2.30
S1-MM-CPT-009	45°08.98'N	124°31.02'W	5000695	380787.9	341	3.00
S1-MM-CPT-010	45°08.86'N	124°33.48'W	5000526	377514.9	327	3.03
S1-MM-CPT-011	45°09.12'N	124°36.54'W	5001091	373538.7	387	3.00
S1-MM-CPT-012	45°10.10'N	124°40.08'W	5003012	368950.2	529	3.00
S1-MM-CPT-013	45°11.47'N	124°43.32'N	5005634	364714	557	3.00
S1-MM-CPT-014	45°11.29'N	124°46.62'W	5005406	360389.8	616	3.01
S1-MM-CPT-015	45°10.99'N	124°47.58'W	5004861	359156	619	3.00
S1-MM-CPT-015-DEV1	45°11.02'N	124°47.51'W	5004912	359232	619	3.00
S1-MM-CPT-016	45°10.43'N	124°48.66'W	5003857	357687.7	659	3.00
S1-MM-CPT-017	45°08.77'N	124°51.06'W	5000842	354481.6	706	3.00
S1-MM-CPT-018	45°08.06'N	124°53.10'W	4999598	351761.1	744	2.32
S1-MM-CPT-019	45°07.83'N	124°55.20'W	4999253	349003.8	756	3.01
S1-MM-CPT-020	45°08.00'N	124°56.88'W	4999603	346837.1	834	2.67
S1-MM-CPT-021	45°08.73'N	124°59.88'W	5001062	342955.5	1087	1.88
S1-MM-CPT-022	45°09.04'N	125°03.00'W	5001723	338837.9	1358	3.00
S1-MM-GC-001	45°11.36'N	124°02.52'W	5004515	418172.8	57	Cutting shoe dented

Name	Location				Water Depth (m)	Penetration Depth (m)
	Coordinates		UTM Zone 10N			
	Latitude	Longitude	Northing	Easting		
S1-MM-GC-001a	45°11.38'N	124°02.46'W	5004547	418212.5	54	Cutting shoe dented
S1-MM-GC-002	45°10.87'N	124°09.78'W	5003732	408660.8	119	0.36
S1-MM-GC-002a	45°10.84'N	124°09.78'W	5003678	408657.1	119	0.28
S1-MM-GC-003	45°10.40'N	124°18.06'W	5003028	397736.3	194	0.34
S1-MM-GC-003a	45°10.37'N	124°18.06'W	5002975	397802.9	194	0.36
S1-MM-GC-004	45°09.59'N	124°25.98'W	5001712	387386.3	364	2.30
S1-MM-GC-005	45°08.89'N	124°34.98'W	5000636	375539.3	355	0.62
S1-MM-GC-005a	45°08.87'N	124°34.98'W	5000595	375525	356	2.05
S1-MM-GC-006	45°10.72'N	124°41.28'W	5004179	367335.6	533	4.70
S1-MM-GC-007	45°10.94'N	124°47.58'W	5004778	359134.1	618	2.05
S1-MM-GC-007a	45°10.96'N	124°47.64'W	5004811	359085.4	618	1.80
S1-MM-GC-008	45°09.65'N	124°49.74'W	5002441	356228.7	685	4.70
S1-MM-GC-009	45°07.89'N	124°56.10'W	4999382	347818.6	793	3.50
S1-MM-GC-010	45°08.80'N	125°00.37'W	5001204	342283.3	1131	0
S1-MM-GC-010a	45°08.77'N	125°00.36'W	5001142	342332.6	1135	2.40
S1-IN-GS-001	45°11.80'N	123°59.46'W	5005279	422172.2	26	Grab sample
S1-IN-GS-002a	45°11.87'N	123°59.10'W	5005411	422611.2	20	Grab sample
S1-IN-GS-003	45°11.94'N	123°58.92'W	5005530	422903.2	14	Grab sample
S1-IN-GS-004a	45°11.99'N	123°58.68'W	5005611	423217.1	10	Grab sample
S1-MM-GS-001	45°11.41'N	124°02.46'W	5004595	418194.4	54	Grab sample

TABLE 5-5 SEGMENT 1 SEAFLOOR SAMPLE SUMMARY

5.2.6 Areas of Concern

Areas of concern, as discussed in this report, are defined as regions of outcropping strata, thin veneer of sediment over strata, or bedrock that are transected by the survey route - areas that require special consideration prior to burial but do not preclude burial by default. Regions of thin or absent soft sedimentary cover and heavy bottom trawling activity pose the greatest potential hazard along this segment. The following table summarizes these areas:

Area	Type	Start Coordinates		End Coordinates		Route Distance (km)	Chart
		Latitude	Longitude	Latitude	Longitude		
S1 a	Strata Outcrop	45°11.05'N	124°47.48'W	45°11.01'N	124°47.56'W	0.128	RSN.S1.NU. CHART-009B
S1 b	Strata Outcrop	45°8.03'N	124°56.71'W	45°8.04'N	124°56.75'W	0.045	RSN.S1.NU. CHART-010B
S1 c	Strata Outcrop	45°8.80'N	124°59.80'W	45°8.89'N	125°0.35'W	0.745	RSN.S1.NU. CHART-011B

TABLE 5-6 AREAS OF CONCERN FOR SEGMENT 1

5.2.6.1 Area of Concern S1-a

Of chief concern in this area is the presence of bottom contact fishing scars in places where the thickness of the soft sedimentary cover is too thin to be measured from the subbottom record. The numerous pockmarks here (Figure 5-16) suggest there is some surficial sediment, but nothing shows in the subbottom profile to verify that conclusion. The outcropping strata are evident as highly reflective patches on the sonar record. To the north, these strata form ledges with acoustic shadows. The outcropping strata are surrounded by undifferentiated sediment that may be stiff to hard. Surficial unconsolidated silt/clay is present southwest of the blue line in Figure 5-16. Burial may be difficult in this area.

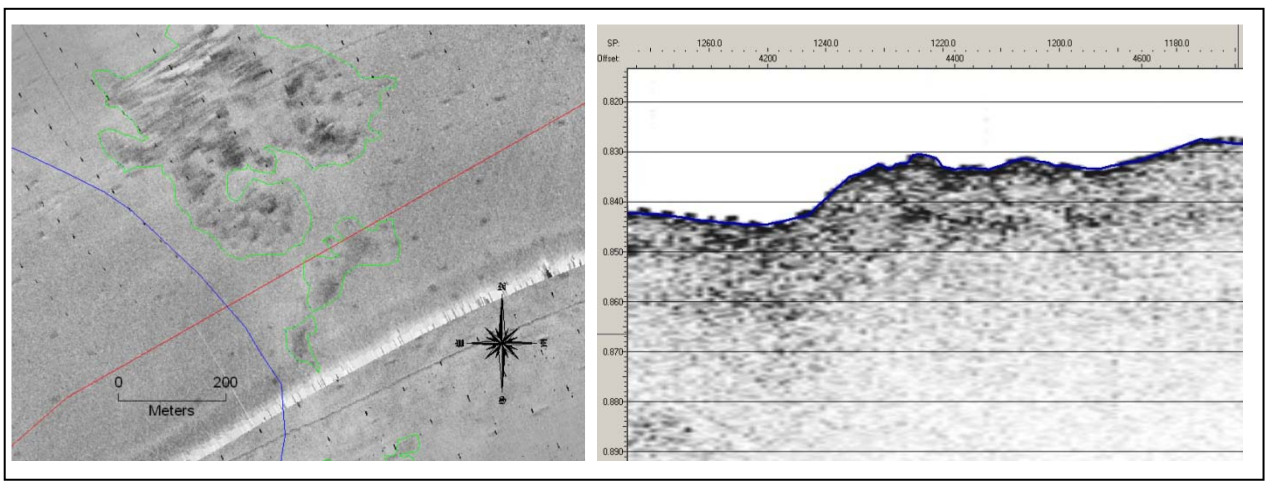


FIGURE 5-16 AREAS OF CONCERN S1-A

Side scan sonar mosaic image of outcropping strata (green patches) and the edge of undifferentiated sediment (blue line). The route is shown in red. In the subbottom profiler image, vertical scale lines are 10 msec. (labeled in seconds) 'Offset' indicates horizontal distance in meters; southwest is towards the left.

5.2.6.2 Area of Concern S1 b

Although the RSN route misses the largest sections of outcropping bedrock through this area, it crosses the extreme northern extent of an area of exposed strata. CPT S1-MM-CPT-020 was recovered from the northern margin of the outcropping strata (Figure 5-17). This CPT achieved 2.67 m of penetration and the material is classified as very stiff silt/clay.

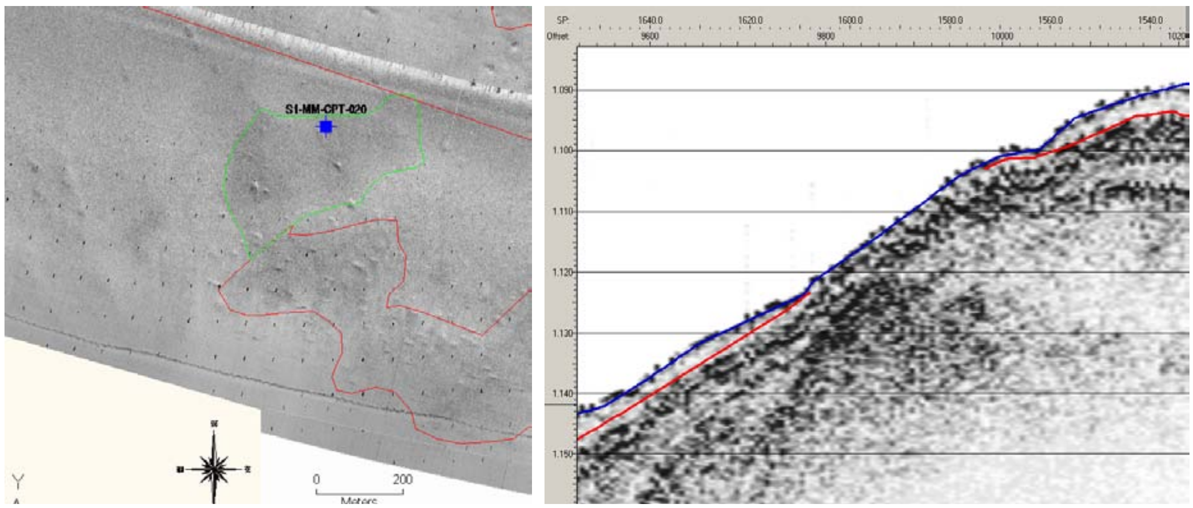


FIGURE 5-17 AREA OF CONCERN S1 B

Side scan sonar mosaic image of outcropping strata (green patch) and outcropping bedrock (red patches). The route is shown in red trending WNW. In the subbottom profiler image, vertical scale lines are 10 msec. (labeled in seconds) 'Offset' indicates horizontal distance in meters west is towards the left.

5.2.6.3 Area of Concern S1 c

Like S1 b, this area is called out for its exposures of strata (Figure 5-18). Gravity core S1-MM-GC-010 achieved no penetration. Gravity core S1-MM-GC-010a achieved 2.4 m of penetration and described stiff sandy clay. CPT S1-MM-CPT-021 was acquired within the outcropping strata and achieved 1.87 m of penetration before the instrument failed and recorded stiff/dense material.

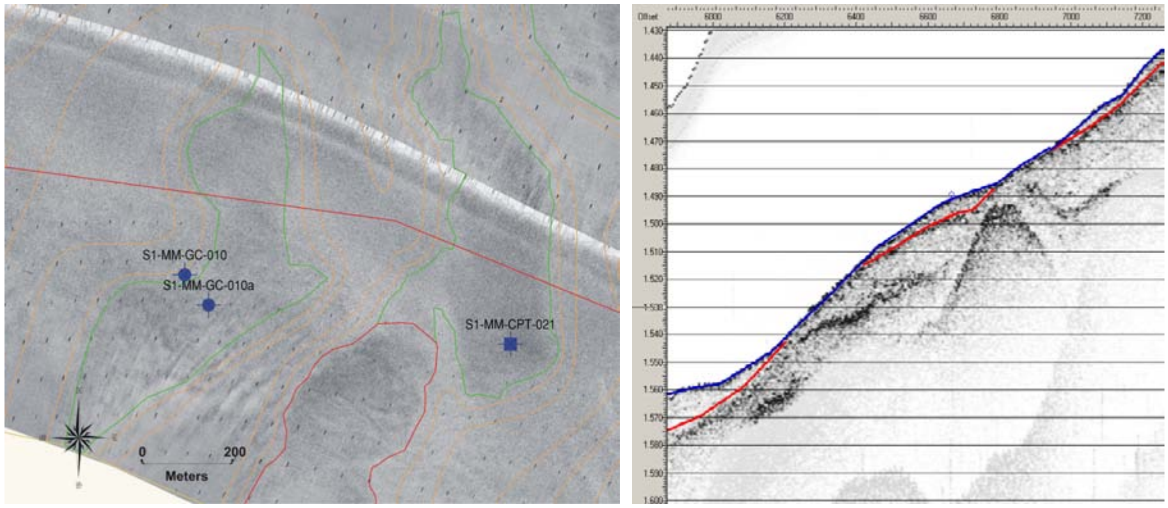


FIGURE 5-18 AREA OF CONCERN S1 C

Side scan sonar mosaic image of outcropping strata (green patch) and outcropping bedrock (red patches). The route is shown in red trending WNW. In the subbottom profiler image, vertical scale lines are 10 msec. (labeled in seconds) 'Offset' indicates horizontal distance in meters; west is towards the left. (Note, subbottom profile is ~175 meters south of route at S1 c). Where the red lines are present in the profiler image, unconsolidated silt/clay is present; where absent, strata are exposed.

5.2.7 Route Recommendations

Evidence of bottom fishing within the Segment 1 survey corridor is ample. Trawling and other modes of bottom fishing pose a real and serious hazard to any cable exposed on the seabed between the shoreline and the 1500 m isobath. It is therefore of the utmost importance that the cable be buried where possible even if full burial depth cannot be achieved.

Sonar contacts should be avoided, and the cable installer should be made aware of the area's many pockmarks.

5.3 SEGMENT 2

5.3.1 Bathymetry

The depth at the Primary Node PN1A is 2920 m. From PN1A, Segment 2 of the survey route heads south for approximately 5.5 km before shifting eastward to cover another 5.5 km on approach to the shelf slope (RSN.S2.NU.CHART-001). The seafloor is nearly flat along this part of the route. The base of the slope is encountered along the 2890 m isobath. On its eastward ascent of the slope, the route encounters two terraces. Slope gradients on the western flanks of these features are up to 103% (45.9°) and 38.8% (21.2°), respectively. The route along Segment 2 begins to level off at the 1450 m isobath and rises up a gentle slope to the 1300 m isobath, where the route turns northward to its terminus at Primary Node PN1B, just south of South Hydrate Ridge (RSN.S2.NU.CHART-002A). The depth at Primary Node PN1B is 1230 m. Figure 5-19 depicts the topography along Segment 2.

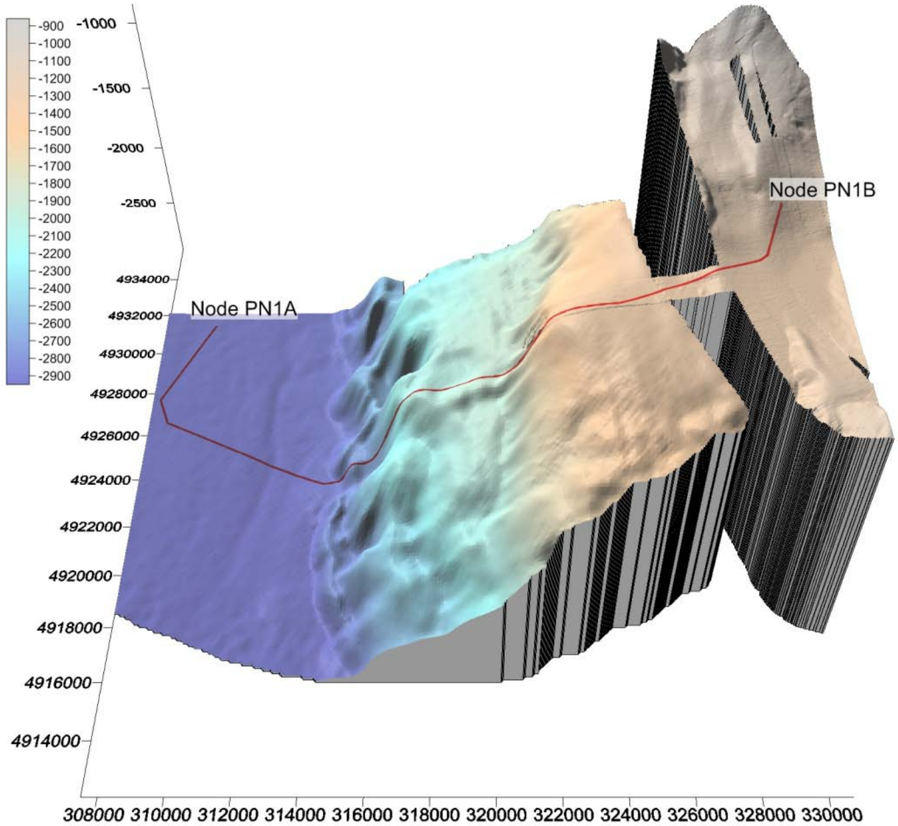


FIGURE 5-19 SEGMENT 2 TOPOGRAPHY

5.3.2 Seabed Features

Sonar and subbottom profiler coverage begins along Segment 2 at about the 1580 m isobath; below this level, only multibeam data were acquired. The seabed above the 1580 m level is characterized by outcropping sub-horizontal strata of indeterminate age. The sonar reveals a featureless seabed from the 1580 m isobath to the 1350 m isobath, so any bedrock is likely blanketed by pelagic sediment. A couple of dark patches appear in the sonar data between the 1340 and 1330 m isobaths. This area is interpreted as an authigenic carbonate formation with partially cemented surficial mud. Authigenic carbonates form when upward migrating methane comes in contact with seawater causing a chemical reaction that forms calcium carbonate. Chart RSN.S2.NU.CHART-002B shows the seabed features from the 1340 m isobath to Primary Node PN1B. A CPT was taken in one authigenic carbonate patch located south of the planned route (S2-MM-CPT-001) that recorded interbedded undrained and drained over undrained. This character is what would be expected for a surficial authigenic crust.

5.3.3 Shallow Geology

The subbottom profiler (Figure 5-20) indicates a measurable surficial sediment drape commences at about the 1380 m isobath along the route and thickens eastward. From the 1380 m isobath to the 1580 m isobath along the route, these sediments are unmappable. Where measurable accumulations of sediment are present at the seabed, they display an acoustically transparent to amorphous character indicating it is undifferentiated (no stratification). The older sediment layers are high amplitude and closely-spaced, which is typical of interbedded sand and silt. The older strata may be partially lithified (hardened). Gas may be present in the older strata, as evidenced by a hazy acoustic character and brightening (increased amplitudes). The authigenic carbonate patches mentioned in the previous section, as seen on the seabed, occur where the surficial sediment thins above localized highs in the underlying strata.

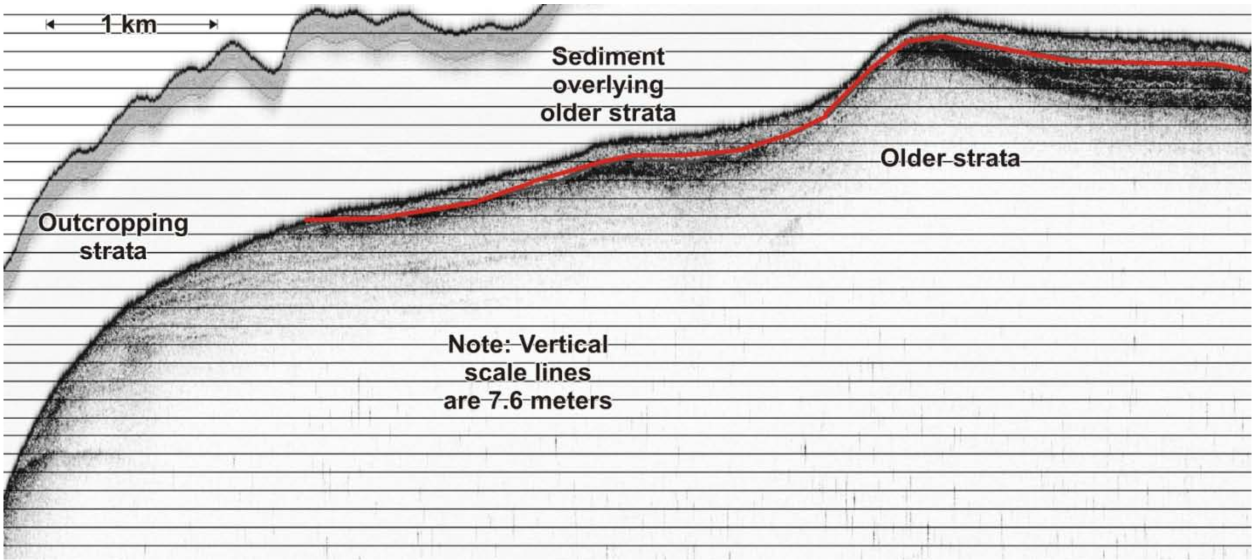


FIGURE 5-20 SUBBOTTOM PROFILE SEGMENT 2

The base of unconsolidated surficial sediment is shown in red. Vertical scale lines are 10 msec. (labeled in seconds) 'Offset' indicates horizontal distance in meters west is towards the left.

5.3.4 Hazards and Obstructions

Authigenic carbonate patches and exposed strata could affect cable burial operations. Authigenic carbonate patches are areas where gas may have formed hard carbonate cement crust which may hinder plowing operations. Exposed strata may be too hard to plow.

5.3.4.1 Wrecks and Sonar Contacts

No sonar contacts were detected for Segment 2. There are no reported wrecks in the Segment 2 survey area.

5.3.4.2 Fishing Activities

Bottom contact fishing scars are absent within the Segment 2 survey corridor. There are no fishing related observations noted within daily progress reports.

5.3.4.3 Dumping and Dredging

There were no recorded observations of dumping and dredging activities during the Segment 2 portion of the RSN survey. No activities are expected in these areas per the DTS.

5.3.4.4 Hydrocarbon Exploration

There were no recorded observations of hydrocarbon exploration activities during the Segment 2 portion of the RSN survey. No intent to perform hydrocarbon exploration was reported by the DTS.

5.3.4.5 Military Activities

There were no recorded observations of military activities during the Segment 2 portion of the RSN survey.

5.3.5 Seabed Samples

Table 5-7 summarizes the location of seabed samples along the Segment 2 portion of the RSN survey. Detailed logs of these samples are included in Appendix B.

Name	Location				Water Depth (m)	Penetration Depth (m)
	Coordinates		UTM Zone 10N			
	Latitude	Longitude	Northing	Easting		
S2-MM-CPT-001	44°27.22'N	125°11.46'W	4924590	325673.5	1336	Push to 3.00 m
S2-MM-CPT-002	44°29.05'N	125°8.88'W	4927886	329231.4	1219	Push to 3.00 m
S2-MM-GC-001	44°27.45'N	125°9.59'W	4924957.63	328165.3	1290	1.58

TABLE 5-7 SEABED SAMPLES ALONG SEGMENT 2

5.3.6 Areas of Concern

There are no specific areas of concern along Segment 2.

5.3.7 Route Recommendations

No evidence of bottom fishing within the Segment 2 survey corridor was observed. However, trawling and other methods of bottom contact fishing pose a very serious hazard to any cable exposed on the seabed between the shoreline and the 1500 m isobath. It is therefore of the utmost importance that the cable be buried where possible even if full burial depth cannot be achieved.

Strata of varying ages and cohesive properties outcrop at or very near the seabed along the western part of the Segment 2 survey corridor however the route avoids these areas.

5.4 SEGMENT 3

5.4.1 Bathymetry

The final-survey route deviated significantly from the pre-survey route for this segment, as Primary node PN1C was relocated some 29.6 km to the south-southwest. From Primary Node PN1B, Segment 3 of the RSN route heads to the south, then progressively turns eastward as it steadily ascends the southwestern slope of Southeast Knoll (Figure 4-1), where gradients are less than 5.5% (3.1°; RSN.S3.NU.CHART-001A). Segment 3 ends at Primary Node PN1C on a gently sloping terrace near the 616 m isobath. The only topographic feature on the route is a large seabed crater (~230 m diameter and 6 m deep) located at the eastern end of the route, about 825 m southwest of Primary Node PN1C. The planned route curves around the south and east side of this crater on approach to Primary Node PN1C (see chart RSN.S3.NU.CHART-004B). Figure 5-21 depicts the topography along Segment 3.

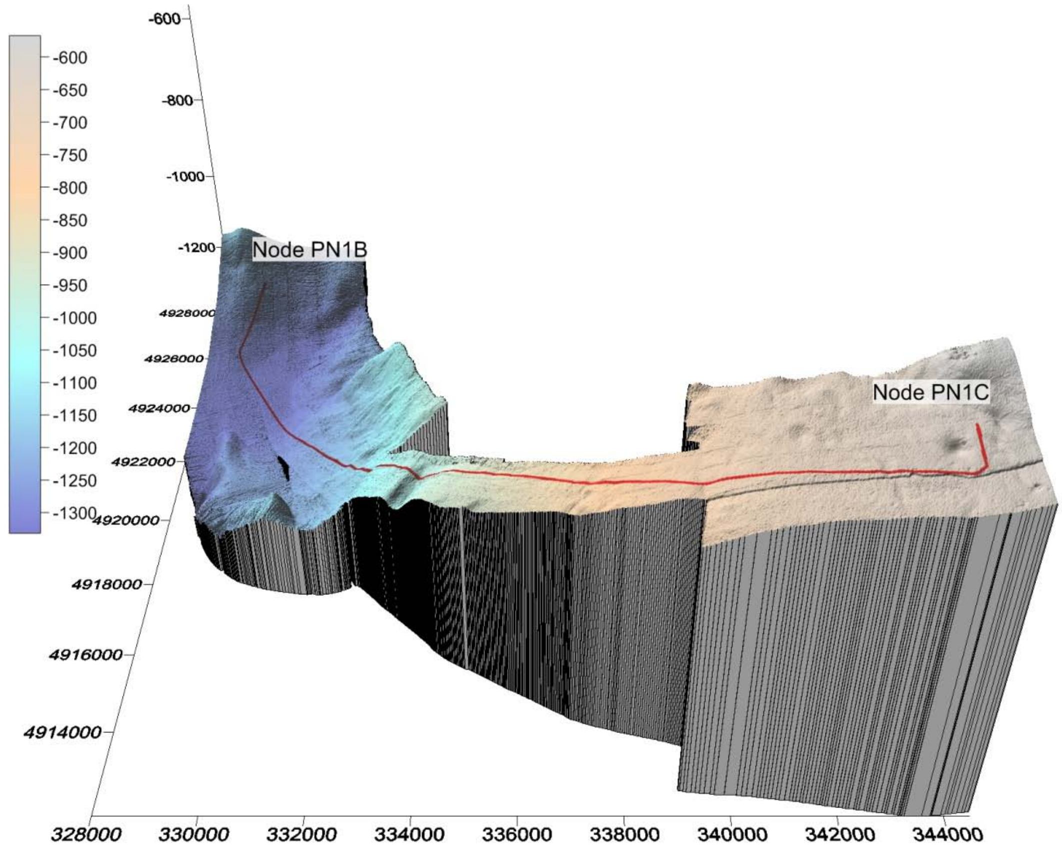


FIGURE 5-21 SEGMENT 3 TOPOGRAPHY

5.4.2 Seabed Features

From Primary Node PN1B, the route heads south across a small basin filled with sediment and blanketed by more than 5 m of stiff to very stiff silt. As the route heads up the slope in a southeast direction, it passes to the east of an elongated patch of authigenic carbonate corresponding with darkened areas on the sonar records (see RSN.S3.NU.CHART-002B). A core in this area recovered stiff clay/silt.

As the route curves to the east at 44°23.88'N, 125°04.75'W, it passes to the northeast of a patch of outcropping strata, east of which the seabed is covered by numerous pockmarks (see RSN.S3.NU.CHART-003B). A CPT taken near here (CPT S3-MM-CPT-003) indicates the sediment is stiff (undrained) clayey silt over medium (drained) sandy silt. At about the 810 m isobath, the route skims the northern edge of a patch interpreted as undifferentiated sediment, where the seabed is slightly darkened on sidescan records (see RSN.S3.NU.CHART-003B). A core taken near this area (S3-MM-GC-002) recovered 1.66 m of soft to hard silt and clay. The route passes south of more patches of undifferentiated sediment between the 730 m and 690 m isobaths.

A large crater lies close to the end of the route where it breaks north towards Primary Node PN1C. Strata of indeterminate hardness are likely exposed in the walls of this crater, which may have resulted from a large-scale gas expulsion event. Figure 5-22 depicts this crater.

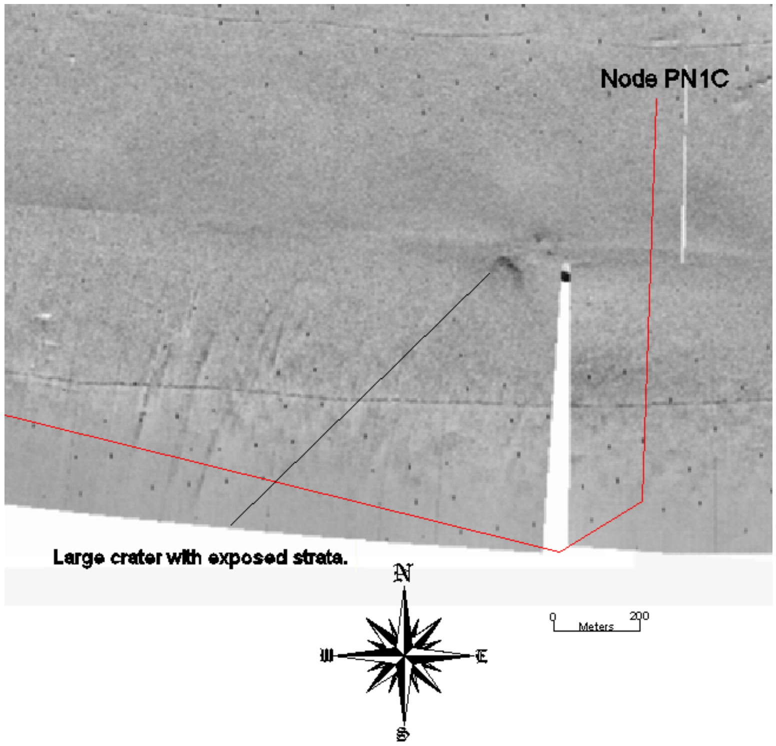


FIGURE 5-22 SEGMENT 3 SONAR IMAGE OF CRATER

Side scan sonar mosaic image of a crater southwest of Primary Node PN1C. The route is shown in red

5.4.3 Shallow Geology

As the route runs south from Primary Node PN1B, it drops down into a sediment-filled minibasin then rises up a gentle slope, where the surficial sediment conformably blankets sedimentary strata of uncertain age. At 44°23.73'N, 125°05.27'W, the route crosses a terrace for 440 m before ascending a steeper slope, where the surficial sediment thickness thins to about 4 m. The surficial sediment in this area thins towards the southwest (away from the route) and eventually thins to nil at an outcropping strata patch located 300 m southwest of the route (see RSN.S3.NU.CHART-003B). Figure 5-23 is a subbottom profile along the route showing the terrace and the thinning of surficial sediment as the route proceeds upslope.

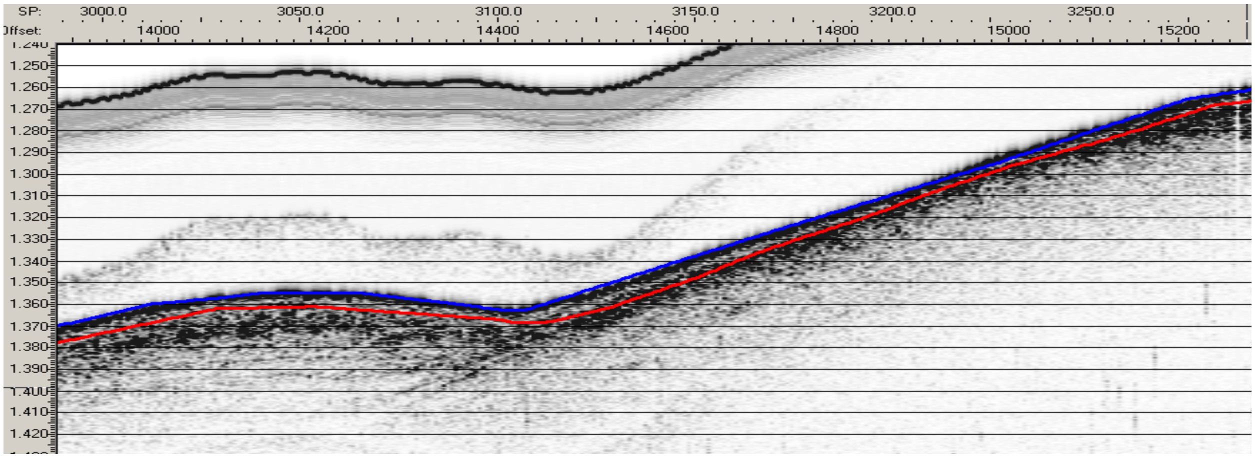


FIGURE 5-23 SEGMENT 3 SUBBOTTOM PROFILER IMAGE

The base of unconsolidated surficial sediment is shown in red. The slight rise to the left is the terrace. Vertical scale lines are 10 msec. (labeled in seconds) 'Offset' indicates horizontal distance in meters northwest is towards the left.

As the route continues up the slope, the sediment thickens slightly and the underlying older strata become gassy, as evidenced by numerous seabed pockmarks. Figure 5-24 depicts the subbottom profiler record beneath the route at 44°22.71'N, 125°03.55'W. The gassy strata appear as hazy dark reflections in this image. These gassy undifferentiated sediments outcrop south of the route at this location as the route starts to curve east. The underlying strata remain gassy and the surficial sediment thins gradually on approach to Primary Node PN1C.

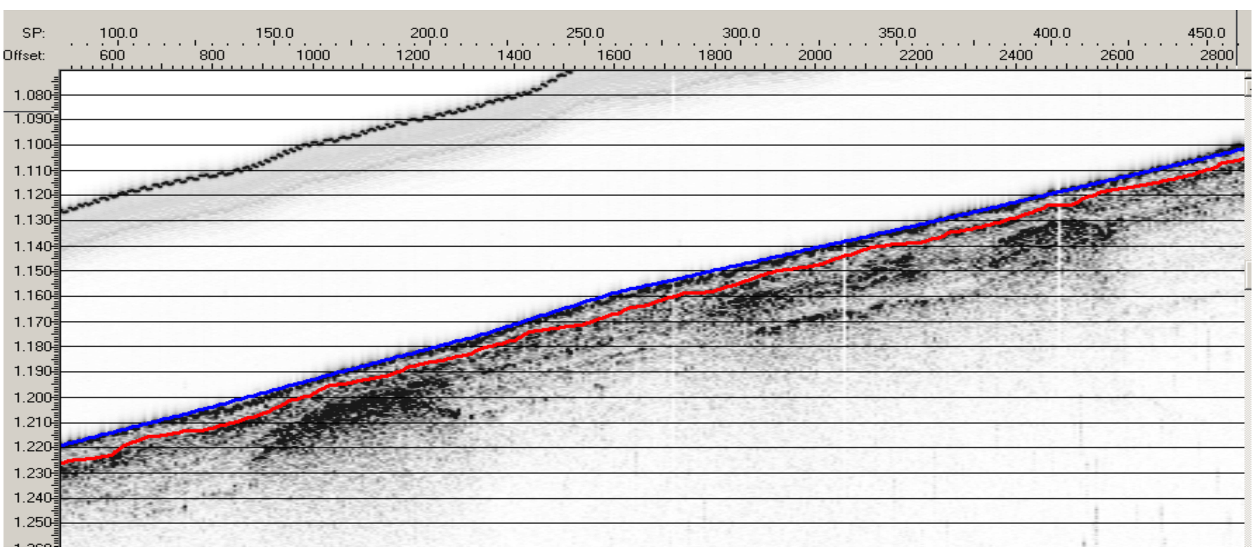


FIGURE 5-24 SUBBOTTOM PROFILE SHOWING GASSY STRATA

The base of unconsolidated surficial sediment is shown in red. Gassy strata are the hazy dark reflections that underlie the surficial sediments. Vertical scale lines are 10 msec. (labeled in seconds) 'Offset' indicates horizontal distance in meters northwest is towards the left.

5.4.4 Hazards and Obstructions

Pockmarks, authigenic carbonate patches and exposed strata could impede cable burial operations. Pockmarks could potentially have steep slopes and their floors may be blanketed with stiff to hard carbonate-cemented mud, or authigenic carbonate. Exposed strata may be too hard to achieve full burial. Areas where thin sediments blanket strata of indeterminate age are zones where the plow may contact strata of indeterminate or variable hardness. In some cases, the plow may not be affected by these underlying strata, in other cases plowing operations could be hindered resulting in possible damage to the plow.

5.4.4.1 Wrecks and Sonar Contacts

One (1) unidentified sonar contact is located within the Segment 3 survey corridor, 1998 meters north of Primary Node PN1B. Contacts are summarized in the following table. For complete details, see Appendix E.

Contact ID	Latitude	Longitude	Dimensions (LxWxH) (m)	Distance from Route (m)	Description
S1-SC-012	44°30.10'N	125°8.69'W	22.9 x 4.3 x 0.0	1998	Linear object lying atop the seabed

TABLE 5-8 SONAR CONTACT SUMMARY FOR SEGMENT 3

5.4.4.2 Existing and Planned Cables

There are no known cable crossings within the Segment 3 survey corridor.

5.4.4.3 Fishing Activities

A few fishing scars were detected in the survey area. It is prudent to exercise caution along the entire Segment 3 survey corridor.

Fishing related activities that were observed and reported during the survey of Segment 3 are summarized in Table 5-9.

Segment	Date	Time	Notes
3	4/18/2010	16:39	Entry regarding deviation to avoid buoy was a bridge watch decision; not at OFCC request. OFCC identified the float as free-floating and not connected to fishing gear.
3	4/20/2010		At approximately half the distance down the line were long line fishing gear across the route. There appears to be less communication and cooperation with the long line fishing community than with the crabbers. OFCC reps onboard indicated that the gear would be removed by 10:00 am tomorrow.
3	4/21/2010		Survey on Segment 3c was interrupted today by long line fisherman who "had set gear" across the route which caused a long southerly diversion around the southern end of the long line fishing gear. We have been advised of other long line fishing going on in the area. Advised by OFCC that the long line gear across the Seg3c route would be removed by the vessel owner by 10:00 tomorrow morning
3	4/21/2010		Contacted the Winona J, trawling in the area; skipper agreed to avoid our survey area and towed gear. The F/V Ossian overheard the radio call and contacted the R/V Mt Mitchell. Worked with the F/V Ossian to determine that his long line gear was in the survey route and the vessel was unable to recover this gear in time to clear our path. The F/V Ossian had other gear in which the buoy lines may have been in the survey swath between 600 and 700 fathoms. (The MM had no choice but to divert from the survey to avoid the heavy long line string of pots).

TABLE 5-9 FISHING RELATED OBSERVATIONS FOR SEGMENT 3

5.4.4.4 Dumping and Dredging

There were no recorded observations of dumping and dredging activities during the Segment 3 portion of the RSN survey. Dumping and dredging sites were not identified in this area in the DTS. No activities are expected in these areas per the DTS.

5.4.4.5 Hydrocarbon Exploration

There were no recorded observations of hydrocarbon exploration activities during the Segment 3 portion of the RSN survey. Hydrocarbon exploration sites were not identified in this area in the DTS.

5.4.4.6 Military Activities

There were no recorded observations of military activities during the Segment 3 portion of the RSN survey. Military activity areas were not identified in this area in the DTS.

5.4.5 Seabed Samples

Table 5-10 summarizes the location of seabed samples collected along Segment 3 of the RSN cable route. Gravity cores were acquired at 10 km intervals and CPTs every 4-5 km. Detailed records of these samples are included in Appendix B and C.

Name	Location				Water Depth (m)	Penetration Depth (m)
	Coordinates		UTM Zone 10N			
	Latitude	Longitude	Northing	Easting		
S3-MM-GC-001	44°25.98'N	125°07.55'W	4922172.5	330808.8	1258	>3.0
S3-MM-GC-002	44°22.45'N	125°03.03'W	4915482.3	336638.2	840	>3.0
S3-MM-CPT-001A	44°26.72'N	125°08.04'W	4923559.6	330176.8	1310	Push to 3.00 m
S3-MM-CPT-002F	44°24.82'N	125°06.54'W	4919986.6	332083.3	1179	Push to 3.00 m
S3-MM-CPT-003	44°23.27'N	125°04.68'W	4917056.5	334526.5	958	Push to 3.00 m
S3-MM-CPT-004	44°21.80'N	125°00.96'W	4914201.2	339373.7	728	Push to 3.00 m
S3-MM-CPT-005	44°21.99'N	124°57.84'W	4914456.1	343517.8	616	Push to 3.00 m

TABLE 5-10 SEABED SAMPLES ALONG SEGMENT 3

5.4.6 Areas of Concern

There are no specific areas of concern along Segment 3.

5.4.7 Route Recommendations

Although evidence of bottom fishing along the Segment 3 survey corridor is moderate, trawling and other methods of bottom fishing pose a real and serious hazard to any cable exposed on the seabed between the shoreline and the 1500 m isobath. It is therefore of the utmost importance that the cable be buried where possible even if full burial depth cannot be achieved.

Areas of authigenic carbonate may increase shear strengths and hinder burial. If possible, these areas should be avoided to maximize burial.

5.5 SEGMENT 4

5.5.1 Bathymetry

From Primary Node PN1C at the 615 m isobath, the route obliquely descends the slope in a southerly direction to a depth of 623 m, and then turns northeast and ascends an undulating slope for 8 km (charts RSN.S4.NU.CHART-001A and RSN.S4.NU.CHART-002A). The route crosses the 500 m isobath at 44°23.76'N, 124°52.00'W (RSN.S4.NU.CHART-002A). As the route continues to rise up the slope in a northeast direction, the seabed slope direction progressively changes from southwest to northwest, resulting in the route crossing the seabed slope obliquely. As the route begins to curve to the north-northeast at 44°26.00'N, 124°47.24'W at the 287 m isobath, the route more or less parallels the seabed slope (which slopes northwest at 7% (4°; RSN.S4.NU.CHART-003A). The route continues up slope to the 267 m isobath at 44°26.75'N, 124°45.39'W, at which point the route starts to obliquely descend the seabed slope (RSN.S4.NU.CHART-003A). The route continues descending the slope oblique to the isobath contours until reaching the 310 m isobath at 44°29.22'N, 124°45.54'W, beyond which point the descent continues on a slightly larger oblique angle to the isobaths (RSN.S4.NU.CHART-004A).

The route crosses the distal end of a turbidite channel at 44°30.94'N, 124°45.32'W (RSN.S4.NU.CHART-004A) at the 374 m isobath, at which point it rises a half meter up the northern channel levee and descends 1.5 m to parallel the slope for another 1100 m along the 375 m isobath. At 44°31.71'N, 124°45.09'W, the route curves north-northeast and begins to climb a gentle slope that becomes slightly steeper as the route continues to curve to the east (RSN.S4.NU.CHART-004A and RSN.S4.NU.CHART-005A). The seabed undulates slightly where the route crosses the 324 m isobath at 44°33.48'N, 124°42.19'W (RSN.S4.NU.CHART-005A). From this point, the route rises up a slope that progressively flattens towards the northeast. The route crosses the 291 m isobath at 44°35.20'N, 124°39.01'W (RSN.S4.NU.CHART-006A), beyond which the route begins to obliquely ascend a relatively steep seabed gradient where the seabed slopes towards the west. The route at this point runs toward the northeast, but it curves to the north-northeast to eventually parallel the isobaths; side slopes are generally about 3.5% (2°) in this area. The route parallels the 226 m isobath at 44°38.08'N, 124°37.30'W (RSN.S4.NU.CHART-007A), after which it descends oblique to the isobaths for a distance of 9.6 km to the 240 m isobath at 44°43.25'N, 124°36.51'W. Beyond this point, the seabed slopes to the northwest and the route continues in a north direction (RSN.S4.NU.CHART-008A). At 44°45.03N, 124°36.21'W the route approaches the 261 m isobath, where the route curves progressively northeast then east to rise up a northwest-sloping seabed (RSN.S4.NU.CHART-009A). Beyond the shelfbreak at about the 205 m isobath, which the route crosses at 44°46.50'N, 124°34.05'W, the northwest-sloping seabed gradient begins to decrease (RSN.S4.NU.CHART-009A). The route curves to the southeast and rises directly upslope. The route continues to the south-southeast in a gradual ascent to Primary Node PN1D, which lies between the 113 and 114 m isobaths (RSN.S4.NU.CHART-011A).

5.5.2 Seabed Features

From Primary Node PN1C, the route heads south, crossing a seabed where older strata are blanketed by about 2 m of unconsolidated sediment (probably silt/clay). As the route curves to the northeast, it crosses a small patch of authigenic carbonate, as evidenced by a slight darkening of the sonar record. The unconsolidated surficial sediment thins to nil and the underlying strata are exposed at the seabed as the route crosses an exposed strata patch at 44°21.40'N, 124°56.78'W (see chart RSN.S4.NU.CHART-001B). As the route proceeds northeast, it passes between patches of undifferentiated sediments and exposed strata remaining within areas where unconsolidated silt/clay blankets the seabed (see charts

RSN.S4.NU.CHART-001B and RSN.S4.NU.CHART-002B). At 44°24.23'N, 124°50.35, the route passes into an area mapped as undifferentiated sediment. The side scan sonar does not indicate any changes in reflectivity between the undifferentiated sediment and the areas where unconsolidated silt/clay are present. This boundary is drawn based on subbottom profiler data and will be discussed below.

As the route curves to the north, the side scan sonar reveals slight reflectivity increases in several patches (RSN.S4.NU.CHART-003B). These patches are interpreted as authigenic carbonate (crusts). Shallow gas is evidenced in the subbottom profiles (discussed below).

At 44°30.93'N, 124°45.35 the route crosses a gully that is flanked by two low-relief ridges. The side scan sonar shows apparent ripples/sand waves on the eastern margin of the sonar coverage at this gully. This feature is interpreted as the distal end of a (turbidite) channel, where the ripples/sand waves have formed on the inner margins of the channel levees. The channel appears to be unconfined in the western part of the sonar coverage, which would explain the absence of ripples/sand waves. The bathymetric contours are also consistent with this interpretation, as the gully/levee system is less noticeable to the west. Figure 5-25 depicts the channel ripples as seen in the sonar data.

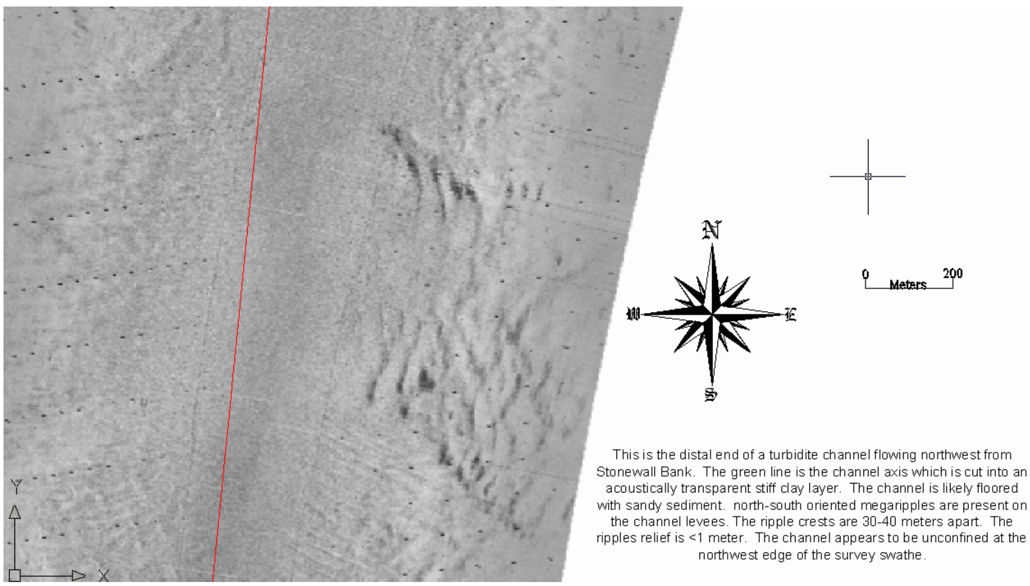


FIGURE 5-25 SIDE SCAN SONAR IMAGE SHOWING TURBIDITE CHANNEL

Side scan sonar mosaic image of a turbidite channel. The route is shown in red

Pockmarks dot the seabed along nearly the entire section of the route between Halibut Hill and Rogers Ridge. Some of these pockmarks are quite large and floored with gravel or authigenic carbonate material. Large pockmarks in this section occur near 44°33.72'N, 124°42.3'W and farther north at about 44°43.20'N, 124°37.02'W. The pockmarks to the north have diameters of 75-100 m and depths of 1-3 m (see chart RSN.S4.NU.CHART-008B).

A few fishing (trawler) scars were seen scattered throughout Segment 4. Intensive scarring occurs a short distance northeast of Halibut Hill.

Near the apex of the curve at 44°46.34'N, 124.34.53'°W, north of Rogers Ridge, a fragment of living coral was recorded as being caught in the cutting shoe of gravity core S4-MM-GC-008. A faint darkening of the sonar record is interpreted as a possible area where coral may be found. This patch is mapped on chart RSN.S4.NU.CHART-009B.

Sand comprises the surficial sediment southeast of the 138 m isobath at 44°43.64'N, 124°28.79'W. This sand dominates the seabed for the remainder of the route to Primary Node PN1D.

The only definite patch of bedrock is mapped a short distance southwest of Primary Node PN1D, where the subbottom profiler reveals a north-plunging bedrock ridge is present. There is a chance that corals may be associated with this bedrock patch.

5.5.3 Shallow Geology

From Primary Node PN1C, the route proceeds south across a seabed blanketed by about 2 m of unconsolidated silt/clay. The surficial sediments are underlain by strata (or sediment) of indeterminate hardness. Where the route breaks to the east, the unconsolidated surficial sediment thins to nil. The underlying strata are exposed at the seabed as the route crosses an exposed strata patch at 44°21.40'N, 124°56.78'W (see chart RSN.S4.NU.CHART-001B). Figure 5-26 shows a subbottom profile taken across this patch a short distance north of the route. The sonar shows no changes in reflectivity, just a few scattered pockmarks. Neither a CPT nor a gravity core was acquired in this particular patch, precluding a prediction of the sediment properties.

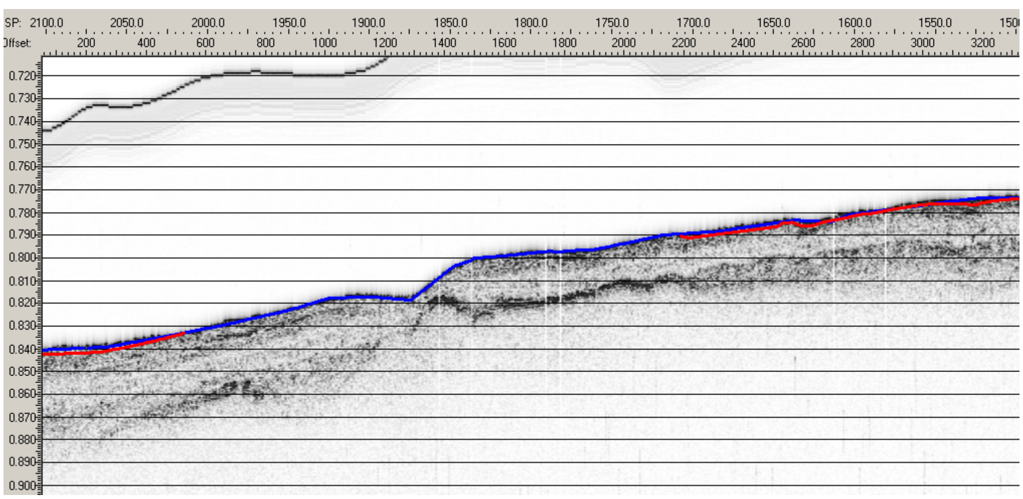


FIGURE 5-26 SUBBOTTOM PROFILE SEGMENT 4 ACROSS OUTCROPPING STRATA

The base of unconsolidated surficial sediment (where present) is shown in red. The dark hazy reflectors may be either gassy strata or the top of a north-plunging bedrock ridge. Vertical scale lines are 10 msec. (labeled in seconds) 'Offset' indicates horizontal distance in meters west is towards the left.

The route passes between two authigenic carbonate patches near 44°23.17'N, 124°52.18'W. A subbottom profiler line runs through the westernmost patch. Often authigenic carbonates can be seen on subbottom profiles as darkened seabed or near seabed reflections. Figure 5-27 shows such darkening as it crosses the western patch that lies north of the planned route. A CPT (S4-MM-CPT-002) taken near this patch recorded undrained over stiff (silt/clay), and a gravity core taken in the surficial silt clay, farther to the southwest (S4-MM-GC001), recorded soft to very stiff olive gray silt over very stiff sandy silt.

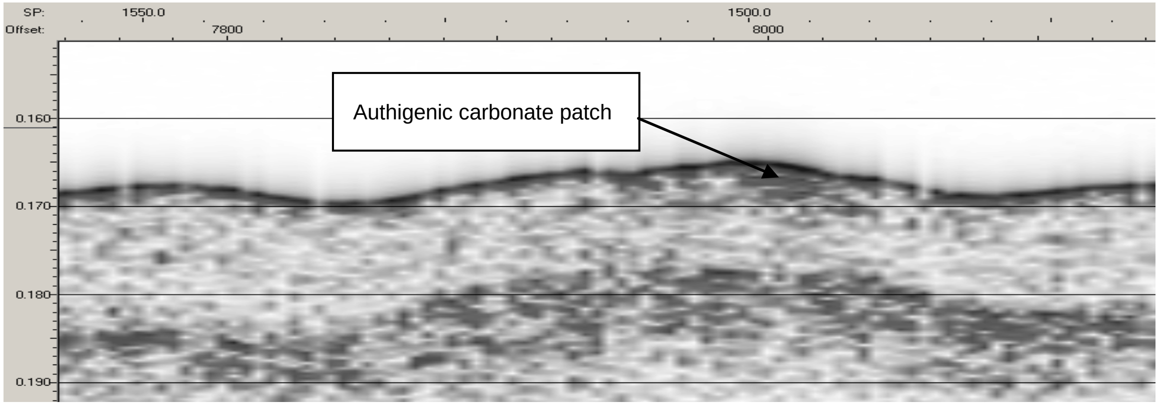


FIGURE 5-27 SUBBOTTOM PROFILE SEGMENT 4 ACROSS AUTHIGENIC CARBONATE

Vertical scale lines are 10 msec. (labeled in seconds) 'Offset' indicates horizontal distance in meters west is towards the left.

At 44°24.23'N, 124°50.35, the route passes into an area mapped as undifferentiated sediment (RSN.S4.NU.CHART-002B). The side scan sonar does not indicate any changes in reflectivity between the undifferentiated sediment and the areas where unconsolidated silt/clay are present. The base of a mappable surficial sediment layer that is evident to the southwest comes to the surface at this point. To the northeast, the character of the subbottom profiler data is chaotic, with laterally-discontinuous reflectors visible to a depth of 30 milliseconds. Dipping discontinuous reflectors often intersect the seabed. Figure 5-28 shows the transition from mappable surficial silt/clay to the southwest to undifferentiated sediment to the northeast.

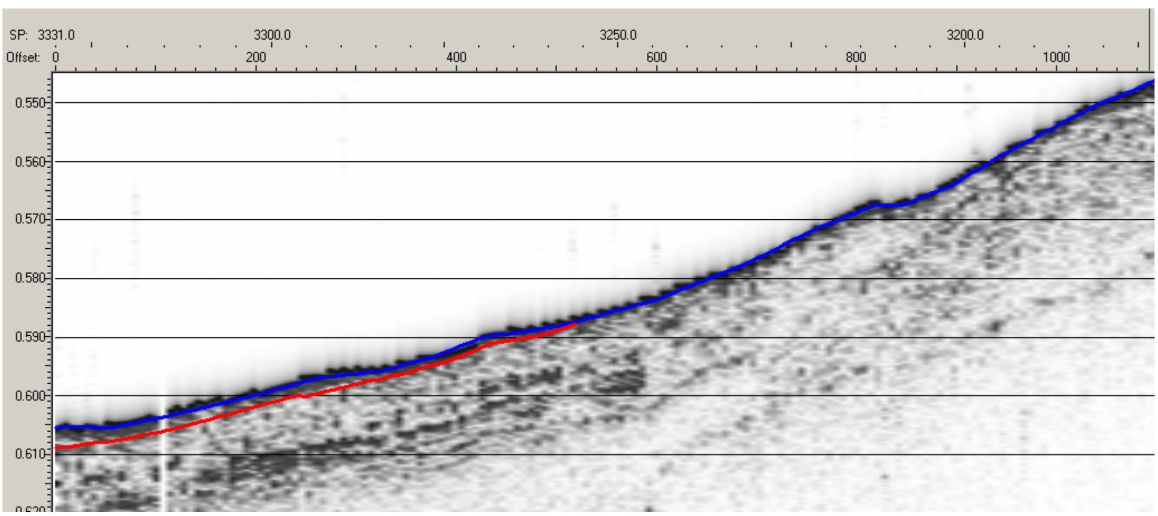


FIGURE 5-28 SUBBOTTOM PROFILE SEGMENT 4 UNDIFFERENTIATED SEDIMENT TRANSITION

The base of unconsolidated surficial sediment (where present) is shown in red. Southwest is to the left. Layered sediment is evident to the southwest while a chaotic-laterally discontinuous seismic character predominates to the northeast. Vertical scale lines are 10 msec. (labeled in seconds) 'Offset' indicates horizontal distance in meters.

Detailed analysis of the subbottom profiler reveals that a distinguishable unconsolidated surface sediment unit is absent along the route for the entire distance from about 44°24.23'N, 124°50.35'W to where sand is encountered just before Primary Node PN1D (44°43.64'N, 124°28.79'W). Along this length, the shallowest reflectors are laterally discontinuous, oblique to the seabed and of low to moderate amplitude. The acoustic character is amorphous to chaotic. Deeper strong reflectors are often visible, but their depths usually exceed 10 m beneath the seabed. A number of CPTs and gravity cores were taken along the route in this extensive patch of undifferentiated sediment. The vast majority of these geotechnical samples recorded fine-grained (silt/clay) sediment as stiff, very stiff and hard, and coarser grained material (sand) as dense to very dense. CPTs S4-MM-CPT-007, S4-MM-CPT-008, and S4-MM-CPT-009 are exceptional in that they recorded layers of soft to medium and loose along with the stiff/dense interlayers. CPT S4-MM-CPT-017 recorded very soft to medium stiff (silt/clay) over dense to very dense (sand).

At 44°30.93'N, 124°45.35'W, the route crosses a gully that is flanked by two low-relief ridges (RSN.S4.NU.CHART-004B). The side scan sonar shows apparent ripples/sand waves on the eastern margin of the sonar coverage at this gully. This feature is interpreted as the distal end of a (turbidite) channel, where the ripples/sand waves have formed on the inner margins of the channel levees. The subbottom profiler shows an amorphous seismic character in the channel basal deposits, and an acoustically-transparent character beneath the channel levees (see Figure 5-29).

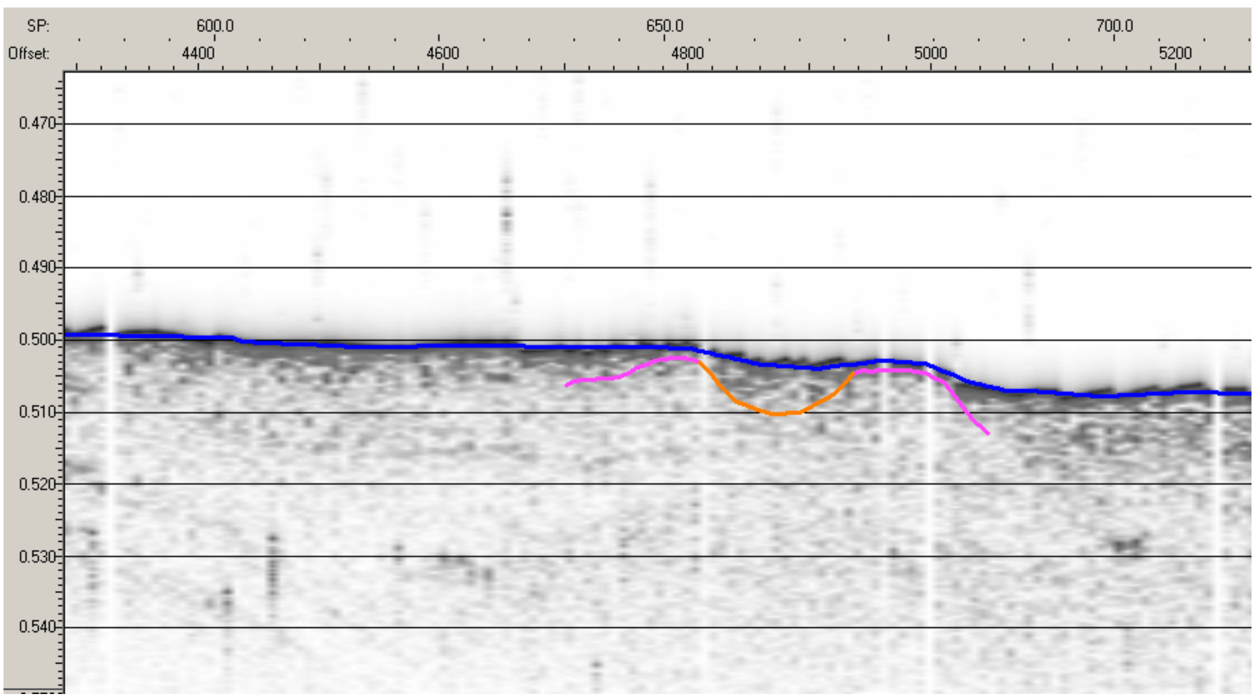


FIGURE 5-29 SUBBOTTOM PROFILE SEGMENT 4 TURBIDITE CHANNEL

The channel basal deposit (gravel) is shown in gold, the levees are shown in pink. South is to the left. Vertical scale lines are 10 msec. (labeled in seconds) 'Offset' indicates horizontal distance in meters.

The shelfbreak occurs at about the 205 m isobath, which the route crosses at 44°46.50'N, 124°34.05'W, and the subbottom profiler records show a generally amorphous character beneath the seabed. The darker, deeper reflectors (often indicative of gas) disappear, as does the presence of pockmarks on the seabed. Pockmarks tend to form in clayey soils and are usually never found in sandy sediments (probably because gas disperses more rapidly through the larger interstices). As the route curves south to Primary Node PN1D, the subbottom profiler data show no laterally continuous sub-seabed reflectors until the 138 m isobath at 44°43.64'N, 124°28.79'W. Here, a noticeable acoustically-transparent (classic surficial sediment) layer appears and thickens rapidly to the south and east. Figure 5-30 depicts this first appearance of surficial sand in the subbottom profiler records (RSN.S4.NU.CHART-011B).

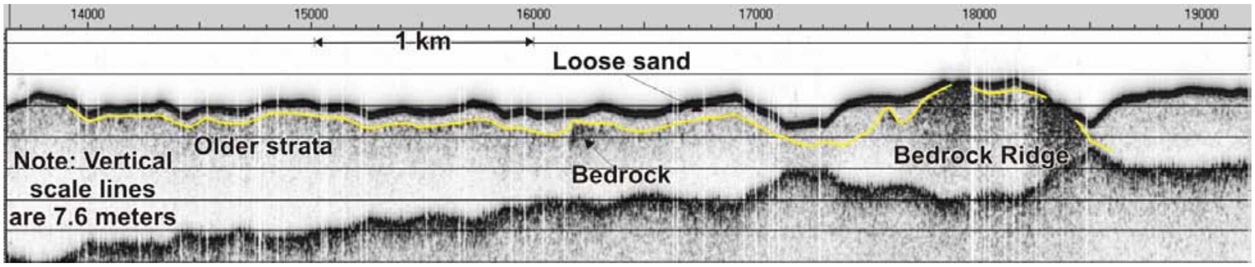


FIGURE 5-30 SUBBOTTOM PROFILE SEGMENT 4 NEAR PRIMARY NODE PN1D

Also seen in Figure 5-30 is a buried bedrock ridge that comes to the surface, where it is exposed in a shallow depression and forms a dark patch visible in the sonar data. There is a chance that hard-bodied fauna may inhabit this patch. Living coral was reported in the shoe of a core (S4-MM-GC008) at the northernmost tip of Segment 4.

5.5.4 Hazards and Obstruction

Pockmarks, authigenic carbonate patches and exposed strata could impede cable burial operations. Pockmarks could potentially have steep slopes and their floors may be blanketed with stiff to hard authigenic carbonate, or carbonate-cemented mud. Exposed strata may be too hard to achieve full burial. Areas where thin sediments blanket strata of undetermined age are zones where the plow may contact strata of indeterminate hardness. In some cases, the plow may not be affected by these underlying strata, in other cases plowing operations could be hindered resulting in possible damage to the cable or plow.

The exposed bedrock near Primary Node PN1D will not likely be plowed as the outcrop lies outside the area where the plow will operate. The present route avoids the possible coral patch at the northernmost extent of Segment 4 survey area.

Large pockmarks occur near 44°33.72'N, 124°42.30'W and farther north at about 44°43.20'N, 124°37.02'W. The pockmarks to the north have diameters of 75-100 m and depths of 1-3 m.

The route crosses the distal end of a turbidite channel at 44°30.84'N; 124°45.24'W. While this channel has probably been inactive for 10,000 years, future gravity flows cannot be ruled out.

5.5.4.1 Wrecks and Sonar Contacts

There are no unidentified sonar contacts within the Segment 4 survey corridor and no confirmed shipwrecks. Walter's Wreck is a place-name located at the rocky outcrop near Primary Node PN1D, but no actual shipwreck was found in this area.

5.5.4.2 Existing and Planned Cables

There are no known crossings of the Segment 4 survey corridor.

5.5.4.3 Fishing Activities

Fishing scars were detected in the survey area. It is prudent to exercise caution along the entire Segment 4 survey corridor. Fishing related activities that were observed and reported during the survey of Segment 4 are summarized in Table 5-11.

Segment	Date	Time	Notes
4	4/23/2010	20:00	After 20:00 the bridge contacted the OFCC to assist with two targets about 7 nm ahead. They were determined to be long line black cod vessels. SM contacted both vessels and after determining that one string of black cod pot gear was in the S4 Alt 1 N250 route, requested that the vessel move her gear from the route. The vessel did so, allowing the Mt. Mitchell survey to procedure without hindrance.
4	4/24/2010	3:58	.2 mile CPA on fishing vessel. Contacted the F/V Miss Ann. I passed our route positions to him he said he would not be outside the 125 line and He would move north of our operating area very cooperative.
4	4/24/2010	4:50	Vessel heading for us with a CPA of 0. Contacted the Western Breeze who was aware of our survey. He has talked to Scott and was turning towards us to go North and he passed without us turning off line.
4	4/24/2010	?	Crabber F/V Loraine C did not attempt to clear gear today as he felt it would be unproductive; intends to clear pots on 4/25. OFCC rep in Newport has the parts for the chart plotter.

TABLE 5-11 FISHING RELATED OBSERVATIONS FOR SEGMENT 4

5.5.4.4 Dumping and Dredging

There were no recorded observations of dumping and dredging activities during the Segment 4 portion of the RSN survey. No activities are expected in these areas per the DTS.

5.5.4.5 Hydrocarbon Exploration

There were no recorded observations of hydrocarbon exploration activities during the Segment 4 portion of the RSN survey. No active hydrocarbon exploration areas were reported in the DTS.

5.5.4.6 Military Activities

There were no recorded observations of military activities during the Segment 4 portion of the RSN survey. No designated military activity areas were reported in the DTS.

5.5.5 Seabed Samples

Table 5-12 summarizes the location of seabed samples along Segment 4 of the RSN survey. Gravity cores were acquired at 10 km intervals, CPTs every 5 km approximately. Detailed records of these samples are included in Appendix B.

Name	Location				Water Depth (m)	Penetration Depth (m)
	Coordinates		UTM Zone 10N			
	Latitude	Longitude	Northing	Easting		
S4-MM-GC-001	44°21.86'N	124°55.08'W	4914136	347206.1	572	>3.0
S4-MM-GC-002	44°24.60'N	124°49.62'W	4919042	354513.2	389	1.28
S4-MM-GC-003	44°27.29'N	124°46.14'W	4923918	359265.9	272	0.93

Name	Location				Water Depth (m)	Penetration Depth (m)
	Coordinates		UTM Zone 10N			
	Latitude	Longitude	Northing	Easting		
S4-MM-GC-003a	44°27.28'N	124°46.14'W	4923903	359294.3	272	2.02
S4-MM-GC-004	44°32.07'N	124°44.52'W	4932720	361624.9	373	1.33
S4-MM-GC-004a	44°32.06'N	124°44.70'W	4932702	361386.7	373	2.27
S4-MM-GC-005	44°33.67'N	124°41.76'W	4935608	365308.1	316	1.15
S4-MM-GC-006	44°37.88'N	124°37.44'W	4943273	371148.5	228	2
S4-MM-GC-006a	44°37.86'N	124°37.50'W	4943244	371113.7	232	1.7
S4-MM-GC-007	44°41.95'N	124°36.66'W	4950793	372330	232	2.27
S4-MM-GC-008	44°46.41'N	124°34.68'W	4959008	375118.9	219	0.82
S4-MM-GC-008a	44°46.44'N	124°34.68'W	4959052	375120.4	219	0.52
S4-MM-CPT-001	44°22.16'N	124°54.06'W	4914649	348528.9	560	Push to 3.01 m
S4-MM-CPT-002	44°23.14'N	124°52.26'W	4916415	350992.7	508	Push to 3.00 m
S4-MM-CPT-003	44°25.71'N	124°47.64'W	4921033	357198.4	305	Push to 3.00 m
S4-MM-CPT-004	44°26.69'N	124°46.44'W	4922808	358829.6	269	Push to 3.00 m
S4-MM-CPT-005	44°28.17'N	124°45.96'W	4925537	359565.2	297	Push to 3.00 m
S4-MM-CPT-006	44°30.73'N	124°45.30'W	4930262	360541.9	366	Push to 3.01 m
S4-MM-CPT-007	44°33.17'N	124°42.96'W	4934707	363680.9	345	Push to 3.00 m
S4-MM-CPT-008	44°34.30'N	124°40.92'W	4936738	366480	303	Push to 3.00 m
S4-MM-CPT-009	44°35.61'N	124°38.52'W	4939106	369681.1	273	Push to 3.00 m
S4-MM-CPT-010	44°37.19'N	124°37.56'W	4942014	370985.7	233	Push to 3.00 m
S4-MM-CPT-011	44°39.38'N	124°37.08'W	4946044	371716.5	231	Push to 3.00 m
S4-MM-CPT-012	44°41.39'N	124°36.78'W	4949768	372226.5	234	Push to 3.00 m
S4-MM-CPT-013	44°43.51'N	124°36.54'W	4953683	372620.9	244	Push to 3.00 m
S4-MM-CPT-014	44°45.53'N	124°36.12'W	4957405	373193.3	266	Push to 3.00 m

Name	Location				Water Depth (m)	Penetration Depth (m)
	Coordinates		UTM Zone 10N			
	Latitude	Longitude	Northing	Easting		
S4-MM-CPT-015	44°46.56'N	124°34.02'W	4959262	376008.1	206	Push to 3.00 m
S4-MM-CPT-016	44°46.27N	124°31.38'W	4958663	379471.6	175	Push to 3.01 m
S4-MM-CPT-017	44°44.82'N	124°29.58'W	4955931	381788.2	148	Push to 3.00 m
S4-MM-CPT-018	44°43.27'N	124°28.56'W	4953040	383081.9	124	Push to 3.01 m
S4-MM-CPT-019	44°41.62'N	124°27.48'W	4949948	384460.5	108	Push to 3.00 m

TABLE 5-12 SEABED SAMPLES SEGMENT 4

5.5.6 Areas of Concern

Areas of concern, as discussed in this report, are defined as regions of outcropping strata or other features that could adversely affect cable installation and burial. Areas of concern are regions where special consideration is required prior to burial; they do not preclude burial.

Areas of exposed strata may hinder burial; one such area is crossed by the route southeast of Primary Node PN1C. Burial may be difficult in these areas. The following table lists the areas of concern for Segment 4

Area	Type	Start Coordinates		End Coordinates		Route Distance (km)	Chart
		Latitude	Longitude	Latitude	Longitude		
S4 a	Exposed strata	44°21.56'N	124°57.09'W	44°21.59'N	124°56.78'W	0.4	RSN.S4.NU.CHART-001B
S4 b	Turbidite channel	44°30.73'N	124°45.27'W	44°30.95'N	124°45.23'W	0.4	RSN.S4.NU.CHART-004B

TABLE 5-13 AREAS OF CONCERN FOR SEGMENT 4

5.5.6.1 Area of Concern S4 a

The route crosses through a patch where the overlying surficial sediment is unmappable within the subbottom profiler records (Figure 5-31 and Figure 5-32). The underlying strata hardness cannot be assessed from geophysical data. There is a possibility that the underlying strata are hard enough to hinder plowing.

5.5.6.2 Area of Concern S4 b

The route crosses a turbidite channel with levees and sand waves on the levees (Figure 5-33 and Figure 5-34). The sand waves are likely relict features; however they may also be the result of strong bottom current flows.

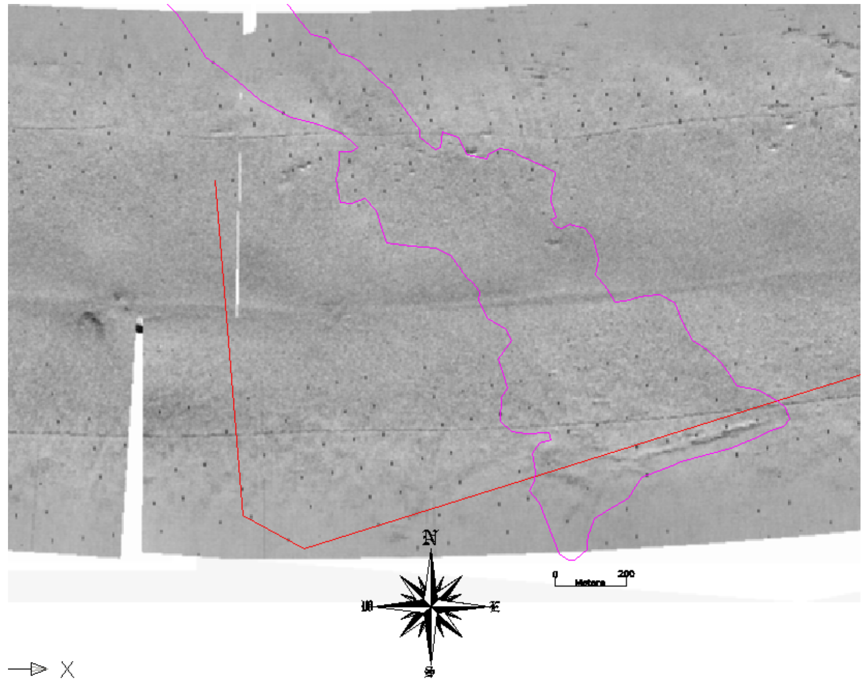


FIGURE 5-31 SONAR IMAGE AOC S4 A

Showing area of outcropping strata of indeterminate hardness.

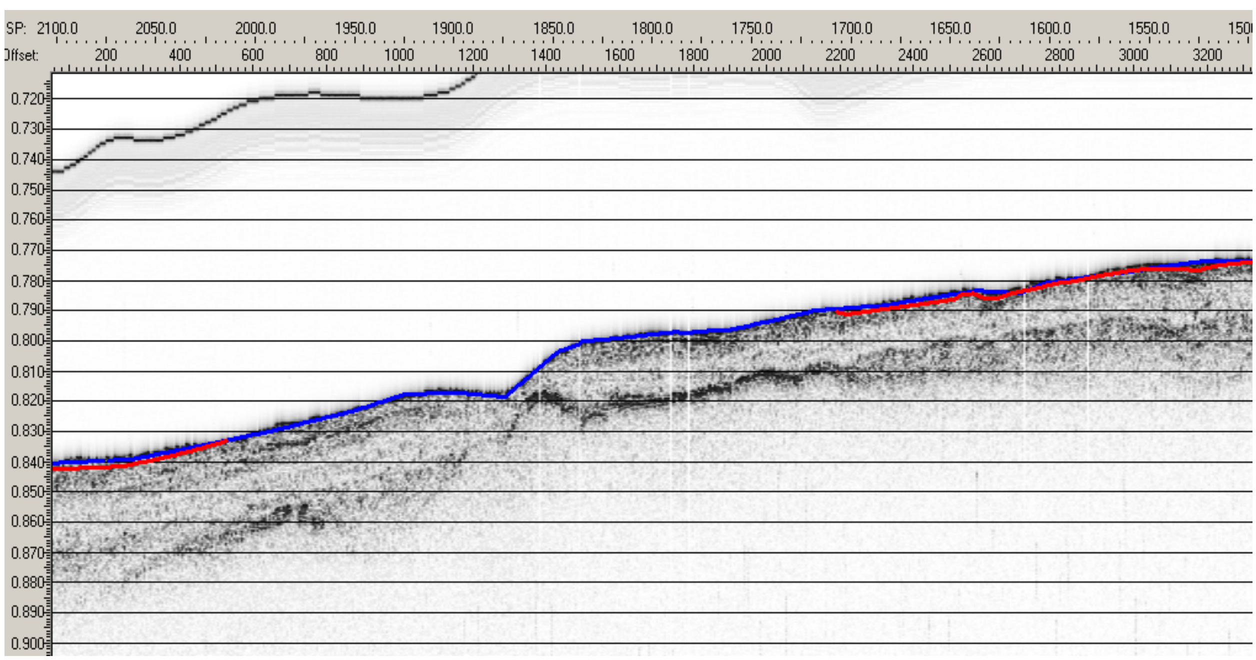


FIGURE 5-32 SUBBOTTOM IMAGE AOC S4 A

Showing area of outcropping strata of indeterminate hardness. Scale lines are 7.6 meters. 'Offset' is horizontal distance in meters. Red lines are base of surficial sediment.

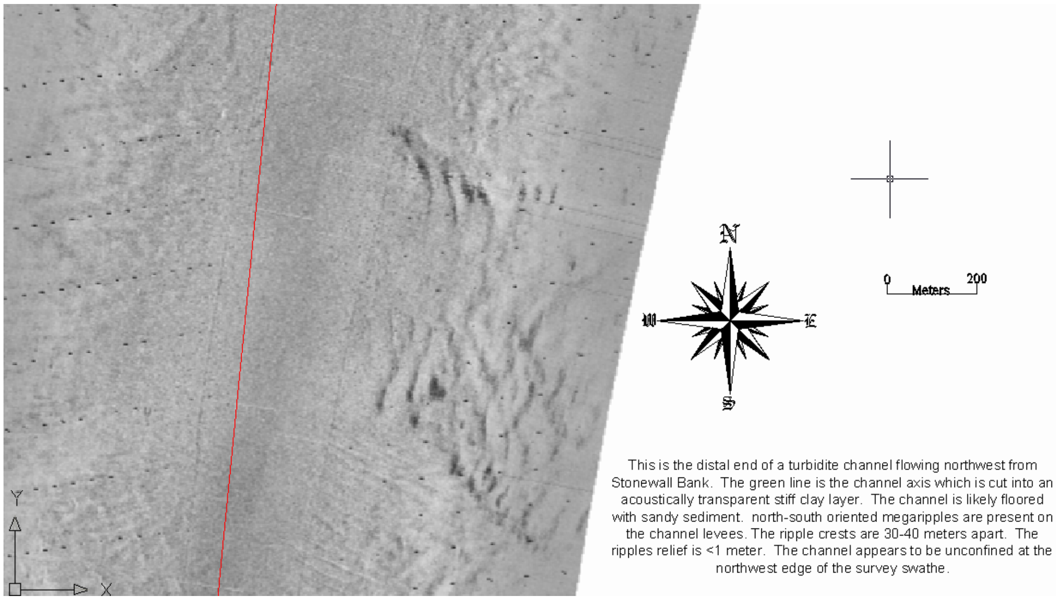


FIGURE 5-33 SONAR IMAGE AOC S4 B

Showing ripples from turbidite channel. The red line is the route

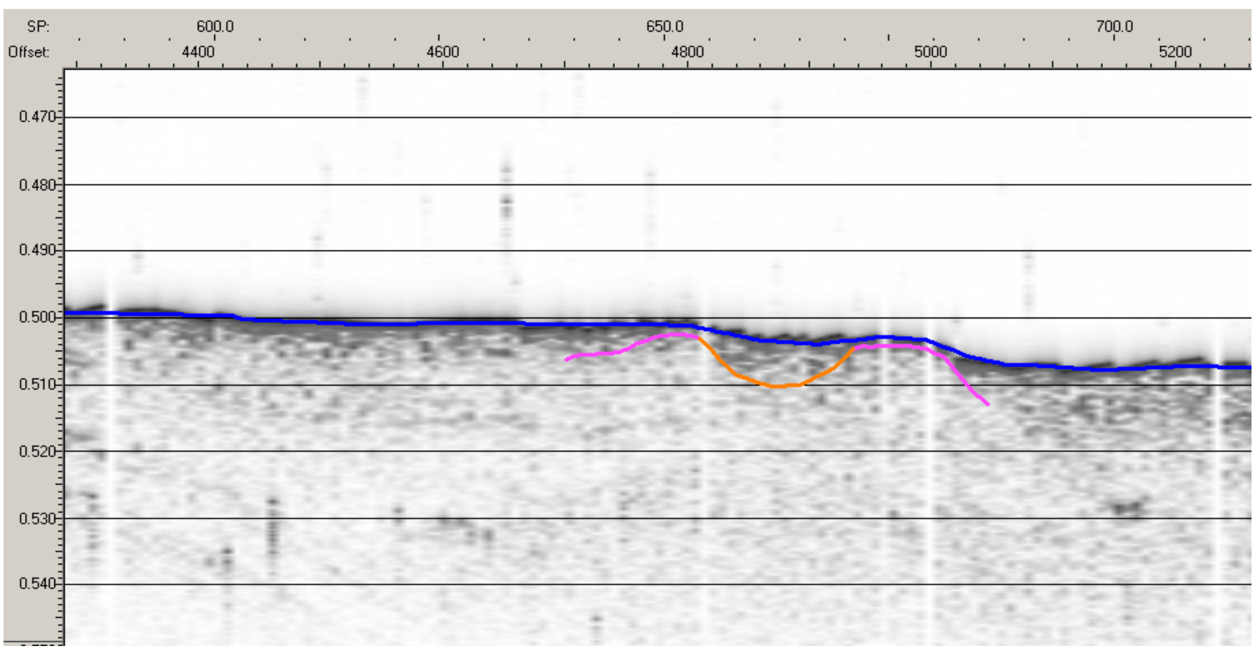


FIGURE 5-34 SUBBOTTOM IMAGE AOC S4 B

The channel basal deposit (gravel) is shown in gold; the levees are shown in pink. South is to the left. Vertical scale lines are 10 msec. (labeled in seconds) 'Offset' indicates horizontal distance in meters

5.5.7 Route Recommendations

There is evidence of bottom fishing within the Segment 4 survey corridor. Trawling and other methods of bottom fishing pose a real and serious hazard to any cable exposed on the seabed between the shoreline and the 1500 m isobath. It is therefore of the utmost importance that the cable be buried where possible even if full burial depth cannot be achieved.

Areas of authigenic carbonate crusts could hinder burial. If possible, these zones should be avoided to maximize burial.

Strata of varying ages and cohesive properties outcrop at or very near the seabed throughout the central part of the Segment 4 survey corridor. Areas of transected ‘outcropping strata’ or ‘undifferentiated sediment’ may have unpredictable plowability. Burial should proceed with extreme caution through these areas.

The route crosses the distal end of a documented turbidite channel. The presence of sand waves within this channel indicates that turbidity flows have occurred sometime in the recent (~10 Ka) past, so the possibility of future flow cannot entirely be ruled out. If such a flow does occur, it could scour and expose a cable. The present route has been deviated west to a less confined area where turbidity flow will be minimized.

5.6 SEGMENT 4NP

5.6.1 Bathymetry

Segment 4NP, offshore Newport, heads approximately 6 km east-northeastward from Primary Node PN1D before turning to the south-southeast (along the northern slopes of Stonewall Bank), where it terminates at Node LV01D (see Figure 5-35).

The route ascends from the 112 m isobath at Primary Node PN1D (RSN.S4NP.NU.CHART-001A) to the 94 m isobath (44°42.26N, 124°21.50’W) at a gradient of 0.20% (0.12°). The route then continues to gradually ascend from the 94 m isobath to the 81 m isobath around 44°40.52’N, 124°19.82’W at a gradient of 0.37% (0.21°). As the route crosses this area, it passes over several arcuate, NNW-oriented ridges and troughs with reliefs of 0.5 to 2 m. Segment 4NP continues from the 81 m isobath to the Low Voltage Node (LV01D) over relatively flat terrain with a gradient of 0.01% (0.01°). LV01D is located at a water depth of 79 m (RSN.S4NP.NU.CHART-003A).

5.6.2 Seabed Features

Sand blankets the seabed with a thickness exceeding 5 m along the entire route. Perhaps the most notable feature is a series of arcuate ridges and troughs that appear on the eastern half of the route (east of 124°21.25’W) where it starts to curve to the south-southeast (Figure 5-35). These ridges and troughs appear to be surficial expression of some kind of structural deformation. A few channels erode these ridge-trough features, while others flow between them (RSN.S4NP.NU.CHART-003B), suggesting that channeling has also been episodic over time. Whatever process caused these ridges and troughs has likely been ongoing, as these features deform recent sediment. The troughs appear to be floored in some locations with coarse sand or possibly gravel.

Pockmarks that were prevalent below the shelf break are sparse in Segment 4NP, possibly because the porosity and permeability of sand is not conducive to pockmark formation and retention.

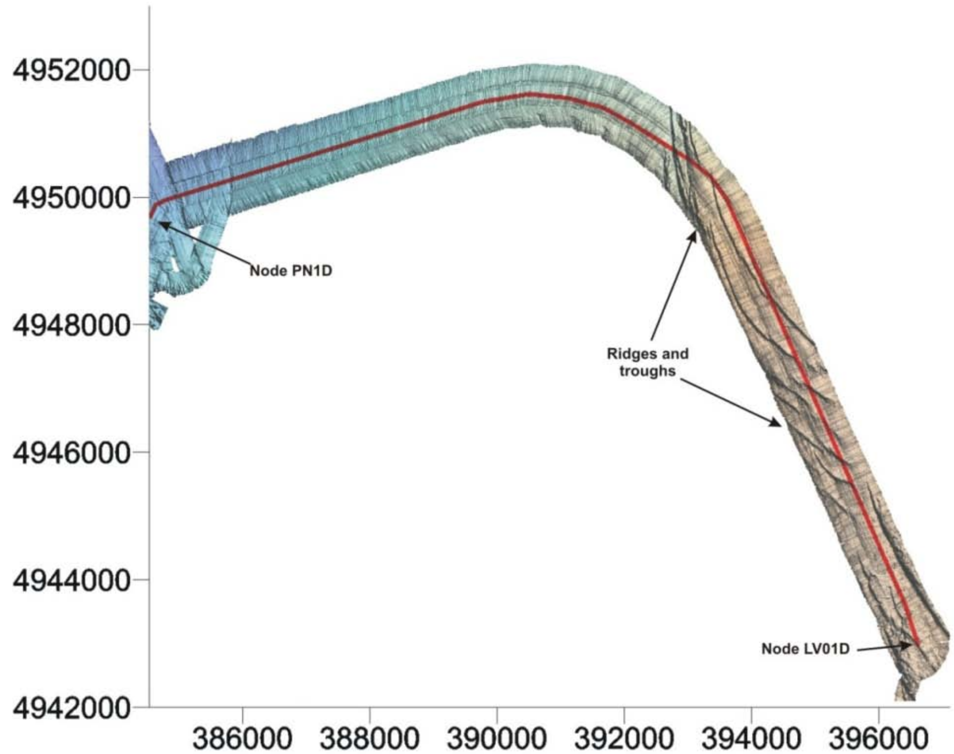


FIGURE 5-35 OVERVIEW MAP OF SEGMENT 4NP

5.6.3 Shallow Geology

The subbottom profiles show a largely featureless, acoustically-amorphous character in the subsurface sediments. Figure 5-36 is a subbottom profile along the centerline across one of the ridge-trough features. The slight darkening of the seabed and shallow sediment in the middle of this image are interpreted as coarse sand or gravel deposited by channels in the middle of the trough. The surrounding sediment is likely finer-grained muddy sand.

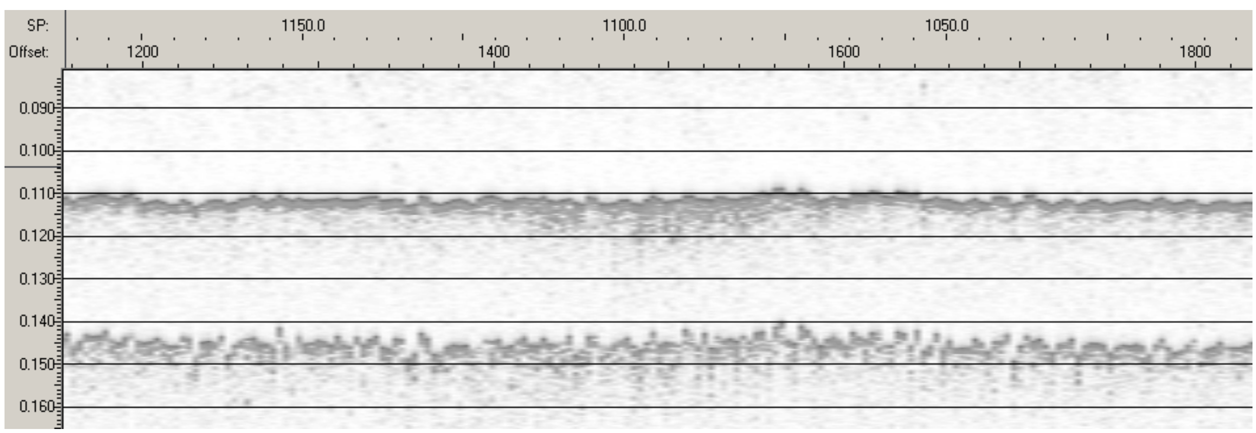


FIGURE 5-36 TYPICAL SUBBOTTOM PROFILE SEGMENT 4NP

Taken along the centerline across one of the ridge-trough features. The slight darkening of the seabed and shallow sediment in the middle of this image is interpreted as coarse sand or gravel deposited by channels in the middle of the trough. Vertical scale lines are 10 msec. (labeled in seconds) 'Offset' indicates horizontal distance in meters.

5.6.4 Hazards and Obstructions

The ridges and troughs and channels present a minor hazard to plowing. These features are likely composed of muddy sand and clay. The floor sediments of the troughs are coarser-grained in most instances (possibly close to gravel-sized particles). The vertical relief can be as high as 2 m between peaks and troughs, and slope gradients are sometimes as high as 3.7% (2.1°). The short crest-to-crest distance of 60-80 m may adversely impact plow performance.

5.6.4.1 Wrecks and Sonar Contacts

There are two (2) sonar contacts within the Segment 4NP survey corridor. One is an unidentified linear object (Contact SSS-Contact-008) and the other is the OSU Buoy NH10. The unidentified contact is linear and may be a length of chain or wire rope. Specific details regarding this contact can be found in Appendix E.

Contact ID	Latitude	Longitude	Dimensions (LxWxH) (m)	Distance from Route (m)	Description
S1-SC-008	44°38.01'N	124°18.53'W	57.5 x 0.3 x 0.0	352	Linear contact, possible length of chain or wire rope
S1-SC-015	44°37.92'N	124°18.18'W	N/A	74	OSU Buoy NH-10

TABLE 5-14 UNIDENTIFIED SONAR CONTACTS WITHIN SEGMENT 4NP

5.6.4.2 Existing and Planned Cables

There are no known cable crossings along the Segment 4NP survey corridor.

5.6.4.3 Fishing Activities

Bottom contact fishing scars are absent from the Segment 4NP survey area. There were no recorded fishing-related observations made during survey operations.

5.6.4.4 Dumping and Dredging

There were no recorded observations of dumping and dredging activities during the Segment 4NP portion of the RSN survey. No activities are expected in these areas per the DTS.

5.6.4.5 Hydrocarbon Exploration

There were no recorded observations of hydrocarbon exploration activities during the Segment 4NP portion of the RSN survey. Active hydrocarbon exploration areas are not identified in this area in the DTS.

5.6.4.6 Military Activities

There were no recorded observations of military activities during the Segment 4NP portion of the RSN survey. Designated military exercise areas are not identified in this area in the DTS.

5.6.5 Seabed Samples

Table 5-15 summarizes the location of seabed samples along the Segment 4NP portion of the RSN survey. Gravity cores were acquired at 10 km intervals and CPTs every 5km. Detailed records of these samples are included in Appendix B.

Name	Location				Water Depth (m)	Penetration Depth (m)
	Coordinates		UTM Zone 10N			
	Latitude	Longitude	Northing	Easting		
S4NP-MM-GC-001	44°40.87'N	124°20.04'W	4948404	394293.7	83	No recovery
S4NP-MM-GC-001a	44°40.85'N	124°20.04'W	4948372	394279	83	No recovery
S4NP-MM-GC-002	44°41.89'N	124°25.92'W	4950416	386581	108	0.30
S4NP-MM-CPT-001	44°42.28'N	124°24.45'W	388499	4951117	102	2.15
S4NP-MM-CPT-002	44°42.21'N	124°21.21'W	392769	4950727	94	2.05
S4NP-MM-CPT-003	44°40.86'N	124°20.04'W	394276	4948380	83	3.00
S4NP-MM-CPT-004	44°38.86'N	124°18.78'W	395879	4944664	80	2.12

TABLE 5-15 SEABED SAMPLES SEGMENT 4NP

5.6.6 Areas of Concern

There are no areas of concern for Segment 4NP. The slopes along the edges of the ridge-trough features may present challenges for the plow if crossed directly, but the low oblique angle that the route crosses these features should mitigate any concerns. It is recommended however that the burial contractor be made aware of these features.

5.6.7 Route Recommendations

Evidence of bottom fishing within the Segment 4NP survey corridor is absent, but fishing activities cannot be ruled out. Trawling and other methods of bottom fishing pose a real and serious hazard to any cable exposed on the seabed between the shoreline and the 1500 m isobath. It is therefore of the utmost importance that the cable be buried where possible, even if full burial depth cannot be achieved.

5.7 SEGMENT 5

5.7.1 Bathymetry

The bathymetric summary of the Segment 5 survey corridor commences seaward from the 40 m isobath (seaward terminus of the inshore discussion) to its terminus at the Primary Node (PN5A) location. See §5.1 for details regarding the results gathered along the Inshore survey portion of the RSN route.

Along the route from the 40 m to 69 m isobaths, the seafloor dips gently and evenly to the west at an average gradient of 0.6% (0.3°; see chart RSN.S5.NU.CHART-002A). From the 69 m isobath (45°11.75'N, 124°7.20'W) to the 95 m isobath (45°11.77'N, 124°4.43'W), the slope dips gently to the west-northwest at an average gradient of 0.7% (0.4°). Superimposed on the slope are several north-northwest trending ridges, which protrude up to 1 m above the surrounding seafloor; however average relief is less than 0.7 m. Local gradients along the flanks of the ridges do not appear to exceed 2.3% (1.3°). The ridges disappear near the 95 m isobath and the seabed becomes generally smooth and featureless, sloping gently to the west across the shelf out to the 190 m isobath at 45°12.80'N, 124°17.82'W. The seabed gradient between the 95 m isobath and the 190 m isobath averages 1.3% (0.75°). Numerous large pockmarks dot the seafloor between 45°12.78'N, 124°17.72'W and 45°12.89'N, 124°18.31'W. Pockmarks within this area reach diameters of 85 m and exhibit depths of no more than 2 m (RSN.S5.NU.CHART-004B). Local gradients at or near the walls of individual pockmarks do appear to exceed 5.0% (2.4°).

The seafloor steepens gradually westward from slope gradients of 1.2% (0.7°) near the 200 m isobath (45°12.90'N, 124°18.55'W) to 11.6% (6.6°) near the 310 m isobath (45°13.27'N, 124°21.06'W; RSN.S5.NU.CHART-005A). The west-sloping seabed gradient then progressively decreases to 0.8% (0.5°) along the 410 m isobath (45°14.90'N, 124°29.5'W; RSN.S5.NU.CHART-006A). Pockmarks, on the order of 50 m across and 0.5 m deep, dot the seabed throughout the part of the route between the 310 m isobath and the 510 m isobath.

The seabed slopes generally to the west at an average gradient of 0.7% (0.4°) between the 410 m isobath and the 500 m isobath (45°16.65'N, 124°39.42'W). The route then curves to the southwest and descends slightly to the 505 m isobath at 45°16.63'N, 124°40.08'W before rising abruptly to the 455 m isobath at 45°16.43'N, 124°41.13'W, where the route crosses a north-northwest plunging ridge. Gradients on the flanks of this ridge are about 7.0% (4.0°) near the route (see chart RSN.S5.NU.CHART-008A). The route descends the western flank of this ridge to about the 485 m isobath at 45°16.27'N, 124°41.75'W, beyond which the route crosses a slight terrace for a distance of about 490 m to the 485 m isobath. The route then descends a slope upon which the gradient progressively increases to 5.2% (3.0°) near the 528 m isobath (45°15.70'N, 124°43.01'W). At this point, the route runs parallel to the contours along the northwestern edge of a small minibasin for a distance of 500 m (RSN.S5.NU.CHART-008A – western edge). The route then rises obliquely along a slight slope to cross a saddle at the 523 m isobath at 45° 15.37'N, 124°43.60'W (RSN.S5.NU.CHART-009A).

From the saddle, the route descends a slope to the 606 m isobath at 45°14.33'N, 124°45.63'W. Numerous small pockmarks – with diameters of 20-30 m across and depths of less than one meter – dot the seabed for the first 1000 m of this descent, but gradually decrease westward. From the 606 m isobath (45°14.33'N, 124°45.63'W), the route crosses a slightly undulating terrace for a distance of 260 m, and then descends another slope to the 634 m isobath at 45°14.13'N, 124°46.22'W, beyond which the route crosses another terrace for a distance of 707 m to the 633 m isobath at 45°14.08'N, 124°46.35'W (see chart RSN.S5.NU.CHART-009A). From this point, the route descends to the 645 m isobath at 45°14.02'N, 124°46.66'W, where it crosses a small terrace for a distance of 660 m before again descending a long, west-dipping slope to the 800 m isobath at 45°13.58'N, 124°49.78'W. Gradients along this descent are in the 3.5-5.2% (2.0-3.0°) range (see chart RSN.S5.NU.CHART-009A). Numerous small pockmarks with diameters 20-30 m and depths of less than one meter dot the seabed along this slope. At this point (800 m isobath), the route proceeds toward the west, and the seabed slope direction begins to change to dip in a northwest direction.

The slope gradient decreases slightly between the 800 m isobath (45°13.85'N, 124°53.05'W) and the 875 m isobath, beyond which the seabed again begins to slope in a westerly direction. The slope gradients increase to 5.2-8.8% (3-5°) as the route descends into a small minibasin at the 999 m isobath (45°14.55'N, 124°55.17'W). The route then turns slightly to the northwest and parallels the 999 m isobath for 335 m before obliquely rising up to the nose of a subtle southwest-plunging ridge at the 994 m isobath (45°14.88'N, 124°55.72'W). From this point, the seabed slopes to the west, and the route descends this slope in a northwest direction. The seabed slope gradient progressively increases to about 8.8% (5.0°) at the 1090 m isobath (45°16.03'N, 124°57.52'W). At this point, the seabed slope direction begins to turn toward the northwest, and the gradient decreases to about 3.5-7.0% (2.0-4.0°). From the 1205 m isobath (45°16.90'N, 124°59.42'W), the seabed gradient progressively increases to a maximum of 20% (11°) along the 1285 m isobath (45°17.17'N, 125°00.17'W), beyond which the northwest slope gradient averages 14% (8.1°) to the 1500 m isobath (45°17.52'N, 125°01.02'W; see chart RSN.S5.NU.CHART-011A).

The route continues to descend this slope until reaching the 1610 m isobath (45°17.72'N, 125°1.80'W), whereupon the route abruptly levels off on an intraslope basin. The route crosses this relatively flat-floored basin in a westerly direction, shifting to the southwest before ascending a ridge that commences at the 1620 m isobath (45°17.27'N, 125°8.92'W) and terminates upon a saddle at the 1470 m isobath (45°17.00'N, 125°09.98'W). Slope gradients near the route approach 21% (12°) south of the route on this ascent (see chart RSN.S5.NU.CHART-012). From the saddle, the route descends into a small basin where the depth is 1810 m (45°16.82'N, 125°13.35'W), rises up onto a north-plunging ridge that it crosses at the 1690 m isobath (45°16.85'N, 125°14.30'W), and descends into an intraslope basin where the depth is 2050 m (45°17.03'N, 125°16.30'W). The route crosses this basin to ascend another ridge, crossing its saddle at a depth of 1630 m (45°17.32'N, 125°19.28'W). From this saddle, the route descends to the abyssal plain of the Cascadia Basin near the 2550 m isobath (45°18.60'N, 125°24.60'W).

The route crosses the relatively flat-floored Cascadia Basin in a northwest direction over a distance of 160 km. Depths along the route range from about 2400 m to 2850 m where the route crosses the Cascadia Sea Channel (45°45.00'N, 127°00.75'W; RSN.S5.NU.CHART-015). The route crosses the Astoria Sea Channel at 45°22.90'N, 125°36.05'W (RSN.S5.NU.CHART-014). This sea channel is not very apparent, indicated only by a slight northward extension of the 2600 m isobath. The planned location of the Primary Node (PN5A) lies in a very flat region of seafloor at a water depth of approximately 2820 m (RSN.S5.NU.CHART-015).

5.7.2 Seabed Features

Near the 40 m isobath, the predominantly terrigenous sand deposits of the Inshore survey become patchy in a region of north/south-trending linear features spaced by about 15 m. These features are interpreted as large ripple marks or sand waves. They are visible in side scan sonar, and extend to a slight slope break near the 63 m isobath (45°11.76'N, 124°03.75'W; Figure 5-37). These ripples occur in a large area mapped as gravel (see chart RSN.S5.NU.CHART-002B and CPT's S5-MM-CPT-001, S5-MM-CPT-001A, and S5-MM-CPT-001B (Appendix B)) and are interpreted as very dense material within the top 0.3 m of record. Given the immeasurably low relief of the sand waves, it is difficult to rule out the possibility that they are instead gravel lag deposits. Since gravel deposits produce more wear on plows than sand, precautions should therefore be taken to account for increased wear throughout this portion of Segment 5. These features are visible in side scan sonar acquired within survey corridor between the 42 and 63 m isobaths (Figure 5-37). The north/south orientation and geometry of the ripples suggest they are formed as a result of wave oscillation. Sand waves are not resolved within the multibeam bathymetry data.

Immediately west of the ripple patch the muddy sand returns with scattered patches of gravel, and some of these form along the western faces of linear, generally northwest-trending ridges. These ridges are present along the route to about the 95 m isobath (45°11.76'N, 124°07.15'W; see chart RSN.S5.NU.CHART-002B). The predominant surficial sediment between the 95 m and 136 m isobaths is medium to dense sand, which grades to silt near the 136 m isobath (45°11.55'N, 124°11.35'W; chart RSN.S5.NU.CHART-002B). The boundary between the sand and silt is rather arbitrary and is based on CPTs and gravity cores acquired to either side of the boundary; there is no clear reflectivity change apparent on the sonar records. Gravity core S5-MM-GC-002 (Appendix B) was acquired at a depth of 158 m, and indicates that seafloor sediments are mostly silt with a significant sand and shell fraction.

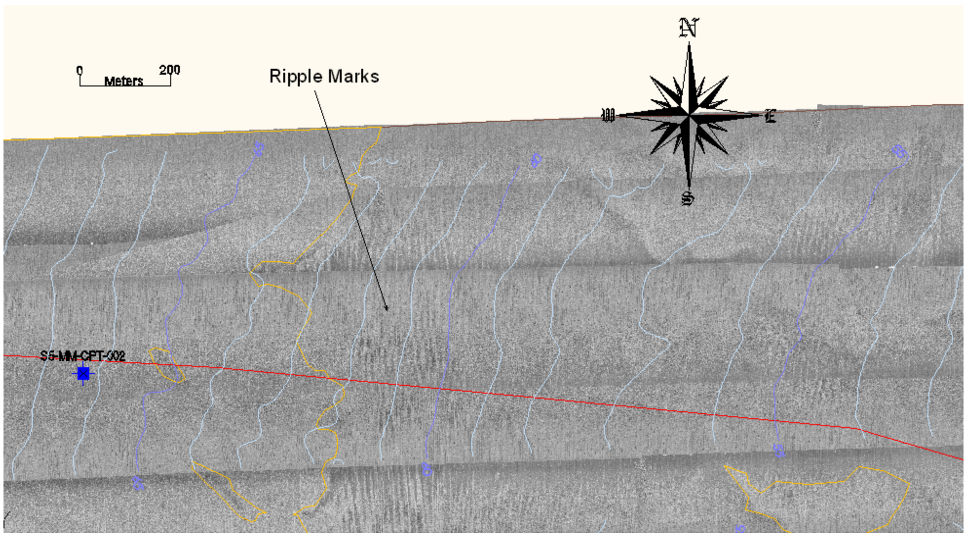


FIGURE 5-37 LINEAR SAND AND GRAVEL FEATURES ON SEGMENT 5

Side scan sonar image of sub-parallel sand/gravel ripples constitute the surface of gravel patch at right; the much larger northwest-trending gravel ridges (yellow patches) appear in the sand at left. The jagged, north-south division between these features marks the exposure of an unconformity. The red line shows Segment 5, and bathymetry is indicated in blue. See RSN.S5.NU.CHART-002B for more information.

The seafloor between the 136 m isobath (45°11.55'N, 124°11.35'W) and the 504 m isobath (45°16.60'N, 124°40.16'W) can be summarized as 37 km of relatively featureless gentle slope dominated by sandy silts (Charts RSN.S5.NU.CHART.004-008A/B). The few features that occasionally break the monotonous seafloor within this portion of the Segment 5 survey corridor include small ripple patches, frequent pockmarks and numerous bottom fishing scars. Diameters of the pockmarks rarely exceed 80 m, and the average diameter is closer to 20 m.

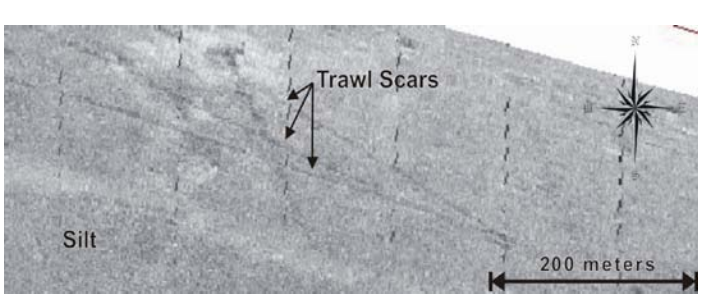


FIGURE 5-38 SSS IMAGE OF SEGMENT 5 TRAWL SCARS

Mappable bottom fishing scars are abundant between the 397 m (45°14.45'N, 124°26.94'W) and 500 m isobaths (45°16.62'N, 124° 39.38'W) as shown in Figure 5-38. Scar lengths and shapes are typical of those made by trawling vessel equipment, but their orientations are uncharacteristic, as the majority of mappable scars are perpendicular to the strike of the slope.

The morphology of the seafloor within the Segment 5 corridor changes west of the 500 m isobath (45°16.62'N, 124°39.38'W) as the route begins a transect of the Cascadia fold and thrust belt (§4.1.2). Regional faulting, folding and erosion have exposed dipping Pleistocene, Pliocene, and Miocene strata (§4.2.1). As the route rises up west of the 500 m isobath, a slight increase in sonar reflectivity is apparent that corresponds with an area mapped as undifferentiated sediment (see RSN.S5.NU.CHART-008B).

Near 45°16.08'N, 124°42.12'W, the route passes through an area charted as outcropping bedrock. The sonar record through this area was acquired with the C3D sonar system, which due to the higher frequency and lower transmit power had a tendency to subdue seabed features relative to the AMS sonar system at 60 kHz (see discussion in §9.1.1). Nevertheless, a faint mottling of the sonar record is sufficiently visible to delineate the boundaries of features interpreted as bedrock outcrops primarily on the basis of corresponding subbottom profiler data (see discussion in the next section). Figure 5-39 shows the route crossing this outcrop area. Gravity core S5-MM-GC005 and CPT S5-MM-CP014 were collected from an area of seafloor interpreted as undifferentiated sediment that lies in small isolated patches within the general outcropping bedrock area (Appendix B). Both samples achieved a penetration of 3.0 m, but while gravity core S5-MM-GC-005 recovered medium sand and silt, CPT S5-MM-CPT-014 indicates the sediment is stiff silt/clay. Outcropping ledges and rocks are not visible, suggesting the bedrock in this particular outcrop may be mantled by a layer of stiff sediment that is not apparent in the subbottom profiler record.

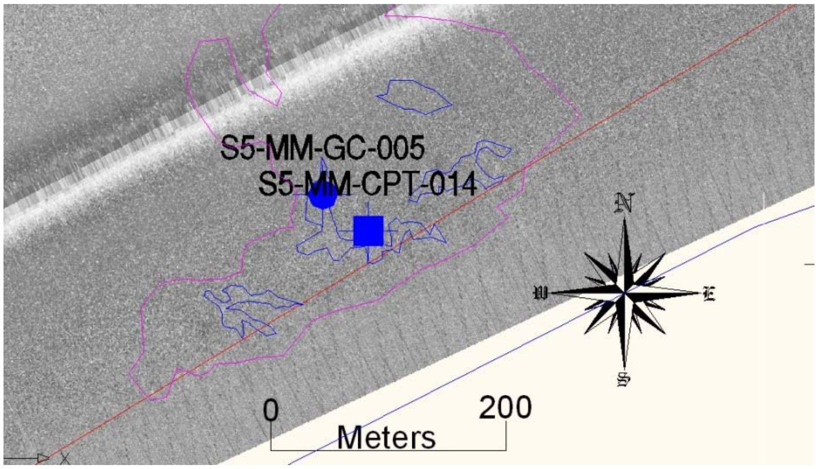


FIGURE 5-39 SIDE SCAN MOSAIC SHOWING OUTCROPS ALONG SEGMENT 5

Side scan sonar image of the route crossing outcrop areas. The red line shows Segment 5, pink lines are outcropping bedrock and the blue lines highlight lower reflectivity undifferentiated sediment patches within the bedrock. See RSN.S5.NU.CHART-008B for more information

The route proceeds southwest from the outcrop area and descends a slope to the southwest to the 528 m isobath (45°15.70'N, 124°43.01'W). At this point the route runs parallel to the contours along the northwestern edge of a small minibasin infilled with unconsolidated silt for a distance of 500 m. Where the route climbs out of this minibasin, it crosses into a patch mapped as undifferentiated sediment beginning about 45°15.5'N, 124°43.42'W.

The route rises up a slight slope to cross a saddle at the 523 m isobath at 45°15.37'N, 124°43.60'W. Below this saddle, the route descends a slope covered with numerous pockmarks. It is interesting to note that these pockmarks are elongated towards the southwest (i.e. downslope). Figure 5-40 depicts the route crossing this pockmark field. The elongated pockmarks probably indicate a strong bottom current flowing downslope (toward the southwest).

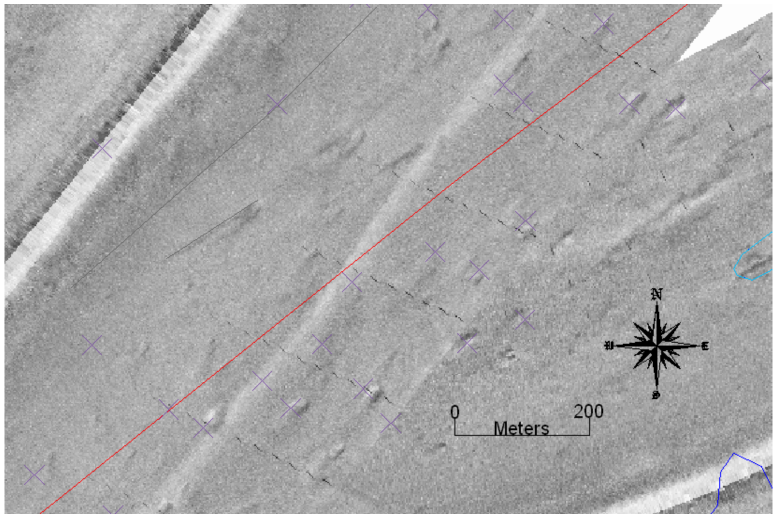


FIGURE 5-40 SIDE SCAN MOSAIC SHOWING ELONGATED POCKMARKS

Side scan sonar image of the route crossing pockmark field. Pockmarks are elongated to the southwest (downslope). The red line shows Segment 5.

The route crosses over an area mapped as sand at 45°14.73'N, 124°44.72'W. The crossing point occurs where two linear depressions (trenches) join together (see Figure 5-41). The depressions are about 0.5 m deep. The southernmost depression is oriented to the southwest, possibly related to scouring there, and the westernmost is oriented to the south. There is no evidence that these depressions are related to mass movement (e.g. no depositional lobes). Sand is inferred at the bottoms of these depressions, as evidenced by an increase in sonar reflectivity on the depression floors. If these features are scours, then a sand lag deposit would not be unusual. These depressions incise sediment classified as undifferentiated; CPT S5-MM-CPT-015 recorded medium to dense sand over stiff clay/silt.

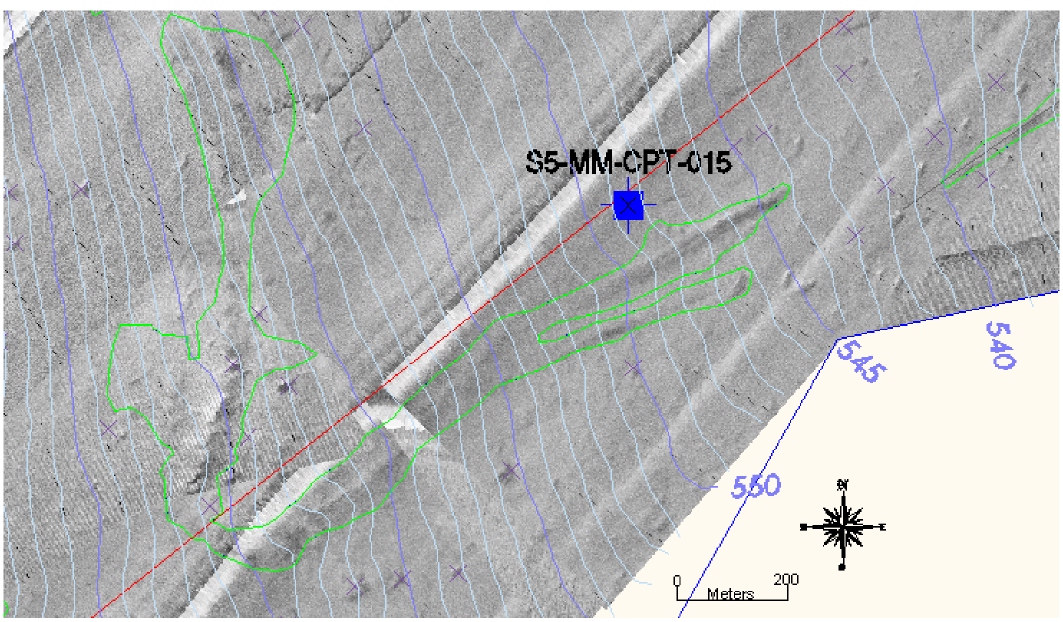


FIGURE 5-41 SIDE SCAN MOSAIC SHOWING LINEAR DEPRESSIONS

Side scan sonar image of the route, crossing two depressions that join together at the route crossing point. Sand is inferred at the bottoms of these depressions. The red line is Segment 5.

At 45°14.62'N, 124°44.92'W, the route crosses from undifferentiated sediments onto an area mapped as unconsolidated silt/clay. This change is primarily indicated by the presence of a mappable layer on the subbottom profiler (discussed in the next section); the side scan shows only a minor decrease in sonar reflectivity to the southwest across this boundary. The unconsolidated silt again transitions to undifferentiated sediment near 45°14.31'N, 124°45.75'W. The route passes through a gap between two areas of outcropping strata before encountering another field of unconsolidated silt/clay at 45°14.13'N, 124°46.20'W (see in Figure 5-42). This area lies on a slope where the route descends from one terrace to another (discussed in the previous section). It is interesting to note the elongated pockmarks in Figure 5-42 occur where the slope breaks just below the upper terrace. Two ridges plunge to the north in the southern edge of the survey area and bedrock outcrops at the western flanks of these ridges.

The route crosses another 242 m stretch of undifferentiated sediment beginning at 45°14.20'N, 124°54.27'W. The sonar reveals only a slight (nearly imperceptible) increase in reflectivity, and the subbottom profiler shows dipping faint reflectors coming to the surface here (discussed in the next section). Two more patches of undifferentiated sediment appear at about 45°17.15'N, 125°00.15'W and 45°17.60'N, 125°1.50'W. These patches again are not clearly apparent on the side scan sonar, and the boundaries are drawn based on subbottom profiler data (see below).

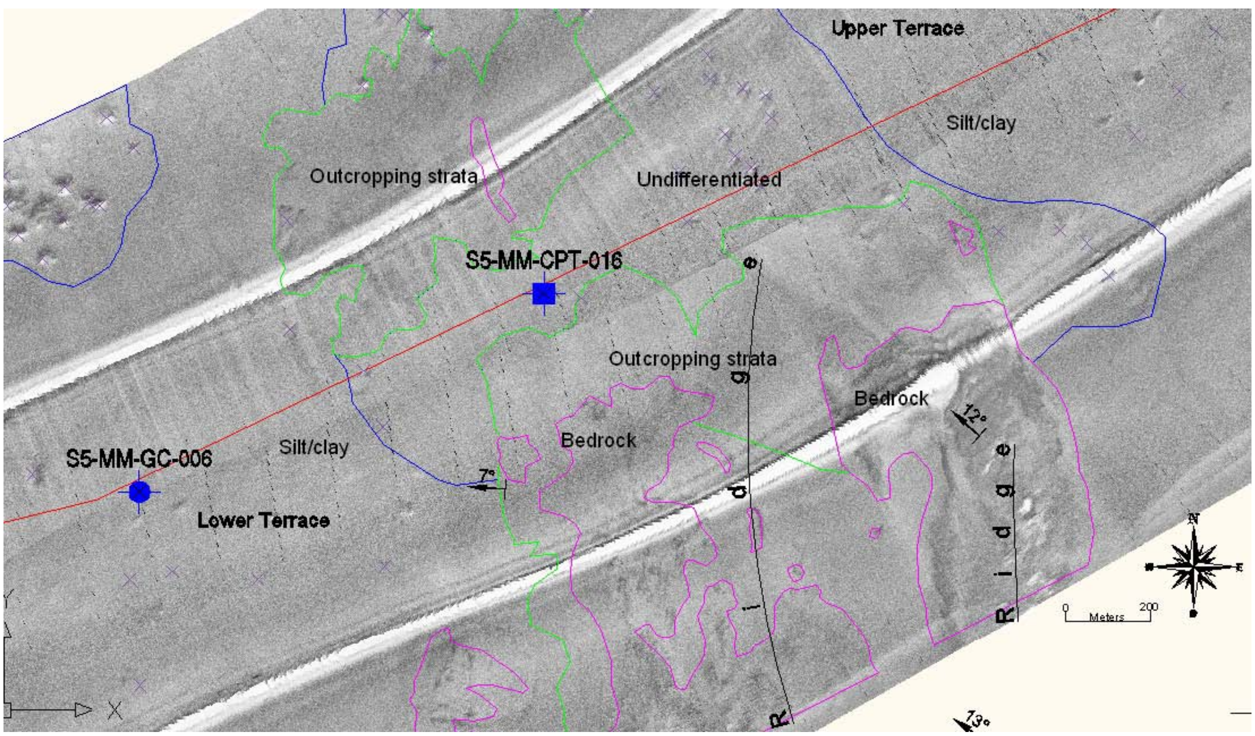


FIGURE 5-42 SIDE SCAN MOSAIC SHOWING BEDROCK AND OUTCROPPING STRATA

Side scan sonar image of the route, crossing undifferentiated sediments as it descends a slope between two terraces. Blue line is undifferentiated sediment, outcropping strata is green and bedrock is pink. The red line is Segment 5.

5.7.3 Shallow Geology

At approximately 45°11.68'N, 124°00.86'W, the loose sandy surficial sediment identified in the Inshore survey corridor (§5.1.3) onlaps and pinches out against an older layer of sand and gravel that is exposed on the seabed west of this point. Neither the thickness nor hardness of this unit is evident in the geophysical data, but a cone penetrometer test taken to the south (S1-

MM-CPT-001) was refused at a depth of 1.55 m at 45°11.56'N, 124°01.02'W. Gravel and sand patches dominate the seabed to near 45°11.75'N, 124°03.75'W. A number of CPTs taken in this area had various penetrations ranging from 0.17-3.0 m; all recorded medium to dense (sand/gravel) and sometimes stiff (clay) at depth. Superimposed on this surface are the sub-parallel sand waves discussed in §5.7.2. The sandy sedimentary cover resumes at 45°11.75'N, 124°03.75'W along with northwest-oriented sand/gravel waves (see §5.7.2) that are indicated in the subbottom profiler data by a faint sub-seabed reflector at a depth of about 1 m (Figure 5-43). This reflector degrades westward into a somewhat discontinuous series of reflections. Figure 5-43 is a profile along the centerline taken near 45°11.83'N, 124°05.58'W that shows the base of the surficial sediment along a discontinuous horizon, with gravel evidenced by a slight darkening of the seabed signature. CPTs S5-MM-CPT-002 and S5-MM-CPT-003 both recorded medium to very dense material (sand; see charts RSN.S5.NU.CHART-002B and RSN.S5.NU.CHART-003B).

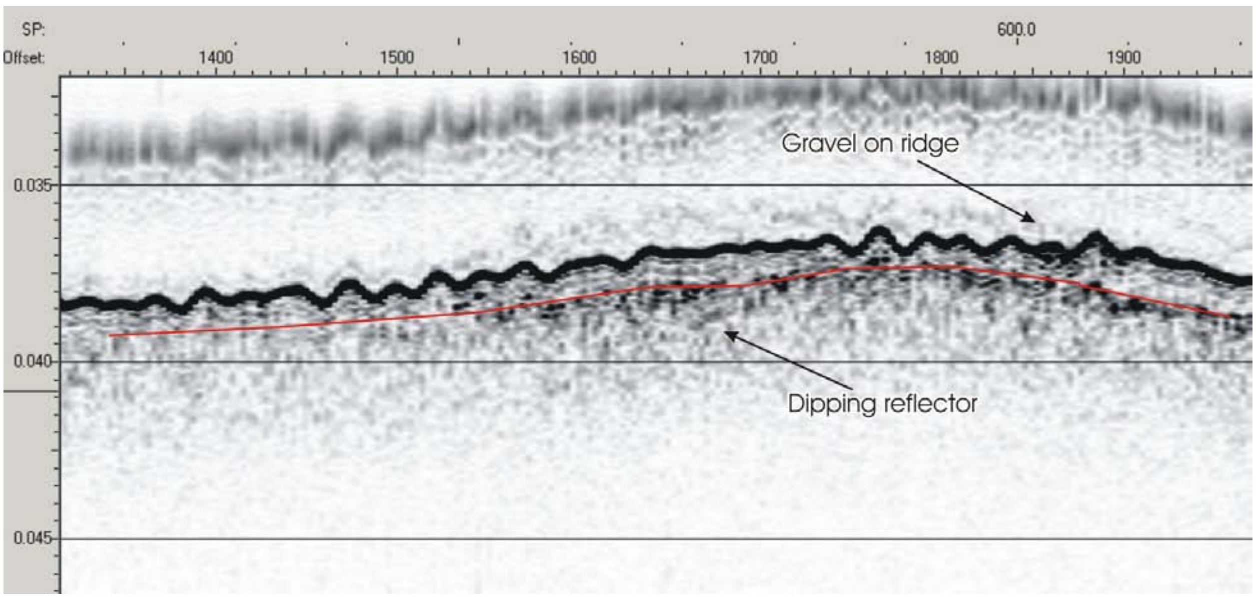


FIGURE 5-43 SUBBOTTOM PROFILE SHOWING SURFICIAL SEDIMENTS

Subbottom profiler image showing base of surficial sediments (red line) and a gravel patch on the seabed. West is to the left. Vertical scale lines are 10 msec. 'Offset' indicates horizontal distance in meters.

The erosional unconformity seen along Segment 1 to the south cannot be resolved in the subbottom profiler records in the area between 45°11.63'N, 124°09.75'W and 45°14.57'N, 124°27.45'W. From 45°11.55'N, 124°11.33'W, the surficial sediment grades from silty sand to silt, and no reflectors are evident in the subsurface to indicate that this sediment type changes with depth. The delineated boundary between these sediment types is therefore rather arbitrary, and is based on CPTs and gravity cores acquired on either side; there is no clear reflectivity change apparent on the sonar records. Gravity core S5-MM-GC-002 (Appendix B) was acquired at a depth of 158 m, and indicates that seafloor sediments are mostly silt with a significant sand and shell fraction. CPT S5-MM-CPT-004 indicates the sediment is medium stiff to hard (silt/clay), and CPT S5-MM-CPT-005 indicates very soft to hard (silt/clay; see chart RSN.S5.NU.CHART-004B); the subbottom profiler is reflection free between them.

As surficial sediments fine to the west, the acoustic signal achieves more apparent penetration, and the subbottom profiler data resolve a reflector at depth (>15 m beneath the seabed), commencing about 45°13.43'N, 124°21.92'W. CPT S5-MM-CPT-006, taken about 3.8 km east of this point, recorded medium to dense sediment (sand/silt) over stiff to hard (silt/clay) sediment. CPT S5-MM-CPT-007, taken 1.2 km west of this point, recorded medium stiff to stiff sediment (silt/clay; see chart RSN.S5.NU.CHART-005B) as did gravity core S5-MM-GC003 and CPT S5-MM-CPT-008 farther to the west (see chart RSN.S5.NU.CHART-006B).

At 45°14.57'N, 124°27.45'W, the subbottom reflector seen at depth (>15 m) farther to the east (e.g. 45°13.43'N, 124°21.92'W), rises to within 5 m of the seabed. This reflector is the basis for the isopach contours on charts RSN.S5.NU.CHART-006B through RSN.S5.NU.CHART-008B. Figure 5-44 shows this reflector as well as the location of S5-MM-CPT-008, which recorded medium stiff to stiff sediment (silt/clay). As the route progresses to the northwest, CPTs S5-MM-CPT-009 through S5-MM-CPT-012 recorded soft to medium stiff, medium stiff to stiff, stiff, and medium stiff to stiff sediments, respectively. Gravity core S5-MM-GC-004 reported very soft to very stiff clayey silt.

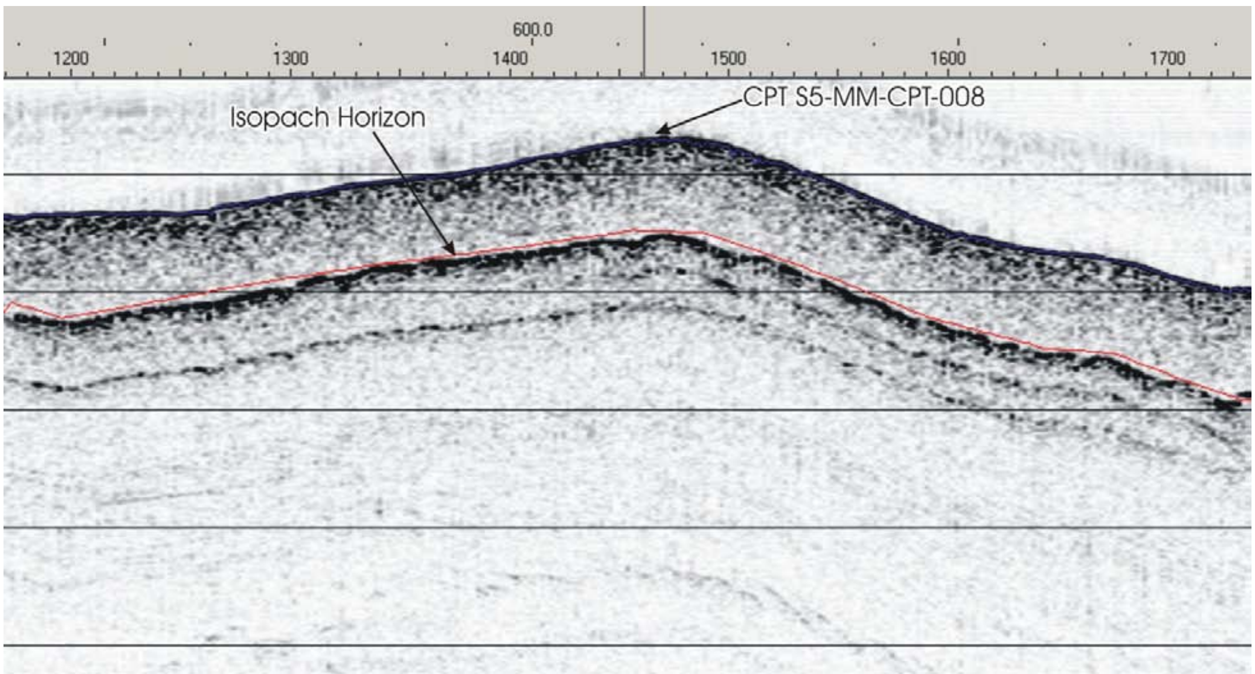


FIGURE 5-44 SUBBOTTOM PROFILE SHOWING SURFICIAL SEDIMENT AND UNDERLYING REFLECTORS

Subbottom profiler image showing base of surficial sediments (red line) and CPT location. Northwest is to the left. Vertical scale lines are 10 msec. 'Offset' indicates horizontal distance in meters.

The surficial sediment layer thins abruptly and pinches out at 45°16.61'N, 124°40.33'W on approach to a hill west of this point. The reflectors (strata) that underlie the isopach horizon outcrop the seabed from this point westward. These outcropping sediments are classified as undifferentiated sediments on chart RSN.S5.NU.CHART-008B. Figure 5-45 depicts the pinch-out of the surficial isopach layer and the closely-spaced reflectors that outcrop to the west of it. Some of the underlying reflectors appear to diverge toward the east.

The closely-spaced character of the reflectors that outcrop (Figure 5-45) suggests these sediments may be interbedded sand and silt layers. CPT S5-MM-CPT013 recorded medium to dense (sand) over very stiff (silt/clay).

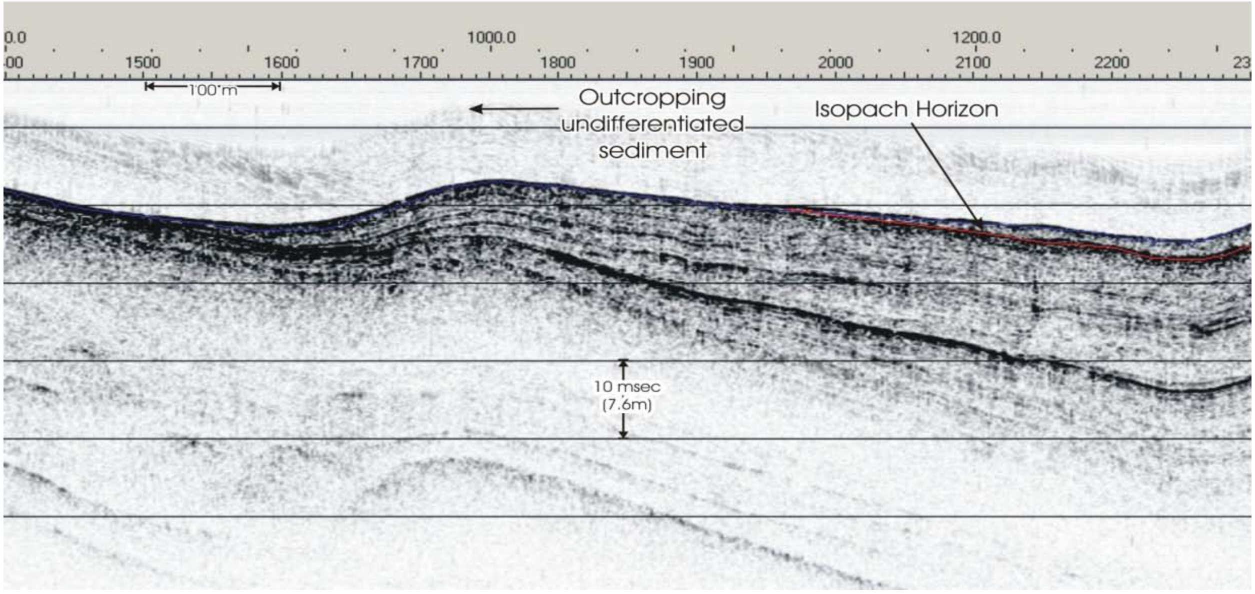


FIGURE 5-45 SUBBOTTOM PROFILE SHOWING PINCH-OUT OF SURFICIAL SEDIMENT

Subbottom profiler image showing pinch-out of surficial sediments (red line). West is to the left.

As discussed in the previous section, near 45°16.08'N, 124°42.12'W, the route passes through an area charted as outcropping bedrock (chart RSN.S5.NU.CHART-008B). Figure 5-46 is taken from a subbottom profiler line that crosses this outcrop 95 m northwest of the route (this is the closest subbottom profiler line to the route). In Figure 5-46, the top of the bedrock is indicated by a heavy dark reflection. A few hints of steeply-dipping reflectors appear within the bedrock. The arcuate (parabolic) reflections within the bedrock to the right may be caused by gas.

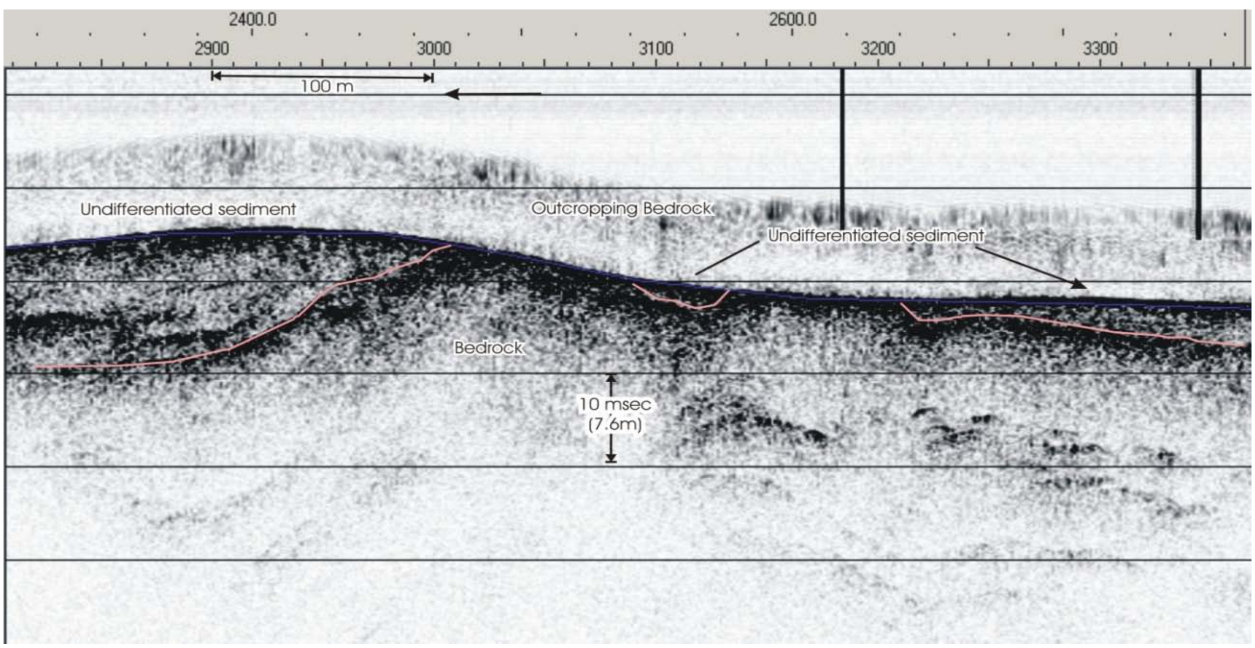


FIGURE 5-46 SUBBOTTOM PROFILE SHOWING OUTCROPPING BEDROCK

Subbottom profiler image showing bedrock outcrops. The top of the bedrock is defined by the pink lines. Southwest is to the left.

As mentioned in the previous section, as the route proceeds southwest from the bedrock outcrop, it descends into a mini-basin (45°15.70'N, 124°43.01'W) infilled with unconsolidated sediments, which have been mapped with isopach contours on chart RSN.S5.NU.CHART-009B. This unconsolidated surficial sediment lies conformably on acoustically-amorphous, undifferentiated sediments, which have been interpreted from CPT S5-MM-CPT-015 as medium to very dense (sand) over stiff (silt/clay). Internal reflections are not apparent in the subbottom profiles to define the interface between sand and silt/clay.

At 45°14.62'N, 124°44.92'W, the route crosses from undifferentiated sediments onto an area mapped as unconsolidated silt/clay. The subbottom profiler shows a layer of acoustically-transparent material conformably overlying a strong acoustic reflector that conformably overlies a thick sedimentary sequence characterized by low amplitude, parallel reflectors. The strong acoustic reflector outcrops at 45°14.31'N, 124°45.75'W, and the underlying reflectors outcrop the seabed to the west of this point. These reflectors (undifferentiated sediment) unconformably rest on folded strata that outcrop to either side of the route (see chart RSN.S5.NU.CHART-009B). These strata overlie tightly folded bedrock strata, which outcrop as ledges to the south (southern margin of the survey area). The bedrock forms a north-plunging ridge that lies about 15 milliseconds (11 m) beneath the seabed where the route crosses. Figure 5-47 is taken from the nearest subbottom profiler line to the route (~160 m north of the route).

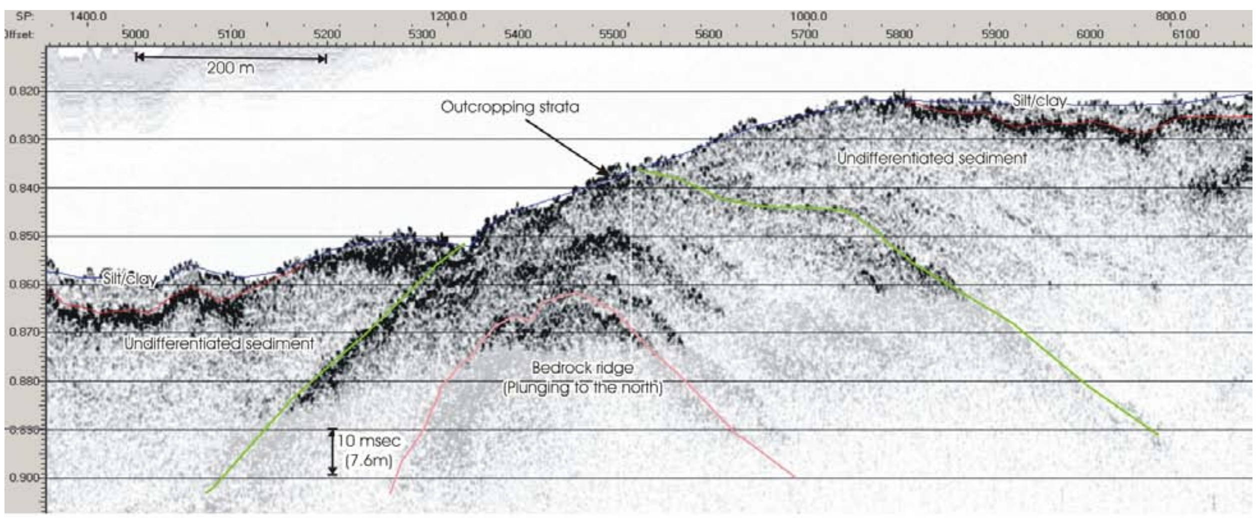


FIGURE 5-47 SUBBOTTOM PROFILE SHOWING OUTCROPPING STRATA

Subbottom profiler image showing a buried bedrock ridge, overlying deformed strata, undifferentiated sediment and surficial silt/clay. The top of the bedrock is defined by the pink line, top of strata by the green line, and the base of the surficial silt/clay (or top of undifferentiated sediment) is the red line. Southwest is to the left.

The route crosses a 242 m stretch of undifferentiated sediment beginning at 45°14.20'N, 124°54.27'W. The subbottom profiler data indicate that a few faint reflectors come to the surface here. These reflectors have very low amplitudes, suggesting that the undifferentiated sediments have very similar properties to the surrounding silt/clay. A gravity core taken nearby (S5-MM-GC-007) recovered very soft to stiff clayey silt.

Two more patches of undifferentiated sediment are crossed before the end of burial (see chart RSN.S5.NU.CHART-0011B). One patch at about 45°17.15'N, 125°00.15'W is depicted in Figure 5-48; a profile from a line run east-west across the undifferentiated sediment patch south of the route. The north-plunging bedrock ridge outcrops the seabed at the southern margin of the survey area. CPT S5-MM-CPT-021 was taken in this patch and recorded stiff silt/clay. A gravity core taken in this patch (S5-MM-GC-008) recorded soft to very stiff silt. The other exposed strata area is located just to the west at 45°17.60'N, 125°01.50'W. Again, the same undifferentiated sediments are erosionally exposed here.

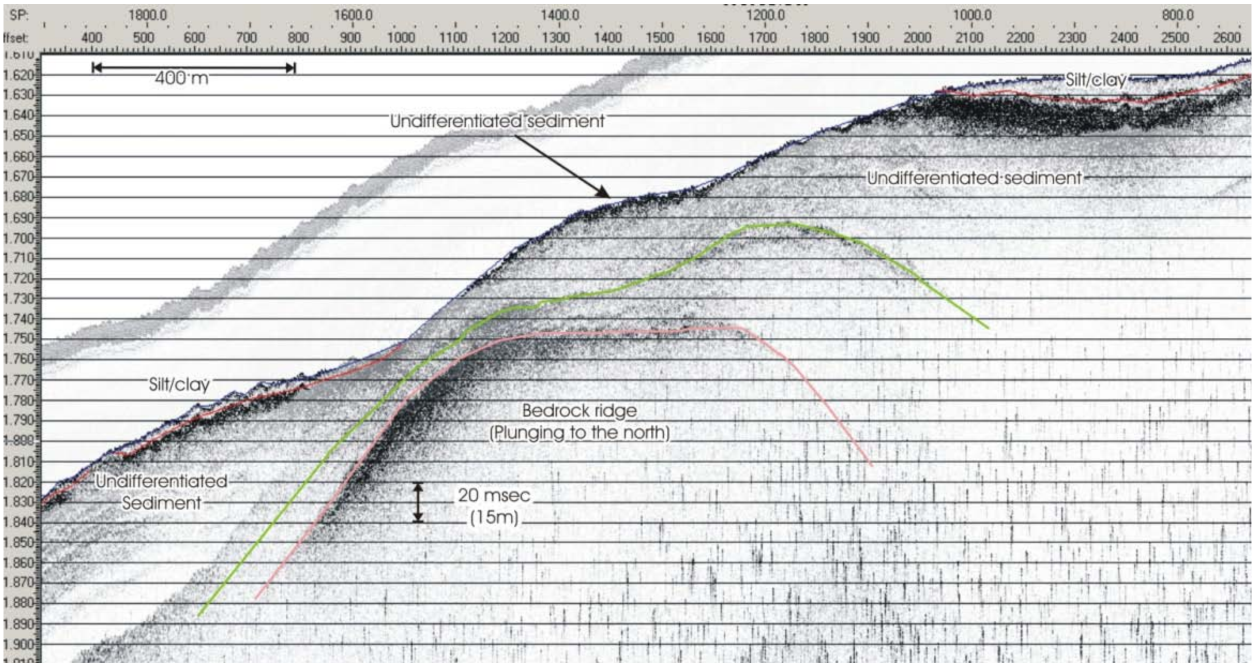


FIGURE 5-48 SUBBOTTOM PROFILE SHOWING OUTCROPPING STRATA

Subbottom profiler image showing a buried bedrock ridge, overlying deformed strata, undifferentiated sediment and surficial silt/clay. The top of the bedrock is defined by the pink line, top of strata by the green line, and the base of the surficial silt/clay (or top of undifferentiated sediment) is the red line. West is to the left.

5.7.4 Hazards and Obstructions

5.7.4.1 Wrecks and Sonar Contacts

Six (6) unidentified sonar contacts are located within the Segment 5 survey corridor, one within 103 m of the survey route. Contacts are summarized in the following table. For complete details, see Appendix E.

Contact ID	Latitude	Longitude	Dimensions (LxWxH) (m)	Distance from Route (m)	Description
S5-SC-004	45°13.63'N	124°21.92'W	6.6 x 1.2 x 0.4	339	Linear object protruding from the seafloor
S5-SC-005	45°14.10'N	124°24.49'W	13.6 x 1.3 x 0.0	254	Partially buried linear object
S5-SC-006	45°14.56'N	124°27.06'W	2.9 x 1.0 x 1.3	136	Nondescript object protruding from the seafloor
S5-SC-007	45°16.59'N	124°38.36'W	14.3 x 10.9 x 0.1	103	Group of nondescript objects lying on the seafloor

Contact ID	Latitude	Longitude	Dimensions (LxWxH) (m)	Distance from Route (m)	Description
S5-SC-009	45°15.19'N	124°43.69'W	6.4 x 1.7 x 0.6	217	Nondescript object protruding from a shallow depression
S5-SC-011	45°15.34'N	124°55.27'W	15.7 x 0.6 x 0.1	1017	Nondescript linear object protruding slightly from the seafloor
S5-SC-014	45°13.91'N	124°24.50'W	3	175	Core weights and pipe

TABLE 5-16 SONAR CONTACT SUMMARY FOR SEGMENT 5

5.7.4.2 Existing and Planned Cables

The Segment 5 survey route crosses three existing fiber optic cables (Table 5-17). All cables are in service. Existing cables were not identified within the survey data.

Segment	Cable Name	Latitude	Longitude	Water Depth (m)	Crossing Angle	Remarks
5	VSNL Pacific Seg G5	45°17.08'N	125°16.67'W	2045	72°	Crossing not identified within geophysical data
5	Southern Cross Seg F	45°23.12'N	125°36.49'W	2575	73°	Crossing not identified within geophysical data
5	PC 1 Seg E	45°34.24'N	126°17.57'W	2660	73°	Crossing not identified within geophysical data

TABLE 5-17 CABLE CROSSING TABLE FOR SEGMENT 5

5.7.4.3 Fishing Activities

The number of bottom contact fishing scars mapped within the Segment 5 survey corridor decrease in frequency with distance from the area known to local fisherman as 'the Nose' (Figure 4-1). These scars range from parallel to perpendicular to the slope contours. Fishing related activities that were observed and reported during the survey of Segment 5 are summarized in Table 5-18.

Segment	Date	Time	Notes
5	4/10/2010	22:30	Forced to alter course for fishing vessel at 22:30 local resulting in data gap.

TABLE 5-18 FISHING RELATED OBSERVATIONS FOR SEGMENT 5

5.7.4.4 Dumping and Dredging

There were no recorded observations of dumping and dredging activities during the Segment 5 portion of the RSN survey. No dumping or dredging areas are identified in the DTS in the vicinity of Segment 5. No activities are expected in these areas per the DTS.

5.7.4.5 Hydrocarbon Exploration

There were no recorded observations of hydrocarbon exploration activities during the Segment 5 portion of the RSN survey. No active hydrocarbon exploration areas are identified in the DTS in the vicinity of Segment 5.

5.7.4.6 Military Activities

There were no recorded observations of military activities during the Segment 5 portion of the RSN survey. No military exercise areas are identified in the DTS in the vicinity of Segment 5.

5.7.5 Seabed Samples

Table 5-19 summarizes the location of seabed samples and CPTs completed along Segment 5. Gravity cores (GC) were taken at 10 km intervals. Cone penetrometer readings were acquired at approximately 5 km intervals. In areas where gravity cores could not be achieved, grab samples were taken. Detailed description of sample results can be found in Appendix B.

Name	Location				Water Depth (m)	Penetration Depth (m)
	Coordinates		UTM Zone 10N			
	Latitude	Longitude	Northing	Easting		
S5-MM-GC-001	45°11.93'N	124°00.54'W	5005538	420777.0	45	No recovery
S5-MM-GC-001a	45°11.93'N	124°00.54'W	5005549	420755.7	45	No recovery
S5-MM-GC-002	45°11.74'N	124°13.44'W	5005411	403845.2	158	0.94
S5-MM-GC-003	45°13.91'N	124°24.48'W	5009663	389447.3	388	Lost weights/pipe
S5-MM-GC-004	45°15.46'N	124°31.98'W	5012713	379747.7	429	2.95
S5-MM-GC-005	45°16.13'N	124°42.18'W	5014227	366437.0	488	3
S5-MM-GC-006	45°14.06'N	124°46.38'W	5010519	360818.5	634	3.19
S5-MM-GC-007	45°14.17'N	124°53.94'W	5010933	350936.7	908	3
S5-MM-GC-008	45°17.22'N	125°3.18'W	5016888	339028.6	1322	2.5
S5-MM-GS-001	45°11.92'N	124°0.54'W	5005528	420747.6	44	No recovery
S5-IN-GS-001	45°11.74' N	124°0.53' W	5005174.6	420751.69	40	Grab Sample
S5-IN-GS-002	45°11.88' N	123°59.71' W	5005427.7	421837.58	28	Grab Sample
S5-IN-GS-003	45°11.95' N	123°59.14' W	5005557.5	422577.59	19	Grab Sample
S5-IN-GS-004a	45°12.01' N	123°59.85' W	5005649.2	422964.95	15	Grab Sample
S5-IN-GS-005	45°11.99' N	123°58.66' W	5005624	423210.74	10	Grab Sample

Name	Location				Water Depth (m)	Penetration Depth (m)
	Coordinates		UTM Zone 10N			
	Latitude	Longitude	Northing	Easting		
S5-MM-CPT-001	45°11.84'N	124°1.86'W	5005385	419060.1	49	Refusal at 0.54 m
S5-MM-CPT-001a	45°11.84'N	124°1.86'W	5005396	419052.4	48	Refusal at 0.37 m
S5-MM-CPT-001b	45°11.82'N	124°1.86'W	5005352	419036.1	49	Refusal at 0.36 m
S5-MM-CPT-002	45°11.76'N	124°4.20'W	5005280	415995.0	67	Push to 2.04 m
S5-MM-CPT-003	45°11.72'N	124°8.16'W	5005262	410794.0	105	Refusal at 2.88 m
S5-MM-CPT-004	45°11.57'N	124°11.76'W	5005076	406022.4	141	Push to 3.03 m
S5-MM-CPT-005	45°12.20'N	124°15.42'W	5006314	401288.2	171	Push to 3.00 m
S5-MM-CPT-006	45°13.00'N	124°19.08'W	5007857	396537.2	210	Push to 3.00 m
S5-MM-CPT-007	45°13.60'N	124°22.80'W	5009049	391688.1	373	Push to 3.00 m
S5-MM-CPT-008	45°14.36'N	124°26.46'W	5010539	386899.8	399	Push to 3.00 m
S5-MM-CPT-009	45°15.09'N	124°30.18'W	5011993	382094.6	419	Push to 3.00 m
S5-MM-CPT-010	45°15.83'N	124°33.84'W	5013449	377327.5	445	Push to 3.00 m
S5-MM-CPT-011	45°16.42'N	124°36.78'W	5014617	373488.3	470	Push to 3.00 m
S5-MM-CPT-012	45°16.62'N	124°39.78'W	5015066	369531.2	503	Push to 3.00 m
S5-MM-CPT-013	45°16.41'N	124°41.16'W	5014722	367740.3	455	Push to 3.01 m
S5-MM-CPT-014	45°16.12'N	124°42.12'W	5014196	366475.6	487	Push to 3.00 m
S5-MM-CPT-015	45°14.90'N	124°44.46'W	5012003	363411.6	548	Push to 3.02 m
S5-MM-CPT-016	45°14.20'N	124°46.02'W	5010755	361299.5	617	Push to 3.00 m
S5-MM-CPT-017	45°13.66'N	124°48.60'W	5009824	357912.5	740	Push to 3.00 m
S5-MM-CPT-018	45°13.76'N	124°52.38'W	5010126	352995.7	857	Push to 3.00 m
S5-MM-CPT-019	45°14.94'N	124°55.80'W	5012424	348587.1	994	Push to 3.01 m
S5-MM-CPT-020	45°16.01'N	124°57.48'W	5014453	346377.9	1086	Push to 3.00 m
S5-MM-CPT-021	45°17.17'N	125°00.12'W	5016693	343023.1	1286	Push to 3.01 m

Name	Location				Water Depth (m)	Penetration Depth (m)
	Coordinates		UTM Zone 10N			
	Latitude	Longitude	Northing	Easting		
S5-MM-CPT-021	45°17.17'N	125°00.12'W	5016689	343026.0	1286	Push to 3.01 m
S5-MM-CPT-GC003	45°13.95'N	124°24.36'W	5009745	389368.0	388	Push to 2.07 m

TABLE 5-19 SEABED SAMPLE SUMMARY FOR SEGMENT 5

5.7.6 Areas of Concern

One area of concern is identified for Segment 5. The following table summarizes this area.

Reference Number	Type	Start Coordinates		End Coordinates		Route Distance (km)	Comments
		Latitude	Longitude	Latitude	Longitude		
S5 a	Bedrock	45°16.15'N	124°42.03'W	45°16.04'N	124°42.27'W	0.374	Very thin and/or absent sediment cover over bedrock

TABLE 5-20 SEGMENT 5 AREAS OF CONCERN

5.7.6.1 Area of Concern S5-a

The route passes through an area charted as outcropping bedrock (chart RSN.S5.NU.CHART-008B) between 45°16.15'N, 124°42.03'W and 45°16.04'N, 124°42.27'W. Subbottom profiles paralleling the Segment 5 survey route show steeply-dipping bedrock outcropping at or just below the seafloor (Figure 5-46). Outcropping or subcropping strata are observed as a very slight increase in acoustic reflectivity within the side scan sonar record (Figure 5-39). Weak acoustic return of seafloor variations are attributed in part to the subdued amplitude response of data acquired with the C3D system due to the higher frequency and low transmit power. It is also possible that the outcrop is mantled by a veneer of sediment. A CPT (S5-MM-CP014) and gravity core (S5-MM-GC005) were recovered from within S5-b (Appendix B). Both samples achieved penetrations of 3 m. However upon close inspection, samples were recovered from an isolated patch in the middle of the outcrop where subbottom profile clearly shows a pocket of younger sediment within the bedrock patch as seen in the center of Figure 5-46.

5.7.7 Route Recommendations

Evidence of bottom fishing within the Segment 5 survey corridor is ample. Trawling and other modes of bottom fishing pose a real and serious hazard to any cable exposed on the seabed between the shoreline and the 1500 m isobath. It is therefore of the utmost importance that the cable be buried where possible even if full burial depth cannot be achieved.

Sonar contacts should be avoided, and the cable installer should be made aware of the area's many pockmarks.

5.8 SEGMENT 6

5.8.1 Bathymetry

From Primary Node PN5A (45°45.22'N, 127°16.72'W) where the depth is 2820 m (RSN.S6.NU.CHART-001), Segment 6 runs to the west-northwest over the relatively flat and featureless plain of the Cascadia Basin with a slope gradient of 0.007% (0.04°) to the 2700 m isobath (45°56.18'N, 129°21.63'W). At this point the route heads west then southwest to pass north of the SOBB (Son of Brown Bear) seamount (RSN.S6.NU.CHART-003). The route continues southwest, rising slightly to Primary Node PN3A (45°49.22'N, 129°45.40'W) at the 2615 m isobath (RSN.S6.NU.CHART-003).

5.8.1.1 Dumping and Dredging

There were no recorded observations of dumping and dredging activities during the Segment 6 portion of the RSN survey.

5.8.1.2 Hydrocarbon Exploration

There were no recorded observations of hydrocarbon exploration activities during the Segment 6 portion of the RSN survey.

5.8.1.3 Military Activities

There were no recorded observations of military activities during the Segment 6 portion of the RSN survey.

5.8.2 Route Recommendations

Lay the cable as planned.

5.9 SEGMENT 7

5.9.1 Bathymetry

From Primary Node PN3A (45°49.22'N, 129°45.40'W), Segment 7 heads north-northeast for approximately 4 km before veering northwest to ascend a steep escarpment (11.37%; 6.49°), delineating the eastern boundary of Axial volcano. This ascent begins near the 2600 m isobath at 45°51.32'N, 129°44.70'W and climbs at an average gradient of 12% (6.8°), with local slopes along the route as high as 25% (14°), to the 2000 m isobath at 45°52.73'N, 129°48.08'W. From this point, the route climbs up a lava flow, where local gradients are variable with the steepest along the route measured at 20% (11°). The route terminates at Primary Node PN3B (45°56.95'N, 129°58.88'W), where the depth is 1510 m (RSN.S7.NU.CHART-001).

Since one goal of the RSN project is to monitor the active Axial Volcano, it goes without saying that this segment is in jeopardy from volcanic eruption. Beyond this potential hazard, there are no identified areas of concern for this route.

5.9.1.1 Dumping and Dredging

There were no recorded observations of dumping and dredging activities during the Segment 7 portion of the RSN survey.

5.9.1.2 Hydrocarbon Exploration

There were no recorded observations of hydrocarbon exploration activities during the Segment 7 portion of the RSN survey.

5.9.1.3 Military Activities

There were no recorded observations of military activities during the Segment 7 portion of the RSN survey.

5.9.2 Route Recommendations

Since one goal of the RSN project is to monitor the active Axial Volcano, it goes without saying that this segment is in jeopardy from volcanic eruption. It would otherwise be prudent to advise against laying a cable in this area.

The cable installer should be made that the terrain in this area is highly irregular, but the slopes do not exceed 18.8% (10.6°) along the route.

6 RECOMMENDATIONS

Recommendations are given in a table for the areas of concern addressed in the previous sections. The following tabulates these concerns and recommends possible actions.

Area	Type	Start Coordinates		End Coordinates		Route Distance (km)	Recommendation
		Latitude	Longitude	Latitude	Longitude		
S1 a	Strata Outcrop	45°11.05'N	124°47.48'W	45°11.01'N	124°47.56'W	0.098	Monitor plow tensions closely in this area.
S1 b	Strata Outcrop	45°08.03'N	124°56.71'W	45°08.04'N	124°56.75'W	0.045	Monitor plow tensions closely in this area.
S1 c	Strata Outcrop	45°08.80'N	124°59.80'W	45°08.89'N	125°00.35'W	0.746	Monitor plow tensions closely in this area.
S4 a	Exposed strata	44°21.56'N	124°57.09'W	44°21.59'N	124°56.78'W	0.711	Monitor plow tensions closely in this area.
S4 b	Turbidite channel	44°30.73'N	124°45.27'W	44°30.95'N	124°45.23'W	0.334	Ensure burial to target depth
S5 a	Bedrock	45°16.15'N	124°42.03'W	45°16.04'N	124°42.27'W	0.374	Plow up

TABLE 6-1 RECOMMENDATIONS BASED ON SURVEY RESULTS

7 NEARSHORE AND DEEP WATER SURVEY OPERATIONS

7.1 SUMMARY OF OPERATIONS

Mobilization was conducted in Seattle, Washington, alongside the NW Dock at Fisherman's Terminal, beginning on March 29, 2010. Calibration and survey operations were conducted between April 4 and May 12, 2010 offshore Pacific City, Oregon. After completion of survey, the vessel transited back to Seattle for demobilization. Demobilization was completed at Fisherman's Terminal on May 14, 2010. A brief summary of significant operational events is presented in Table 7-1. Full operational details are provided in the Daily Progress Reports (DPR) included in Appendix D. All times are reported in PST unless otherwise noted. Delays to survey operations resulted primarily from equipment failures and/or poor weather. There were no significant safety or security incidents during survey operations.

Date (PST)	Time (PST)	Significant Operational Events
March 29		Started mobilization activities aboard the R/V Mt Mitchell while alongside at Fisherman's Terminal, Seattle, WA
April 1	16:30	Moved to fuel pier on Harbor Island, Seattle, WA
April 2	00:30	Departed fuel pier, began transit to survey area offshore Pacific City, OR
	11:45	Weather (Storm) at Cape Flattery prevented transit southward. Wait on weather.
April 3	08:20	Weather subsided enough to resume transit south toward survey area.
April 4	01:00	Arrived at survey area; weather prevents survey operations. Standby.
	18:00	Started deep water MBES test run on S1; weather too rough for calibration.
April 5	00:55	Started deep water MBES survey on S1.
	14:28	Started deep water MBES survey on S5.
April 6	10:13	MBES survey of deep water area at PN5A node.
	13:19	Started deep water MBES survey of S6.
April 7	09:20	Started deep water MBES survey of area at PN3A node.
	14:46	Started deep water MBES survey of S7.
	19:21	Conducted deep water development survey at PN3A.
April 8	10:50	Transited to development area at base of continental slope on S5.
April 9	06:06	Started development survey of S5 at base of continental slope.
	11:23	Started calibration survey for EM120 and EM710 MBES systems.
	18:00	Onsite S5 at 200 m WD, prepared to launch AMS60 when winch failed briefly. After launch, USBL beacon failed and was swapped out.

Date (PST)	Time (PST)	Significant Operational Events
April 10	06:20	AMS60 launched, started shallow survey on S5.
	12:54	Brought towfish to surface to transfer spares from supply vessel. Winch failed briefly due to water in electronics control. Winch repaired.
	16:47	Resumed AMS60/EM710 survey on S5.
	19:01	Abandoned S5 centerline survey for development survey on a major route deviation (DEV2) to the South.
April 11	03:08	Started AMS60/EM710 survey of wing lines on deviated S5 DEV2.
	12:15	Depressor damaged tow sheave. Broke off survey to recover towfish and repair tow sheave.
	14:25	Resumed survey on S5 DEV2 in area of route deviation.
	17:37	Recovered AMS60 towfish due to noise in port side scan channel, discovered water in electronics bottle.
	20:10	Launched AMS60 and resumed survey on S5 DEV2. Port side transducer failed again when towfish reached survey depth at about 21:55.
April 12	00:12	Recovered AMS60 towfish because of port side transducer problem.
	02:25	Launched AMS60 towfish and maneuvered to resume survey; port side transducer problems re-occurred when towfish reached deep water.
	10:30	Recovered towfish to deck; transit to fill existing EM710 bathymetry data gaps along S5 Dev2.
	12:46	Started S5 Dev2 EM710 gap infill survey. Discovered that the AMS60 towfish portside transducer was completely flooded; prepared to launch C3D towfish.
	23:54	Launched C3D towfish; transited to start of line; tuned system for local survey conditions.
April 13	05:51	Resumed survey on S5 with C3D towfish.
	19:33	Topside C3D computer crashed; circled around and re-ran S5line.
April 14	00:40	Resumed C3D survey S5 and continued with survey on S1 inshore.
	22:38	C3D topside computer (for SBP) crashed; circled around to re-run lines while trying to restore SBP data logger.
	03:10	Ran two C3D Roll calibration lines while continuing to troubleshoot topside SBP data logger software problems
	06:47	SBP data logger repaired; resumed C3D survey on S1 inshore.
	13:06	Completed S1c Inshore survey; began transit to S5 for infill and development line surveys.

Date (PST)	Time (PST)	Significant Operational Events
	14:52	Commenced C3D patch test lines for pitch and yaw calibrations.
	17:51	Completed patch test lines; maneuvered to start of C3D/AMS60 data comparison survey line.
	19:27	Completed C3D/AMS60 comparison survey line; resumed transit to S5 development areas.
	20:17	Started C3D survey on S5 Dev3 and Dev 4 lines.
April 16	01:59	Started S5 re-runs over data gap areas.
	15:59	Completed S5 re-runs; began transit to start of additional S5 Dev4 line while Clients reviewed existing data.
	19:04	Started C3D survey additional S5 Dev4 line.
	22:50	Started C3D survey of infill lines on S5 route.
April 17	01:02	SBP data logger crashed; turned off line to fill gap.
	03:16	Resumed C3D survey on S5 and S1.
April 18	18:19	Suspended S1 survey to swap from C3D to AMS60 towfish at Client request.
	19:30	Recovered C3D towfish to deck. Began AMS60 deployment; surveyed with only starboard side array operational.
	23:40	AMS60 deployed; began system configuration; began troubleshooting topside logger software errors.
April 19	09:53	Corrected topside logger software configurations; resumed S1 survey with AMS60 and EM710.
	21:43	Sonar data logger software required restart; turned offline for gap fill on S1.
April 20	00:12	Resumed AMS60 survey on S1.
	01:10	Sonar data logger crashed; turned to re-survey over data.
	04:01	Resumed AMS60 survey on S1.
	13:21	Commenced EM710 MBES infill lines in areas where ocean currents offset towfish (SSS and SBP) from vessel (MBES) track.
April 21	01:55	Started AMS60 survey on S1 Dev1 and Dev 2 development lines.
	07:26	Completed AMS60 survey on S1 Dev 2 development line; stood-by while waiting for Client decision regarding where to resume main survey.
	14:40	Started AMS60 survey on S3 route at PN1C.
	17:20	Advised that long-line gear would prevent further survey on S3c in this area,

Date (PST)	Time (PST)	Significant Operational Events
		diverted to survey in area of node PN1B.
	22:07	Started AMS60 survey at node PN1B.
April 22	04:30	Completed area survey at node PN1B; proceed to SOL S2.
	08:37	Started AMS60 survey on S2.
	16:30	Resumed AMS60 survey on line S3.
	23:40	Clients decided to abandon S3 route due to rough terrain and seabed gradients; began transit to SOL S3.
April 23	02:04	Started AMS60 survey on S3 and S4.
April 24	14:05	Started development lines at node PN1B.
April 25	03:22	Completed development lines at node PN1B.
	06:35	Resumed AMS60 survey along S2 main and infill lines and S3 Alt1 infill lines.
	16:00	Started AMS60 area survey at node PN1C.
	21:31	Completed AMS60 area survey at node PN1C.
April 26	00:17	Started MBES infill survey on S4-.
	01:05	Resumed AMS60 main line survey on S4-.
	11:05	Weather conditions began to affect MBES data quality; continued with AMS60 deep tow survey along S4 with plans to run MBES lines after weather calms.
	13:16	Positioning (QINSy) computer crashed; turned offline to re-run.
	14:14	Resumed AMS60 survey on S4; MBES still unusable due to weather/vessel motion. Several attempts were made over the following few hours to find a survey direction/area where the vessel could maintain steerage along the planned survey lines; MBES remained unusable due to weather/vessel motion.
	22:04	Completed AMS60 survey along shallower sections of S4; continued survey in heavy weather along S4NPC.
April 27	12:31	Completed AMS60 survey along S4NPC; transited to S4 for re-shoot of MBES lost due to weather.
	15:27	Began re-shoot of MBES lines lost due to weather along S4.
	22:38	Continued re-shoot of MBES lines lost due to weather along S4; recovered AMS60 towfish and raised USBL after review of deep tow data indicated no additional survey required.

Date (PST)	Time (PST)	Significant Operational Events
April 28	07:25	Broke off MBES re-survey along S4 and transited to Yaquina Bay, near Newport, OR, for crew change and parts swap.
	10:03	Arrived in Yaquina Bay for crew change and minor ship stores re-supply via small boat; also swapped tow sheave mounting positions on aft A-frame while in relatively calmer waters of Yaquina Bay.
	12:00	Departed Yaquina Bay to resume MBES re-shoots along S4NPC.
	13:34	Began re-shoot of MBES lines lost due to weather along S4NPC.
	20:02	Broke off to re-shoot MBES lines at test core site
	20:29	Made two attempts at test core site with no measurable recovery of seabed sediments, but some medium sand held in catcher.
	21:02	Resumed re-shoot of MBES lines lost due to weather along S4NPC.
	22:45	Broke off MBES re-shoot to conduct cores/grabs at S4NP-MM-GC001. Coring cable jumped out of sheave and vessel Captain advised surveyors must wait until daylight for repairs.
April 29	02:06	Resumed re-shoot of MBES lines lost due to weather along S4NPC.
	03:08	EOL re-shoot of MBES lines lost due to weather along S4NPC; maneuvering to start MBES calibration run along local linear seabed feature.
	04:24	Resumed re-shoot of MBES lines lost due to weather along S4NPC and S4.
	10:22	Attempted core at S4NP-MM-GC002; corer cable jumped sheave again; decided to initiate CPT survey while corer is re-rigged.
	13:30	CPT suffered several electrical failures; stood by at S4NP-MM-CP004 while both CPT and core rigs are repaired.
	20:47	Started S4 MBES gap fills (re-runs) while corer and CPT repairs continued.
	23:22	Deploy CPT, CPT suffered power problems while on seafloor; began recovery operations.
	23:40	CPT recovered to deck; transited to core location S4-MM-GC008.
April 30	01:58	Commenced coring along S4, S3 and S2.
	23:47	Successfully recovered sample at core location S2-MM-GC001; began transit to deep water MBES survey on S2.
May 1	01:07	Began deep water MBES-only main and infill survey lines along S2, Node 1A and S1.
	11:10	Completed deep water MBES-only infill lines along S1; began preparations for CPT survey.

Date (PST)	Time (PST)	Significant Operational Events
	15:40	Deployed CPT at location S2-MM-CP001; CPT hydraulics and/or motor failed.
	16:05	Recovered CPT to deck.
	21:45	Began transit to coring locations along S1.
May 2	02:31	Attempted core at location S1-MM-GC010; lost core barrel; replaced with spare.
	04:35	Successfully recovered core at S1-MM-GC010a; continued coring along S1.
	17:55	Diverted to shallow water core locations along S5 for daylight operations in areas busy with fishing activity.
	19:33	Resumed coring operations along S1.
May 3	00:45	Suspended coring operations due to weather.
	22:13	Resumed coring operations along S5/S1 in areas where the two route corridors overlap.
May 4	00:56	Corer lost at S5-MM-GC003; spare corer needed to be sourced from onshore; concluded that the corer was accidentally triggered mid-water during descent by motion from 4 to 5 m swell. Went to weather stand-by as swell too large for CPT operations
	09:16	Attempted to deploy CPT but swell was still too large, continued weather stand-by.
	13:09	Began CPT operations at location of S5-MM-GC007.
	20:50	Vessel could not hold position during CPT push resulting in a bent cone at location S5-MM-CP001; recovered CPT to deck for repair.
	22:10	Resumed CPT operations at S5-MM-CP001a.
May 5	06:00	Vessel could not hold position during CPT retraction resulting in a bent cone at location S1-MM-CP006; recovered CPT to deck for repair.
	08:13	Resumed CPT operations at S5-MM-CP007.
	18:27	USBL beacon mounted on the CPT frame failed at location S1-MM-CP015; decided to continue CPT operations using vessel stern position and wire angle observations for CPT positioning.
	22:05	Resumed CPT operations at S1-MM-CP016.
May 6	06:12	CPT suffered telemetry and motor failures during push at S1-MM-CP021.CPT recovered to deck and cone salvaged; began CPT trouble-shooting and repairs.
	12:00	Determined that replacement parts for CPT need to be brought from shore; stand-by for parts.

Date (PST)	Time (PST)	Significant Operational Events
May 7	09:13	Arrived Yaquina Bay / Newport, OR, for equipment and personnel transfer via small boat.
	11:00	Departed Yaquina Bay and transited to resume CPT operations at S4NP-MM-CP004.
	16:20	CPT successfully repaired and tested; USBL beacon successfully replaced and wet-tested; Deployed CPT at location S4NP-MM-CP004.
	16:44	Resumed CPT operations at S4NP-MM-CP004.
May 8	09:18	Lost power to CPT during deployment at S4-MM-CP006; recovered to deck for repairs to electrical system.
	14:44	Resumed CPT operations at S4-MM-CP006.
May 9	04:57	CPT cone values became erratic during test at S3-MM-CP002; CPT recovered to deck for trouble-shooting and repair.
	22:27	Successfully completed CPT at location S3-MM-CP002f and resumed CPT operations along S3.
	23:42	Lost communications with CPT at location S3-MM-CP001; CPT recovered to deck and re-terminated.
May 10	05:55	Resumed CPT operations at S3-MM-CP001a.
	20:38	Deployed gravity core at location S5-MM-GC008.
	22:23	Resumed CPT operations at location S5-MM-CP020.
	23:55	Winch level wind failed during CPT recovery after successful test at location S5-MM-CP019.
May 11	04:13	Winch level wind successfully repaired and CPT recovered to deck.
	06:39	Deployed gravity core at location S5-MM-GC007.
	10:39	Completed re-termination of CPT due to kinks in cable; deployed CPT at location S5-MM-CP018; resumed CPT operations along S5.
	12:23	Began CPT operations at development site S1-MM-CP015-Dev1.
	15:23	Deployed gravity core at location S5-MM-GC006.
	16:52	Resumed CPT operations at location S5-MM-CP016.
	19:36	Deployed gravity core at location S5-MM-GC005.
	20:25	Resumed CPT operations at location S5-MM-CP013.
	23:47	Deployed gravity core at location S5-MM-GC004.

Date (PST)	Time (PST)	Significant Operational Events
May 12	01:05	Resumed CPT operations at location S5-MM-CP009.
	04:05	Deployed gravity core at location S5-MM-GC003.
	04:17	Raised USBL pole for faster transit to location S5-MM-CP001-Dev2.
	06:54	Resumed CPT operations at development locations along S5/S1.
	10:42	Completed CPT operations; end of Mt Mitchell survey operations; began transit back to Seattle for demobilization.
May 14		Arrived at NW Dock at Fisherman's Terminal in Seattle, completed dockside demobilization.

TABLE 7-1 OPERATIONAL SUMMARY

7.2 SURVEY SYSTEMS

7.2.1 Survey Vessels

The Shallow and Deep Water surveys were conducted using the 70 m long R/V Mt Mitchell operated by Global Seas, LLC of Seattle, Washington. The Mt Mitchell is a seaworthy vessel (Figure 7-1) capable of continuous, 24 hour survey operations with a maximum duration of 45 days. The Mt Mitchell is in compliance with current required documentation and USCG Regulations. The vessel has accommodations for up to 48 passengers apart from the vessel crew.

The Mt Mitchell is able to operate in conditions up to 17 to 21 kts wind speed, and wave height of 2.0 to 2.5 m for towed bathymetry and side scan, and 3.0 to 3.5 m for deep bathymetry.

FIGURE 7-1 R/V MT MITCHELL

7.2.2 Equipment

Mobilized survey equipment included two suites of marine geophysical survey systems, positioning systems and seabed sampling equipment as follows:

	C3D Geophysical Suite:
	Benthos C3D towed side scan sonar / interferometric bathymetry / subbottom profiler (20 to 1500 m)
	Kongsberg EM120 12 kHz hull-mounted multibeam echo sounder (greater than 1500 m)
	AMS60 Geophysical Suite:
	Kongsberg EM710S 70 to 100 kHz hull-mounted multibeam echo sounder (20 to 1500 m)
	W&A AMS-60 Deep Tow side scan / subbottom profiler (20 to 1500 m)
	Kongsberg EM120 12 kHz hull-mounted multibeam echo sounder (greater than 1500 m)
	Common Survey Equipment:
	W&A Crossline winch with 4500m of .45” coaxial tow cable
	PosMV DGPS Positioning, Motion Reference and Heading
	IXSEA GAPS USBL with transponders (towed system tracking)
	Trimble SPS851 DGPS (backup / comparison)
	Marine Magnetics pulsed Overhauser magnetometer
	Sippican XBT / MK21 data acquisition system
	SeaBird SBE 19 CTD
	Measurement Technology NW LCI90 digital cable counter
	Geotechnical Equipment:
	W&A SOSI Winch with 1700 m of .68” coaxial cable
	W&A CPT Mini Cone Penetrometer
	3m Gravity Corer
	Van Veen Grab Sampler (backup to corer)

	Data Acquisition and Processing Software:
	QINSy for marine navigation, positioning and geophysical data acquisition
	ISIS SS-Logger and SB-Logger (primary system side scan sonar acquisition)
	SonarWiz.Map (secondary system side scan sonar acquisition)
	CARIS HIPS (v. 7)
	SonarWiz5 side scan sonar and subbottom profiler data processing
	ISIS side scan sonar data processing
	Global Mapper (GIS) (v. 11)
	ESRI ArcGIS Desktop / ArcView (v. 9.3)
	AutoCAD Map 3D 2008, with AutoChart
	CPeT-IT - CPTU data presentation & interpretation software (v.1.6.4.14) SIS – Seafloor Information Systems (Multibeam acquisition)

TABLE 7-2 EQUIPMENT MOBILIZED ABOARD THE MT. MITCHELL

The AMS60 was used for the majority the survey data acquisition in areas of burial, primarily for its lower frequency signal penetration of surficial mud. Please refer to Section 9.1 for a complete discussion of C3D and AMS60 utilization.

7.3 PERSONNEL

Name	Position	Dates Aboard	Company
Pat Harwell	Client Representative	April 1 to May 14	L-3 MariPro
Cris Christianson	Client Representative	April 1 to May 14	L-3 MariPro
Cecile Durand	Purchaser Representative	April 1 to April 28	University of Washington
Amanda Maness	Cable Installer Representative	April 1 to May 14	TE SubCom
Scott McMullen	Fishermen Representative	April 1 to April 28	OFCC
Gerald Gunnari	Fishermen Representative	April 1 to April 28	OFCC
Colin Stewart	Party Chief	April 1 to May 14	Williamson

Name	Position	Dates Aboard	Company
Bill Heather	Watch Lead, Sonar Operator, Mechanical Technician	April 1 to May 14	Williamson
Jay Larsen	Watch Lead, Sonar Operator, Electronics Technician	April 1 to May 14	Williamson
Brian Bunge	Senior Surveyor	April 1 to May 14	Williamson
Tim Jamison	Surveyor	April 1 to May 14	Williamson
Greg Schultz	Sonar Operator, Mechanical Technician	April 1 to May 14	Williamson
John Moran	Sonar Operator, Electronics Technician	April 1 to May 14	Williamson
Mark Amend	MBES/SSS Processor	April 1 to April 28	Williamson
Donny Brouillette	MBES/SSS Processor	April 1 to May 14	Williamson
Mike Kelly	Geophysicist, SSS/SBP Processor	April 1 to May 7	Williamson
Nell Beedle	Geologist, SSS/SBP Processor	April 1 to May 7	Williamson
Kyle Fankhauser	Surveyor	April 28 to May 14	Williamson
Phil Colvin	Sonar Operator, Mechanical Technician	April 28 to May 14	Williamson
Brian Ittig	Purchaser Representative	April 28 to May 14	University of Washington
Brad Pettinger	Fishermen Representative	April 28 to May 14	OFCC
Dave Jordan	Fishermen Representative	April 28 to May 14	OFCC

TABLE 7-3 PERSONNEL SERVING ABOARD THE MT MITCHELL

7.4 SURVEY METHODS

7.4.1 Vessel Offsets

The PosMV inertial measurement unit (IMU) was the reference point for all vessel offsets. The PosMV vessel motion sensor was mounted along the vessel centerline and near the water in an interior space just aft of the hull-mounted MBES transducers. All other sensor locations were offset from the IMU location (Figure 7-2). Offset values for permanently installed sensors

(Figure 7-3) were provided by Global Seas, LLC. Additional offsets were recorded during mobilization. Distance to waterline measurements for use in MBES data processing were taken over the side using a weighted tape measure.

Sensor	Offset Y (m)	Offset Y (m)	Offset Z (m)	Status
PosMV IMU	0.261	0.072	-0.168	Permanently Installed
PosMV Port GPS Antenna	-4.791	-1.085	-14.499	Permanently Installed
PosMV Stbd GPS Antennae	-4.789	0.913	-14.497	Permanently Installed
EM120 Transmit	5.375	-0.020	2.500	Permanently Installed
EM120 Receive	2.764	-0.024	2.593	Permanently Installed
EM710 Transmit	4.319	0.893	2.526	Permanently Installed
EM710 Receive	3.685	1.000	2.553	Permanently Installed
Trimble SPS851 DGPS	0.000	-4.96	14.50	Survey Installation
IXSEA GAPS USBL	-7.10	-11.00	-5.90	Survey Installation
Core/CPT Sheave	-1.50	-38.00	0.00	Survey Installation

TABLE 7-4 SUMMARY OF VESSEL OFFSETS

SURVEY POINTS	STATION (Y)	OFFSET (X)	ELEV. (Z)
IMU PC	0.261	0.072	-0.168
EM 120 TX	5.375	-0.020	2.500
EM 120 RX	2.764	-0.024	2.593
EM 710 TX	4.319	0.893	2.526
EM 710 RX	3.685	1.000	2.553
POSMV_ANT_PORT	-4.791	-1.085	-14.499
POSMV_ANT_STBD	-4.789	0.913	-14.497
EDGETECH 4200	10.794	0.700	2.063

MT. MITCHELL EQUIPMENT LOCATIONS

(PLAN VIEW)

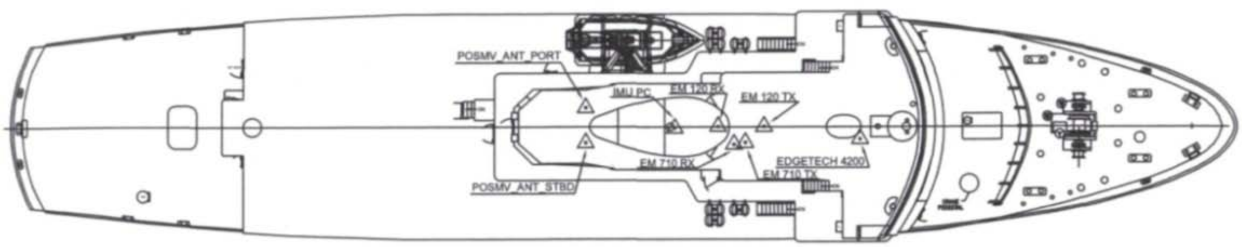


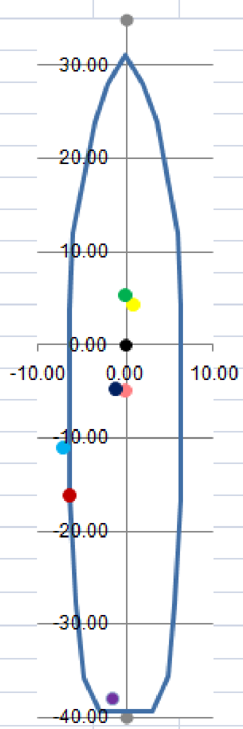
FIGURE 7-2 VESSEL OFFSET DIAGRAM

WILLIAMSON & ASSOCIATES	*Form Name :* **VESSEL OFFSETS**	*Procedure Type*	**Operations**
		Form No	**WASV_Vessel offset diagram**
		Revision	3
		Date	**25-Apr-10**
		Approved by	

		Project	L3-RSN 2010
Client	L3 Maripro	**Vessel**	R/V Mount Mitchell

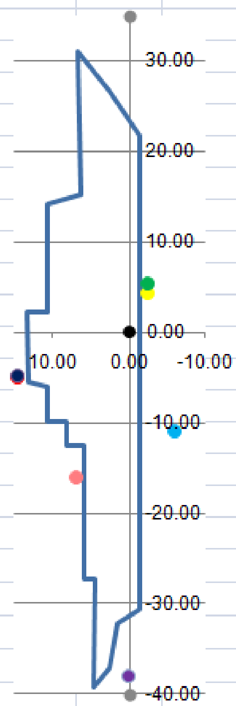
No	Description	X (m) (Stbd+)	Y (m) (Fwd+)	Z (m) (Up+)
Datum	Vessel Reference Point	0.00	0.00	0.00
1	Trimble SPS 851 DGPS Antenna	0.00	-4.96	14.50
2	Applanix POS/MV DGPS Port Antenna	-1.09	-4.79	14.50
3	EM 710 Multibeam TX Transducer	0.89	4.32	-2.53
4	EM 120 Multibeam TX Transducer	-0.02	5.38	-2.50
5	IXSEA GAPS Transducer Head	-7.10	-11.00	-5.90
6	IXSEA DGPS Antenna	-6.40	-16.10	6.80
7	Tow Point	-1.50	-38.00	0.00

Vessel Horizontal Diagram



X Value	Y Value
-4.80	-35.70
-5.70	-27.70
-6.40	-16.00
-6.40	-2.70
-6.30	3.90
-6.00	12.00
-3.50	24.00
-2.00	28.00
0.00	31.09
2.00	28.00
3.50	24.00
6.00	12.00
6.30	3.90
6.30	-2.70
6.30	-16.50
5.60	-27.70
4.80	-35.60
3.00	-39.28
-3.00	-39.28
-4.80	-35.70

Vessel Vertical Diagram



Y Value	Z Value
21.82	-1.49
-30.55	-1.49
-32.19	1.51
-37.09	2.51
-39.28	4.54
-27.28	4.31
-27.28	5.75
-12.55	5.75
-12.55	8.16
-9.82	8.16
-9.82	10.57
-6.00	10.57
-5.46	13.01
2.18	13.26
2.18	10.57
14.18	10.57
15.27	6.25
31.09	6.75
26.73	2.51
21.82	-1.49

Filename		**Comments**	

SIGNED

Position	Name	Signature	Date
Navigator	Brian Bunge		4/25/2010
Party Chief	Colin Stewart		4/25/2010

FIGURE 7-3 VESSEL OFFSET DIAGRAM

7.4.2 Calibration and Quality Control

Patch tests were performed on both multibeam systems and the results for corrections were used to verify the calibration numbers already input to the EM710 and 120 MB Systems. Patch test results are included in Appendix F.

The IXSEA GAPS USBL positioning system had integrated internal acoustic and inertial modules that were pre-calibrated obviating the need to measure installation offsets or lever arms to the USBL transducer. Additionally, the GAPS had a dedicated, externally mounted GPS antenna with location offsets measured to an accuracy of <5 cm. The GPS antenna offsets were internally integrated into the real-time positioning data logged by the GAPS system. No further shipboard calibration of the acoustic tracking system was required.

Individual CPT cones were factory calibrated, and no further shipboard calibrations were required.

Collected data were continually monitored online for data gaps and any indication of position jumps. Processed multibeam and side scan sonar data were also checked consistently for errors in the positioning by comparing seabed feature correlation for lines run in opposite directions.

7.4.3 Surface Positioning

Offsets for the vessel supplied equipment were provided by the vessel. The vessel-supplied equipment included the Applanix POS MV, and the Kongsberg EM 710 and EM120 multibeam systems. Both MBES systems were integrated with the POS MV for motion, heading and positioning data.

Williamson provided backup positioning with a Trimble SPS851 DGPS. The offset for the backup DGPS antenna was measured from the vessel reference point to an accuracy of <5 cm.

A QINSy Integrated Navigation System was used for acquisition and processing of all survey positioning data for the vessel and the hull-mounted and towed sonar systems. While at Fisherman's Terminal in Seattle, WA, QINSy was used to record position data for both the integrated GAPS and back-up DGPS antennae for several hours. These data were analyzed for duplicity in position and determined to be correct within <1 m. QINSy also had alerts activated to monitor all data inputs to the system and to notify if the GPS positioning lost its differential correction.

7.4.4 Acoustic Positioning

An IXSEA GAPS USBL was used for acoustic positioning of the AMS60, C3D towfish, and the CPT rig. The system included a 20 to 30 kHz acoustic beacon, operating in a frequency sweep mode, mounted on the towfish body or the CPT frame. The USBL system measured the range and bearing of the deployed beacon relative to the position of the transducer, and then integrated this information with the precise DGPS position of the transducer to compute a final position of the towfish or CPT rig. The rate of position updates were dependent on USBL ranges, but averaged between 2 and 8 seconds.

One of the main factors affecting the reliable range of the GAPS system is environmental noise, particularly noise generated from the vessel as it moves through the water. Every effort was made to minimize this noise using a variety of techniques for vessel propulsion. The vessel speed was also closely monitored and continuously adjusted in order to minimize, as much as possible, the length of tow cable and thus the total range to the towed system.

The GAPS system provided reliable ranges up to approximately 2500 m. In the rare instances where the ranges to the towfish acoustic beacon resulted in erratic or unreliable USBL positioning, manual layback positioning was used. Manual layback position was calculated in the QINSy acquisition system using a logged cable out and towfish depth values. The AMS60 and C3D towfish both contained integrated depth sensors. Cable out values were measured using a LCI-90 digital cable counter mounted on the tow sheave. The computed layback position accounted for the offset between the mounted sheave position on the A-frame and the DGPS antenna used to log the vessel position. No acoustic beacon was attached to the coring rig. All core locations were logged using the real-time GPS position and measured offsets to the vessel A-frame/tow point location.

7.4.5 Sound Velocity profiles

Water column data were acquired using a Sippican Expendable Bathythermograph (XBT). These data were used to generate sound velocity profiles primarily for MBES acquisition and processing. At least one XBT was deployed daily, or at the start or end of a survey line, or as required to update MBES acquisition parameters.

The XBT continuously measures temperature versus depth, where depth is derived from an assumed rate of descent. The XBT consists of a sensor attached to a lead weight by a coiled copper cable launched over the side using a hand-held launcher. Two different types of XBTs were used: a T5 for measurements up to 1830 m water depth and a T6 for measurements up to 460 m water depth.

The XBT was deployed while the vessel was underway reducing the need to interrupt survey operations for SVP data acquisition. The Sippican LM3A Hand Launcher with attached XBT was connected to a computer and alerted the user when the device was properly armed. The data acquisition system included a Lockheed Martin MK21/USB device connected to a Windows XP computer running the WinMK21 acquisition software. Data were exported for use in MBES processing in an ASCII-formatted export data file (.edf).

Test water column data were acquired using a SeaBird SBE19 CTD. These data were acquired after the vessel came to a full stop. The CTD was deployed immediately following an XBT cast in order to confirm the quality of the XBT data in the upper water column, particularly where the mixing layer caused the largest temperature variability. Sound velocity profiles are provided in Appendix F.

7.4.6 Bathymetry

Two different multibeam sonar systems were used in order to meet the deep-water bathymetric requirements and to provide bathymetry data in areas of AMS60 side scan sonar survey. The hull mounted EM120 operated at 12 kHz and was used for water depths greater than 1500 m. In areas shallower than 1500 m, the hull mounted EM710 multibeam was used. Kongsberg's Seafloor Information Systems (SIS) software was used to operate the systems and acquire multibeam data. The data were stored in their native .all file format. The EM120 was run with full swath and no filters. The EM710 was generally set to 400 m swath to ensure a 2 m across track sounding spacing. Wing lines were generally steered 100 m away from the centerline. This provided 100 m of coverage toward the centerline and 300 m of coverage away from the centerline, allowing for a wider corridor to be covered without reducing the line spacing.

The C3D towfish acquired co-located interferometric bathymetry and sidescan sonar simultaneously using a SARA CAATI (Small Aperture Range Angle Computed Angle of Arrival Transient Imaging) system. Operated at a frequency of 200 kHz, the system acquired bathymetry across approximately 60% of the acquired 300 m wide side scan sonar swath, i.e. in a swath about 180 m wide. Bathymetry data were acquired using customized Triton ISIS logging software and stored in standard XTF format together with the side scan sonar intensity data and towfish positioning data.

7.4.7 Side scan Sonar

Side scan sonar imagery was collected using both the AMS60 and C3D towfish. The AMS60 operated at a frequency of 60 kHz and a maximum 1000 m total swath, depending on towfish altitude. Initially, the AMS60 was operated using a 500 m range per side for a total across track swath of 1000 m. After seawater flooded the port side transducer array, the AMS60 was operated using the starboard side array only with a range of 1000 m to starboard. The C3D operated at a frequency 200 kHz and provided a maximum across track swath of 300 m.

AMS60 side scan intensity data were acquired using SonarWiz and stored in XTF format that included towfish positioning data. C3D side scan sonar intensity data were acquired using customized Triton ISIS software and stored in the XTF format that included towfish positioning data. Data were monitored real-time for appropriate acquisition gain settings and data quality.

7.4.8 Subbottom Profiler

Both the AMS60 and the C3D towfish contained an integrated subbottom profiler. The AMS60 subbottom profiler operated at 4.5 kHz. The C3D subbottom profiler operated in a dual-hydrophone, sweep frequency mode ranging from 2 to 7 kHz. AMS60 subbottom data were logged using SonarWiz in XTF format. C3D subbottom profiler data were logged using Triton SB-Logger in SegY format. Both file formats contained towfish depth, altitude and positing information that allowed for topographic corrections of profiler data and the generation of geo-located digital profiler imagery.

All subbottom profiler data were monitored real-time for appropriate acquisition gain settings, appropriate trace length and data quality.

In both systems, the subbottom profiler transducer and the side scan sonar triggered simultaneously, so the subbottom profiler ping rate was correlative to the towfish altitude above the seabed. Generally speaking, towfish altitudes above the seabed were held relatively constant for a given water depth, and ranged between about 20 and 150 m above the seafloor over the course of the survey.

7.4.9 Seabed Sampling

Gravity coring was conducted in burial areas (to 1500 m water depth) at a nominal spacing of one core every 10 km along the surveyed routes.

The surveyor directed the vessel to the target location using QINSy heads-up navigation display showing the target point location and a target circle with a typical diameter of 25 to 50 m. Once the vessel stern was in position, the gravity corer was deployed using the vessel A-frame and Williamson's Crossline winch. The gravity corer comprised a 3 m long, 3 inch diameter, steel pipe with integral lead weights and an in-line weighted trigger arm. The trigger arm, line and weight system allowed for an approximately 5 m vertical free fall once the trigger weight touched the seabed.

Water depths at the target location were confirmed using the vessel fathometer. The wire-out measure, effectively the gravity corer depth, was monitored using a digital wire counter mounted on the A-frame sheave. The wire counter was zeroed at the start of each core deployment.

When the gravity corer was determined by wire-out length to be within 50 m of the seafloor, the wire-out rate was slowed to less than 30 m/min and the wire was closely monitored for reaction to the gravity corer free fall. After release was detected, the gravity corer was recovered to the deck.

The surveyor logged the release position from real-time GPS data corrected with offsets to the tow point location, water depth (from fathometer), date and time (UTC) at each location.

Upon recovery, the clear PVC barrel liner ("core tube") was removed from the steel core barrel and checked for adequate sample recovery. The core tube and sample were split, and the sample was photographed and described using standardized field identification techniques. Standard identification techniques included visual manual soil classification (ASTM D-2488 and ASTM D-2487 [Unified Soil Classification System]), color description using Munsell soil color chips, description of relative consistency of cohesive soils using a hand-held Torvane, and description of odor if detected. Coring results are presented in Appendix B.

7.4.10 CPT

The cone penetration test (CPT) is an in situ testing method used to determine certain geotechnical properties of soils and to delineate soil stratigraphy. Mini Cone Penetrometer Tester (CPT) data were collected using a ruggedized platform set upon the seafloor while tethered to the survey vessel via a UNOLS cable. The 0.68 UNOLS cable was used to deliver power and multiplex data communications.

The CPT position was tracked using the GAPS USBL tracking system, with a beacon mounted on the CPT and a tracking transducer pole mounted on the ship. When the CPT landed on the bottom, a baseline value was taken to ensure hydrostatic pressure-compensated tip and sleeve values. The cone was then thrust into the bottom to a depth of 3 m or until refusal by rock or other hard layers. As the cone was thrust down, a microcontroller in the subsurface electronics logged depth, raw sleeve strain gauge value, raw tip strain gauge value, and several other parameters including platform pitch and roll, subsurface voltage, subsurface amps, etc. These data were transmitted real-time to a surface Graphical User Interface (GUI). The CPT operator monitored the topside display for data quality and stopped the thrust if a hard layer or rock was encountered. CPT control commands available in the GUI included start thrust, stop thrust, take baseline measurement, etc. These commands were transmitted to the subsurface microcontroller in real-time.

After the push was completed the CPT rig was raised to the sea surface, secured to the stern of the ship and checked out for the next push. Checks included running the cone in and out to verify proper coiling of the rod, checks for hydraulic fluid leaks, pressure compensator volumes, etc. The tag lines used for recovery were taped back to the CPT with suitable open loops for easy retrieval using a boat hook. If the bottom type was extremely soft for a number of tests, or if the cone tip was changed out, the CPT was brought on deck to push into a piece of wood or other soft material to verify loading of the tip and sleeve.

Mechanical damage may occur to the cone or rod under certain operating conditions. Damage to the rod and/or cone usually occurred when the cone encountered a rock or other hard layer relatively early in the push sequence. Damage to the push rod usually occurred when the rod wasn't deep enough to be constrained by the overlying sediments to prevent bending. Lightly bent push rods were straightened by hand upon recovery of the CPT platform to the deck, while more severely bent rod sections were cut away from the coil. On several occasions, damaged cones were swapped out with spares carried on board and the logging software was updated to reflect the new cone's calibration parameters.

7.5 SHIPBOARD DATA PROCESSING

7.5.1 Bathymetry

Shipboard data processing of acquired bathymetry required three major processing steps independent of MBES acquisition system type:

1. Tidal and SVP correction, and cleaning of spurious raw soundings (XYZ-data) resulting in final corrected depths using CARIS HIPS.
2. Gridding and contouring of the corrected depths using Global Mapper
3. Production of digital bathymetry in shapefile format using ArcGIS

Raw data recorded by the MBES acquisition program SIS were imported into CARIS HIPS/SIPS sonar processing software. Data processing in HIPS involved the following stages: adjusting for tide, correction using sound velocity profiles, merging with navigation and attitude, outlier editing, and surface creation. Tides (Section 2.4.4) were applied to the imported data, using a zero-value tide for the deepwater coverage and time and/or distance-based corrections for shallow water coverage. Sound velocity corrections (Appendix F) to EM120 data were applied during acquisition, but re-applied in HIPS due to the total depth limits of the Sippican profiles (1850 m). The software tool mbvelocity, a part of MB-System (w*ww.mbari.org/data/mbsystem/html/mbsystem_home.html)*, was used to generate sound velocity values below 1850 m. EM710 sound velocity corrections were applied in SIS during acquisition and not re-applied in HIPS. After quality checks of the attitude and navigation data, the data were then merged to produce processed, corrected depth values. Data were then edited using CARIS Swath Editor in both point and line-connected modes and then further editing using CARIS Subset Editor in 3D mode and cross-sectional 2D mode. Using CARIS HIPS, bathymetry surfaces (grids) were created at the finest scale achievable for the maximum depths in an area. Initial deepwater grids were at 50 m resolution and shallow water grids were produced at 2 m resolution. If grids contained outliers, a series of iterative steps were then taken with the data editing tools until the grids were considered cleaned.

Finally, processed XYZ data were imported into Global Mapper for surface generation and then contour generation from surface data. Contouring parameters included contour interval, contour vertices smoothing (set to zero), contour feature attribution and a gentle automatic smoothing of the final contour lines (<u>not</u> smoothing of the gridded XYZ surface). Major and minor contours, with index contour intervals reflective of water depths and bathymetric data resolution, were exported as DXF format for further processing in AutoCAD and AutoChart.

AutoCAD and AutoChart processing focused primarily on generating MakaiPlan-compatible contour labels and slope/gradient symbols. Symbols indicating slope value and slope direction were generated from the contour data using the AutoChart utility for slope calculation from contour data. The slope symbols and all annotation (labels) were “burst” or “exploded” from CAD filled polygons and text to linear elements for final shapefile generation. Final files were saved in shapefile format.

Final contour, slope indicator and bathymetry labels were imported into ArcGIS and re-formatted for use in MakaiPlan or down-stream GIS review of digital bathymetry. Final, gridded XYZ data were provided in simple ASCII format.

7.5.2 Side Scan Sonar

Side scan sonar data were recorded as XTF files in SonarWiz.Map (Chesapeake Technology) for the AMS60 data and in ISIS (Triton Imaging) for the C3D files. These raw XTF files were read into ISIS for re-bottom tracking to ensure proper altitude values, and smoothing of navigation. Geo-referenced imagery was then exported from ISIS as .DDS_VIF files, imported into Triton Imaging Delph Map, and exported as geo-referenced TIF files. On board geological interpretation was done on these geo-referenced TIF files in Global Mapper.

7.5.3 Subbottom Profiler

Subbottom profiler (SBP) data were acquired as SEG-Y files for the C3D data, and as XTF files for the AMS60 data. All SBP files were read into Chesapeake Technology SonarWiz.Map. SBP interpretation was done within SonarWiz.Map, where horizons were designated and bottom type identified. Color coded polylines based on this interpretation were then exported from SonarWiz.Map into a GIS package.

7.5.4 Cone Penetrometer Testing Data (CPT)

CPT data were recorded in raw millivolts (mV). The logged values were input into a spreadsheet where the baseline values were subtracted and calibration values and scale factors were applied to derive Cone Resistance and Sleeve Friction in tons per square foot (tsf). The Depth, Cone Resistance, and Sleeve Friction values were then copied into an ASCII text file with the extension ".dat." Major outliers were removed using a text editor, and the files are read into the program CPeT-IT, by GeoLogismiki. CPe-IT was used to generate a report for each CPT that included graphs of Cone Resistance and Sleeve Friction, as well as interpreted soil behaviors.

7.5.5 Digital Deliverables

Processed survey data were made available digitally to the Client Representative for the evaluation of suitability of the surveyed cable route.

Geospatial survey data were provided as ESRI shapefiles or geodatabase files, and geo-referenced imagery in TIFF format. Digital preliminary charts were presented as digital PDF files.

No shipboard charts were produced, but specified charting parameters were based primarily on water depth to best reflect the higher resolution data.

Projection:	Universal Transverse Mercator (UTM)
Spheroid:	WGS 84
Datum:	WGS 84
Depth Reduction:	MLLW
Orientation:	North Up
Size:	Standard A0
Minimum Overlap:	3 cm

Chart Scales:	1:100,000 for water depths greater than 2,000m 1:25,000 for water depths between 1500 and 2000 m 1:10,000 for water depths between 20 and 1500 m 1:5,000 for water depths less than 20 m
Bathymetry Contour Intervals:	1 m interval for water depths between 20 and 1500 m 10 m interval for water depths between 1500 and 2000 m 50 m interval for water depths greater than 2000 m

TABLE 7-5 SHIPBOARD CHARTING PARAMETERS

Digital copies of the preliminary report were provided in PDF, WORD and EXCEL formats. An electronic copy of all processed, gridded bathymetry data was provided in ASCII xyz format.

8 INSHORE SURVEY OPERATIONS

8.1 SUMMARY OF OPERATIONS

Mobilization was conducted in Seattle, Washington, at the Williamson office, beginning on May 21, 2010. Calibrations were conducted May 24 on Lake Union in Seattle (Appendix F), WA. After completion of survey, the vessel was hauled back to Seattle for demobilization. Demobilization was completed at the Williamson office June 2, 2010. A brief summary of significant operational events is presented in Table 8-1. Full operational details are provided in the Daily Progress Reports (DPR) included in Appendix D. All times are reported in PST unless otherwise noted.

Date (PST)	Time (PST)	Significant Operational Events
May 21		Started mobilization activities aboard the Silver Streak at Williamson's office, Seattle, WA
May 24		Multibeam patch test
May 25	12:00	Departed Seattle, hauling Silver Streak to Tillamook, OR
May 26	16:00	Commence acquisition off Pacific City
May 28		In port due to engine problems
May 29		In port due to engine problems
May 30		Resume survey, complete sonar acquisition
May 31	14:00	Silver Streak returns to Seattle; Vessel Sea Q used to acquire sediment samples
June 2		Demobilization in Seattle

TABLE 8-1 INSHORE OPERATIONAL SUMMARY

8.2 SURVEY SYSTEMS

8.2.1 Survey Vessels

Silver Streak is an 8.23m long aluminium hull vessel with a breadth of 2.74 m and a draft of 0.75 m. Silver Streak (Figure 8-1) is powered by a Volvo turbo diesel engine with a dual-prop outdrive, and is capable of 25 knots. The A-frame with mounted winch was used to lower and tow the Edgetech 2000-DSS. The Reson 7125SV was pole mounted on the starboard side.

Sea Q is a 6.1 m long fibreglass and plywood vessel with a breadth of 1.8m, a draft of 0.3 m. She is powered by a Volvo engine with a single prop outdrive and is capable of 25 knots. The vessel Sea Q (Figure 8-2) is a commercial fishing Dory boat out of Pacific City. The vessel's crab davit was used for retrieving grab samples.

FIGURE 8-1 R/V SILVER STREAK

FIGURE 8-2 F/V SEA Q

8.2.2 Equipment

Mobilized survey equipment included a suite of marine geophysical survey systems, positioning systems and seabed sampling equipment as follows:

Primary Geophysical Suite:	
	EdgeTech 2000-DSS - towed sidescan sonar 100 / 400 kHz / subbottom profiler 2-16 kHz
	Reson 7125SV - 200 / 400 kHz pole-mounted multibeam echo sounder
Common Survey Equipment:	
	IXSEA OCTANS - Fiber Optic Gyroscope (heading and vessel motion)
	Trimble SPS851 DGPS (Primary positioning)
	Trimble Ag 132 GPS (Secondary positioning) Hemisphere MBX-4 (Beacon Receiver)
	SeaBird SBE 19 CTD SeaBird SBE 37 MicroCAT (Real time surface sound speed)
Geotechnical Equipment:	
	Van Veen Grab Sampler
Data Acquisition and Processing Software:	
	QINSy for marine navigation, positioning and geophysical data acquisition
	CARIS HIPS (v. 7)
	SonarWiz5 (sidescan sonar and subbottom profiler data processing)
	Global Mapper (GIS) (v. 11)
	DISCOVER – EdgeTech's sonar software interface and acquisition system
	SMT – Kingdom (Sidescan and subbottom profiler processing)

TABLE 8-2 EQUIPMENT MOBILIZED ABOARD THE SILVER STREAK

8.3 PERSONNEL

Name	Position	Dates Aboard	Company
Brian Bunge	Party Chief / Navigator	May 26 to May 29	Williamson
Colin Stewart	Project Lead / Navigator	May 30	Williamson
Kyle Fankhauser	Sonar Operator	May 26 to May 31	Williamson

Name	Position	Dates Aboard	Company
Matt Barnett	Captain (Silver Streak)	May 26 to May 30	Tetra Tech
Chris Burt	Sonar Tech / Deck Hand	May 26 to May 30	Tetra Tech
Phil Colvin	Deck Hand	May 26 to May 31	Williamson
Craig Wenrick	Captain (Sea Q)	May 31	Sea Q Fish
Pat Harwell	Client Representative	May 26 to May 31	L-3 MariPro
Cecile Durand	Purchaser Representative	May 26 to May 31	University of Washington
Amanda Maness	Installer Representative	May 26 to May 31	TE Subcom

TABLE 8-3 INSHORE SURVEY PERSONNEL

8.4 SURVEY METHODS

8.4.1 Silver Streak Vessel Offsets

The MRU was the reference point for all vessel offsets. The Octans was mounted below the floorboards in the cabin as close to the vessels center of gravity as possible. All other sensors were offset from this location. Layback of the towed system was accounted for in post processing. Distance to waterline measurements for use in MBES data processing were taken over the side using a weighted tape measure.

Sensor	Offset X (m)	Offset Y (m)	Offset Z (m)
Octans IMU	0.00	0.00	0.00
Trimble SPS851 GPS Antenna	1.12	-0.25	2.195
Trimble Ag132 GPS Antenna	1.12	2.36	2.195
Reson 7125-SV receiver	1.81	-0.82	-0.54

TABLE 8-3 SILVER STREAK OFFSETS

8.4.2 Calibrations and Quality Control

A patch test was performed on the multibeam system and the results used to correct the acquired multibeam data. A patch test report is included in Appendix F.

Collected data was continually monitored online for data gaps and any indication of position jumps. Processed data was also checked consistently for errors in the positioning by comparing geology correlation for lines run in opposite directions.

8.4.3 Surface Positioning

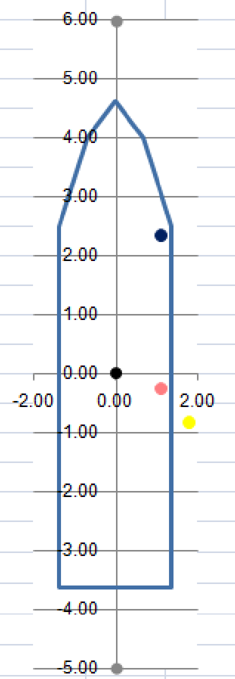
Williamson and Associates, Inc. provided positioning with a Trimble SPS851 DGPS. The antenna offset for this DGPS antenna was measured from the vessel reference point to an accuracy of < 5cm. Backup positioning was provided by a Trimble Ag132 and can be seen in Figure 8.3.

A QINSy Integrated Navigation System was used for online survey positioning and acquisition of the multibeam data. QINSy also had an alert activated to monitor all data arrival to the computer and an alert to notify if positioning lost its differential correction.

WILLIAMSON & ASSOCIATES	*Form Name :* VESSEL OFFSETS	*Procedure Type*	**Operations**
		Form No	**WASV_Vessel offset diagram**
		Revision	3
		Date	**25-May-10**
		Approved by	

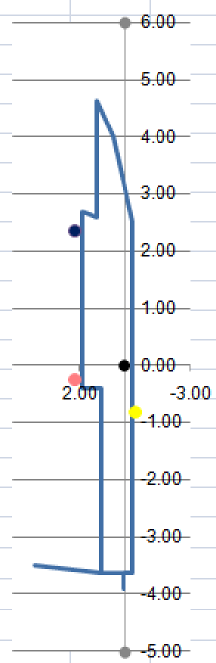
		Project			L3-RSN 2010
Client	L3 Maripro	**Vessel**			R/V Mount Mitchell
No	**Description**		**X (m) (Stbd+)**	**Y (m) (Fwd+)**	**Z (m) (Up+)**
Datum	Vessel Reference Point / IXSEA Octans	●	0.00	0.00	0.00
1	Trimble SPS851 Antenna	●	1.12	-0.25	2.20
2	Trimble Ag132 Antenna	●	1.12	2.36	2.20
3	Reson SeaBat7125-SV	●	1.81	-0.82	-0.54
4		●			
5		●			
6		●			
7		●			

Vessel Horizontal Diagram



X Value	Y Value
-1.37	-3.62
1.37	-3.62
1.37	0.50
1.37	2.50
0.69	4.00
0.00	4.62
-0.69	4.00
-1.37	2.50
-1.37	0.50
-1.37	-3.62

Vessel Vertical Diagram



Y Value	Z Value
-3.90	0.00
-3.62	0.00
-3.62	-0.40
0.00	-0.40
2.50	-0.40
4.00	0.50
4.62	1.20
2.60	1.20
2.70	1.90
-0.40	1.90
-0.40	1.00
-3.62	1.00
-3.50	4.00
-3.62	1.00
-3.62	0.00

Filename		**Comments**	

SIGNED

Position	**Name**	**Signature**	**Date**
Navigator	Brian Bunge		5/25/2010
Party Chief	Colin Stewart		5/25/2010

FIGURE 8-3 SILVER STREAK VESSEL OFFSETS

8.4.4 Sound Velocity Profiles

Water column data were acquired using a Seabird SBE 19 CTD (Appendix F). Sound velocity casts were taken first thing when the vessel got to the survey site, and just before departing the survey area. The SBE 19 was lowered by the winch from the A frame through the water column. Once back on the vessel, the data was downloaded and checked against the surface sound speed from the SBE 37 microCat. The SBE 37 was mounted near the multibeam transducers, and the sound speed at the multibeam head was streamed directly into the Reson topside computer.

8.4.5 Bathymetry

A Reson SeaBat 7125-SV was pole-mounted on the starboard side of the vessel. During transit, the pole was rotated so the multibeam head was out of the water and bolted into place. Once at the survey site, the pole was unbolted and rotated into position. A ratchet strap attached to the end of the pole was used to cinch the multibeam into place.

The SeaBat 7125-SV operated at 400 kHz, with 512 equidistant beams. The Reson topside controller was used to operate the multibeam, and the received data were input into QINSy where it was recorded. Stored multibeam data were exported from QINSy into a format readable by CARIS for processing.

8.4.6 Sidescan Sonar

Sidescan sonar imagery was collected from the EdgeTech 2000-DSS. The sidescan sonar operated at 100 and 400 kHz simultaneously. EdgeTech's DISCOVER software was used to operate the sonar and record the data. Both the high and low frequencies were recorded. The sonar records were stored as .JSF files as well as .XTF files. The Sonar was launched using the mounted winch and A-frame. As tow line was let out, a separate data cable was let out by hand as needed. The tow fish was recovered by bringing the vessel to a stop and placing the outdrive in neutral. The A-frame was extended and the fish was recovered to the water surface. The A-frame and fish were then simultaneously brought in and onboard.

8.4.7 Subbottom Profiler

The EdgeTech 2000-DSS has an integrated CHIRP 2 to 16 kHz subbottom profiler. This subbottom profiler was operated by the DISCOVER software and recorded in JSF file type.

8.4.8 Seabed Sampling

There were 10 locations chosen to attempt grab samples. Grab samples were taken using a Van Veen grab sampler. The first several yielded no recovery due to the grab sampler triggering in the water column because it was being lowered to quickly. The next several attempts also yielded no recovery because the grab sampler never triggered. Successful recoveries started when the sampler was lowered very slowly until it touched down on the seafloor; it was then pulled in 1 m and dropped again before fully being recovered. When the sampler hit the seafloor, the position was marked using the vessels GPS. The samples were recovered and placed into labeled 1 gallon Ziploc bags. Back at the Williamson office, the samples were photographed with their name, water depth and a scale. The samples were then sent to GMT for analysis.

9 DATA QUALITY AND PROCESSING TECHNIQUES

9.1 SIDE SCAN SONAR

9.1.1 Quality

The side scan sonar was acquired with two systems; the Williamson AMS 120 (AMS) and the Benthos C3D (C3D). The AMS is a much lower frequency system (60 kHz) than the C3D (200 kHz). This results in two entirely different sonar characters. The higher frequency C3D may show more detail but is range-limited as the signal attenuates more rapidly than the lower frequency AMS. The AMS is also an analog system whereas the C3D is digital. This impacts the dynamic range that can be recorded (even though the analog signal must be digitized before recording). In general the C3D system recorded highly detailed features out to a range of about 100 m. Beyond 100m, the record quality degrades progressively with range to the point where features at ranges exceeding 200 m are indistinguishable unless they are prominent and special processing is applied. The lower frequency signal propagates through material such as seawater and any nepheloid layers that may be present much easier than the higher frequency signals. This likely explains much of the differences between the two systems. A comparison of the two systems is shown in Figure 9-1.

The AMS system has no problem resolving features out to a range of 300 m. Resolution is slightly impacted by the lower frequency, but generally features with sizes between 0.5 and 1.0 m can be detected as long as the tow-speed is 4 knots or less. In practice, the resolution is less as features need more than one pixel (either along track or cross track) to identify their nature. The interpretable resolution of 4 pixels would be 3.2-4.0 meters, and the interpretable resolution of 3 pixels would be 2.4-3.0 meters. It would be unlikely that accurate identification could be made for any object of a size less than 3 pixels. Nevertheless, objects of sizes 3 pixels or less are detected even though their exact nature cannot be ascertained.

It should be noted that early on the port channel stopped working on the AMS system. As a result, the survey was conducted using just the starboard channel. The final sonar coverage for the AMS is on the order of 120-150%, so some potential features are only imaged once from one direction. Coverage obtained by the C3D is generally better than 200%.

Positioning for both offshore sonar systems was provided with USBL. The USBL system can sometimes be noisy and spiky requiring extensive post-processing and smoothing. This in turn degrades the positional accuracy of detected features. In general, the USBL seemed to be cleaner for the AMS system and noisier for the C3D system in water depth out to about 700 m. From 700 m to 1500 m, increasing degrees of post-processing became necessary to smooth the USBL positions. For the C3D, position spikes were noted in the shallower waters (100 m to 500 m).

An EdgeTech 2000 DSS dual frequency sonar was used for the Inshore survey. This system was recorded at both 100 and 400 kHz. The range-scales were set to 75 m. Positioning was done using straight layback so USBL spikes were not an issue. The effective resolution seen in the inshore data is approximately 2 m and the pixel resolution is good to about 0.5 m. The positioning by layback worked exceedingly well as small (~1 m) crab pots were observed lying between adjacent lines to within 3 m in almost all instances. These transient objects are not mapped. The lower frequency (100 kHz) was used for data interpretation as surface wave chop degraded the sonar image in the higher frequency recordings.

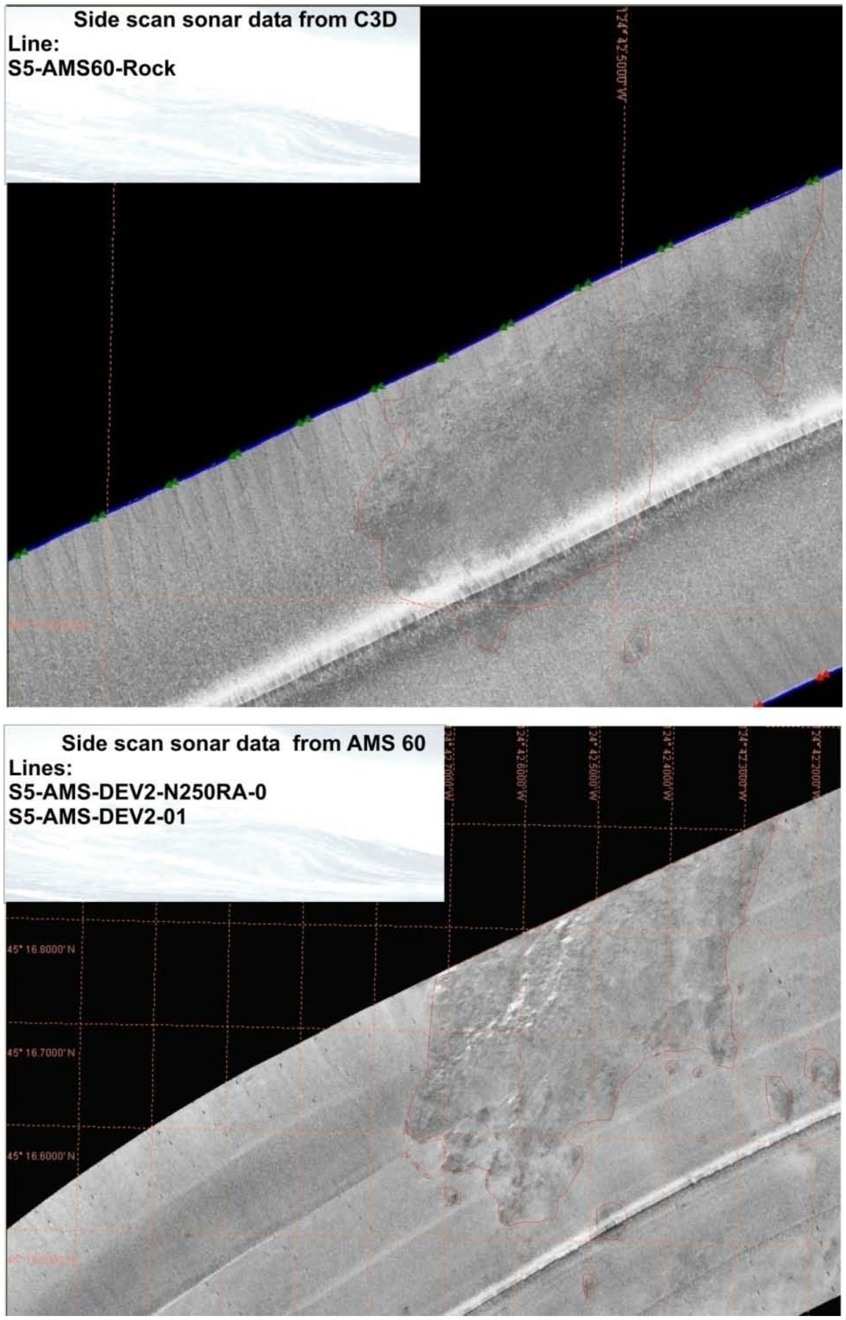


FIGURE 9-1 COMPARISON OF AMS AND C3D SONAR DATA

9.1.2 Processing Techniques

Digital XTF format data were analyzed to detect any objects that may impede cable-lay operations and to determine surficial sediment types and classification. SonarWiz Map by Chesapeake Technology and AutoCAD Raster Design were the primary tools used in sonar processing and Interpretations. Mosaic construction followed this processing flow:

1. Load XTF data to SonarWiz Map to assess and repair USBL positions and bottom track
2. Write repaired navigation and bottom track back to XTF files

3. Export processed sonar images to geo-referenced tiff files
4. Load geo-referenced tiffs into AutoCAD
5. Rubber-sheet Jpeg images to correlate with multibeam bathymetry where necessary
6. Map features such as scars directly in AutoCAD to aid in positioning and reduce duplication
7. Compare sonar areal features with subbottom profiles, core and CPT information, multibeam bathymetric trends, and regional information to determine best plausible interpretation
8. Finalize interpretation, attribute and export to shapefiles.

9.2 SUBBOTTOM PROFILER

9.2.1 Quality

Like the sonar, the C3D and AMS were used to acquire subbottom profiler data. The AMS is an analog 4.5 kHz profiler and the C3D is a lower power CHIRP system with a swept frequency range between 2 and 7 kHz. The AMS system had a depth transducer attached to the towfish, which allowed the towfish depth to be logged to the SEG-Y files. Depths were not logged to the C3D SEG-Y files as this system was logged using ISIS rather than SonarWiz. This has implications that will be discussed in the next section.

The AMS single frequency is a powerful profiler, which in some instances penetrated greater than 120 milliseconds (~90 m) through partially lithified to rocky strata. The maximum penetration achieved by the C3D was in the order of 50 milliseconds. On the shelf for Segments 1 and 3, the C3D averaged about 20 milliseconds penetration (~15 m). In Segment 4, the AMS averaged about 40 milliseconds penetration. It should be noted that these penetration numbers are largely meaningless when it comes to interpretation. Penetration is mostly dependent on the acoustic impedance properties of the material that the signal propagates (travels) through. Echoes are returned whenever there is a change in acoustic impedance; the larger the change, the stronger (higher amplitude) the echo that is returned. The largest impedance change usually occurs at the seabed where water contacts sediment. If the sediment is hard, a strong echo is returned and very little penetration is achieved. If the seabed consists of soft muck, the subbottom profiler will usually penetrate well regardless of whether it is a CHIRP system or a 4.5 kHz analog system. If a layer of muck rests upon bedrock, the signal has a better chance of penetrating rock than if the rock is exposed at the seabed. If the acoustic impedance changes are gradual, a 4.5 kHz signal can penetrate several hundred milliseconds. There have been instances off the Mississippi Delta where a 3.5 kHz system penetrated to resolve strata 500 milliseconds beneath the seabed (Personal Observation, J. Rietman).

Of much more importance for cable burial is the resolution of the received signals in the uppermost 10 milliseconds (7.6 m). The C3D system was able to resolve features in the 0.5 millisecond range while the AMS was more in the 1.0 millisecond range. This may be due to pulse lengths as the two mid frequencies are similar. This means that for the AMS, layers less than 0.76 m beneath the seabed are generally not resolvable and for the C3D, layers less than 0.36 m beneath the seabed are not resolvable. Certain inferences had to be made during interpretation (such as character of the seabed return) to compensate for this lack of resolution. A comparison of the C3D and AMS subbottom profiles is seen in Figure 9-2.

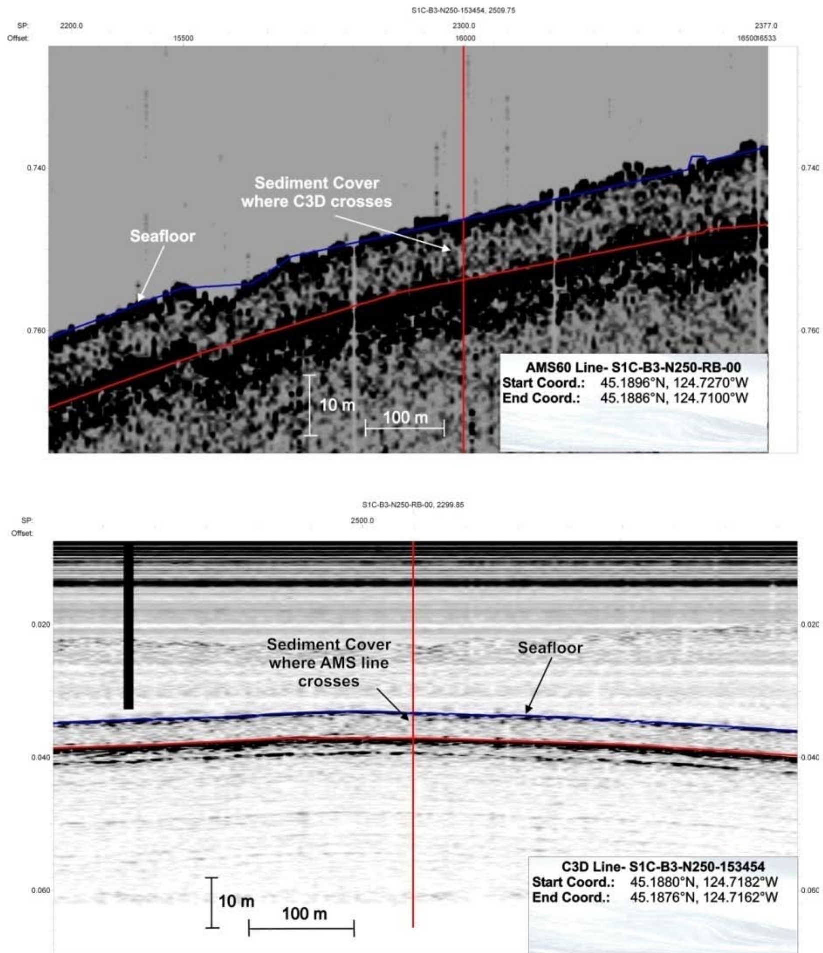


FIGURE 9-2 COMPARISON OF C3D AND AMS SUBBOTTOM PROFILER

One other problem occurred during data analysis. The AMS system seemed to have a TVG problem where at a certain times about 50 milliseconds from time-zero gains were clipped and the amplitudes were artificially attenuated. This was not an insurmountable problem as display gains could be increased to compensate during interpretation.

The Inshore survey used the Edgetech 2000-DSS CHIRP 2-16 kHz system. The system penetrated between 5 and 10 milliseconds through the sandy seabed material and resolution in the upper 2-3 milliseconds is in the order of 0.5 milliseconds.

9.2.2 Processing techniques

AMS and C3D required separate processing techniques. Because the sensor depth was written to the SEG-Y files, a pseudo topographic correction could be made to display subbottom profiles without the effect of varying cable changes and tow depths beneath sea level. This topo-correction could not be made to C3D files because sensor depth was not logged on a ping by ping basis. The effect of topographic corrections to aid in interpretation is depicted in Figure 9-3. The top image shows an undulating seabed where the seabed is actually relatively flat. The bottom image is a true representation of the seabed. The heavy dark line above the seabed is "time-zero" or the towfish in the water column.

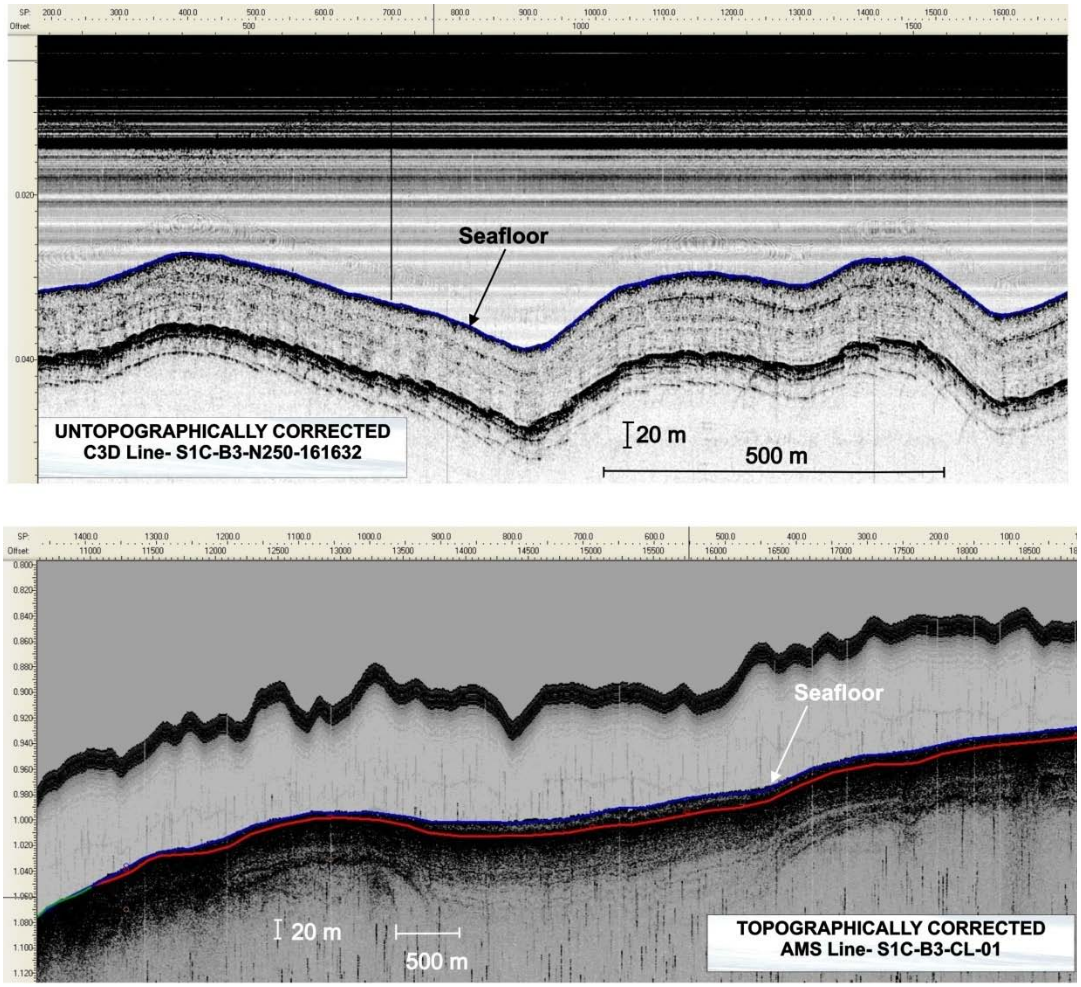


FIGURE 9-3 EFFECT OF TOPOGRAPHIC CORRECTION ON SUBBOTTOM PROFILE

In order to topographically correct, the sensor depths had to be taken from sonar XTF files, cleaned, and read into the SEG-Y files as times in certain specified byte offsets as milliseconds and microseconds. For processing, AMS data followed this flow:

1. AMS XTF (sonar) files are loaded into Sonar Wiz.
2. Sensor depths were corrected, despiked and smoothed in Z-Edit
3. Data files were created for each ping of each file which contain sensor depths
4. SEG-Y files were datum shifted from WGS84 arc seconds to UTM 10
5. Sensor depths data files were edited to match pings in the SEG-Y files.
6. Sensor depths converted to milliseconds and written to bytes 107/109 as times in SEG-Y files using software by Geo-Marine Technology, Inc. (GMT)
7. Ping numbers re-written sequentially to SEG-Y files using GMT software.
8. Import AMS SEG-Y files to Kingdom Suite for interpretation and horizon mapping.
9. Pick seabed and pick base of surficial sediment horizons, differentiate the 2 surface and export to XYZ file

10. Contour thickness values in Surfer and import contours to AutoCAD for adjustment and matching to seabed features.

C3D SEG-Y files followed the same processing flow with the exception of sensor depth manipulation and topographic corrections.

9.3 MULTIBEAM BATHYMETRY

Multibeam data were processed in the field with further processing performed ashore after data acquisition (see section 7.5.1).

9.3.1 Quality

Shipboard data were delivered for interpretation and charting. As a post-processing step, C3D data were omitted from the dataset. Due to the high noise level of the C3D bathymetry dataset compared to the EM710 multibeam dataset, inclusion of C3D bathymetry data in the combined dataset reduced the quality to where subtle features such as relict sand waves were unrecognizable. This was accomplished as a post-processing step ashore. By using the C3D data only in areas not covered by the EM710, these discreet features were resolved. In the area between 200m and 40m water depth on Segments 1 and 5, there are a few areas where there is only C3D data coverage. In these areas, the surface was modeled using the sonar data as a template; revised C3D data were then brought back into the area to effect absolute elevation changes in the modeled regions.

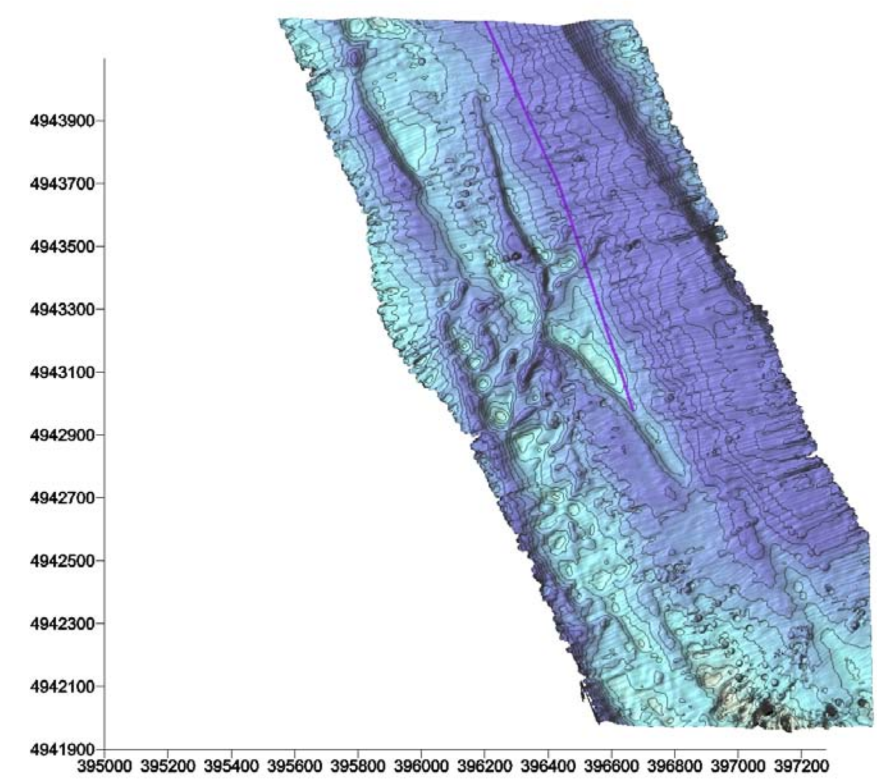


FIGURE 9-4 BATHYMETRY DETAIL AT SEGMENT 4NP (SOUTHEAST END)

In general, the multibeam data from the EM120 and EM710 systems is good quality. At the southeastern end of Segment 4NP, the vertical resolution is about 10 cm and the roll noise is about 6 centimeters vertically. Figure 9-4 shows this area contoured at 250 centimeter intervals.

10 BURIAL ASSESMENT

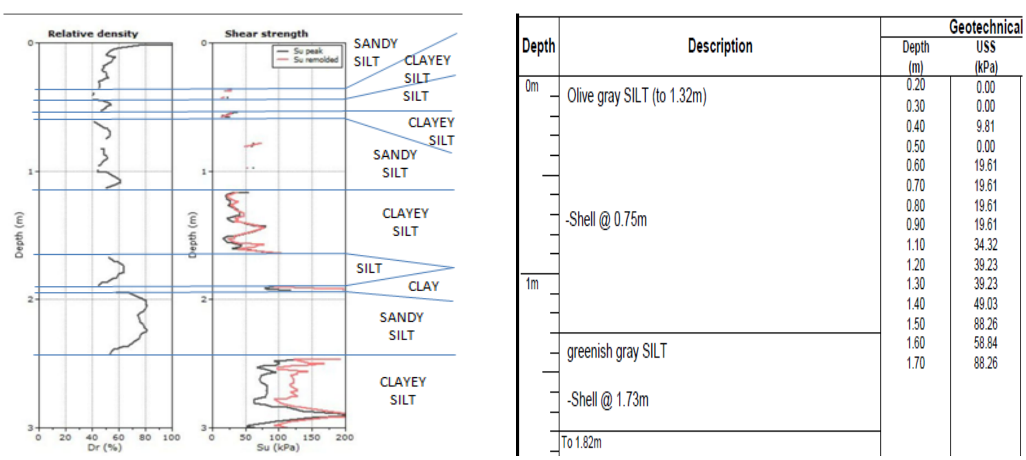
L3 conducted a burial assessment (BAS) of Segments 1, 2, 3, 4, 4NP and 5 of the final RSN cable route (RSN_PSR3_R1.xlsx), and revised it according to route final revisions (RSN_PSR3_R5.xlsx and RSN_PSR3_trunk_R6.xls). A burial assessment integrates geotechnical and geophysical data to provide the best possible interpretation of the cohesive properties and thickness of seafloor sediments, as well as possible morphological hazards. Burial for Segments 1 and 5 of the RSN cable installation will be conducted from the 20 m isobath (at the HDD exit locations, Appendix A) to depths at or beyond the 700 fathom (1280 m) isobath, as defined by RPL RSN_PSR3_R5. Target burial depth is 1.5 m below the seabed.

The burial assessment tables (Appendix H) integrate all available geophysical and geotechnical data to provide an interpretation of the physical properties of the surficial and shallow subsurface sediments. The BAS tables divide the seafloor along the final route into areas of similar physical properties, as it is logical to assume changes in physical properties equate to changes in burial conditions.

The geophysical record has been analyzed to determine the lateral distribution of similar seafloor conditions, the internal geometry of similar shallow subsurface sediments, and morphological or topographical seafloor variations that could potentially affect burial. The results of this analysis have been described by data type (i.e. **S**ide **S**can **S**onar, **S**ub-**B**ottom **P**rofiler, and **M**ulti-**B**eam **E**chosounder) and entered into a cell within the BAS tables. The following is an example of what might be displayed in such a cell:

> **SSS** – Even, moderate acoustic returns with occasional acoustic shadows associated with small depressions.
>
> **SBP** – Massive acoustically amorphous layer overlying flat lying strata. Strata at depth are brightened by gas.
>
> **MBE** – Even, very gently westward dipping seabed dotted by shallow (<0.5 m) pockmarks.

Geotechnical data have been used to quantify the resistance to shear of the seabed and shallow subsurface sediments, and to further refine and quantify areas of similar physical properties. The results of this data integration have been added to the BAS tables in the form of a simple stratigraphic column superimposed over soil strength curves derived from cone penetrometer tests (CPT's). In areas where CPT's are not available, gravity core stratigraphic logs have been substituted. In areas within which there are no geotechnical samples, stratigraphic columns have been deduced from subbottom profiler records. The following figure provides examples of each.



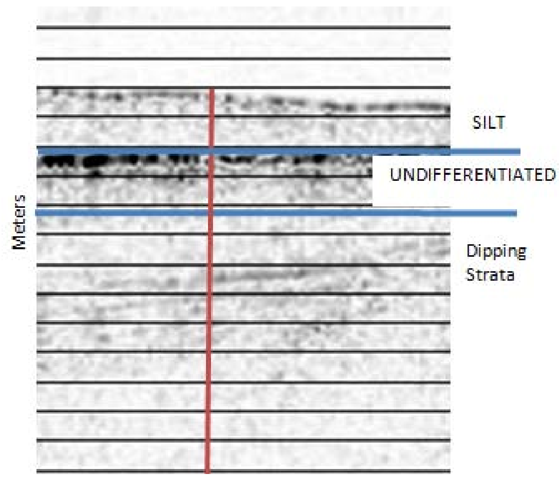


FIGURE 10-1 SUBSURFACE CHARACTERISTICS BY CPT, GRAVITY CORE AND SBP

From top left to bottom center: Interpreted stratigraphic column from CPT, stratigraphic gravity core log, and stratigraphic column derived from subbottom profiler data.

In addition to the geophysical and geotechnical summaries, a cell has been added to the BAS tables that details 'other' external factors that may affect burial. These include but are not limited to: manmade structures, gassy sediments, fishing activities, faults, side slopes, slump deposits, and other potential hazards. An example of what might be presented in this cell follows;

> *'Small pockmarks frequently dot the seafloor. These pockmarks are less than 0.5 meters deep. Mappable bottom fishing scars are frequent. Subbottom records indicate underlying strata are gassy. Very soft seds exist at 30 cm below the surface, although they are likely not soft enough to cause over burial.'*

Precise assessments of achievable burial and potential hazards must be made relative to the capabilities of a given plow. Although TE Subcom has been contracted to install the RSN cable, the specifications of their plow have not been relayed. Therefore the burial assessment (BAS) as presented in Appendix H do not conform to TE Subcom's standard format, but rather provide sufficient information regarding seafloor conditions to allow cable installers to apply whatever burial classification format they prefer. As a first estimation, the geophysical and geotechnical data allow us to classify discrete areas of the seafloor according to the Alcatel trenchability scheme below (Table 10-1).

By this scheme, an area of seafloor mapped as SAND with relative densities around 50% to a depth greater than 1.5 m would have an associated estimation of achievable burial and burial consistency of "Full and Consistent" and the trenchability classification "A". Burial conditions in an area of seafloor mapped as UNDIFFERENTIATED with shear strengths of around 100 kPa to a depth of 1.5 m would be estimated to have "Reduced and Variable" burial conditions and a trenchability classification "B" based on shear strength and the apparent stratigraphic variability of the seafloor as seen in the subbottom profiler record. An area of seafloor mapped as SAND with relative densities around 90-100% to a depth less than 1.5 m would have an associated estimation of achievable burial and burial consistency of "Limited and Variable" and trenchability class "C".

It is important to note that comments and classifications within the BAS tables regarding achievable burial and consistency are based entirely on soil strengths as determined by geotechnical sampling and lateral variability in the geophysical record. More accurate classifications will be necessary once the capabilities of the plow become available.

Neither Williamson and Associates nor Geo-Marine Technology will assume liability for damages or time lost as a direct or indirect result of the classification of the seafloor as outlined in this document.

Trenchability Class	Description
A	Thick very soft to firm clays and up to medium dense sand/silt. Full burial expected to at least 0.8m. Constant burial conditions with low variability. Tow tensions generally low and consistent - <15T. Generally flat seabed (no sedimentary bedforms/low slopes). Low plough pitch/roll expected. Clays - shear strength >4kPa (no plough sinkage expected). Optimal plough progress rate. Low plough share tip wear rate. Seabed also fully jettable.
B	Stiff to very stiff clay and up to dense sand/silt, also anywhere where loose/soft sediment sits over a dense to very dense unit. Reduced and variable burial conditions, but burial not expected to be <0.4m. Tow tensions up to, but not exceeding, 25T. Some plough pitch and roll expected. Minor sedimentary features, but slopes must be <10degrees. Reduced plough progress rate possible. Medium plough share tip wear rate. Reduced jettability and/or multiple passes expected.
C	Stiff to very stiff clay and up to very dense sand/silt, also anywhere where a thin unit of loose/soft sediment sits over a dense to very dense unit, or rock. Poor / variable burial expected - generally <0.4m. Possible spot plough rideouts. Possibility for areas of cable very close to the seabed. Tow tensions may exceed 30T, with high variability and possible renders. Seabed topography may be present, but slopes <10 degrees. High plough pitch/roll events possible. Slow plough progress rate. High plough share tip wear rate. Poor jettability.
D	Not ploughable, due to seabed conditions. Rock outcrop/boulders/seabed debris/slopes >10 degrees Possibly jettable - maybe in short areas between outcrops, on slopes up to 30 degrees, between boulders/debris.
E	Over burial expected with a standard, unmodified plough, due to low seabed bearing capacity. Shear strength <4kPa in upper 0.5m of seabed.

TABLE 10-1 ALCATEL SUBMARINE NETWORKS TRENCHABILITY CLASSIFICATION SCHEME

Alcatel Submarine Networks trenchability classification table (AT&T Asia-America Gateway Project, 2008)

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