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B.J. Todd[1], S.E. Bossey[1], R.R. Boutilier[1], A.O. Brown[1], J.L. Bryk[2], G.L. Bugden[3], C.G. Currie[1], S.E. Hayward[1], E.P. Horne[3], C.A. Jarrett[1], K.W.G. LeBlanc[1], M.Z. Li[1], D.J. Manning[1], P. Meslin[1], R.J. Murphy[1], P.J. Neelands[4], D.P. Potter[1], A.G. Robertson[1], P.L. Spencer[1], and G.B. Standen[5]

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1. Introduction – *B.J. Todd*

1.1 Introduction

The CCGS *Hudson* expedition 2011036 to the Bay of Fundy took place from 30 August to 15 September 2011 (days of the year 242 to 258). The primary scientific objective of this expedition was to collect geophysical and geological information in areas where multibeam sonar data had been collected by the Ocean Mapping Group of the University of New Brunswick, the Canadian Hydrographic Service, and the Geological Survey of Canada (Atlantic) from the mid-1990s to 2008 (Fig. 1). When conceived and planned, *Hudson* 2011036 supported objectives of the Offshore Renewable Energy (ORE) Project of the Offshore Geoscience Program. (ORE Project staff and funds were transferred in late 2011 to the Environmental Geosciences Program). Insights gained from this expedition will contribute to our understanding of the Quaternary evolution of the Bay of Fundy and the seabed conditions that may affect the development of marine renewable energy infrastructure. The expedition was conducted with cooperation of scientific staff of Fisheries and Oceans Canada (DFO).

During the expedition, 1245 kilometres of seismic profiles and sonograms were collected, 24 camera stations were occupied (resulting in 1345 still images and 8 hours and 11.8 minutes of video camera recording time), 90 IKU samples were retrieved, 2 van Veen grabs were obtained, and 13 piston cores and 4 gravity cores taken at seismostratigraphically strategic locations. Seabed landers were deployed and recovered at strategic sites. DFO staff conducted oceanographic observations at stations of opportunity through the expedition.

The general pattern of work on expedition *Hudson* 2011036 consisted of bottom sampling, sea floor video and photography by day, followed by a night watch collecting geophysical data (seismic profiling and sidescan sonar). Work during daylight took place on the foredeck and in the forward lab and in the General Purpose (GP) lab. Night work took place on the quarterdeck and the GP lab (Fig. 2).

The weather on this expedition was uniformly good and was remarked upon by crew and scientific staff.

1.1 Acknowledgments

The outstanding performance of duty by Captain Paul Bragg and the officers and crew of the CCGS *Hudson* contributed greatly to the scientific success of expedition *Hudson* 2011036. The scientific staff displayed enthusiasm for, and dedication to, the expedition work objectives. We thank the ship's crew and Bruce Wile and his staff of the Geological Survey of Canada (Atlantic) for ship mobilization and demobilization. John Shaw (Geological Survey of Canada-Atlantic) reviewed this Open File Report and provided helpful suggestions for its improvement.

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Table 1: List of Canadian Coast Guard personnel, *Hudson* 2011036.

Rank	Name
Commanding Officer	Paul Bragg
Chief Officer	Kenneth Brown
Second Officer	Marie Josée Beaudoin
Third Officer	Chris Brown
Chief Engineer	Derrick Coolen
Senior Engineer	Alexander J. Curry
First Engineer	Saleem Sultan
Second Engineer	Julien P. Marceau
Third Engineer	Charles W. Stoodley
Electrical Officer	James Ward
Electrician	Joe Lucas
Logistics Officer	David Wiswell
Ship Technician	Terry Cormier
Boatswain	Edward O'Quinn
Supn. Boatswain	Ivan Naugle
Leading Seaman	David Boyd
Leading Seaman	D. Gregory MacLellan
Leading Seaman	John Langille
Leading Seaman	Matthew Reeves
Deckhand	Barry Hill
Seaman	Andrew G. Ward
Seaman	Arthur W. Wilson
Oiler	Lionel LeBlanc
Oiler	Virgilio A. Almeda

Rank	**Name**
Chief Cook	Randall Hadley
Storekeeper	Denise Jones
Cook steward	Denise Leppard
Steward cook	Douglas Alexander
Steward	Evelyn Donovan
Steward	Tim Antoft
Steward	Ronald J. Cameron
Steward	Jeff Whittle
Cadet	Nathalie Choquette
Officer Cadet	Chris Wyman

Table 2. List of scientific personnel, *Hudson* 2011036.

Title and duties	**Name**	Affiliation
Chief Scientist	Brian Todd	GSCA
Technologist (Sediment sampling)	Sarah Bossey	GSCA
Watchkeeper	Ross Boutilier	GSCA
Technologist (Sediment sampling)	Owen Brown	GSCA
Student (Marine biology)	Jessica Bryk	Dalhousie
Scientist (Oceanography)	Gary Bugden[1]	DFO
Engineer (All systems)	Claudia Currie	GSCA
Technologist (Navigation, GIS)	Scott Hayward	GSCA
Scientist (Oceanography)	Edward Horne	DFO
Scientist (Benthic habitat)	Vladimir Kostylev[2]	GSCA
Watchkeeper	William LeBlanc	GSCA
Scientist (Marine geology)	Michael Li	GSCA
Technologist (Seismic systems)	Desmond Manning	GSCA
Technologist (sidescan sonar)	Patrick Meslin	GSCA
Technologist (Coring)	Robert Murphy	GSCA
Technologist (GIS)	Peter Neelands	GSCP
Technologist (Data processing, curation)	Patrick Potter	GSCA
Technologist (Photography)	Angus Robertson	GSCA
Watchkeeper	Colin Rothwell	Geoforce

Scientist (Marine geology)	John Shaw	GSCA
Watchkeeper (Station sheets, ED AT SEA)	Philip Spencer	GSCA
Technologist (Huntec DTS system)	Graham Standen	Geoforce

GSCA: Geological Survey of Canada (Atlantic)
GSCP: Geological Survey of Canada (Pacific)
1 Disembarked 9 September 2011-09-08
2 Embarked 9 September 2011-09-08

Table 3. *Hudson* 2011036 duty roster.

Watches (ADT) (UTC)	**0000–0400** (0300–0700)	**0400–0800** (0700–1100)	**0800–1200** (1100–1500)	**1200–1600** (1500–1900)	**1600–2000** (1900–2300)	**2000–2400** (2300–0300)
Activity	***Geophysical surveying***	***Sea floor Sampling***			***Geophysical surveying***	
Watchkeeping	LeBlanc	Currie, Rothwell	Boutilier	LeBlanc	Currie	Boutilier
Deck sheets / ED at Sea		Spencer (Brown, Bossey)				
Regulus, GIS		Hayward, Neelands				
Data processing and curation			Potter (Hayward, Neelands)			
Geological sampling		Murphy, Brown, Bossey, Rothwell				
Towed Camera Sled		Robertson, Bryk, Kostylev				
Seabed lander			Robertson			
DFO oceanography		Bugden, Horne				
	Meslin (0000–0600)				Meslin (1800–2400)	
Seismic	Manning (0000–0600)				Manning (1800–2400)	
Huntec	Standen (0000–0600)				Standen (1800–2400)	
***Hudson* deck crew**		Gear in	Foredeck operations 0600–1800		Gear out	

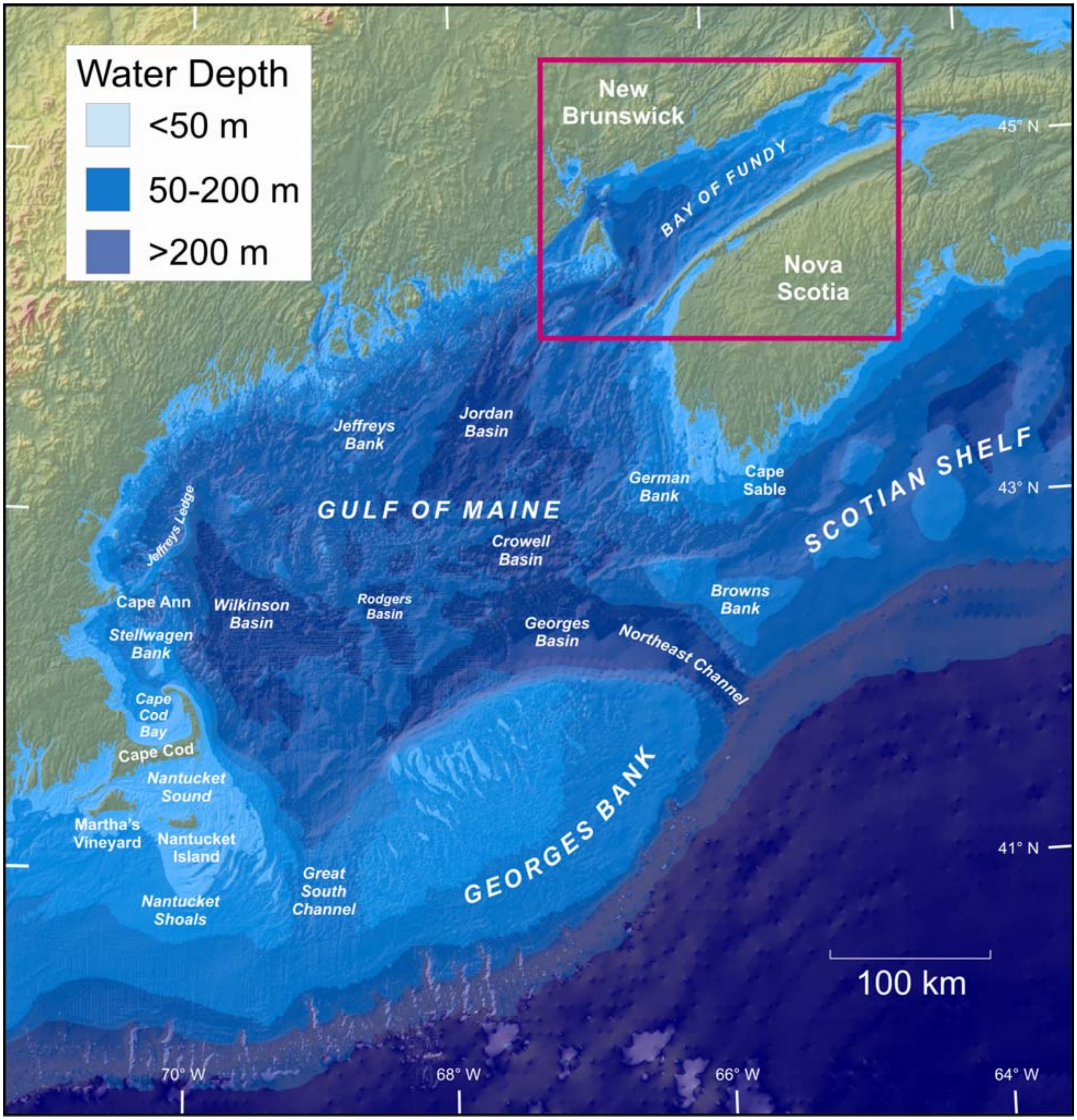

Figure 1. Location map of the Bay of Fundy outlining the area of operations.

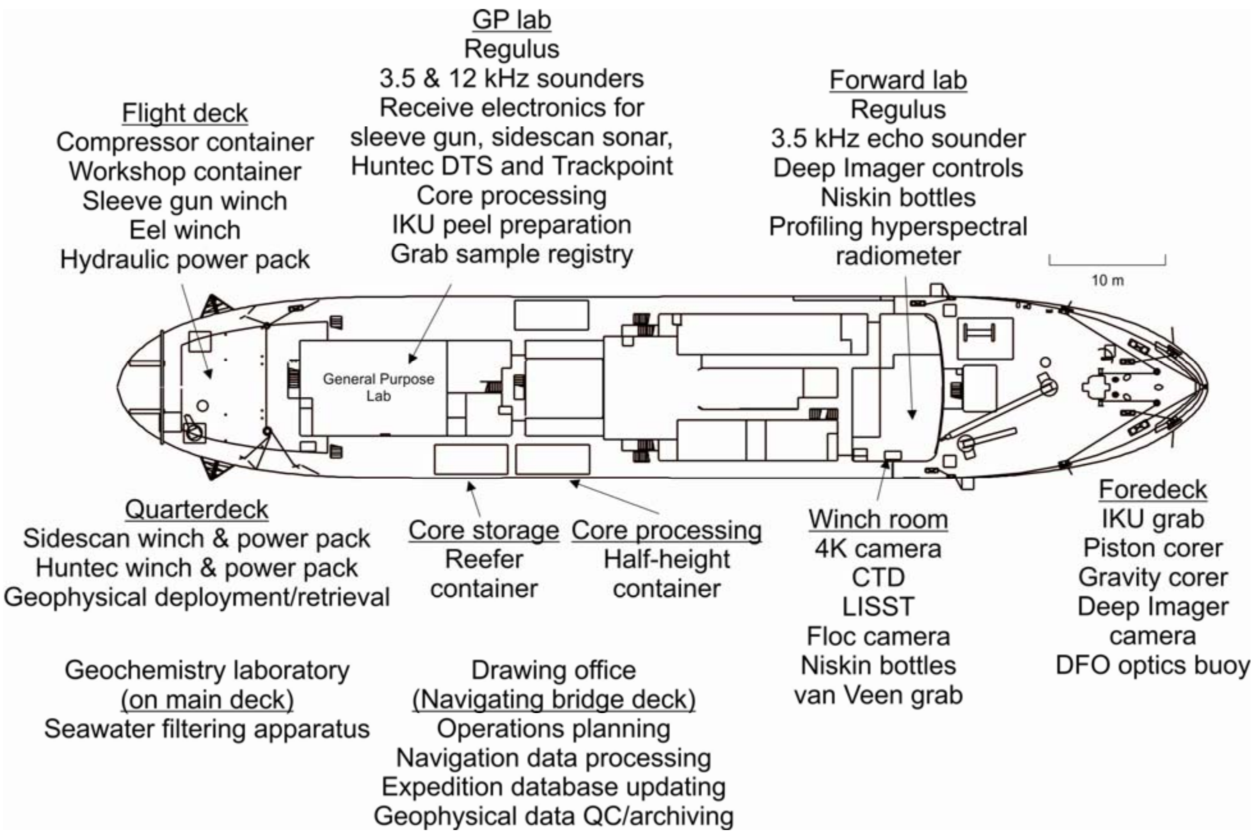

Figure 2. Layout of scientific equipment and activities on the upper deck of the CCGS *Hudson* on expedition *Hudson* 2011036. In the winch room, LISST refers to Laser In-Situ Scattering and Transmissometery.

2. Expedition narrative - *B.J. Todd, S.E. Hayward, M.Z. Li*

The scientific activities during *Hudson* 2011036 were recorded in Coordinated Universal Time (UTC) which at that time of the year is three hours later than the local Atlantic Standard Time (AST) (i.e. 0900 AST is 1200 UTC). Daylight activities included sea floor sampling (IKU, van Veen, piston core) and photography using the and Deep Imager and 4K cameras. Geophysical surveys (seismic reflection and sidescan sonar) were conducted overnight. The layout of the geophysical survey lines was a balance between the location of the ship at the end of each day's sampling activities (thus defining where the survey began) and the overall goal of logically augmenting the network of existing survey lines in the bay to improve insight into the regional and local seismostratigraphy. Figure 3 shows the location of sample stations and the extent of geophysical tracklines in the Bay of Fundy. Decisions regarding sampling and geophysical trackline locations were made each day. The overall survey objective was to achieve geographic coverage of the bay and to further investigate bedforms, topographic features and backscatter signatures gleaned from the mutibeam sonar data.

Tuesday, August 30, Day 242 Sunny, light winds, calm seas

The CCGS *Hudson* was loaded and prepared during the day and departed from the BIO pier at 1515. Fire and lifeboat drills were held while the ship remained in Bedford Basin. By 1745, the ship had cleared Georges Island and was steaming south out of Halifax Harbour en route to the Bay of Fundy. Arrangements were made to meet Bruce Wile at Digby on Wednesday to take delivery of equipment (bird) for the seismic steamer and to take on board crew members. A scientific meeting was held in the lounge at 1900 hours to discuss the general plan of scientific activities for the expedition.

Wednesday, August 31, Day 243 Sunny, light winds, calm seas

The ship steamed southwest overnight to offshore Cape Sable Island and then northwest to the entrance to the Bay of Fundy. The Fast Response Craft (FRC) was deployed at 1630 AST to go to Digby to meet Bruce Wile, obtain equipment for the seismic eel and collect two crew members.

Station 1 (at 2014) was a DFO light meter deployment on the Digby Esker followed by a Deep Imager camera deployment at **Station 2** (at 2038) for approximately 20 minutes (Fig. 4). Strong currents caused the instrument to be dragged unduly, so it had to be brought on board and deployed a second time. Finally, a DFO CTD (with two Niskin bottles) was deployed at **Station 3** (at 2134).

By this time, the current flow was strong to the southwest so it took some time to bring the ship northeast onto survey **Line 1** (Fig. 5). The geophysical gear was deployed later than planned due to waiting for the FRC to return from Digby. The survey line was run northwest from Digby Esker, across the streamlined “crag and tail” in mid-bay, and around to the north of The Wolves close to the entrance to Passamaquoddy Bay. The Huntec DTS system failed half way through the line, but the sleevegun and sidescan sonar records were good.

Thursday, September 1, Day 244 Sunny, light winds, calm seas

The geophysical gear was brought onboard at 0600 (AST) and the ship proceeded to the southeast of The Wolves. Several fields of sediment waves and irregular dunes were identified on the multibeam sonar image (Figs. 6 and 9). Camera, grab and lander stations were conducted in this area to quantify the grain size, morphology, shallow sub-surface texture and structure, and mobility of these seabed features. The Deep Imager camera was deployed at **Station 4** (Figs. 6, 7) several times starting at 1020 but failed to record any data. During **Station 5** (at the same location), the IKU grab failed to trip on five attempts from 1121 to 1201 with only a small amount of mud recovered from the jaws on the third failed attempt. The van Veen grab at **Station 6** (at the same location) also failed to recover any sediment after two attempts at 1230 and 1239. Speculation was that these devices were being mired by the mud and failing to trip. The 4K camera was deployed at **Station 7** (at the same location) and recorded 25 seafloor images. The IKU was greased and new bungee cords were fitted to the trip arm, but **Station 8** was another failed IKU attempt at 1333 at the same location. Finally, lander number 2 (M. Li code) was deployed at **Station 9** at this location at 1402 (see Section 9 for sensors, sampling strategy, and objectives of the lander deployment).

The ship steamed 5 kilometres to the northeast to **Station 10** on an area of sediment waves identified on the multibeam sonar image where the IKU was deployed at 1425 and 1429 with no success (Fig. 6). The ship steamed 2 kilometres to the northeast to **Station 11** on an area of sediment waves identified on the multibeam sonar image where the IKU was deployed at 1519 with no success. The ship steamed 8 kilometres to the southeast to **Station 12** to attempt to get a sediment sample for a scientist at DFO St. Andrews (Figs. 6, 8, 9). Unfortunately, the IKU failed to function at 1601 and 1605. The ship steamed 7 kilometres to the southeast to Station 13 to repeat this objective, but again the IKU failed at **Station 13** at 1646 (Figs. 8, 9). A van Veen was attempted at this site at **Station 14** at 1658 and obtained a full sample of red-brown mud.

The ship then steamed 9 kilometres to the southeast to a region of sediment waves identified on the multibeam sonar image. The IKU was deployed at **Station 15** at 1759. A sediment sample of muddy sand was recovered but suffered partial washout along the sides of the grab. Lander 1 (M. Li code) was deployed at **Station 16** at 1830 (Fig. 10). A twenty foot piston core was deployed at **Station 17** near the site of the Lander 1 deployment at 1918 along the seismic line collected on *Hudson* 2009039 (247/0306). The trigger weight core was full of grey, homogeneous silty clay. Although the apparent penetration was 609 cm, only 22 cm of silty clay was recovered in the bottom section of liner.

In the vicinity of the piston core, the DFO CTD was deployed at **Station 18** between 2004 and 2017 (Fig. 10). This was followed by the DFO light meter at **Station 19** (at the same location) from 2024 to 2042.

The seismic gear was deployed at about 1830 (AST) to run a zigzag survey line pattern (**Line 2**) across the Grand Manan Basin to image the surface of bedrock and the overlying glaciomarine and modern sediments (Fig. 11). The Huntec DTS worked for only a few minutes with the new towfish and it suffered the same signal loss that occurred the previous night. Graham Standen analysed separate components. The conclusion was to call Geoforce in Dartmouth and arrange for the transport of a new power control unit by vehicle to Digby on Friday for pickup using the FRC. This plan was cleared with the ship and then put into action.

Friday, September 2, Day 245 Sunny, light winds, calm seas

The seismic and sidescan sonar systems collected high quality data throughout the calm survey night. The geophysical gear were retrieved at 0600 (AST) and the ship proceeded to **Station 20** in the Grand Manan Basin where the DFO optical buoy was released at 1038 (Fig. 12). The piston core was then rigged for **Station 21** and a sample was taken at 1123 (seismic tie *Hudson* 97020, 179/0110). Here the glaciomarine unit thins to the east above a till layer. The trigger weight core barrel was lost due to lack of tightening following the previous CCGS *Hudson* expedition. There was 30 feet of apparent penetration with approximately 9 feet of core recovered. As the core sections were taken apart, the sediment was remarked on as being quite stiff.

The ship then repositioned 6 kilometres to the northeast to **Station 22** for another piston core at 1336 (seismic tie *Hudson* 97020, 179/0020). Here the modern sediment thins above the glaciomarine unit. In this instance, there was no sediment recovered from the trigger weight core and the piston core had an apparent penetration of 30 feet with 10.5 to 12 feet of gassy sediment recovered.

The ship then transited 21 kilometres south to **Station 23** for a piston core at 1613 near the southern pinch out of glaciomarine sediment (seismic tie *Hudson* 2009039, 241/0526) within Grand Manan Basin (Fig. 13). The trigger weight core apparently fell over on impact with the seabed as there was sediment along one side. There was a small sample of clayey gravel in catcher. The piston core had an apparent penetration of 20 feet with 9 feet of core recovered.

In order to position the ship to release the FRC, the vessel transited 45 kilometres to the east to the Digby drumlin field. The FRC was released to go to Digby to retrieve the replacement Huntec DTS power system unit. **Station 24** was an IKU in the sub-glacial (?) channel in the Digby drumlin field at 1858 (Fig. 14). Unfortunately, the grab jaws were held open by shells and much of the recovered sediment of well sorted medium sand was washed out. The vessel repositioned 500 metres to the northwest to the top of a drumlin to collect an IKU grab at **Station 25** at 1946. Again, the recovered sediment of gravelly coarse sand was partially washed out due to pebbles caught in the jaws.

The ship then transited 50 kilometres back to Grand Manan Basin to pick up the DFO optical buoy released earlier in the day at **Station 20**. The buoy was successfully recovered at 2216 and Peter Neelands explained to us the next day that ED requires the recovery to have its own station identification as **Station 26**.

The geophysical gear was deployed at 2304, an hour later than the time allowed. As this was the second time that this occurred in three days, Captain Bragg requested that it not happen again. **Line 3** was run north and then east across the approaches to Saint John harbour, New Brunswick (Fig. 15).

Saturday, September 3, Day 246 Sunny, light winds, calm seas changing to overcast, moderate winds

The geophysical gear was recovered at 0600 (AST) and the ship steamed northeast to occupy **Station 27** east of McCoy Head, New Brunswick (Figs. 16, 17, 18) where an IKU sample of a flow-normal bedform ("star" dune) was recovered at 1053 after a long fight with the tidal current. The ship repositioned a short distance to obtain an IKU of the "background" seabed at **Station 28** at 1133.

The ship was repositioned to the southwest of the bedform field and the Deep Imager camera was deployed at **Station 29** at 1216 (Fig. 18). The ship steamed northeast into the oncoming current to obtain a camera transect normal to the bedform crests. The transect was concluded at 1245.

In the same vicinity, the DFO light meter was deployed from the forward lab on **Station 30** from 1257 to 1307. This was followed by the deployment of the DFO CTD from the winch room on **Station 31** from 1320 to 1325.

The ship then travelled 4 kilometres west to a small banner bank immediately east of McCoy Head and close to shore. The Captain and First Officer oversaw the insertion of the bow of the ship onto this banner bank and the extraction of an IKU full of sand at **Station 32** at 1421 (Figs. 16, 17) when the tides were almost slack. This was too close for comfort, so other potential sample locations even closer to shore were rejected. The ship then transited 25 kilometres to the northeast to the dune field off Fownes Head to **Station 33** where an IKU full of sand was collected in strong tidal currents at 1535 (Fig. 16).

The wind picked up to 25 kilometres per hour so near shore sites were not possible. The ship steamed 15 kilometres to the south to the area of pockmarked seabed near the centre of the bay. Along the way, the ship stopped and a short memorial service was held on the quarterdeck in memory of Steve Solomon. Sediment was tossed into the bay as an offering. Upon arrival in the pockmarked area, a full IKU grab was taken at **Station 34** at 1706 (Fig. 16) followed by a camera drift at **Station 35** from 1747 to 1822. In the same vicinity, the DFO light meter was deployed from the forward lab on **Station 36** from 1832 to 1844. This was followed by the deployment of the DFO CTD from the winch room on **Station 37** from 1856 to 1906.

Captain Bragg suggested that slack tide was occurring back along the north shore at the western banner bank of Quaco Head. The ship steamed 12 kilometres north to **Station 38** where an IKU full of sand was collected at 1956 (Fig. 16).

The barbeque on the quarterdeck started at 1730 (AST) and the geophysical gear were deployed at 1800 (AST). The Huntec DTS was finally working. **Line 4** was run along the north shore intersecting a possible drowned spit, across the mouth of Chignecto Bay, ending south of Cape Chignecto (Fig. 19).

Sunday, September 4, Day 247 Overcast changing to clear with light winds, calm seas

The geophysical equipment was recovered at 0600 (AST) and the DFO optical buoy released at **Station 39** at 0935 (Fig. 20). This was followed by a DFO bottle cast at **Station 40** at 0937. The ship then proceeded 13 kilometres to the northwest to the Isle Haute sand wave field. An intersecting pattern of nine IKU grabs was designed to sample the length and breadth of the sand wave field (Fig. 21). IKU grab was recovered at **Station 41** at 1029, followed by IKU grabs at **Station 42** (1101), **Station 43** (1139), **Station 44** (1225, second attempt), and **Station 45** (1304). The DFO light meter was then deployed at **Station 46** from 1319 to 1328, followed by the DFO CTD at **Station 47** from 1338 to 1345. The ship then repositioned about a kilometre back to **Station 48** for an IKU grab at 1414.

After the lunch break, IKU **Stations 49** (1508), **50** (1542) and **51** (1621) were collected. The ship then repositioned to the centre of the sand wave field at **Station 52** for a Deep Imager camera drift (1704 to 1734).

The ship then steamed 19 km to the east to the Cape D’Or west banner bank to **Station 53** for a Deep Imager camera drift (Fig. 22). This drift failed due to strong currents. An IKU grab was obtained on this banner bank at **Station 54** at 1916. The DFO optical buoy deployed earlier in the day drifted to a position south of the Cape D’Or east banner bank. The buoy was recovered there at **Station 55** at 1944. At this same location, a DFO light meter was deployed at **Station 56** from 1954 to 2009 and a CTD cast was made at **Station 57** from 2019 to 2046.

The ship steamed into position to deploy the geophysical survey gear at 1800 (AST) for **Line 5** around Minas Channel, including the Scots Bay west banner bank and the east and west Cape D’Or banner banks (Fig. 23). The strong currents at Cape Split and Cape D’Or caused the bridge significant navigational anguish during the night’s survey, and the tortuous trackline demonstrates the result.

Monday, September 5, Day 248 Overcast, light winds, calm seas

The geophysical equipment was recovered at 0600 (AST) and the ship was positioned at **Station 58** on the Scots Bay west banner bank for a Deep Imager camera transect because slack tide was at about 0620 (AST) (Fig. 24). After a long delay of camera difficulties, the camera preparation was abandoned and the IKU was rigged to obtain samples across the minor and major axes of the banner bank. Sediment was recovered at this station at 1039 on the fourth attempt. **Stations 59** (1059), **60** (1136), **61** (1157), **62** (1215), **63** (1249, fourth attempt), and **64** (1314, second attempt) followed. These samples were sand with some gravel with the exception of **Station 64** at the northeast end of the banner bank where cobbles were recovered along with minor sand.

The ship repositioned 3.7 kilometres to the south to sample the seafloor with the IKU over flow-parallel lineations (**Station 65**, 1354, second attempt) and flow-normal, barchanoid bedforms (**Station 66**, 1421, second attempt). Cobbles and minor sand were recovered at **Station 65**. Sand and pebbles were recovered at **Station 66**.

The ship then remained in the vicinity and collected a DFO light meter (**Station 67**, 1437 to 1444) and a CTD cast (**Station 68**, 1455 to 1502).

The ship then steamed 2 kilometres north to the location of **Station 60** in the centre of the banner bank for camera **Station 69**. The Deep Imager camera was still not operational so the "4K Vlad cam with bullet" was used to obtain a series of still photographs (1544 to 1610) that showed sand.

The ship then steamed 2 kilometres northeast to the location of **Station 64** at the northeast limit of the banner bank for camera **Station 70** (Fig. 24). Cobbles were recovered here earlier, so it was deemed important to image. The 4K camera was used to obtain a series of still photographs (1637 to 1645) that showed sand.

The ship then steamed 15 kilometres southwest to an area of gravel megaripples adjacent to the scour trough in Minas Channel southeast of Cape D'Or (Fig. 25). An IKU grab at **Station 71** (1740) recovered clean gravel with centimetre-sized particles.

The ship then steamed 12.4 kilometres west to the western end of the scour trough (Fig. 25). The third attempt at an IKU grab at **Station 72** (1901) over sediment wave-like features within the trough recovered fractured stiff clay with pronounced black anoxic content. Just to the north of this site on the adjacent flat seabed, three attempts at an IKU grab at **Station 73** (2008) recovered fauna-covered individual cobbles wedging open the IKU jaws.

The geophysical equipment was deployed at 1800 hours (AST) west of the Cape D'Or west banner bank and **Line 6** (Fig. 26) was run west and north across Quaco Shoal bedrock outcrop, moraines, the suspected gas expulsion field and then south to intersect a till tongue identified by Gordon Fader on *Hudson* 97020 at 176/1800.

Tuesday, September 6, Day 249 Fog changing to partly sunny, light winds, calm seas

The geophysical equipment was recovered at 0600 (AST) and the ship steamed 21 kilometres west where the DFO optical buoy was released at **Station 74** at 1042, followed by a bottle cast at **Station 75** at 1046. The ship was positioned at **Station 76** to obtain a piston core over a till tongue at the intersection of *Hudson* 97020 169/0800 and *Hudson* 2011036 249/061924 (Fig. 27). The apparent penetration was 26 feet and about 6 feet of sediment was recovered. The ship then steamed 19 kilometres east to sample smaller sand waves in the broad depressions to the southwest of Margaretsville dune field. IKU grabs were obtained at **Station 77** (1305) and at **Station 78** (1350, second attempt), 800 metres to the north (Fig. 28).

The ship then steamed 9 kilometres to the northeast to collect a suite of IKU grabs over sand waves in the northern Margaretsville dune field. An IKU grab was collected at **Station 79** (1435) (Fig. 28).

The ship steamed 3.7 kilometres northeast to where **Station 80** (1534 to 1543) was a DFO light meter deployment and **Station 81** (1555 to 1602) was a DFO CTD cast. At this same location (Fig. 29), an IKU grab was obtained at **Station 82** at 1618 and the Deep Imager camera was deployed at **Station 83** from 1641 to 1701.

The ship then travelled 1.9 kilometres to the northeast where IKU grabs were obtained at **Station 84** (1725), **Station 85** (1758, second attempt) and **Station 86** (1813) (Note that no sample for this station exists at GSCA) (Fig. 29). The addition of **Stations 85** and **86** to the three samples obtained in the January 2010 lander deployment provides a complete transect across the northern Margaretsville dune field. To give the deck crew sufficient time to reterminate the winch cable, the ship steamed 41 kilometres southwest to retrieve the DFO optical buoy at **Station 87** (2024), followed by a bottle cast a **Station 88** (2029).

The ship then steamed 19 kilometres southwest toward the Nova Scotia coast to deploy the geophysical equipment at 1830 (AST). **Line 7** was run southwest, parallel to the coast, across the Digby drumlin field and into the Grand Manan Basin, where it turned northwest toward Grand Manan Island (Fig. 30).

Wednesday, September 7, Day 250 Overcast, light winds, calm seas

The geophysical equipment was brought on board at 0600 (AST) and the ship repositioned to a site chosen on the basis of the night's seismic data over glaciomarine sediment. A piston core was collected at **Station 89** (1031) (2011036 250/0830) (Figs. 31, 32). At the same location, and IKU grab at **Station 90** (1135) and a Deep Imager camera transect at **Station 91** (1202 to 1222) were completed.

The ship then steamed 19 kilometres to the south to the offshore extension of Northwest Ledge, the site of a Campod transect at Station 73 from *Hudson* 2009039. A Deep Imager camera transect was collected at **Station 92** from 1349 to 1420 (Fig. 31). This information will be used by Jessica Bryk in her undergraduate thesis in the Department of Biology at Dalhousie University.

The ship then steamed 17.4 kilometres northeast to an area of bedforms in a water depth of approximately 170 metres. This position corresponds to the geophysical survey line of the previous night (250/0830). The Deep Imager camera was deployed at **Station 93** from 1618 to 1638, followed by an IKU at the same position at **Station 94** at 1718 (Fig. 33).

The ship then steamed 14 kilometres north to outcropping glacially-scoured sediment on the west flank of Grand Manan basin. An IKU grab sample was collected at **Station 95** at 1814 (Fig. 33). This position corresponds to the geophysical survey line of *Hudson* 2009039, 248/0010.

The ship then steamed 61 kilometres northeast to deploy the geophysical equipment at 1830 (AST). **Line 8** was run in a straight line northeast up the bay to the mouth of Chignecto Bay (Fig. 34).

Thursday, September 8, Day 251 Rain, fog, calm seas, then sun with wind rising

Near the end of the geophysical line, the ship had to deviate to starboard due to a flotilla of fishing vessels that did not respond to hails. The geophysical equipment was brought on board at 0600 (AST) and the ship had a 50 minute transit to the mouth of Chignecto Bay where the DFO optical buoy was released at **Station 96** at 1018 (Figs. 35, 36). This was followed at the same location (possibly an erosional channel) by a bottle cast at **Station 97** at 1022 and an IKU grab at **Station 98** at 1039 (second attempt). The bungee cord on the trip arm got wrapped in the winch cable somehow; this is the first time in 40 years that Bob Murphy witnessed this. The bungee cord had to be replaced.

The ship then steamed 6.5 kilometres northeast into Chignecto Bay to **Station 99** where an IKU grab was retrieved from the flat outer platform of a drowned spit at 1138 (Fig. 36).

The ship then steamed 6.9 kilometres northeast into Chignecto Bay to **Station 100** where an IKU grab was retrieved on the southern flank of Chignecto Bay at 1216 (second attempt) (Fig. 36).

The ship then steamed 5.6 kilometres northeast into Chignecto Bay to **Station 101** where an IKU grab was retrieved from the thalweg of the erosional channel off Cape Enragé at 1252 (Figs. 37, 38). A large boulder (0.5 metre), cobbles and some sediment were recovered to the ship's rail where photographs were taken and a surface sample retrieved. At the same location, **Station 102** was the DFO light meter (1310) and Station **103** was the DFO CTD (1339) (Fig. 38).

The ship then repositioned 1.5 kilometres northwest toward Cape Enragé where an IKU grab of sand was retrieved from the Cape Enragé east banner bank at **Station 104** at 1412 (Fig. 37). In the adjacent erosional channel to the southeast, an IKU grab of mud, cobbles and boulders was retrieved at **Station 105** at 1442. Finally, an IKU grab of mud, cobbles and boulders was retrieved from the flat seafloor situated between erosional channels at **Station 106** at 1505.

The ship then repositioned to the main erosional channel at **Station 101** to deploy the Deep Imager camera at **Station 107** from 1536 to 1556 (Figs. 37, 38).

The ship then steamed 9.4 kilometres northeast into Chignecto Bay to a position over barchan dunes where an IKU grab of sand was retrieved at **Station 108** at 1656 (Fig. 39). At the same location, the DFO light meter was deployed at **Station 109** (1703), followed by the DFO CTD at **Station 110** (1721).

The ship then steamed 34.6 kilometres southwest to the mouth of Chignecto Bay where an IKU grab was obtained on top of the enigmatic curvilinear features at **Station 111** at 1916 (Fig. 40). The first attempt retrieved cobbles and boulders. The second attempt retrieved a large boulder and significant sediment.

The ship then retrieved the DFO optical buoy at **Station 112** at 1956 and conducted a bottle cast at **Station 113** at 2008 (Fig. 41).

The geophysical equipment were deployed at 1800 (AST) at the mouth of Chignecto Bay. The zigzag survey pattern of **Line 9** was executed along the length of the bay, avoiding fishing gear on the north side, to the northeast of Cape Enragé (Fig. 42). The **Line 9** continued south around Cape Chignecto to the south and into western Minas Channel, crossing the west scour channel from northwest to southeast.

Friday, September 9, Day 252 Fog clearing late in the day, light winds, calm seas

The geophysical equipment was brought on board at 0600 (AST) and the ship had a 13.3 kilometre transit to the Cape D'Or western banner bank for a series of IKU grabs to characterize the grain size and shallow sub-surface texture and structure of sand waves on this banner bank (Figs. 43, 44). The DFO optical buoy was released over the bank at **Station 114** at 1025, followed by a bottle cast at the same location at **Station 115** at 1029. IKU grab **Station 116** (1040) was collected at the western end of the banner bank. IKU grab **Station 117** (1111) was collected along the crest of the banner bank. IKU grab **Station 118** (1032) was collected on the southern flank of the banner bank. IKU grab **Station 119** (1159), south of the southern flank of the banner bank on the surrounding flat seabed, failed in two attempts other than a few pebbles in the bottom of the bucket on the second attempt.

The ship transited to offshore Halls Harbour at 1000. Gary Bugden left the ship by FRC. An IKU grab was retrieved at **Station 120** at 1319 (Fig. 43) while we awaited the return of the FRC with Vladimir Kostylev on board.

The ship then steamed 16.7 kilometres northwest to the western scour trough in Minas Passage where Deep Imager camera transect was completed at **Station 121** from 1509 to 1540 (Fig. 43). A mixture of mud patches and boulder patches was observed in the scour trough, with a more uniform pebble and cobble cover on the surrounding flat seabed. The bridge crew noted the upwelling of water along the edge of the scour trough and the challenge of nudging the ship in the intended drift direction.

The ship then steamed 3.3 kilometres northeast to the southwest tip of the Cape D'Or west banner bank where an IKU grab of sand was obtained at **Station 122** at 1615 (Figs. 43, 44). **Station 123** (1636) was an IKU grab of sand to the northwest along the major axis of the banner bank. **Station 124** (1715, second attempt) was an IKU grab on the surrounding seabed north of the banner bank. The bridge noted that **Station 123** experienced a tidal velocity of 5 knots, while **Station 124** was zero, only a short time and distance away

After discussion with the Captain, the ship repositioned to Cape D'Or east banner bank to take advantage of slackening tidal velocities. As the ship approached, roiling water was seen on all sides, clear evidence of the powerful tidal flow. Several IKU grabs were taken to characterize the grain size and shallow sub-surface texture and structure of sand waves on the Cape D'Or east banner bank. A very small IKU grab sample was obtained north of the banner bank at **Station 125** at 1815 (second attempt) (Figs. 43, 45). The seafloor here is likely very hard. The top of the banner bank was sampled with the IKU at **Station 126** at 1834 (second attempt). At the eastern end of the banner bank, an IKU grab of coarse sand and pebbles was retrieved at **Station 127** at 1854 (second attempt). The ship then repositioned to the western end of the banner bank and obtained an IKU grab of sand at **Station 128** at 1913.

The ship then steamed west toward Isle Haute where the DFO optical buoy was recovered at **Station 129** at 2005 and a manual bottle cast was performed at the same location at **Station 130** at 2020 (Fig. 43).

The geophysical equipment was deployed at 1800 (AST) and **Line 10** was executed as a pattern of parallel survey lines over the Margaretsville dune field (Fig. 46).

Saturday, September 10, Day 253 Sunny, moderate winds decreasing, moderate seas decreasing

The geophysical equipment was brought on board at 0600 (AST). The vessel was in the so-called Margaretsville sand wave field and spent the first part of the day sampling bedforms to characterize the grain size and shallow sub-surface texture and structure of isolated star dunes and the surrounding seabed there (Fig. 47). **Station 131** (1002) was an IKU grab from the crest of a large flow-transverse bedform in a seabed depression. **Station 132** (1037, third attempt) sampled the flat seabed adjacent to the bedform. The ship steamed 3.6 kilometres north and obtained an IKU grab on a bedform at Station **133** at 1201 on the southern edge of a topographic high. The ship steamed 1.4 kilometres north and obtained IKU grabs from bedforms situated on a topographic high. **Station 134** at 1219 was on a bedform and **Station 135** (1235) sampled the flat seabed adjacent to the bedform. The ship steamed 0.6 kilometres north and obtained an IKU grab on a bedform at **Station 136** at 1257.

The ship then steamed 18.2 kilometres northwest to Quaco Ledge (Fig. 48) where a series of IKU grabs were obtained to characterize the grain size and shallow subsurface texture and structure of complex cross-pattern sand waves. The original planned stations were too close to Quaco Ledge and alternative sampling stations were derived after negotiation with the bridge officers. Eight grabs were obtained across the northeast bank and one grab from the southeast bank: **Stations 137** (1408), **138** (1426), **139** (1443), **141** (1459), **142** (1517), **143** (1534), **144** (1558), **145** (1620) and **146** (1654 second attempt). DFO manual bottle cast was completed at **Station 140** at 1452.

The ship then steamed 17 kilometres northeast for an IKU grab at **Station 147** at 1817 (second attempt) and another IKU at **Station 148** at 1846, 3.9 km to the northeast (Fig. 49). These stations were planned to obtain samples over dunes of the western Isle Haute sand wave field.

The ship then steamed at high speed west toward Saint John until 1800 (AST) when the geophysical equipment was deployed and **Line 11** was executed westward across the sediment body extending south from Saint John (Fig. 50).

Sunday, September 11, Day 254 Sunny, light increasing to moderate winds, calm to moderate seas

Line 11 passed through Owen Basin from east to west, then looped to go south past northern Grand Manan Island. The geophysical equipment was recovered at 0600 (AST) and the ship steamed 18 kilometres northeast to a position south of The Wolves. The DFO optical buoy was released at **Station 149** at 1014, followed by a manual water bottle cast at **Station 150** at 1017 (Fig. 51). The ship then steamed 4.3 kilometres northeast to an area of suspected mud seabed off the eastern tip of The Wolves. Long wavelength bedform features are observed here on the multibeam sonar bathymetry. A Deep Imager camera transect was undertaken over this seabed at **Station 151** from 1053 to 1109. Following this, an IKU grab at **Station 152** was unsuccessful, with two attempts ending at 1137. Mud was observed on the device; it was speculated that the IKU was being buried in the soft sediment and had been unable to trip.

The ship then steamed 8.3 km around the northeast tip of The Wolves to the northwest side of those islands to an area of suspected mud seabed (Fig. 51). Bedform features are observed here on the multibeam sonar bathymetry. As before, multiple attempts to sample the seabed sediment with the IKU grab at **Station 153** failed on two attempts, but at 1216 mud was retrieved from the jaws of the IKU. The Deep Imager camera was deployed here at **Station 154** for a transect from 1239 to 1251.

The ship then steamed 11 kilometres to offshore the east coast of Campobello Island to seabed characterized by iceberg keel impacts (Fig. 51). An IKU grab failed at **Station 155** at 1402 (second attempt), although mud was collected from the grab jaws.

The ship then steamed 12.4 kilometres south into glacially fluted terrain in Grand Manan Channel to obtain an IKU grab at **Station 156** at 1452 (Fig. 51). Pebbles and cobbles were prominent at the surface with a layer of brown mud overlying a very compact grey mud. At the same location, a Deep Imager camera drift at **Station 157** was done from 1510 to 1531.

The ship steamed a further 15.7 kilometres south into Grand Manan Channel to a region characterized by De Geer moraines (Fig. 51). A Deep Imager camera drift at **Station 158** was done from 1637 to 1658. There were few cobbles or boulders in evidence on the smooth seafloor, suggesting that if the features on multibeam sonar bathymetry are indeed De Geer moraines, they are covered in sediment here.

The ship then steamed 6 kilometres southwest to a larger, more regional De Geer moraine. American lobster fishing gear was deployed in abundance not only in the disputed water zone in Grand Manan Passage, but well into Canadian waters. The ship had to adjust the intended Deep Imager camera drift **Station 159** eastward toward Grand Manan Island (Fig. 51). After lengthy manoeuvring of the ship, a drift across the moraine was finally accomplished from 1750 to 1820.

The ship steamed 37 kilometres northeast back to the southeast of The Wolves to recover the DFO optical buoy at **Station 160** at 2053 and a manual bottle cast at **Station 161** at 2059 (Fig. 51).

The geophysical equipment was deployed at 1800 (AST) and **Line 12** was executed around the north coast of The Wolves, southwest across Owen Basin into Grand Manan Channel (Fig. 52). The line looped within the channel to avoid fishing gear and continued out of the channel and southeast across Owen Basin and Owen Moraine.

Monday, September 12, Day 255 Sunny, strong winds abating, moderate seas

The geophysical equipment was recovered at 0600 (AST) and the ship steamed 9 kilometres west to the west flank of Owen Basin adjacent to Grand Manan Channel where a piston core was recovered at **Station 162** at 1034 containing 4 m of sediment (Fig. 51). The apparent penetration on the core barrel was 7.6 metres. This core is situated on laminated sediments identified on the 2011036 Huntec DTS profile at 255/0817.

The ship then steamed 6 kilometres northwest, still on the west flank of Owen Basin, where a piston core was recovered at **Station 163** at 1243 (Fig. 51). The apparent penetration on the core barrel was 9.1 metres and 5 m of sediment was recovered. This core is situated on laminated sediments identified on the 2011036 Huntec DTS profile at 255/020030.

The ship steamed 14.5 kilometres east to the east flank of Owen Moraine adjacent to Grand Manan Basin where a piston core was recovered at **Station 164** at 1533 (Fig. 51). The apparent penetration on the core barrel was 9.1 metres and approximately 4.5 m of sediment was recovered. This core is situated on laminated sediments identified on the 2009039 Huntec DTS profile at 247/0050.

The ship steamed 22 kilometres east to the eastern extent of glaciomarine sediments draped within the Grand Manan Basin where a piston core was recovered at **Station 165** at 1714 (Fig. 53). The apparent penetration on the core barrel was 9.1 metres and approximately 4.5 m of sediment was recovered. This core is situated on laminated sediments identified on the 2009039 Huntec DTS profile at 247/0317.

The ship then steamed 16 kilometres south to the bathymetric high of possible glaciomarine laminated sediment mantled with till identified on the 2011036 Huntec DTS profile at 245/0402. A piston core at **Station 166** was collected at 1910 (Fig. 54). This piston core was done without any previous groundtruth information. Only approximately 50 centimetres of core was recovered, but it appeared to capture the surface gravel and underlying clay.

The Deep Imager camera was deployed at the same location at **Station 167** from 1955 to 2005 (Fig. 54). The seabed appeared gravelly with rare cobbles and boulders.

The ship steamed from this position 24 kilometres to the southwest to the western flank of Grand Manan Basin. The geophysical equipment was deployed at 1815 (AST) and **Line 13** was executed in a zigzag pattern across the deepest part of the Grand Manan Basin, essentially mimicking Line 2 which was run without the benefit of Huntec DTS (Fig. 55).

Tuesday, September 13, Day 256 Fog, light winds, calm seas

The geophysical equipment was recovered at 0600 (AST) after crossing the enigmatic deep water bedforms in Grand Manan Basin. A gravity core was rigged and attempted twice at **Station 168** over the bedforms at 1017 (Fig. 56). This station was approximately 500 m south of the mini-lander 1 site of **Station 16**. Only a few grains of sand were recovered. After discussion, the FRC was put over the side of the ship to attempt to locate the buoy attached to mini-lander 1. The bridge crew detected the buoy before the FRC, and the lander was recovered at **Station 169** at 1138, 87 metres away from its original plotted position. The FRC was brought back on the ship.

The ship then steamed 24 kilometres north to The Wolves to the site of Lander 2. The FRC was launched once again and located the lander surface buoy. The lander was recovered at **Station 170** at 1408. At the same location, a gravity core in mud was recovered at **Station 171** at 1518. A gravity core in mud was collected 4.8 kilometres northeast at **Station 172** at 1539 over the suspected irregular sediment waves. Three kilometres northeast, another gravity core in mud was collected at **Station 173** at 1554 over more regular larger sediment waves.

The ship then steamed 20 kilometres east through thick fog to the edge of basin fill sediments onlapping the till seabed. Here a piston core was collected at **Station 174** at 1722. This core ties seismically to *Hudson* 2011036, day 254/0259. This core may have penetrated to till.

The ship then steamed 4 kilometres southeast. A piston core was collected at **Station 175** at 1904 with apparent penetration of 22 feet but the cutter was deformed by striking a rock and the core barrel drove into the seabed, retaining only a handful of mud at the cutter. This core ties seismically to *Hudson* 97020, day 178/0446.

The ship steamed 30 kilometres northeast to the sediment wedge south of Saint John harbour. The geophysical equipment was deployed at 1815 (AST) and **Line 14** was run south, providing a tie with previous seismic reflection lines oriented along the length of the bay. The line then turned west across Grand Manan Basin and on to the shallow region south of Grand Manan Island.

Wednesday, September 14, Day 257 Sunny with haze, fog, increasing winds, moderate seas

Arrangements were made with the bridge to have the geophysical equipment retrieved at the time required to put the ship on camera station over shallow bedrock seabed at 0600 (AST). The equipment was retrieved at 0438 (AST). The Deep Imager camera was deployed at **Station 176** from 0933 to 1004 situated between Old Proprietor Shoal and Gannet Rock, south of Grand Manan Island. Currents were initially a challenge but the drift went well.

The ship then steamed 34.4 kilometres south to the south flank of Grand Manan Basin to the bedrock extension of Northwest Ledge. The Deep Imager was deployed at **Station 177** from 1155 to 1226. The ship then repositioned about one nautical mile northeast where the Deep Imager camera was deployed at **Station 178** from 1251 to 1321.

The ship then steamed 5.4 kilometres southwest along the bedrock ridge to **Station 179** where the DFO light meter was deployed at 1414. At the same location, the CTD was deployed at **Station 180** at 1451.

To attempt to collect a sample of sponge, an IKU grab was obtained at this location at **Station 181** at 1541. This was the last station of *Hudson* 2011036. The equipment was secured and the CCGS *Hudson* departed the Bay of Fundy for the Bedford Institute of Oceanography.

Thursday, September 15, Day 258 Dense fog, light winds, calm seas

Dense fog was encountered during the night and morning. Even in Halifax Harbour, neither the Halifax nor Dartmouth shores were visible until the CCGS *Hudson* entered the Bedford Basin and the fog became somewhat less dense. The ship arrived at Bedford Institute of Oceanography pier at approximately 1017 (AST) and the expedition *Hudson* 2011036 came to an end.

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Table 3. *Hudson* 2011036 geophysical hard copy record inventory.

Line No.	**Huntec**			**Sleeve gun (Teledyne eel)**			**330 kHz Sidescan Sonar**		
	Start time	**End time**	**Record No.**	**Start time**	**End time**	**Record No.**	**Start time**	**End time**	**Record No.**
1	243/2255	244/0250	1	243/2319	244/0900	1	243/2259	244/0904	1
2	244/2146	244/2205	2	244/2154	245/0900	2	244/2153	245/0900	2
3	No record	No record	3	245/2301	246/0900	3	245/2301	246/0900	3
4	246/2130	247/0900	4	246/2140	247/0900	4	246/2135	247/0900	4
5	247/2151	248/0900	5	247/2155	248/0900	5	247/2201	248/0900	5
6	248/2135	249/0900	6	248/2136	249/0900	6	248/2132	249/0900	6
7	249/2154	250/0900	7	249/2153	250/0900	7	249/2147	250/0900	7
8	250/2127	251/0900	8	250/2135	251/0900	8	250/2134	251/0900	8
9	251/2109	252/0900	9	251/2118	252/0900	9	251/2115	252/0900	9
10	252/2119	253/0900	10	252/2125	253/0900	10	252/2123	253/0900	10
11	253/2116	254/0900	11	253/2120	254/0900	11	253/2120*	254/0252*	11
12	254/2138	255/0900	12	254/2135	255/0900	12	254/2135	255/0900	12
13	255/2145	256/0901	13	255/2140	256/0901	13	255/2148	256/0901	13
14	256/2134	257/0739	14	256/2140	257/0738	14	256/2136	257/0737	14

* Times marked are approximate. Line 11 paper record contains incorrect time stamps. The times are approximately 12 hours too early. The geographic information in the file appears to be correct.

Table 4. *Hudson* 2011036 stations.

Station Number	Station Type	Day/Time (UTM)	Latitude (N)	Longitude (W)	Water Depth (m)
1	DFO Light Meter	243/2014	44.727816	65.886635	72
2	Deep Imager	243/2044	44.723015	65.906605	77.69
3	DFO CTD	243/2134	44.709195	65.949868	81
4	Deep Imager	244/1020	44.919648	66.6792	100
5	IKU Grab	244/1148	44.920688	66.681721	99.9
6	van Veen	244/1230	44.918985	66.680895	100.8
7	4K VladCam	244/1313	44.920321	66.68165	105.3
8	IKU Grab	244/1333	44.921901	66.682006	100
9	Lander 2 (Deploy)	244/1402	44.921664	66.677	99
10	IKU Grab	244/1425	44.963715	66.66483	71.8
11	IKU Grab	244/1519	44.982217	66.653	68.8
12	IKU Grab	244/1605	44.92697	66.1313	76.7
13	IKU Grab	244/1646	44.8952	66.4988	99
14	van Veen	244/1658	44.8934	66.4966	108.7
15	IKU Grab	244/1759	44.854	66.3949	131.9
16	Lander 1 (Deploy)	244/1830	44.8534	66.3944	134
17	AGC Long Core	244/1918	44.852835	66.393283	131.9
18	DFO CTD	244/2004	44.847976	66.393956	134
19	DFO Light Meter	244/2024	44.840847	66.404161	136.8
20	DFO Optical Buoy	245/1038	44.701096	66.42039	168.8
21	AGC Long Core	245/1123	44.703343	66.420586	166
22	AGC Long Core	245/1336	44.737318	66.475318	163.9
23	AGC Long Core	245/1613	44.545873	66.42644	209.9
24	IKU Grab	245/1858	44.689261	65.888343	106
25	IKU Grab	245/1946	44.690195	65.89472	160
26	DFO Optical Buoy	245/2216	44.660483	66.365135	155
27	IKU Grab	246/1053	45.258777	65.666574	52

Station Number	Station Type	Day/Time (UTM)	Latitude (N)	Longitude (W)	Water Depth (m)
28	IKU Grab	246/1133	45.257958	65.662046	47.34
29	Deep Imager	246/1218	45.258535	65.667783	43
30	DFO Light Meter	246/1257	45.259456	65.659559	42
31	DFO CTD	246/1320	45.259972	65.661963	42.5
32	IKU Grab	246/1421	45.261293	65.717514	26.9
33	IKU Grab	246/1535	45.358119	65.4316	38.6
34	IKU Grab	246/1706	45.206857	65.481857	70
35	Deep Imager	246/1752	45.205988	65.481222	65.59
36	DFO Light Meter	246/1832	45.209181	65.470349	66
37	DFO CTD	246/1856	45.218928	65.453718	60
38	IKU Grab	246/1956	45.309075	65.540439	43
39	DFO Optical Buoy	247/935	45.263169	64.871304	56
40	DFO Bottle Cast	247/937	45.263211	64.873122	56.4
41	IKU Grab	247/1029	45.295315	65.034004	58
42	IKU Grab	247/1101	45.298824	65.061903	52
43	IKU Grab	247/1139	45.309865	65.091086	51
44	IKU Grab	247/1225	45.30707	65.090228	48
45	IKU Grab	247/1304	45.302846	65.089242	45
46	DFO Light Meter	247/1319	45.298026	65.097429	46
47	DFO CTD	247/1341	45.294091	65.107826	45
48	IKU Grab	247/1414	45.295569	65.087451	42
49	IKU Grab	247/1508	45.288454	65.086411	51
50	IKU Grab	247/1542	45.284174	65.086357	53
51	IKU Grab	247/1621	45.292981	65.133363	52
52	Deep Imager	247/1704	45.29832	65.07928	51.4
53	Deep Imager	247/1853	45.301821	64.824755	35
54	IKU Grab	247/1916	45.301892	64.826121	30
55	DFO Optical Buoy	247/1944	45.27381	64.736108	45
56	DFO Light Meter	247/1954	45.276523	64.720561	99
57	DFO CTD	247/2046	45.305009	64.664172	65
58	IKU Grab	248/1039	45.308609	64.557794	32

Station Number	Station Type	Day/Time (UTM)	Latitude (N)	Longitude (W)	Water Depth (m)
59	IKU Grab	248/1059	45.320214	64.557646	72
60	IKU Grab	248/1136	45.316673	64.547494	23.6
61	IKU Grab	248/1157	45.312728	64.535365	39
62	IKU Grab	248/1215	45.311608	64.532515	41
63	IKU Grab	248/1248	45.323253	64.53805	32.4
64	IKU Grab	248/1314	45.329991	64.52849	43
65	IKU Grab	248/1353	45.289148	64.544255	35
66	IKU Grab	248/1421	45.286241	64.539916	32
67	DFO Light Meter	248/1437	45.28778	64.540087	31.6
68	DFO CTD	248/1455	45.294549	64.54047	33.4
69	4K VladCam	248/1544	45.317853	64.548038	39.34
70	4K VladCam	248/1637	45.330938	64.527693	43.3
71	IKU Grab	248/1740	45.286485	64.67743	47
72	IKU Grab	248/1901	45.265892	64.833166	75
73	IKU Grab	248/2008	45.269617	64.832676	55
74	DFO Optical Buoy	249/1042	45.04341	65.513169	81
75	DFO Bottle Cast	249/1046	45.043798	65.513142	81
76	AGC Long Core	249/1130	45.044005	65.513446	80.5
77	IKU Grab	249/1305	45.105548	65.281055	85
78	IKU Grab	249/1350	45.111327	65.288042	83
79	IKU Grab	249/1435	45.183006	65.244985	68
80	DFO Light Meter	249/1534	45.200168	65.205855	60
81	DFO CTD	249/1559	45.200563	65.212403	60
82	IKU Grab	249/1618	45.201553	65.202226	58
83	Deep Imager	249/1641	45.200581	65.202713	62.45
84	IKU Grab	249/1725	45.204529	65.181582	68
85	IKU Grab	249/1758	45.213268	65.175578	70
86	IKU Grab	249/1813	45.210975	65.171398	72
87	DFO Optical Buoy	249/2024	45.038678	65.636705	86
88	DFO Bottle Cast	249/2029	45.039942	65.635159	85
89	AGC Long	250/1031	44.385094	66.592305	218

Station Number	Station Type	Day/Time (UTM)	Latitude (N)	Longitude (W)	Water Depth (m)
	Core				
90	IKU Grab	250/1135	44.385204	66.592296	219
91	Deep Imager	250/1202	44.387416	66.593309	217.85
92	Deep Imager	250/1349	44.215856	66.609803	72.75
93	Deep Imager	250/1618	44.445658	66.366792	178.57
94	IKU Grab	250/1718	44.446272	66.366172	177
95	IKU Grab	250/1814	44.531065	66.484644	151
96	DFO Optical Buoy	251/1018	45.505744	64.921959	80
97	DFO Bottle Cast	251/1022	45.505278	64.919346	74
98	IKU Grab	251/1039	45.504822	64.923868	80
99	IKU Grab	251/1137	45.552736	64.87422	36
100	IKU Grab	251/1216	45.532204	64.790529	44
101	IKU Grab	251/1252	45.566855	64.738499	123
102	DFO Light Meter	251/1310	45.566053	64.738563	126
103	DFO CTD	251/1339	45.564243	64.741194	113
104	IKU Grab	251/1412	45.589173	64.764455	37
105	IKU Grab	251/1442	45.583832	64.758315	63
106	IKU Grab	251/1505	45.576695	64.751631	42
107	Deep Imager	251/1536	45.566895	64.739987	102.2
108	IKU Grab	251/1656	45.6352	64.671773	30
109	DFO Light Meter	251/1703	45.635095	64.674231	30
110	DFO CTD	251/1721	45.629125	64.68976	26
111	IKU Grab	251/1916	45.460168	65.040042	37
112	DFO Optical Buoy	251/1956	45.393262	65.043358	43
113	DFO Bottle Cast	251/2008	45.391414	65.043499	41
114	DFO Optical Buoy	252/1026	45.302265	64.844183	36
115	DFO Bottle Cast	252/1029	45.300863	64.840882	27
116	IKU Grab	252/1040	45.303147	64.845912	36
117	IKU Grab	252/1111	45.302417	64.833794	27
118	IKU Grab	252/1131	45.29734	64.832538	36

Station Number	Station Type	Day/Time (UTM)	Latitude (N)	Longitude (W)	Water Depth (m)
119	IKU Grab	252/1159	45.292366	64.832658	48
120	IKU Grab	252/1318	45.216268	64.619364	44
121	Deep Imager	252/1509	45.269801	64.822464	74.3
122	IKU Grab	252/1615	45.291046	64.807562	38
123	IKU Grab	252/1636	45.295753	64.818046	37
124	IKU Grab	252/1715	45.304061	64.818015	40.5
125	IKU Grab	252/1815	45.290125	64.747146	37
126	IKU Grab	252/1834	45.282053	64.747063	45
127	IKU Grab	252/1854	45.289168	64.731957	36
128	IKU Grab	252/1913	45.282727	64.762976	38
129	DFO Optical Buoy	252/2005	45.283211	64.910782	30
130	DFO Bottle Cast	252/2020	45.287097	64.91287	45
131	IKU Grab	253/1001	45.153201	65.114441	72
132	IKU Grab	253/1037	45.156295	65.103719	76
133	IKU Grab	253/1201	45.183829	65.128329	56
134	IKU Grab	253/1219	45.196782	65.128697	52
135	IKU Grab	253/1235	45.195138	65.128279	54
136	IKU Grab	253/1257	45.204207	65.12744	51
137	IKU Grab	253/1408	45.251153	65.347637	52
138	IKU Grab	253/1426	45.251635	65.352059	56
139	IKU Grab	253/1443	45.25038	65.355657	48
140	DFO Bottle Cast	253/1452	45.249497	65.350595	46
141	IKU Grab	253/1459	45.248626	65.351444	45
142	IKU Grab	253/1517	45.247667	65.350417	32
143	IKU Grab	253/1534	45.245253	65.347615	51
144	IKU Grab	253/1558	45.241317	65.348879	56
145	IKU Grab	253/1620	45.23761	65.34839	50
146	IKU Grab	253/1654	45.232545	65.374315	47
147	IKU Grab	253/1817	45.306033	65.187568	56
148	IKU Grab	253/1845	45.320299	65.13719	50
149	DFO Optical Buoy	254/1014	44.94832	66.655567	80
150	DFO Bottle Cast	254/1017	44.948309	66.655963	80

Station Number	Station Type	Day/Time (UTM)	Latitude (N)	Longitude (W)	Water Depth (m)
151	Deep Imager	254/1053	44.986242	66.651742	69.09
152	IKU Grab	254/1136	44.987421	66.648404	66
153	IKU Grab	254/1216	44.98227	66.754793	70
154	Deep Imager	254/1239	44.983589	66.752672	69.09
155	IKU Grab	254/1402	44.913273	66.85007	96
156	IKU Grab	254/1452	44.802041	66.863904	108
157	Deep Imager	254/1511	44.801908	66.864292	103.71
158	Deep Imager	254/1638	44.669349	66.936834	81.45
159	Deep Imager	254/1750	44.631346	66.984778	82.19
160	DFO Optical Buoy	254/2053	44.97576	66.593334	56
161	DFO Bottle Cast	254/2059	44.975733	66.593649	56
162	AGC Long Core	255/1034	44.837584	66.769135	140
163	AGC Long Core	255/1243	44.86659	66.833045	129
164	AGC Long Core	255/1533	44.845548	66.651828	129
165	AGC Long Core	255/1714	44.852834	66.372937	134
166	AGC Long Core	255/1910	44.715374	66.323366	109
167	Deep Imager	255/1955	44.713941	66.321681	109.96
168	Gravity Core	256/1017	44.849401	66.39352	133
169	Lander 1 (Retrieval)	256/1138	44.85431	66.393969	128.3
170	Lander 2 (Retrieval)	256/1408	44.921494	66.675891	105
171	Gravity Core	256/1518	44.92132	66.676545	106
172	Gravity Core	256/1539	44.964126	66.663718	76
173	Gravity Core	256/1553	44.986563	66.648152	70
174	AGC Long Core	256/1722	44.950603	66.392052	107
175	AGC Long Core	256/1904	44.920404	66.365385	117
176	Deep Imager	257/0933	44.515630	66.682702	36.97
177	Deep Imager	257/1155	44.216498	66.583905	48.47
178	Deep Imager	257/1251	44.225453	66.561402	61.1
179	DFO Light Meter	257/1414	44.215845	66.610076	60

Station Number	Station Type	Day/Time (UTM)	Latitude (N)	Longitude (W)	Water Depth (m)
180	DFO CTD	257/1451	44.235245	66.604604	140
181	IKU Grab	257/1540	44.210818	66.613048	60.7

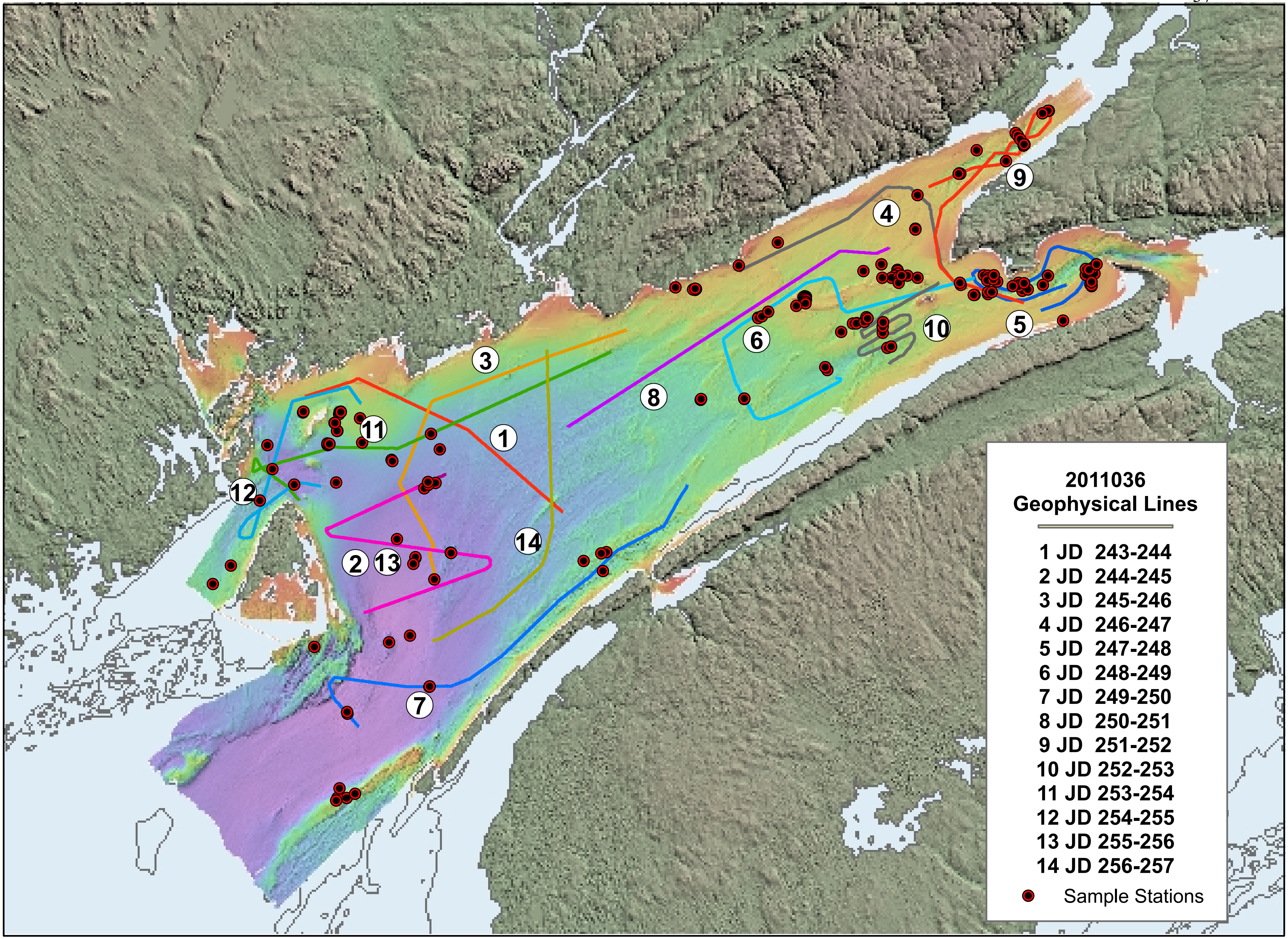


Figure 3. Geophysical survey lines and sample stations occupied during Hudson 2011036. The background bathymetric image is the compilation of multibeam sonar surveys spanning the years 1993 to 2009.

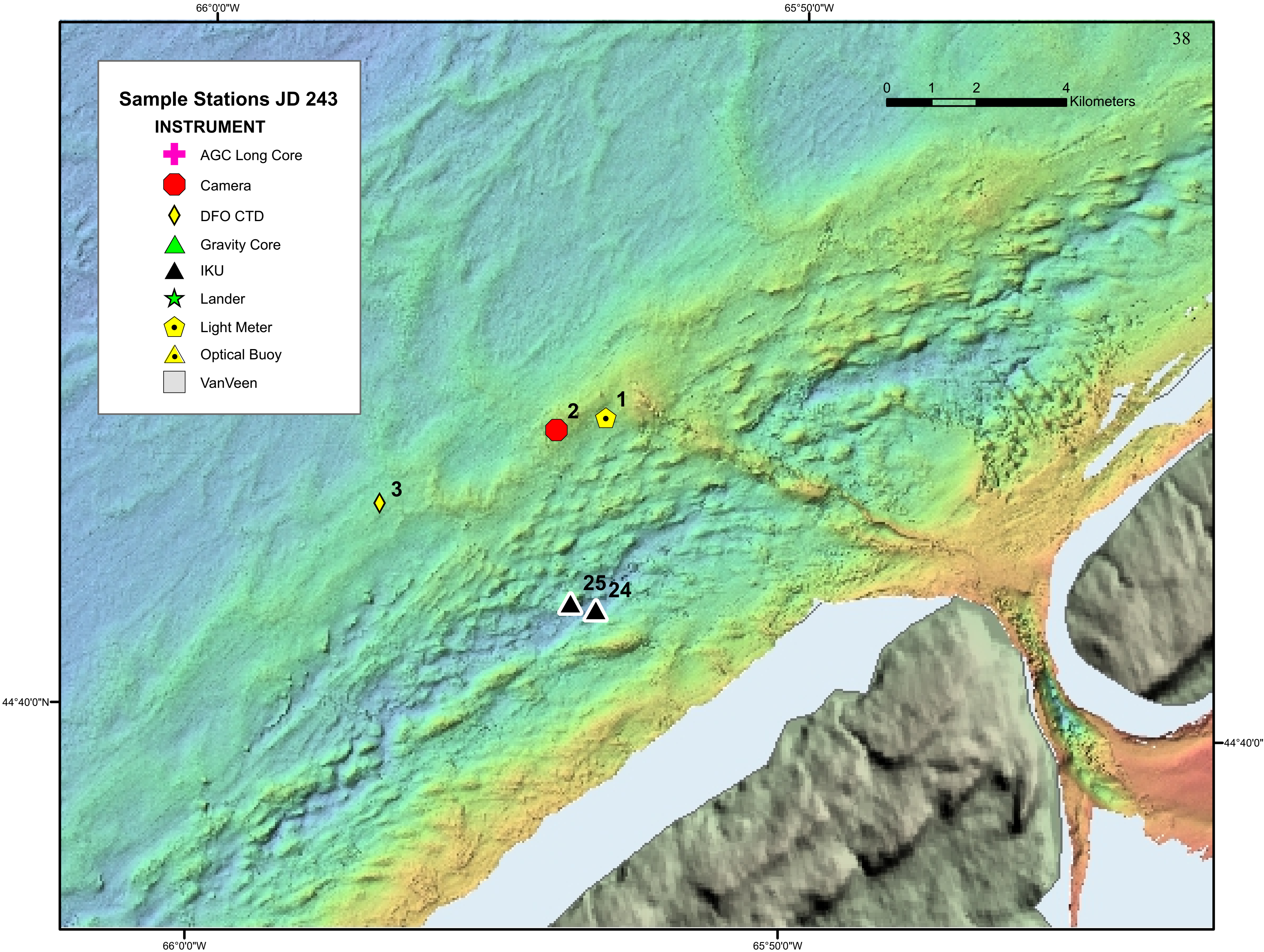


Figure 4. Stations 1 to 3 near Digby Esker, day 243.

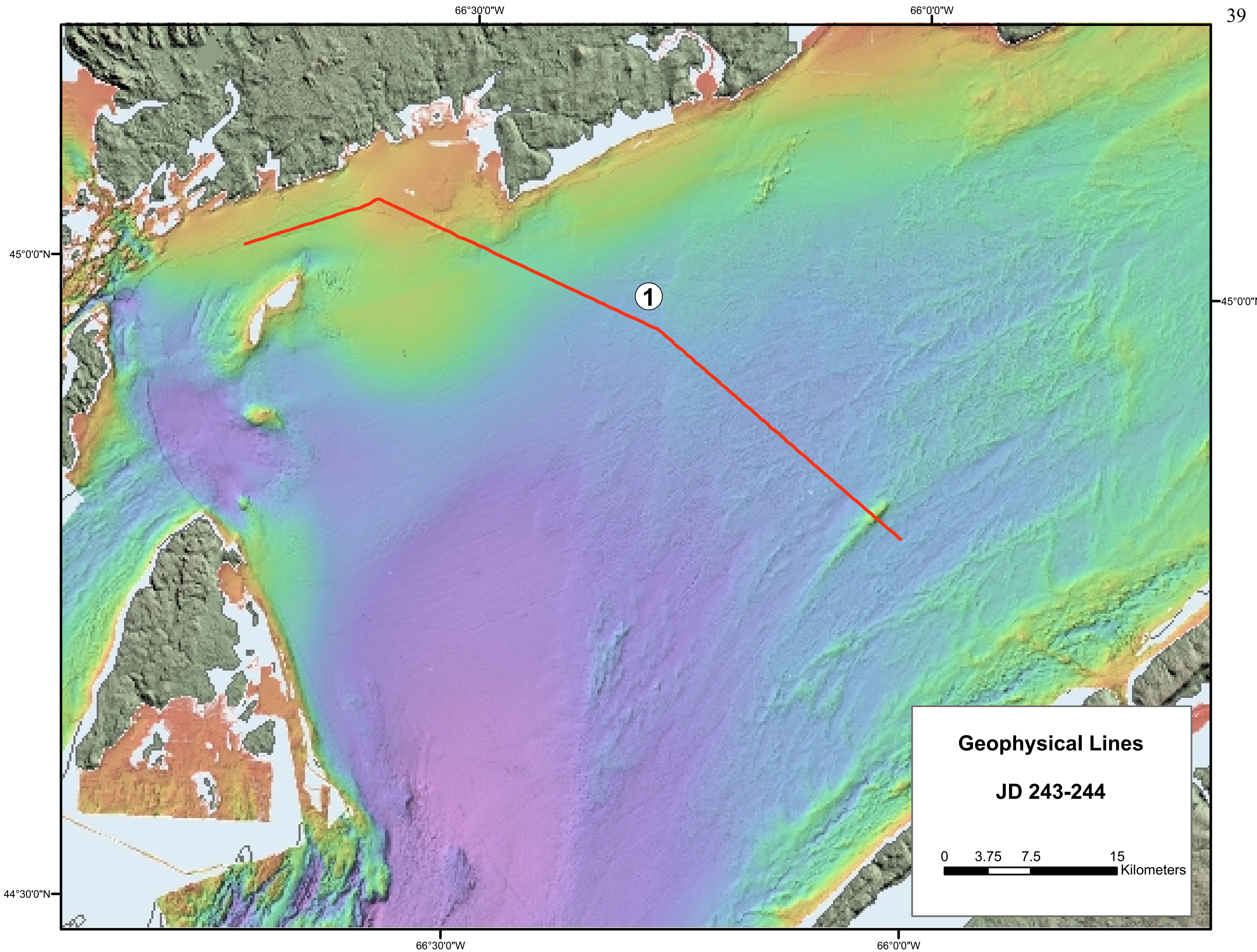


Figure 5. Geophysical survey Line 1, days 243 to 244.

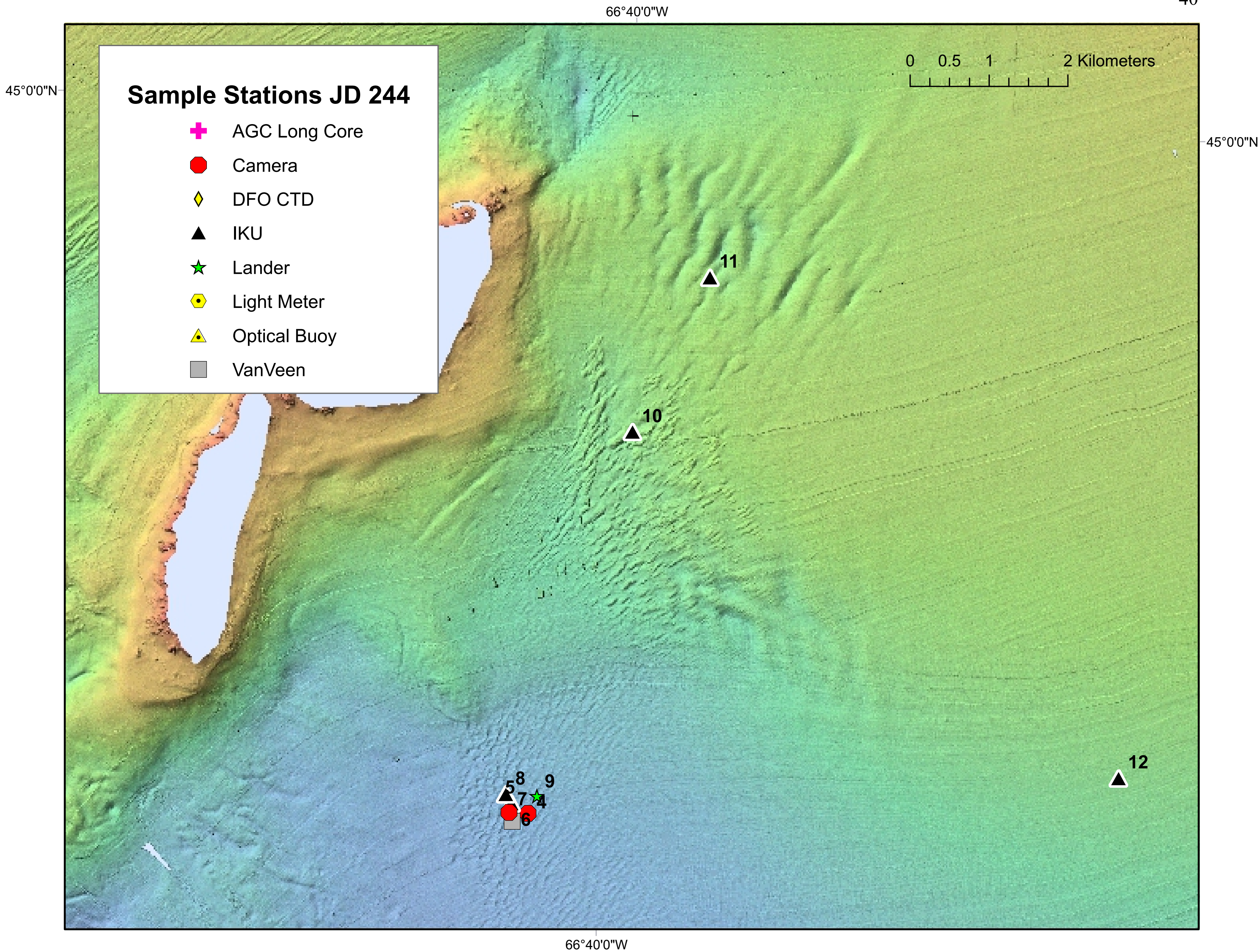


Figure 6. Stations 4 to 12 southeast of The Wolves, day 244.

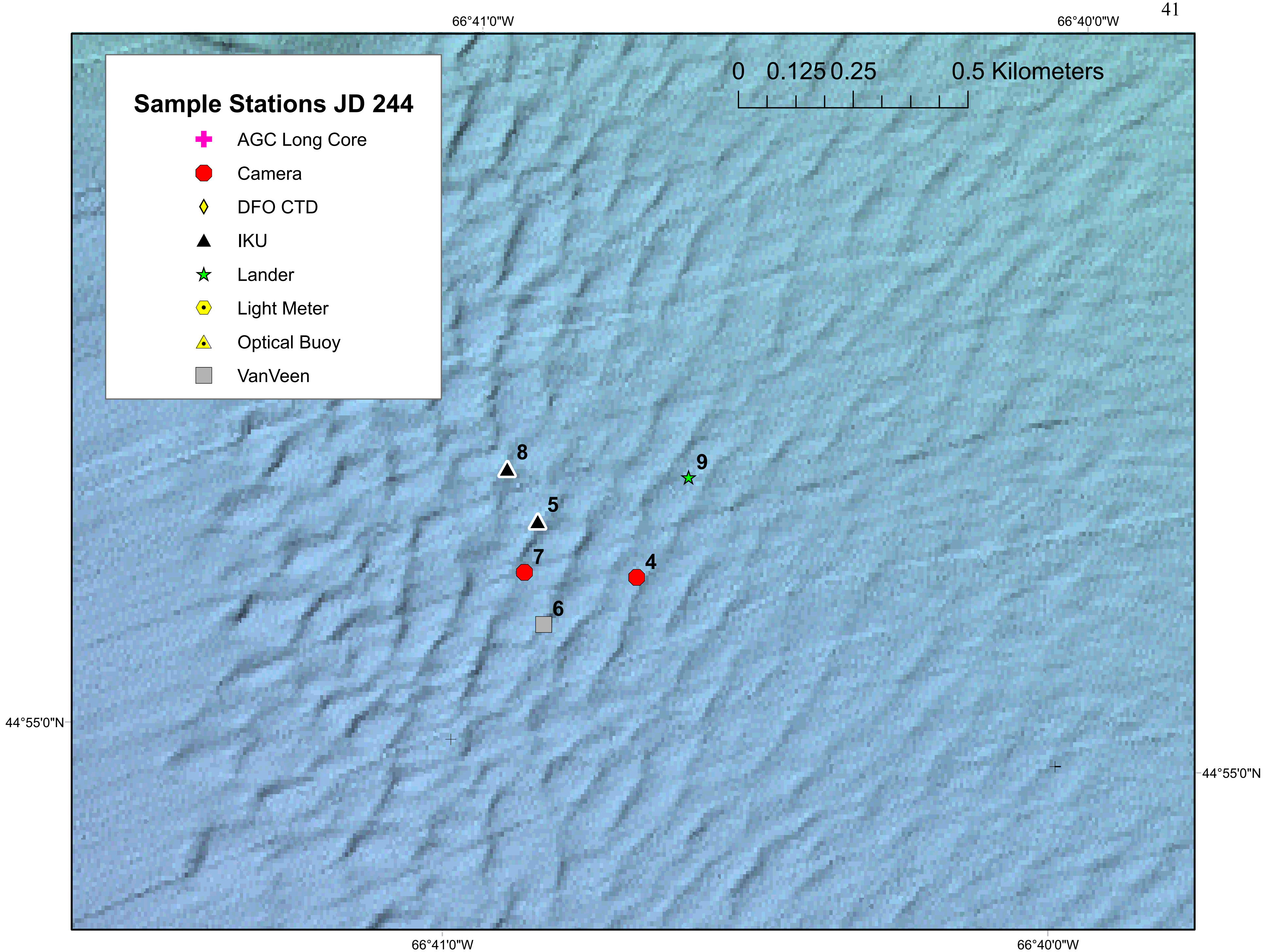


Figure 7. Stations 4 to 9 southeast of The Wolves, day 244.

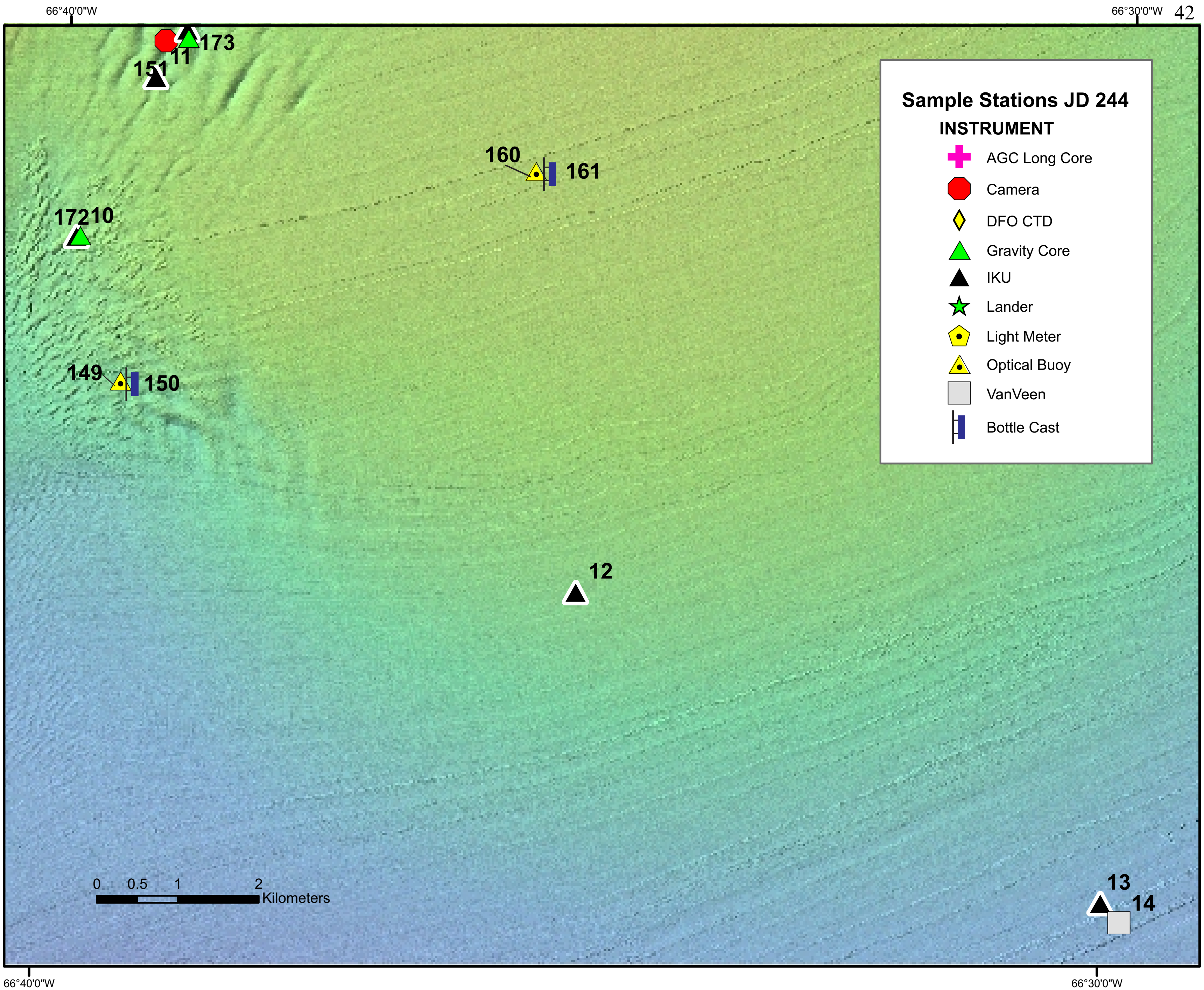


Figure 8. Stations 11 to 15, southeast of The Wolves, day 244.

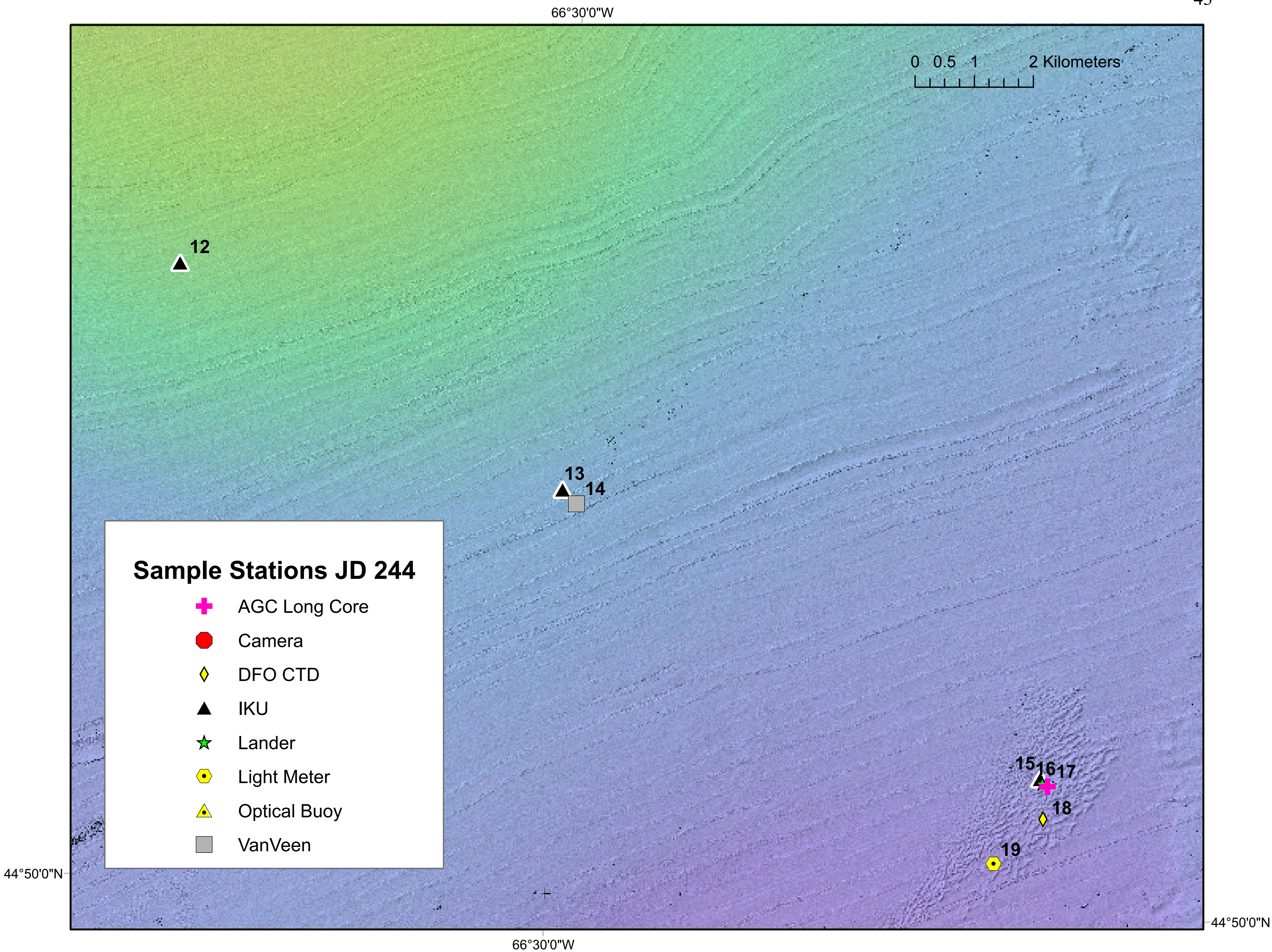


Figure 9. Stations 12 to 19 southeast of The Wolves, day 244.

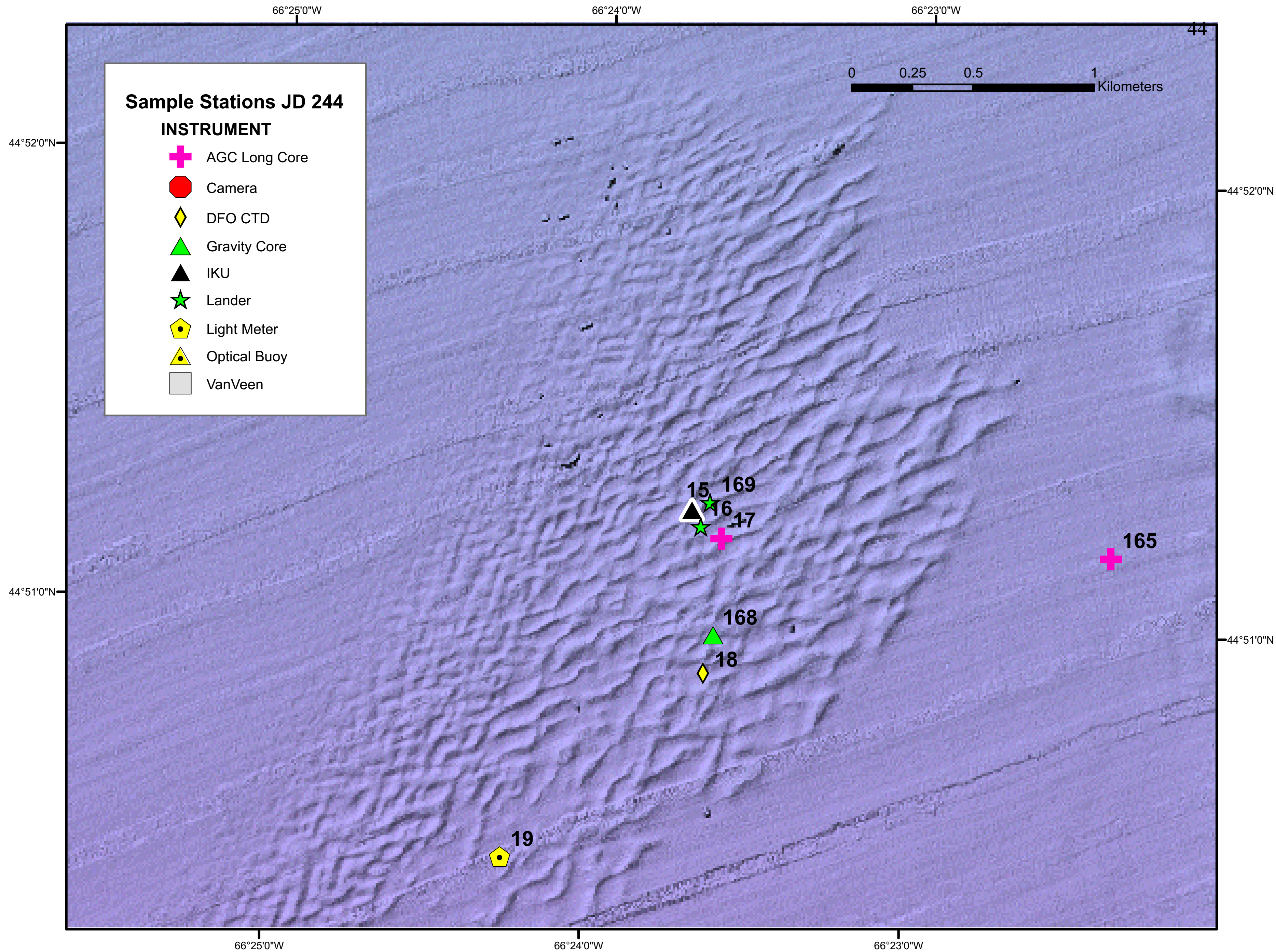


Figure 10. Stations 16 to 19 southeast of The Wolves, day 244.

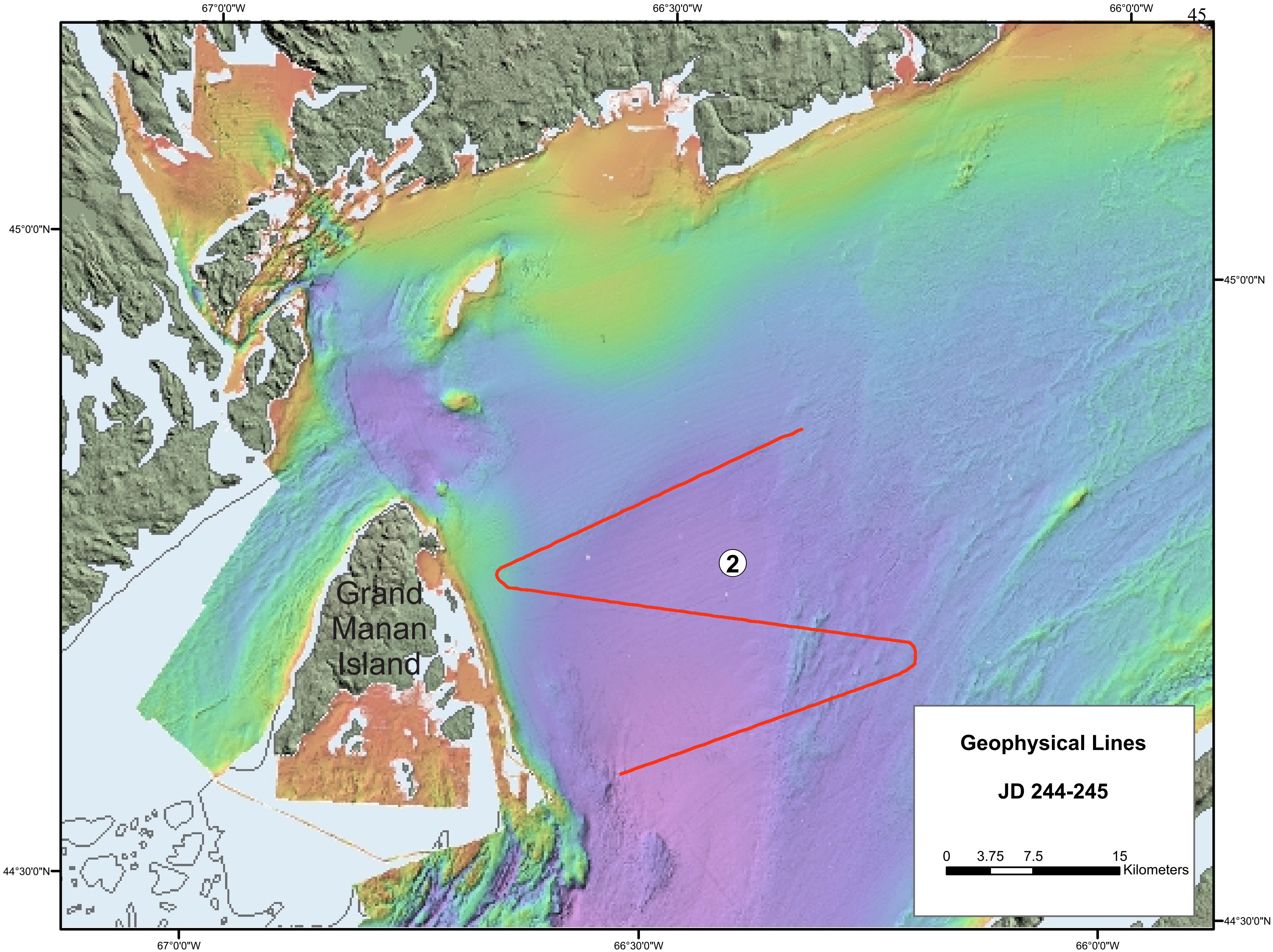


Figure 11. Geophysical survey Line 2, days 244 to 245.

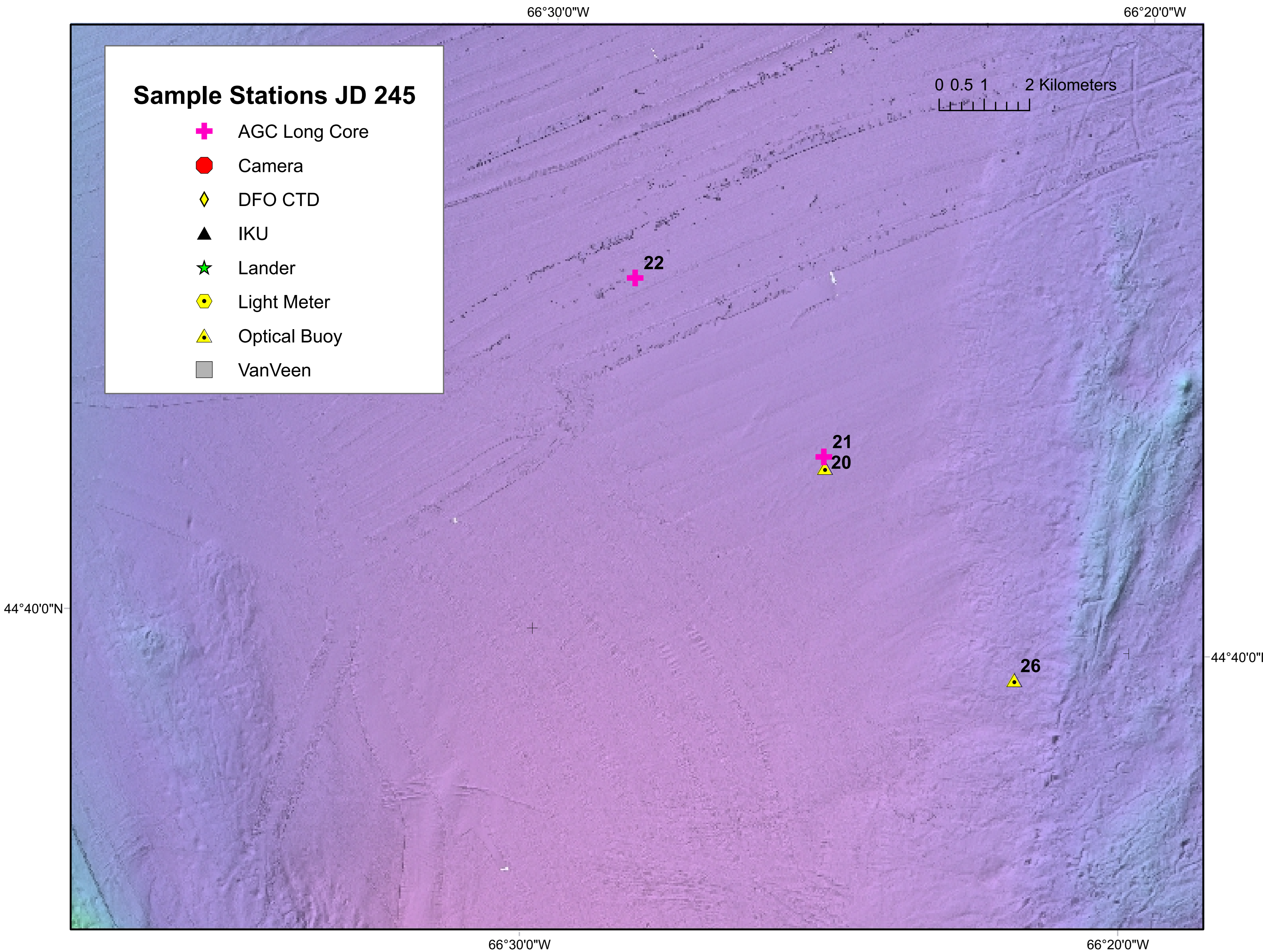


Figure 12. Stations 20 to 22 and 26 in Grand Manan Basin, day 245.

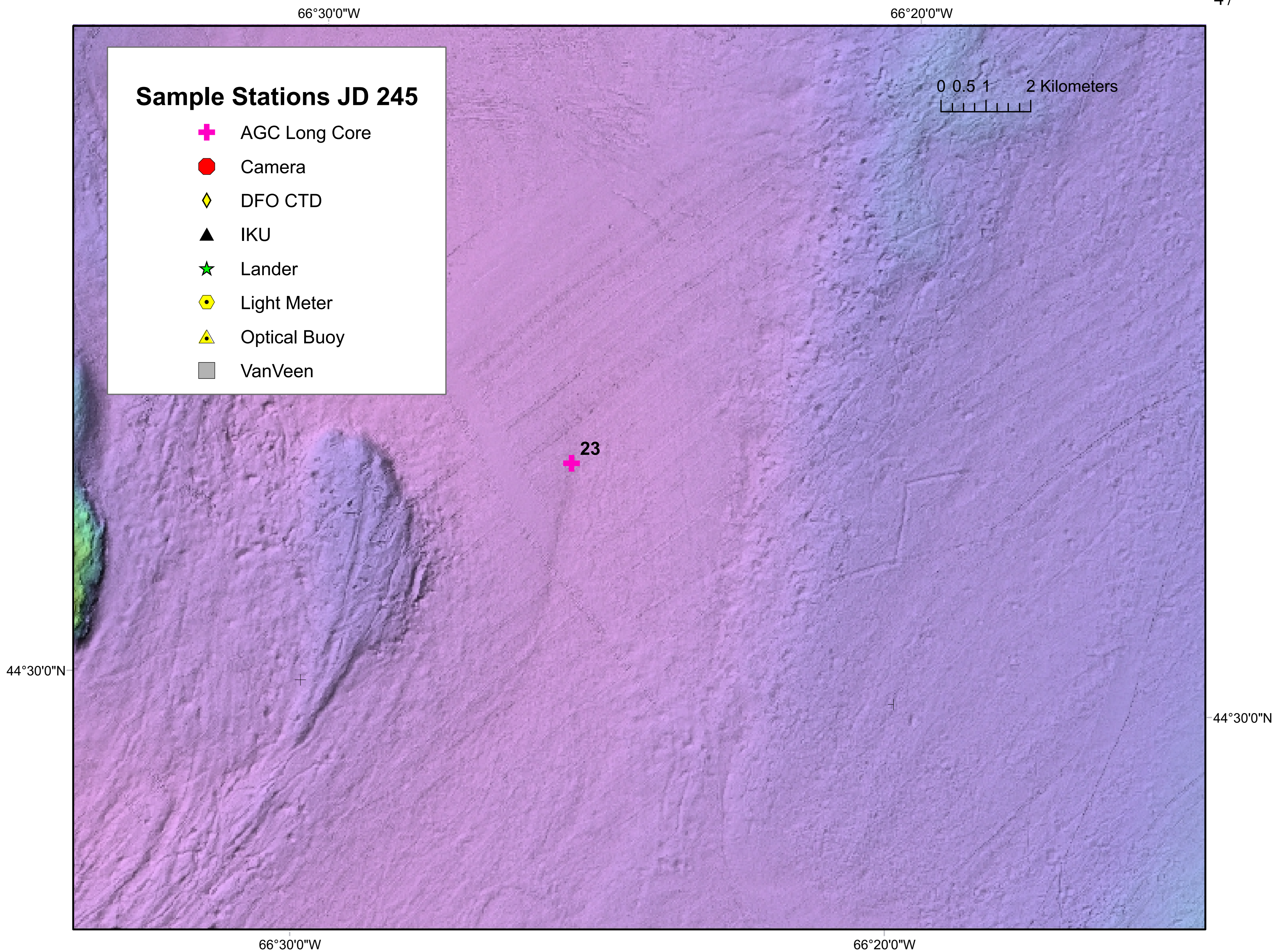


Figure 13. Station 23 in Grand Manan Basin, day 245.

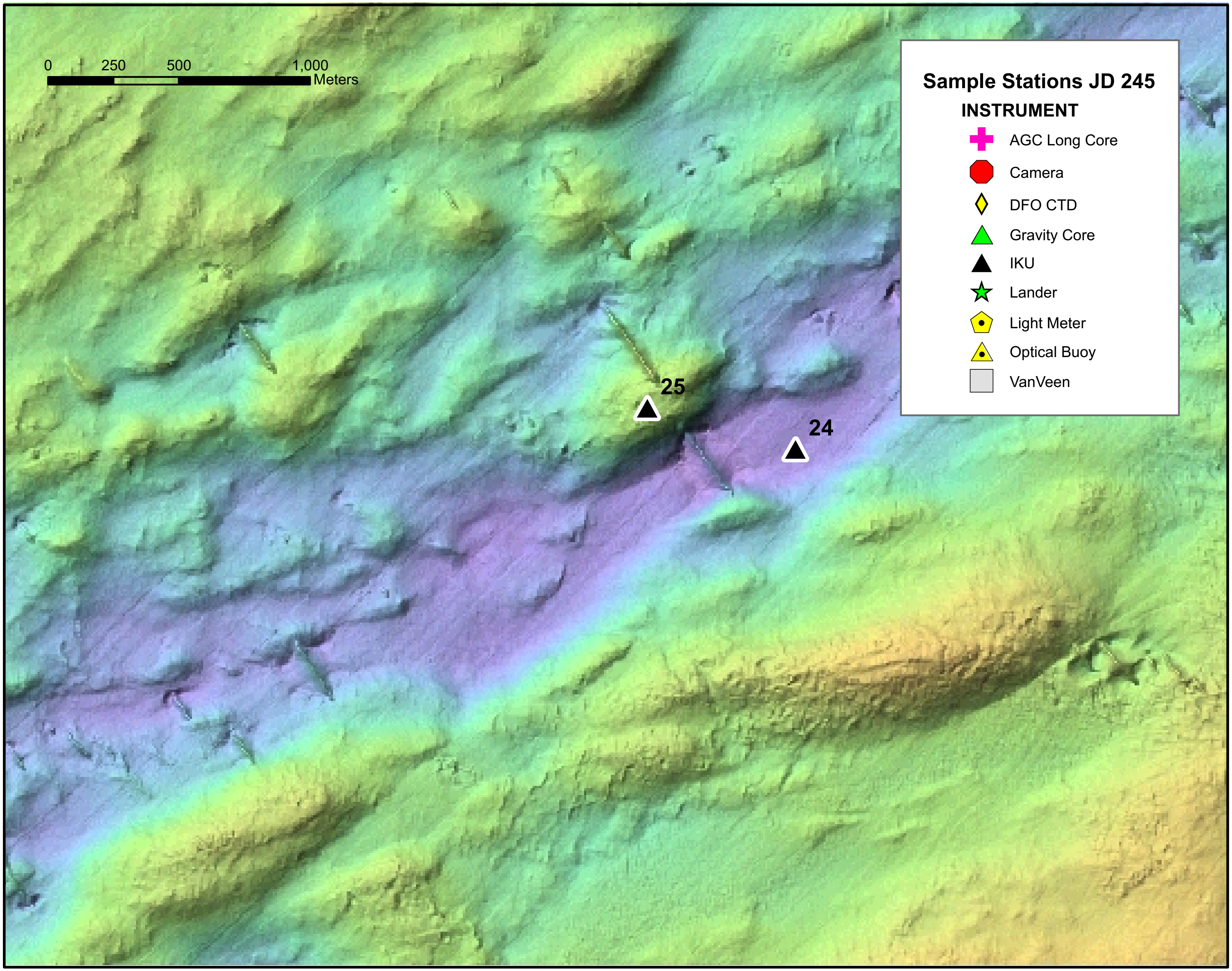


Figure 14. Stations 24 and 25 in the Digby drumlin field, day 245.

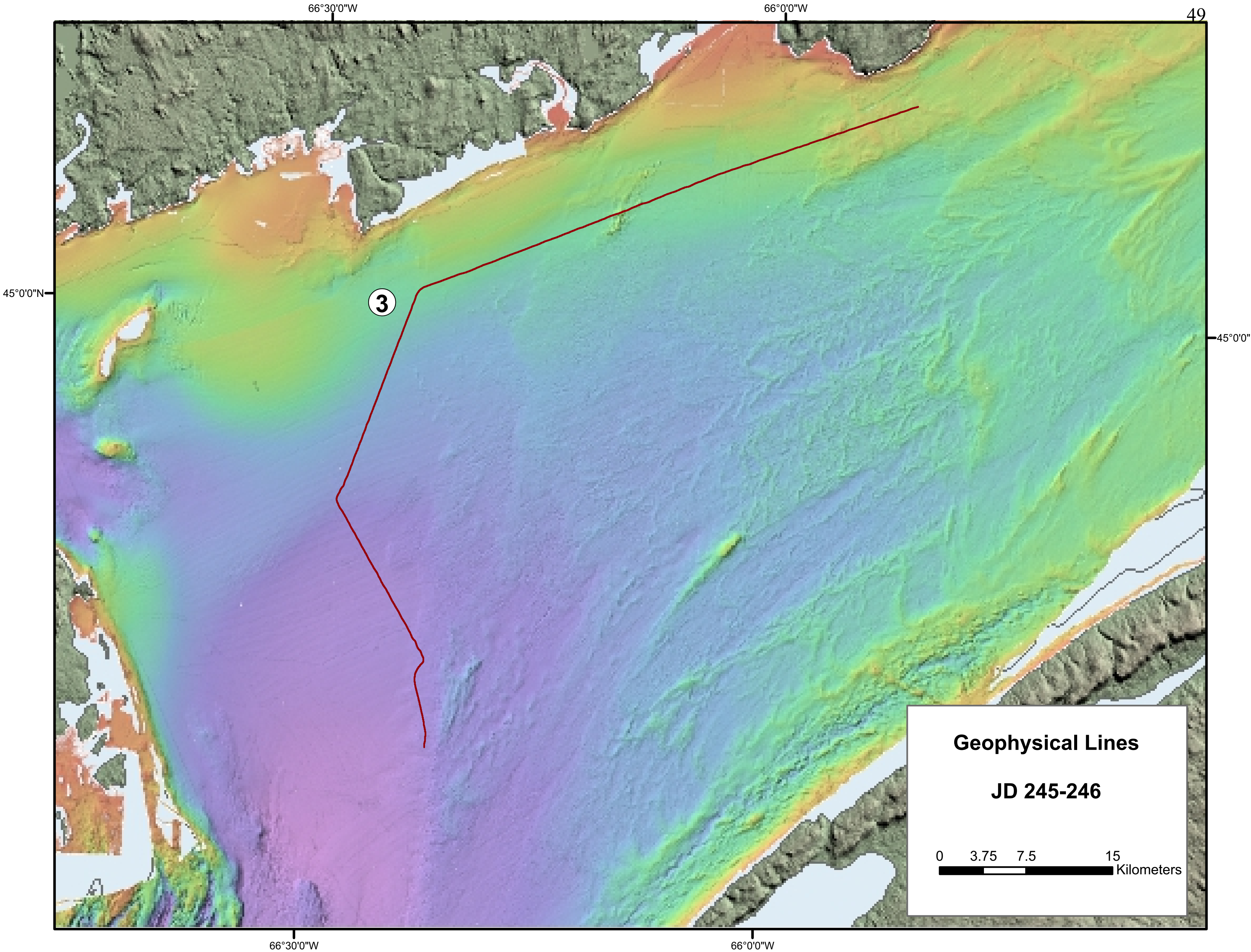


Figure 15. Geophysical survey Line 3, days 245 to 246.

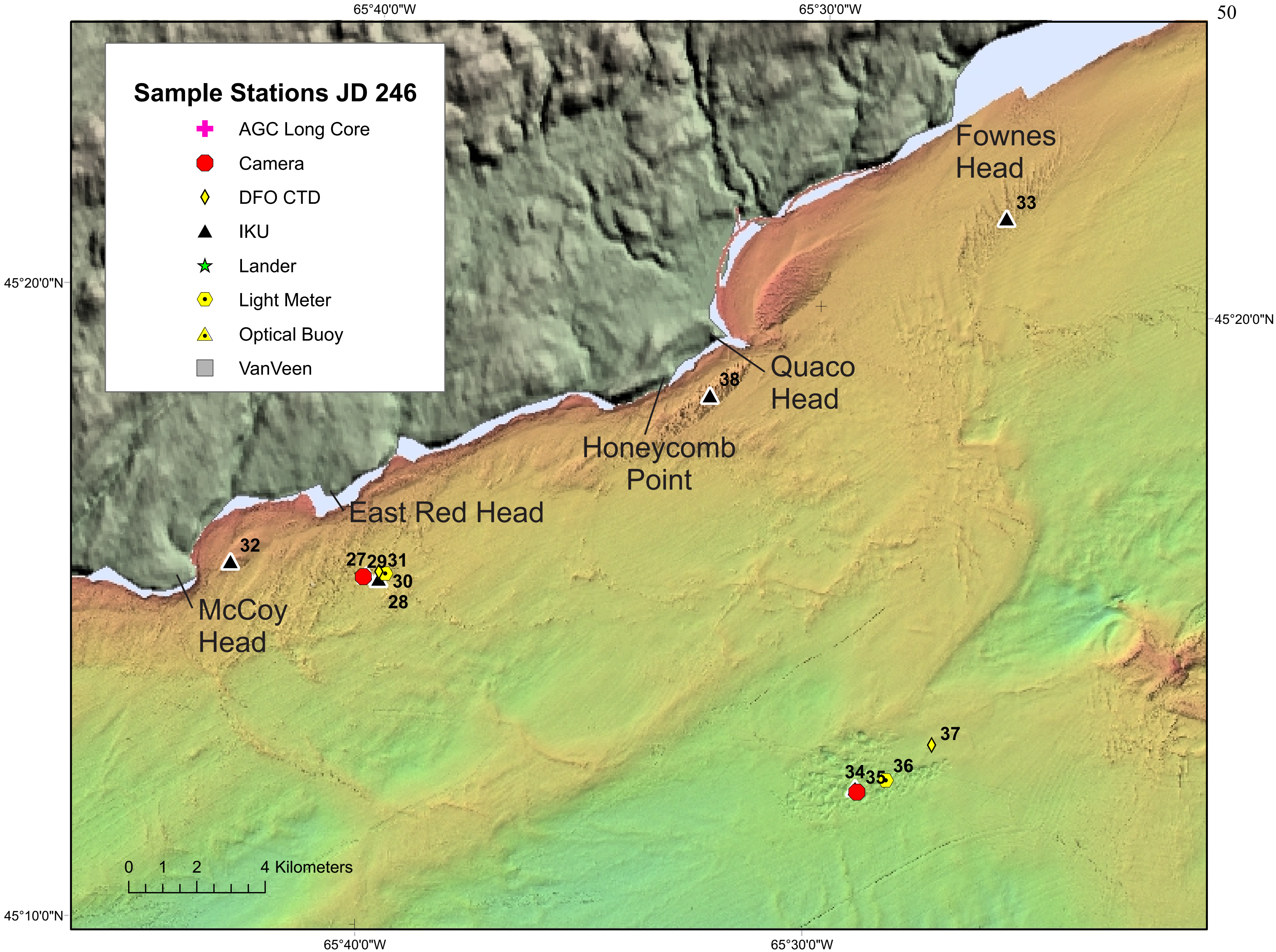


Figure 16. Stations 27 to 38 offshore McCoy Head, New Brunswick, day 246.

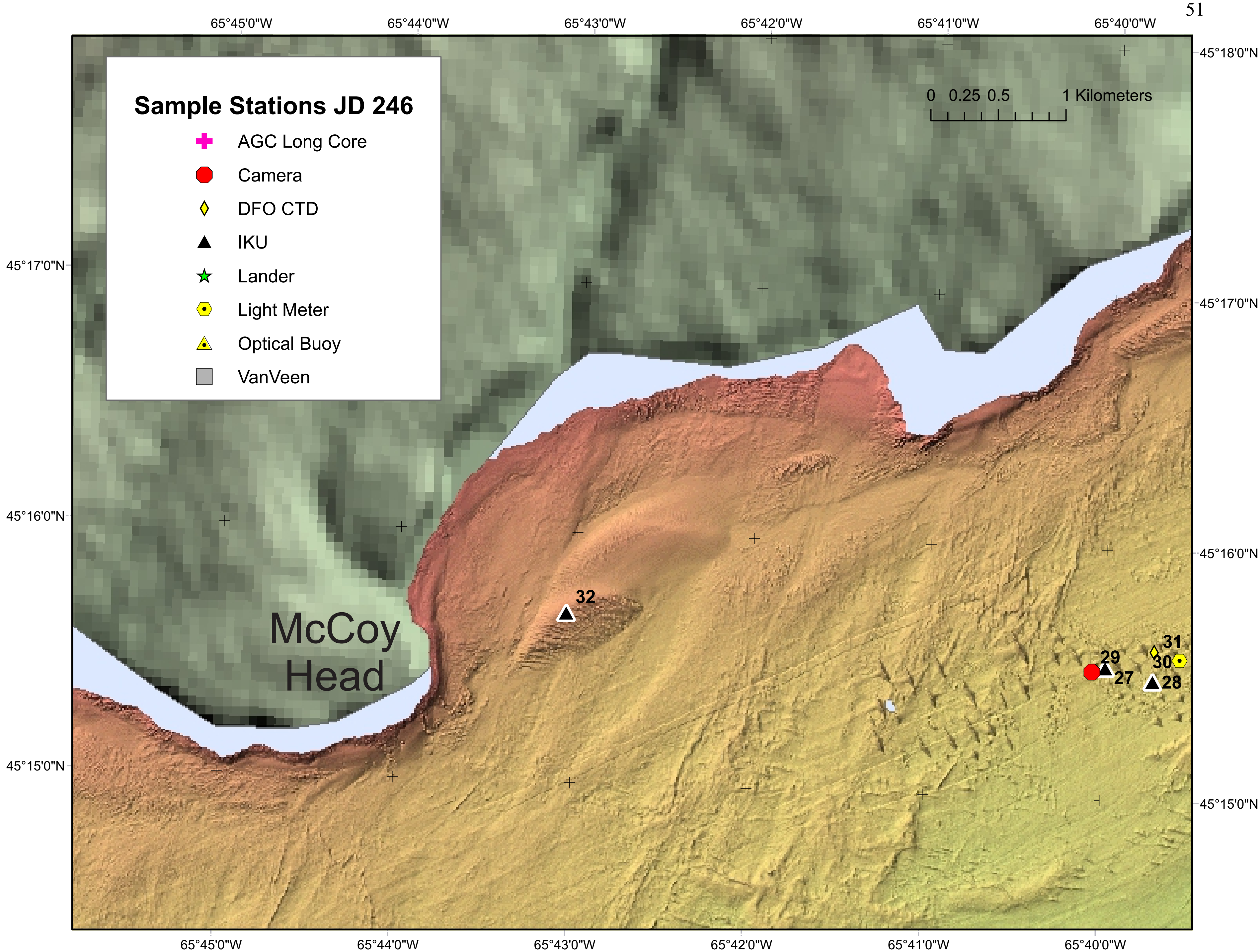


Figure 17. Stations 27 to 32 offshore McCoy Head, New Brunswick, day 246.

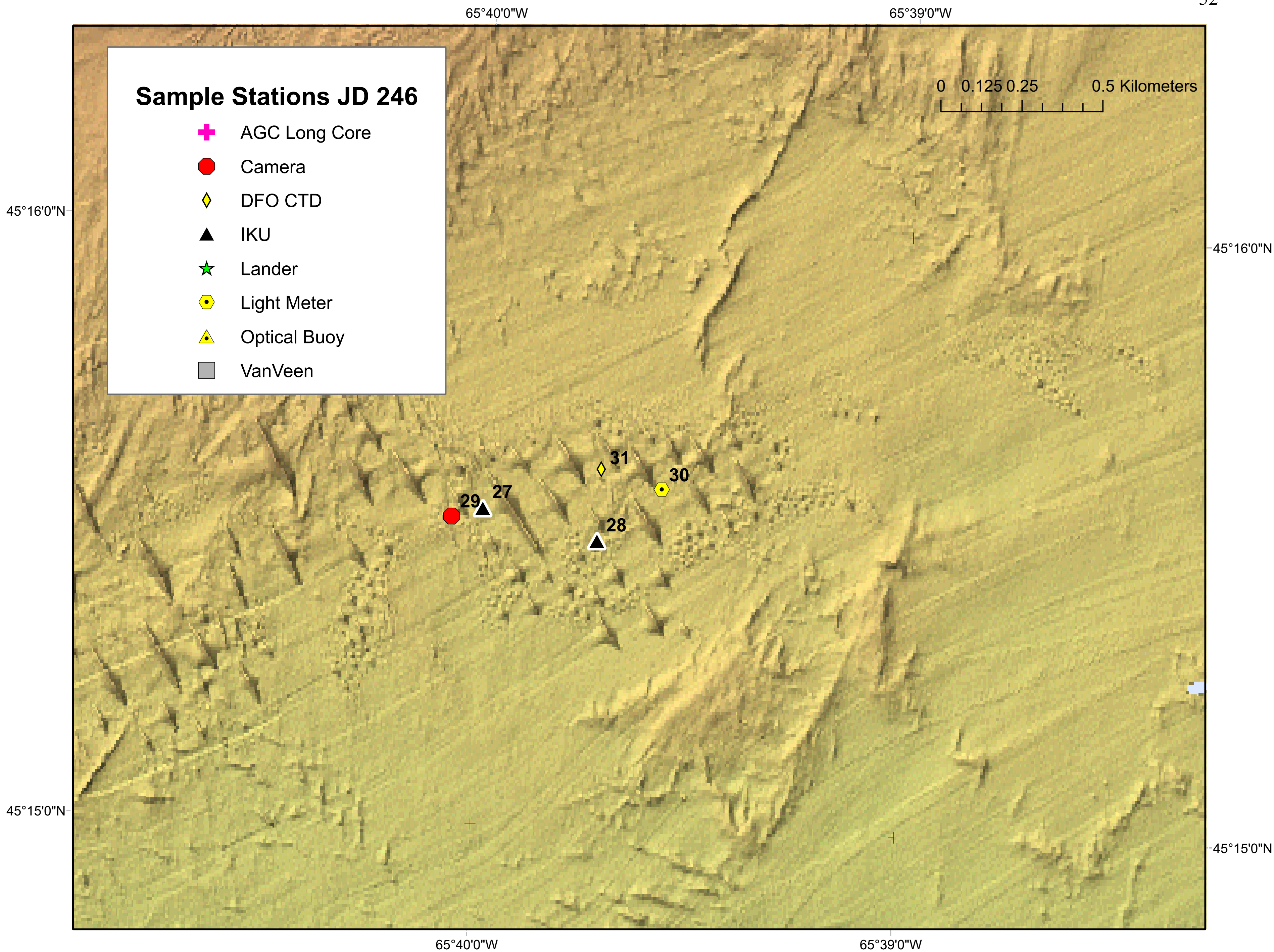


Figure 18. Stations 27 to 31 offshore McCoy Head, New Brunswick, day 246.

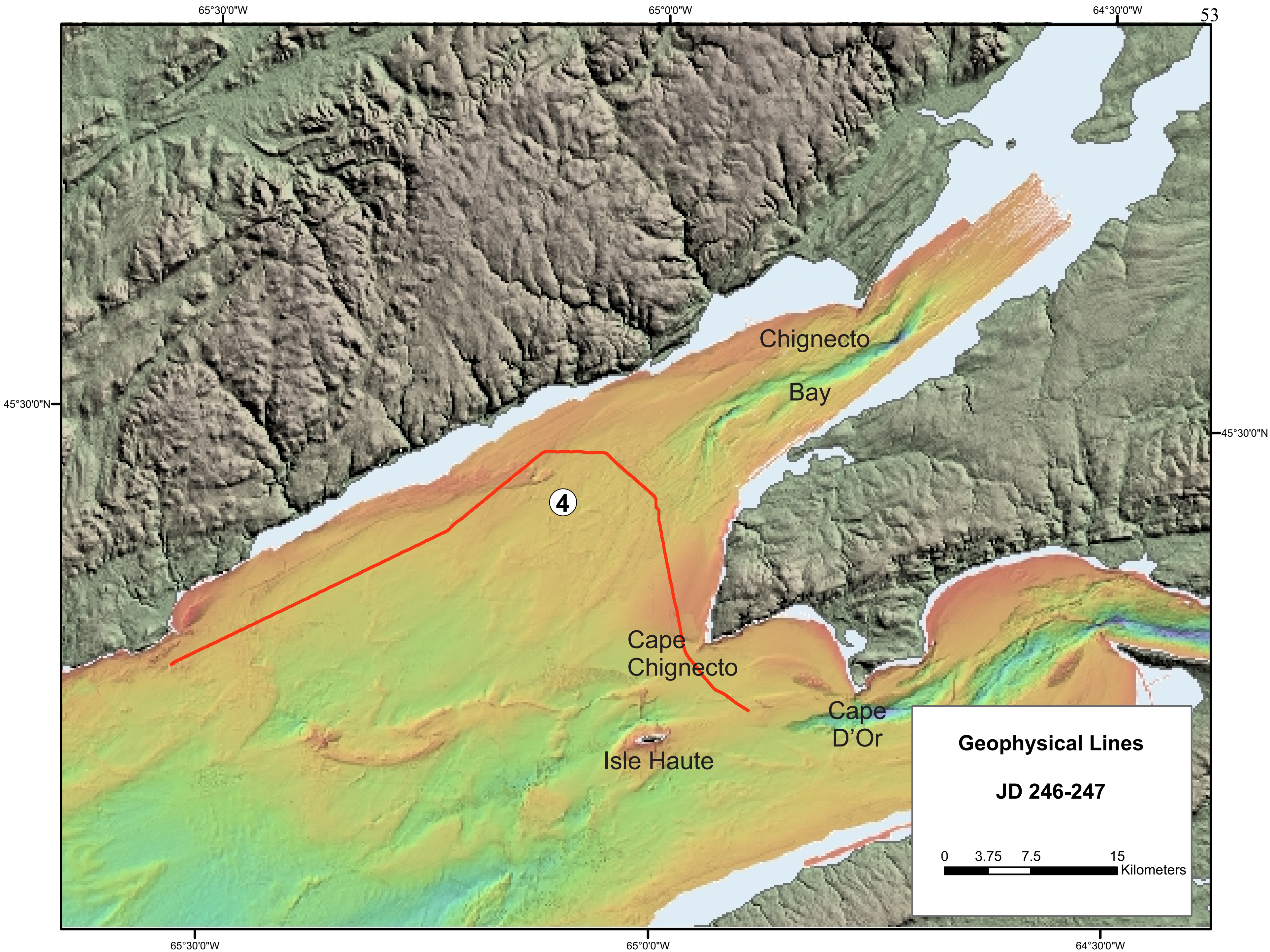


Figure 19. Geophysical survey Line 4, days 246 to 247.

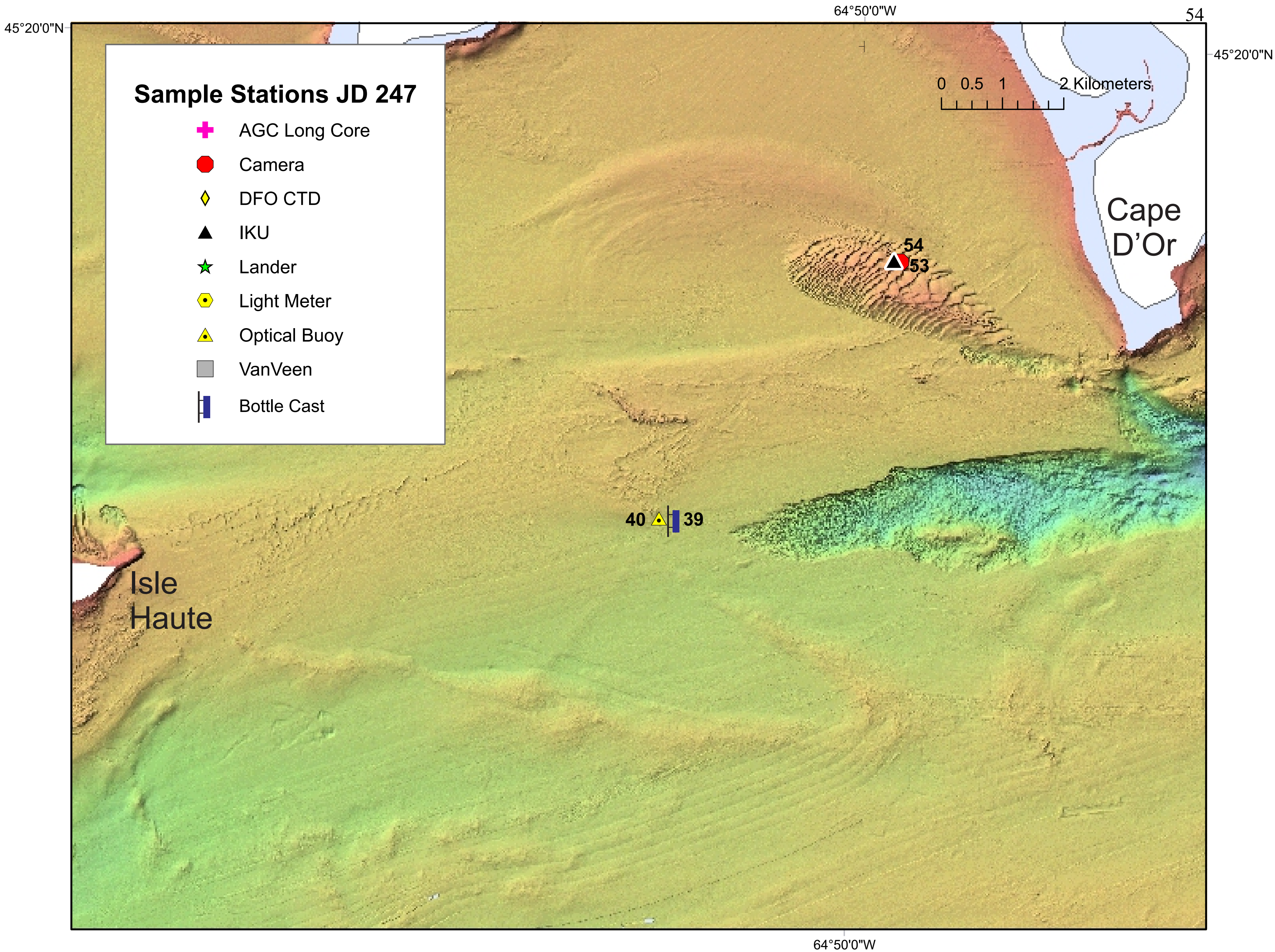


Figure 20. Stations 39, 40, 53, and 54 west of Cape D'Or, day 247.

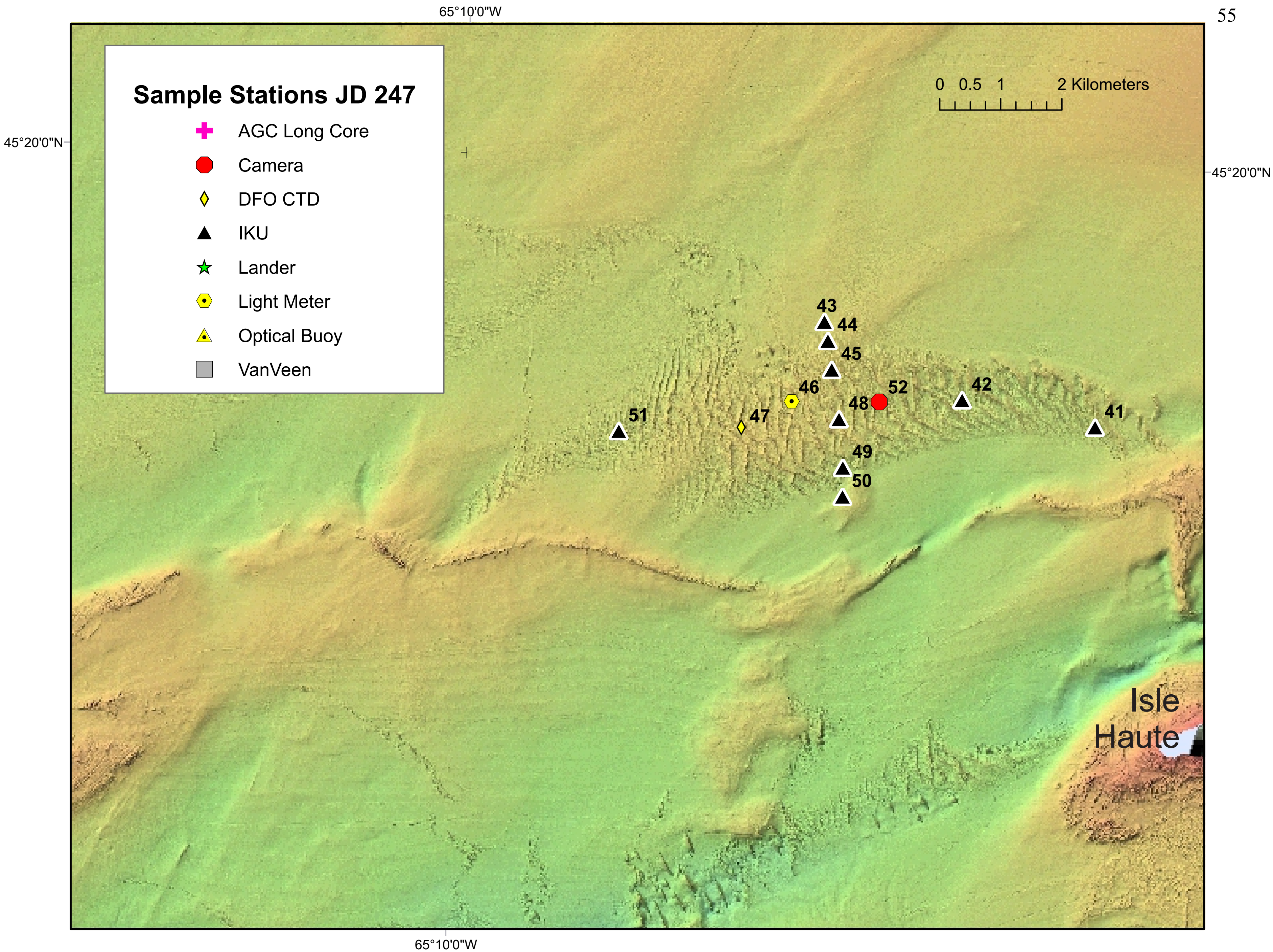


Figure 21. Stations 41 to 51 on sand wave field northwest of Isle Haute, day 247.

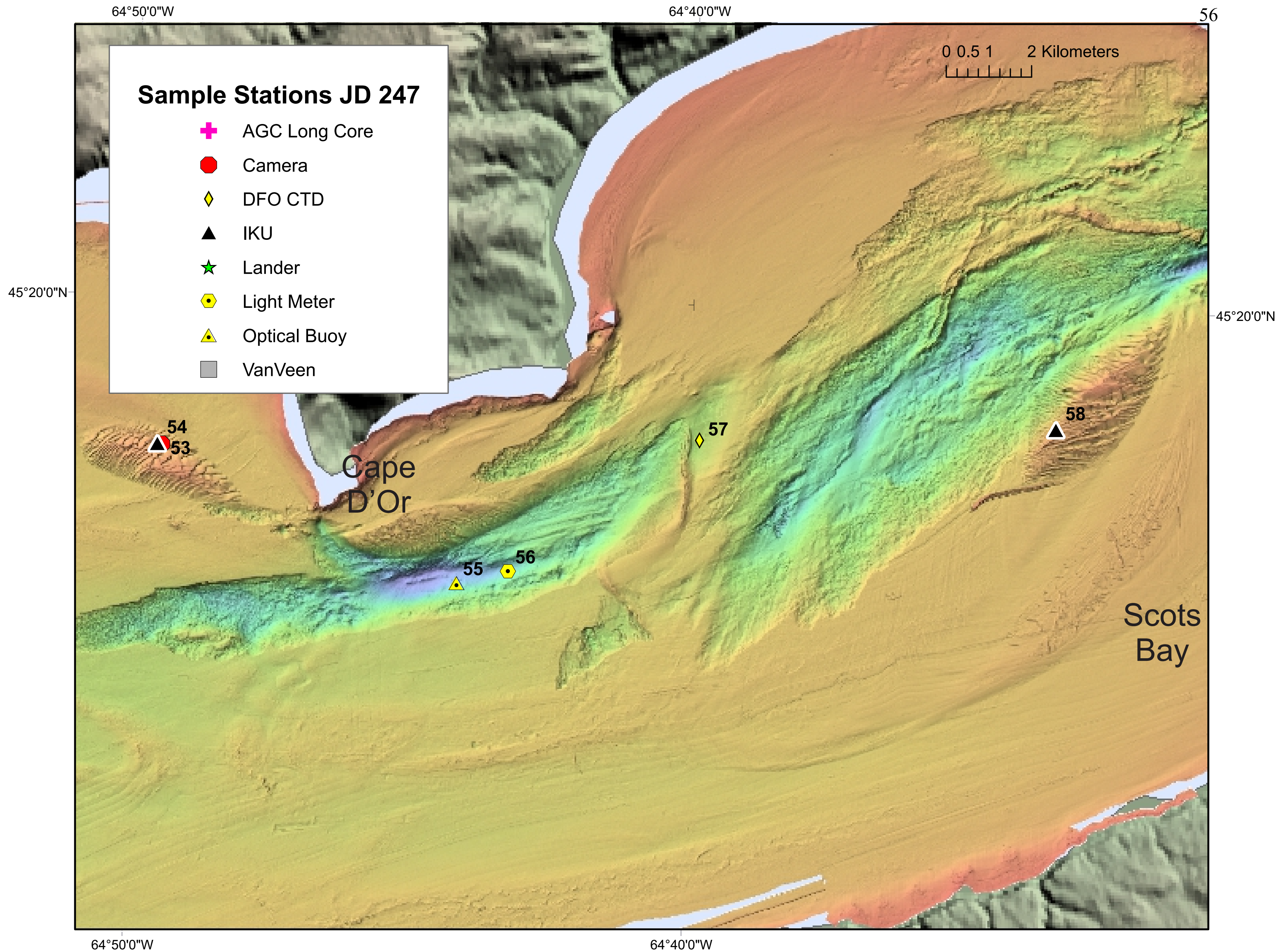


Figure 22. Stations 53 to 58 on Cape D'Or west banner bank, scour trough, and Scots Bay banner bank, day 247.

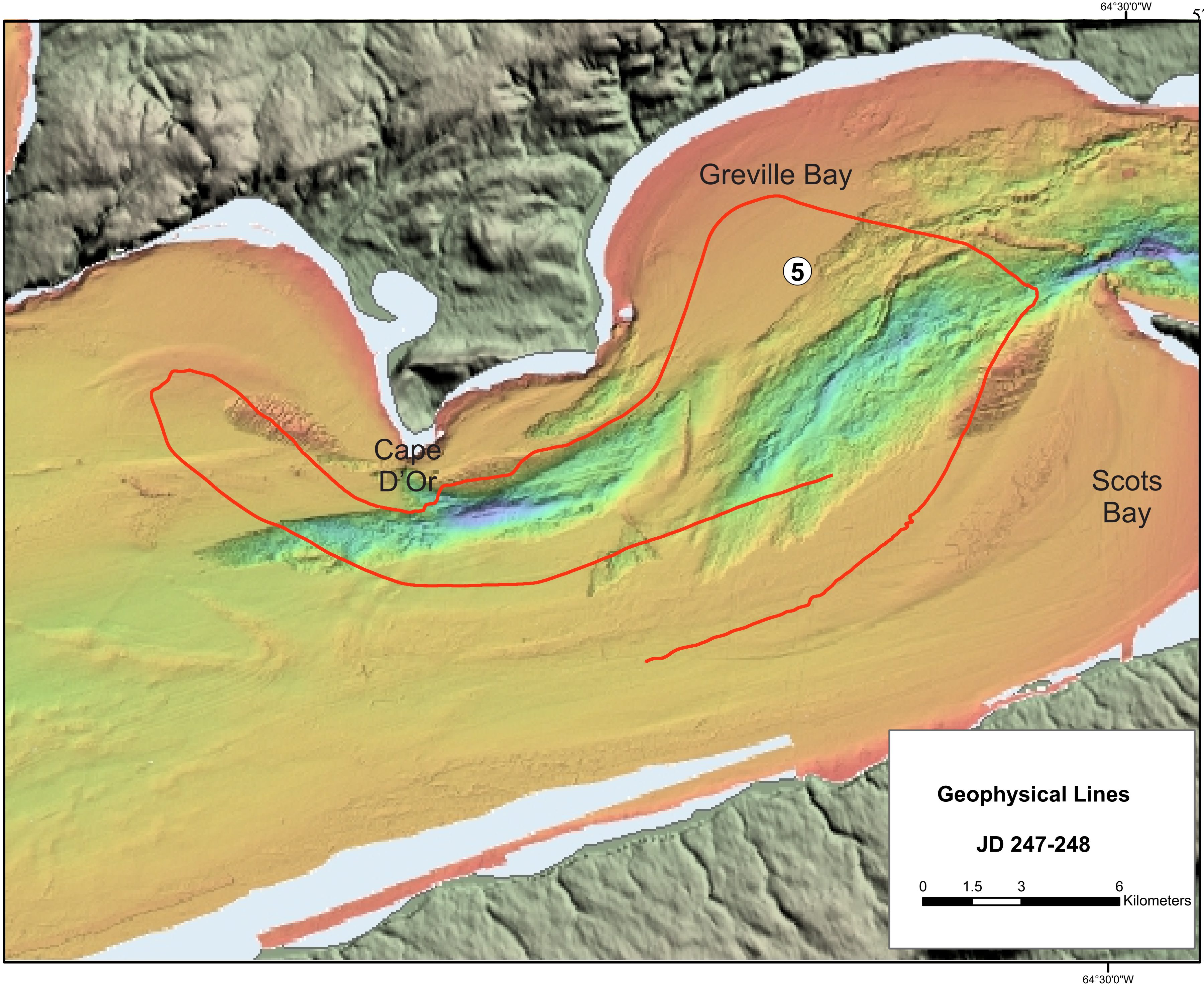


Figure 23. Geophysical survey Line 5, days 247 to 248.

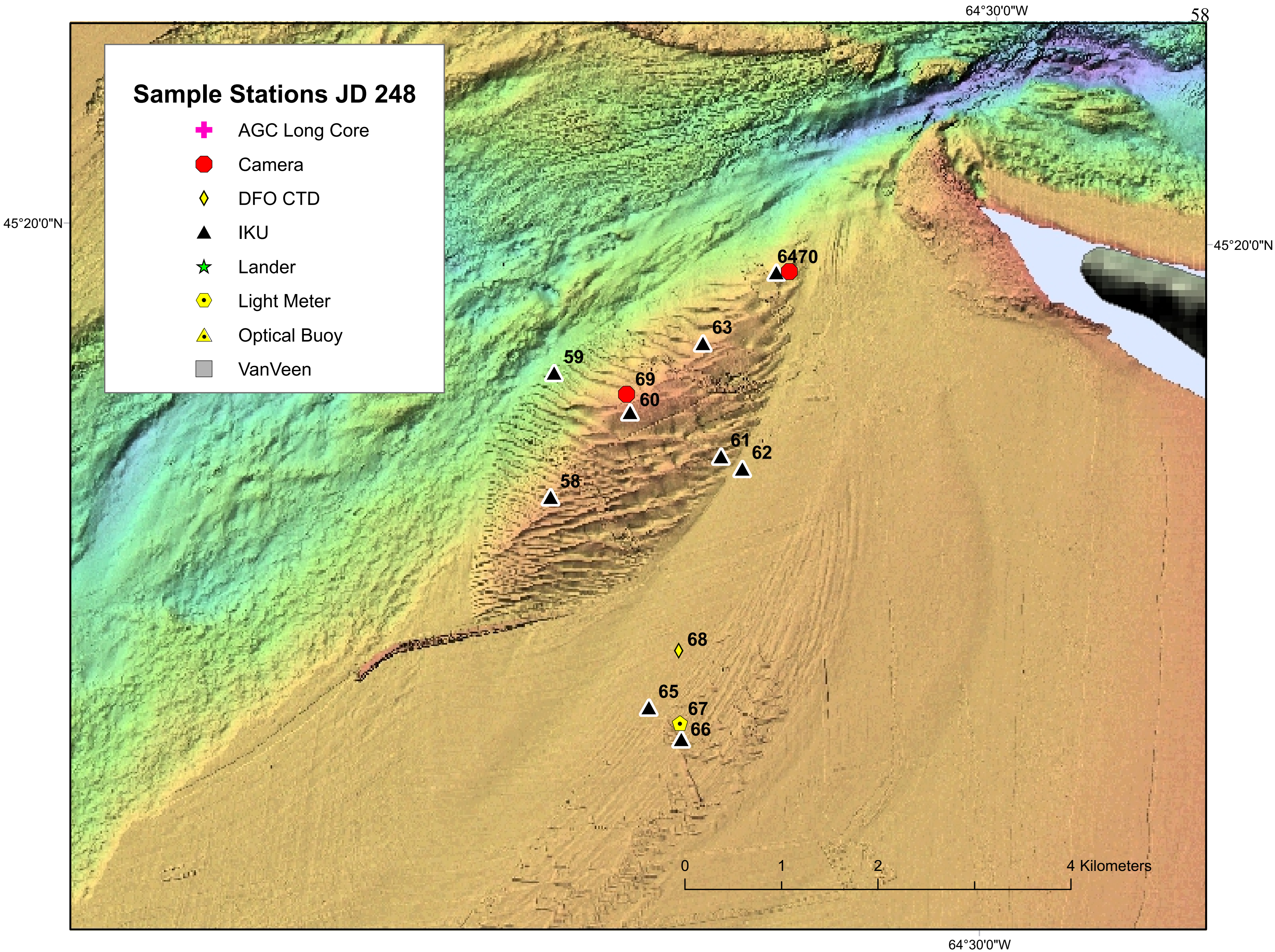


Figure 24. Stations 58 to 70 on Scots Bay banner bank, day 248.

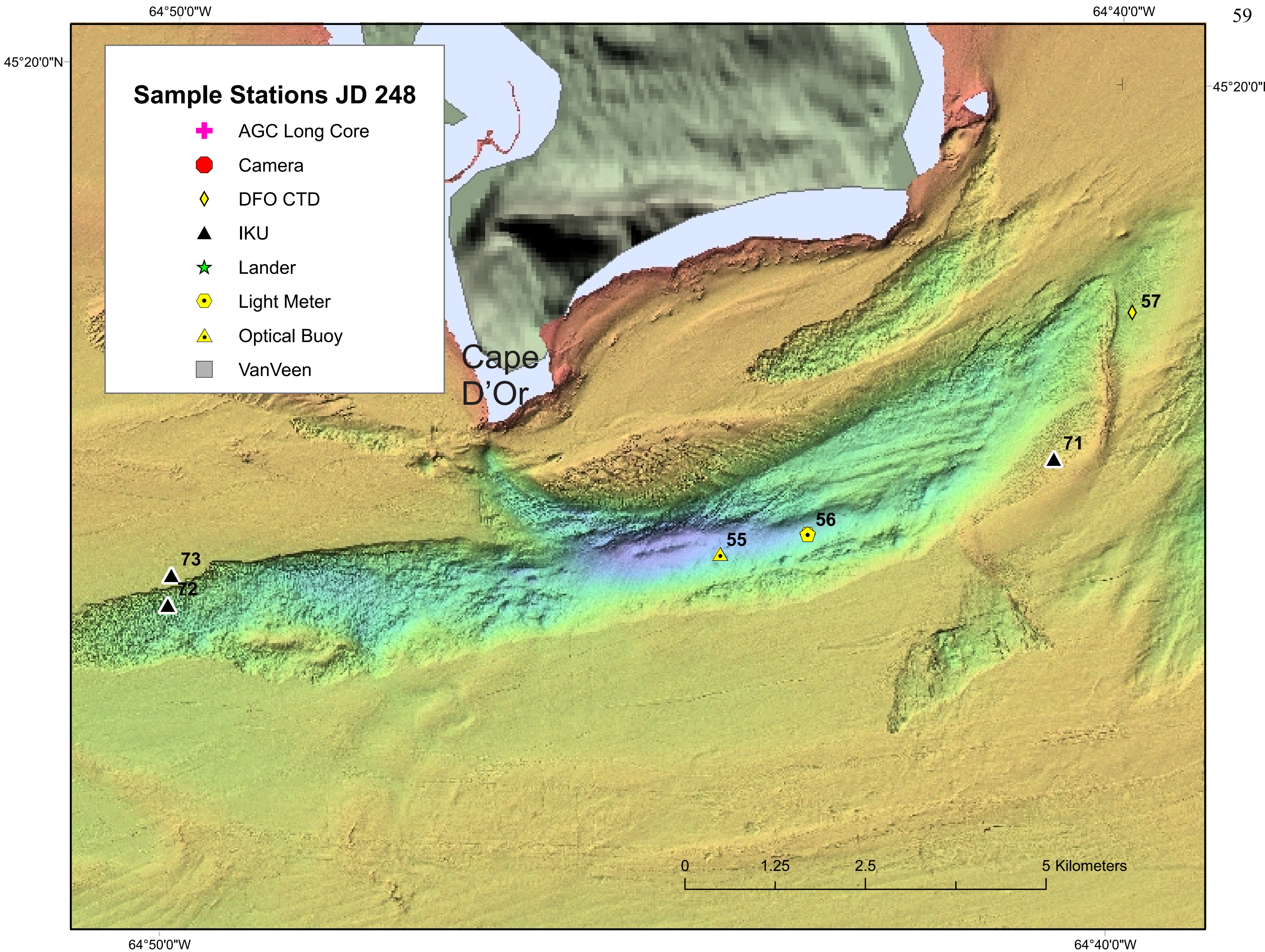


Figure 25. Stations 71 to 73 near Cape D'Or scour trough, day 248.

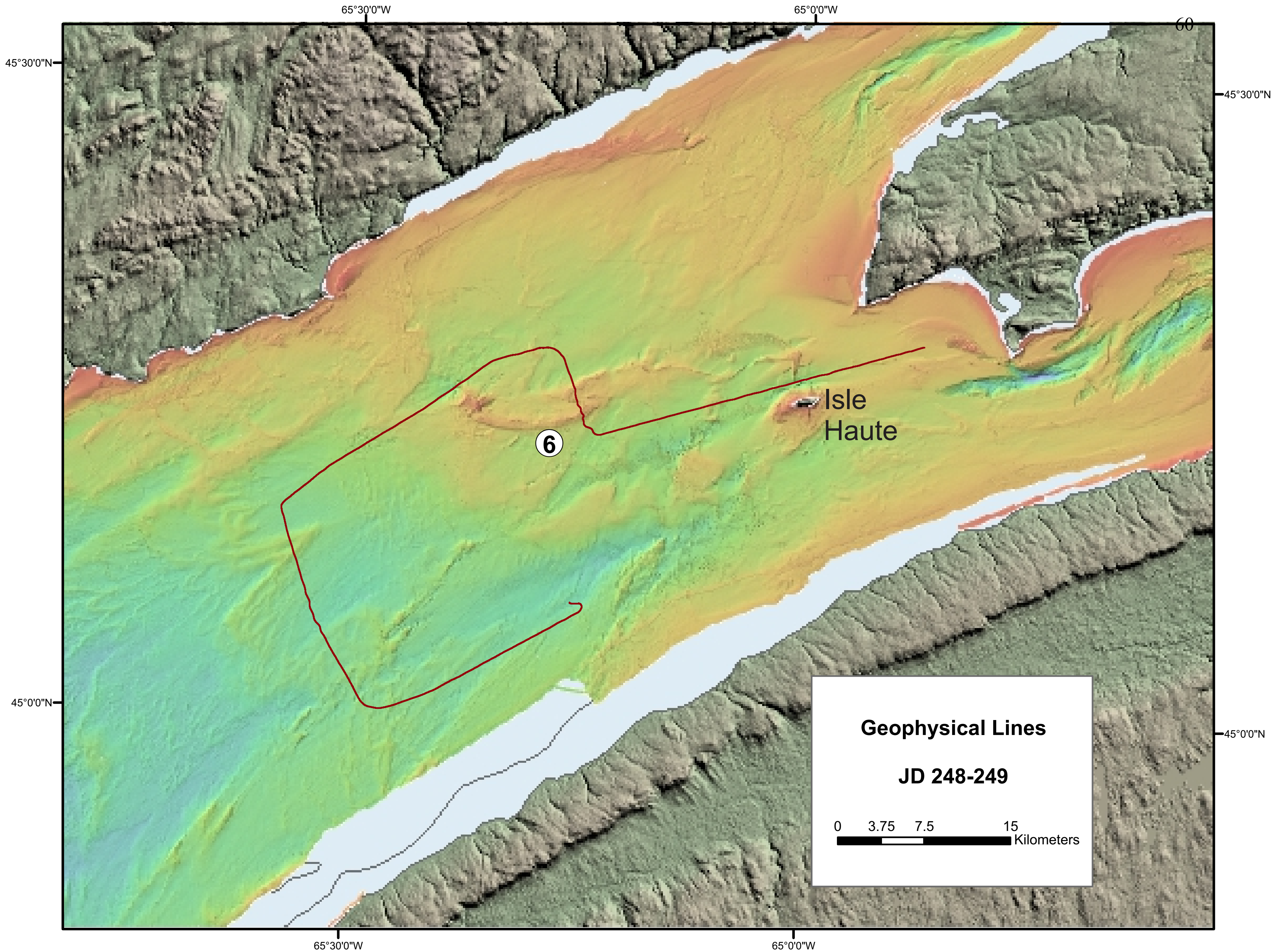


Figure 26. Geophysical survey Line 6, days 248 to 249.

Figure 27. Stations 74 to 76 over till tongue, day 249.

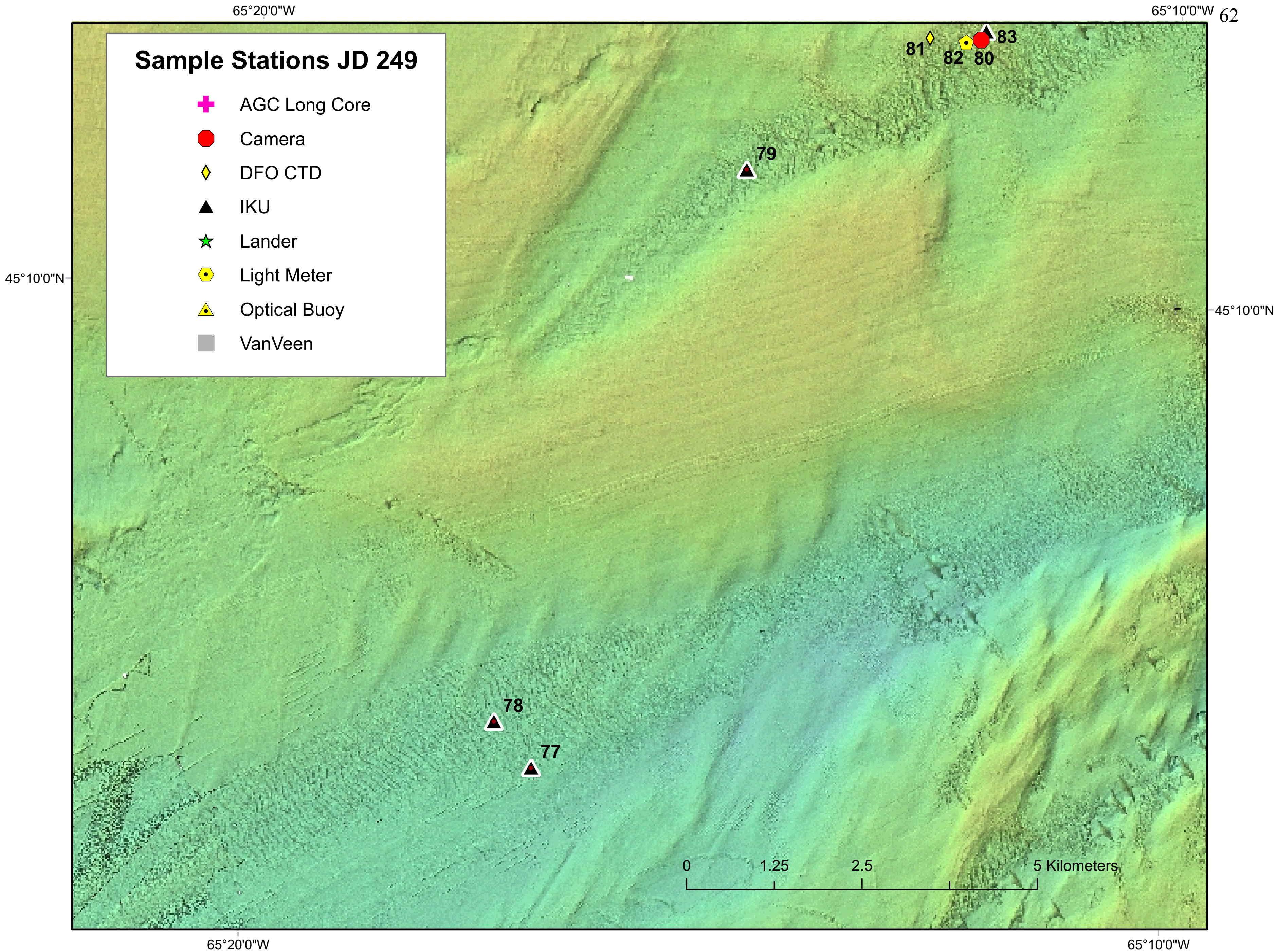


Figure 28. Stations 77 to 83, sand wave field, northeast Bay of Fundy, day 249.

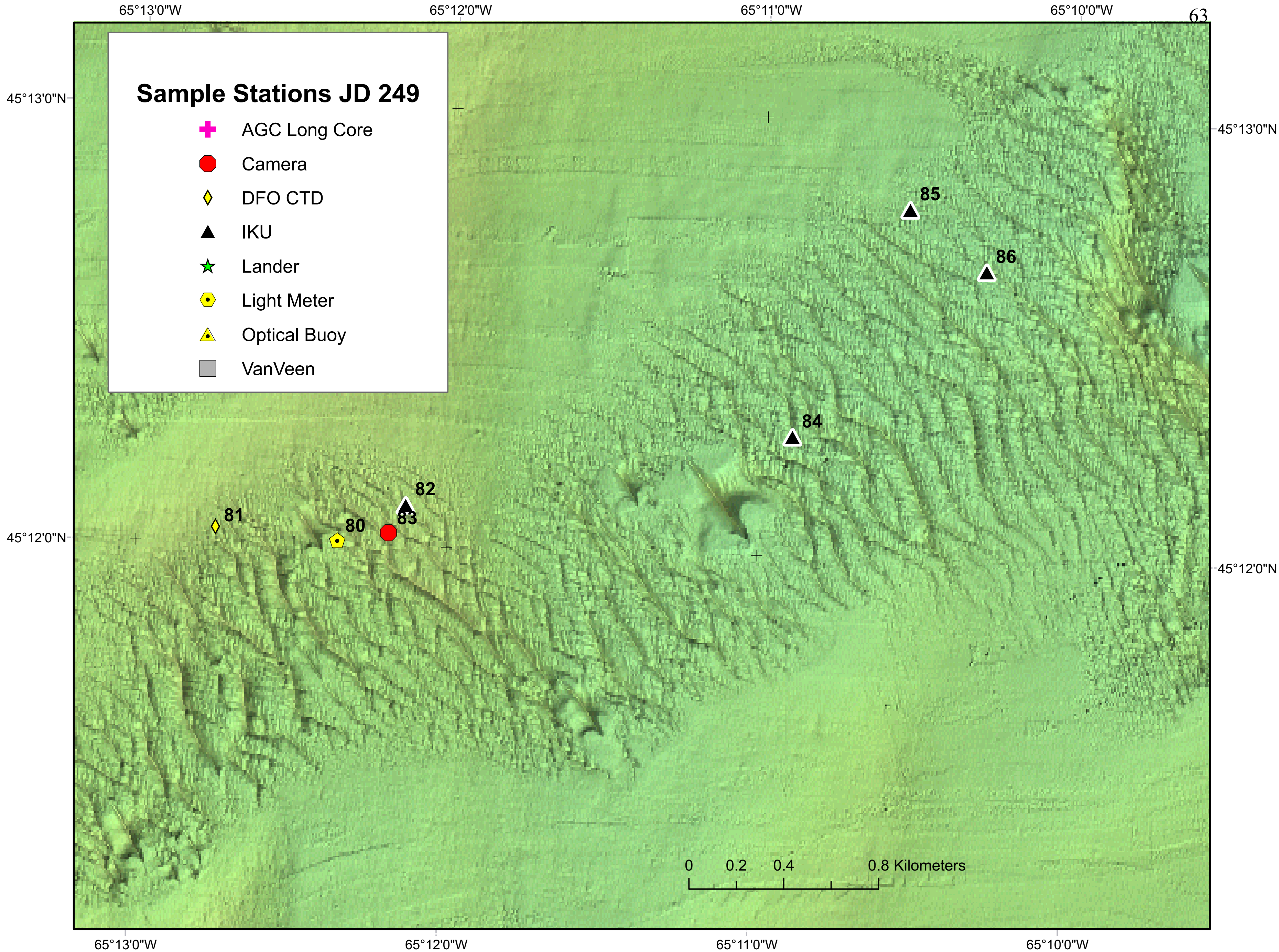


Figure 29. Stations 80 to 86, sand wave field, northeast Bay of Fundy, day 249.

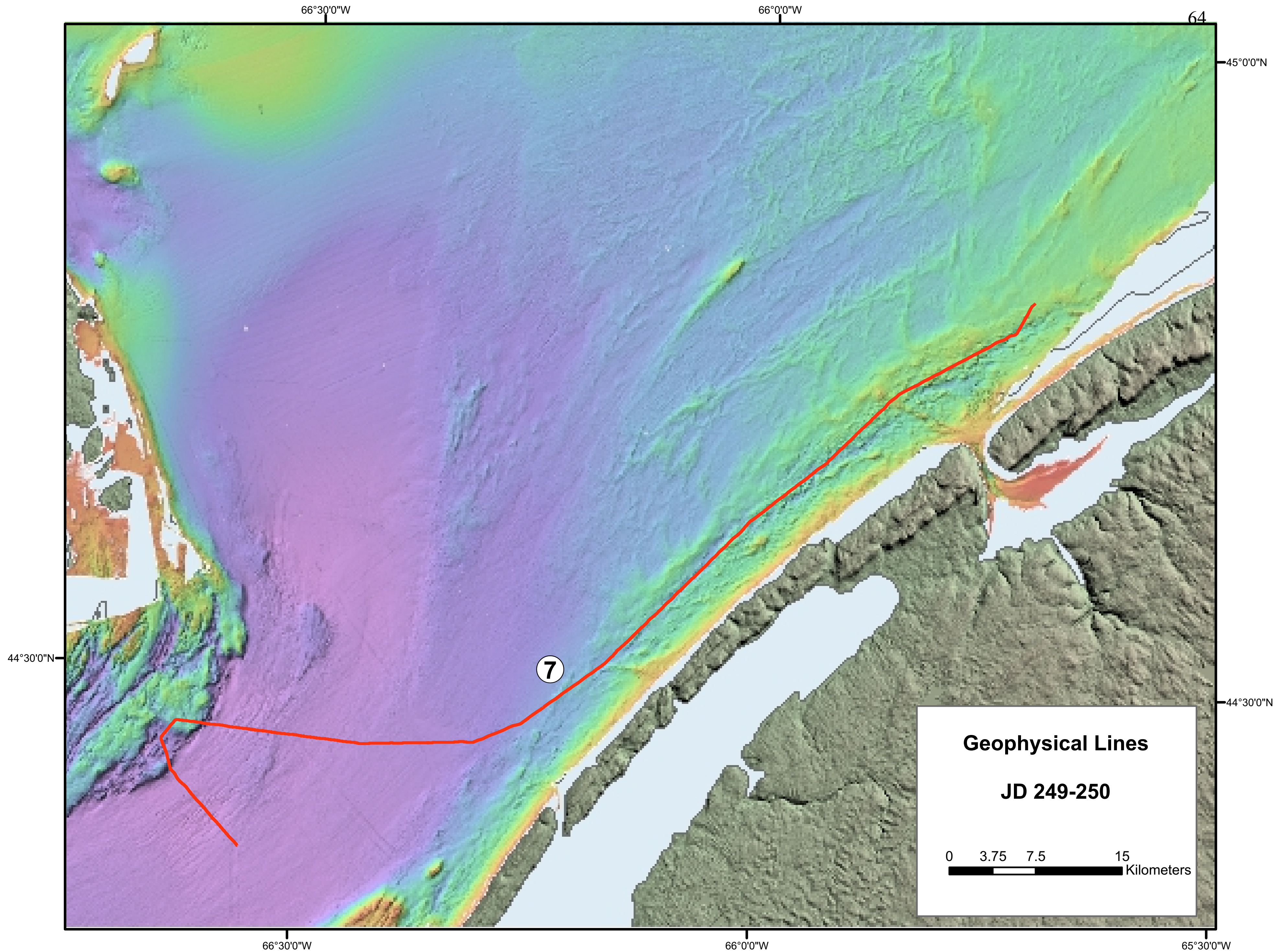


Figure 30. Geophysical survey Line 7, days 249 to 250.

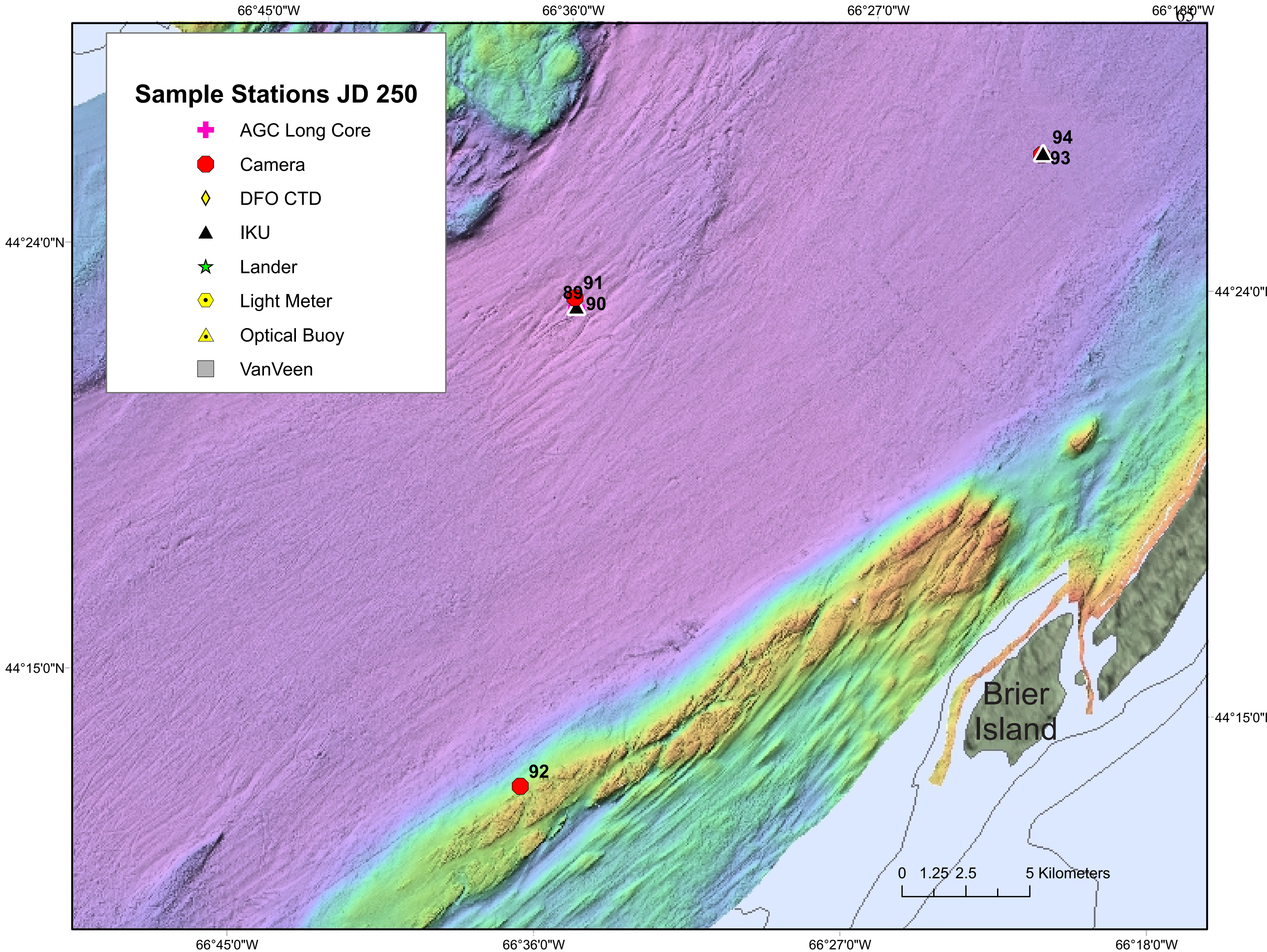


Figure 31. Stations 89 to 94, Grand Manan Basin, day 250.

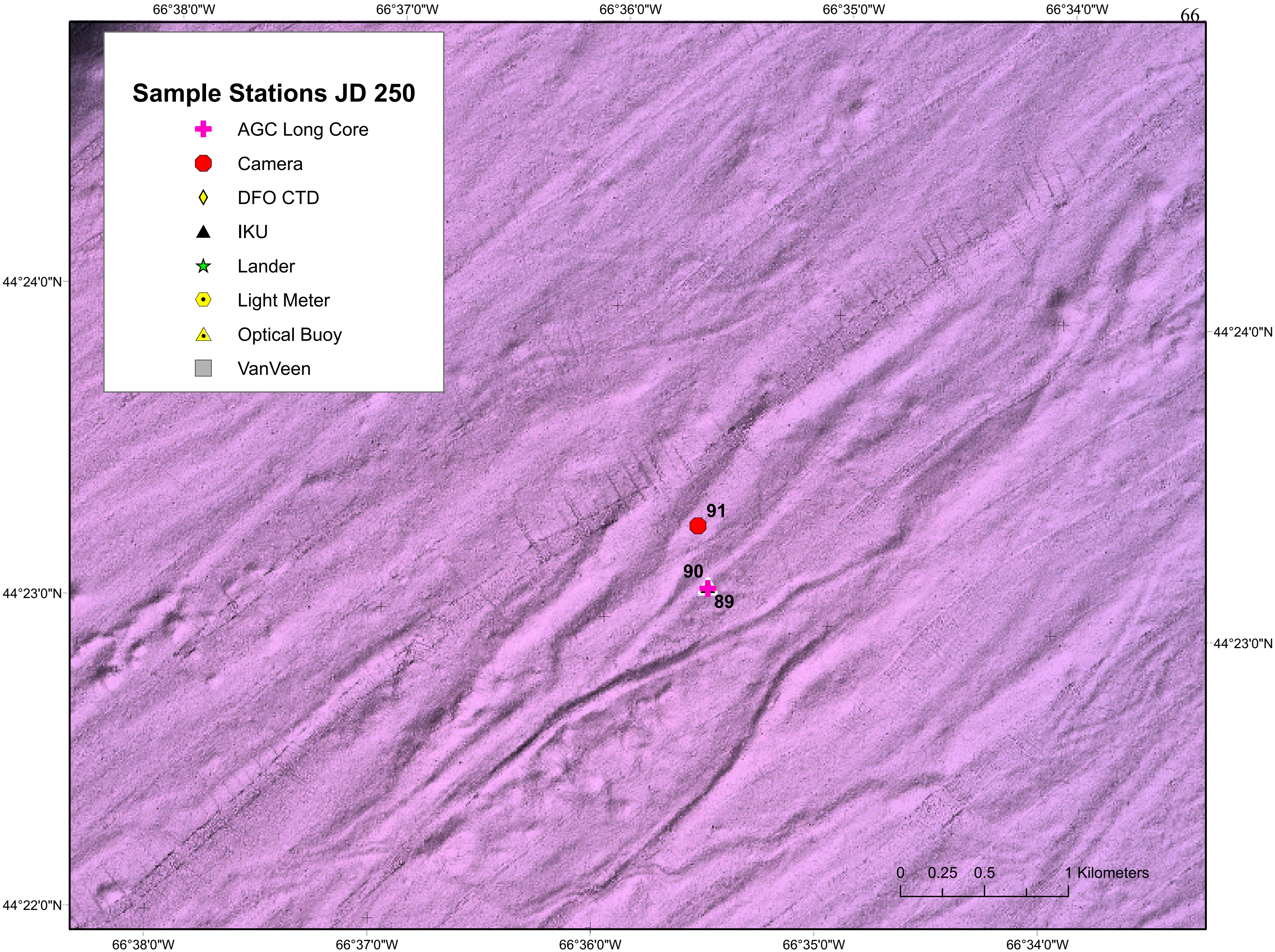


Figure 32. Stations 89 to 91, Grand Manan Basin, day 250.

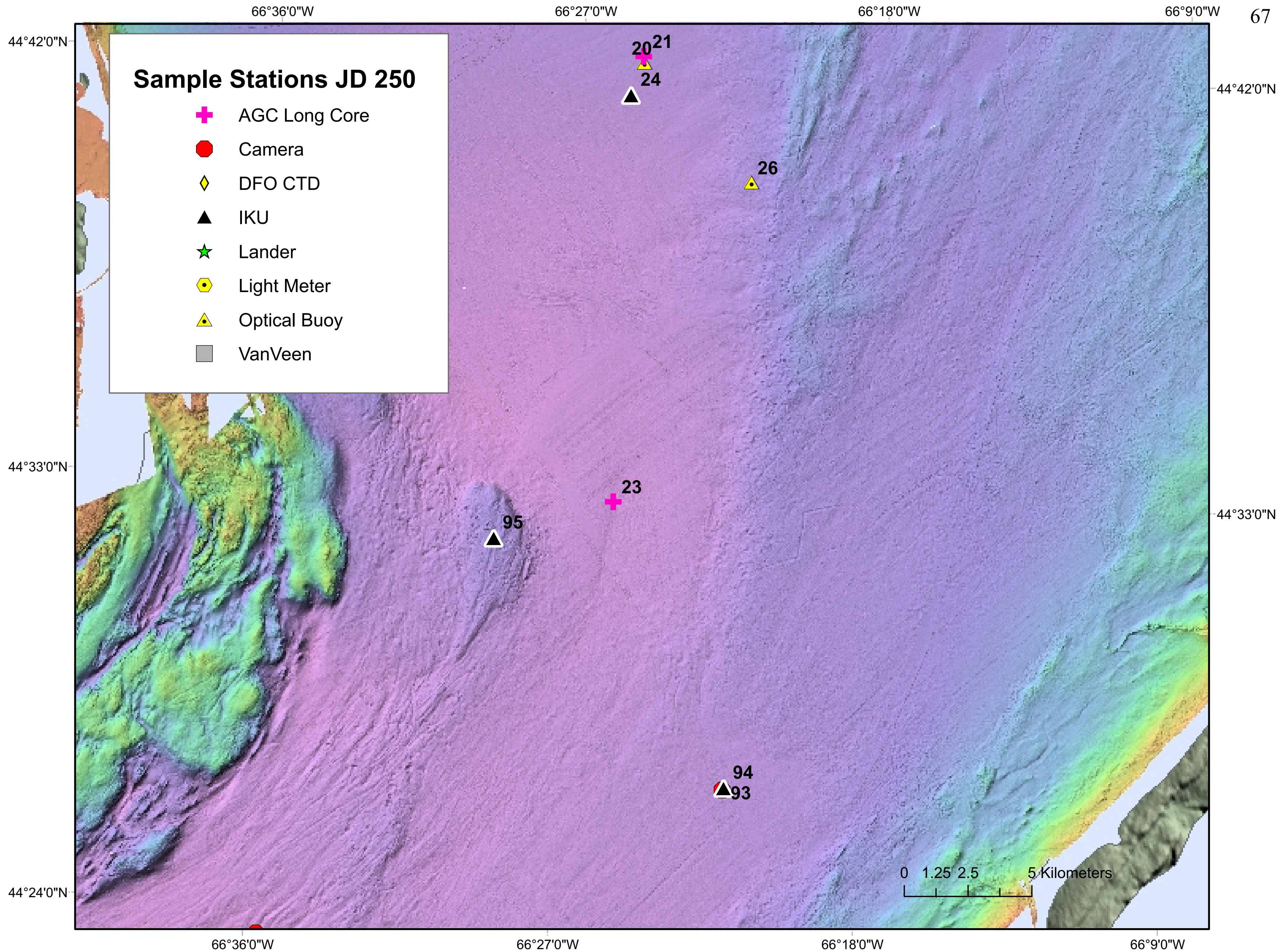


Figure 33. Stations 93 to 95, Grand Manan Basin, day 250.

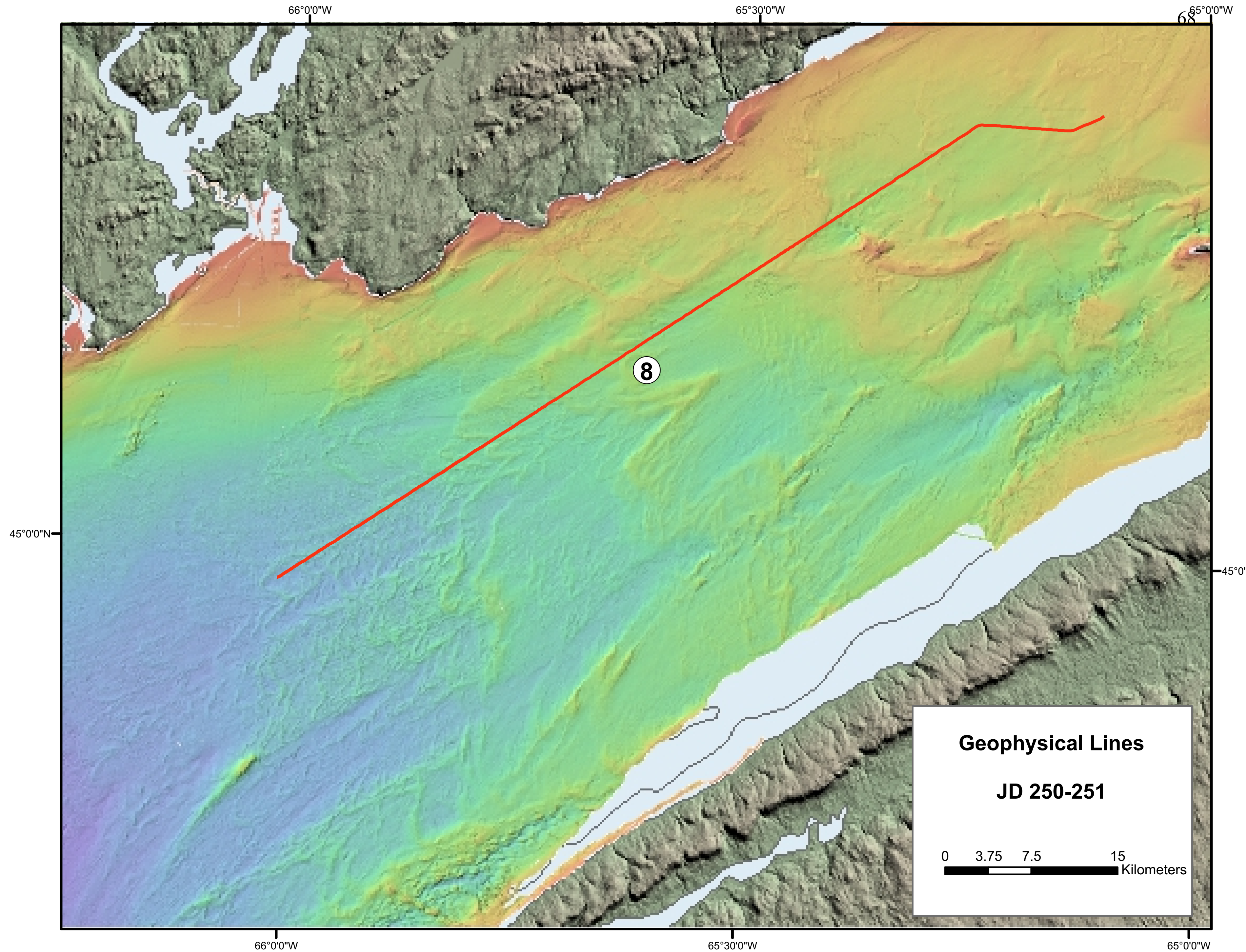


Figure 34. Geophysical survey Line 8, days 250 to 251.

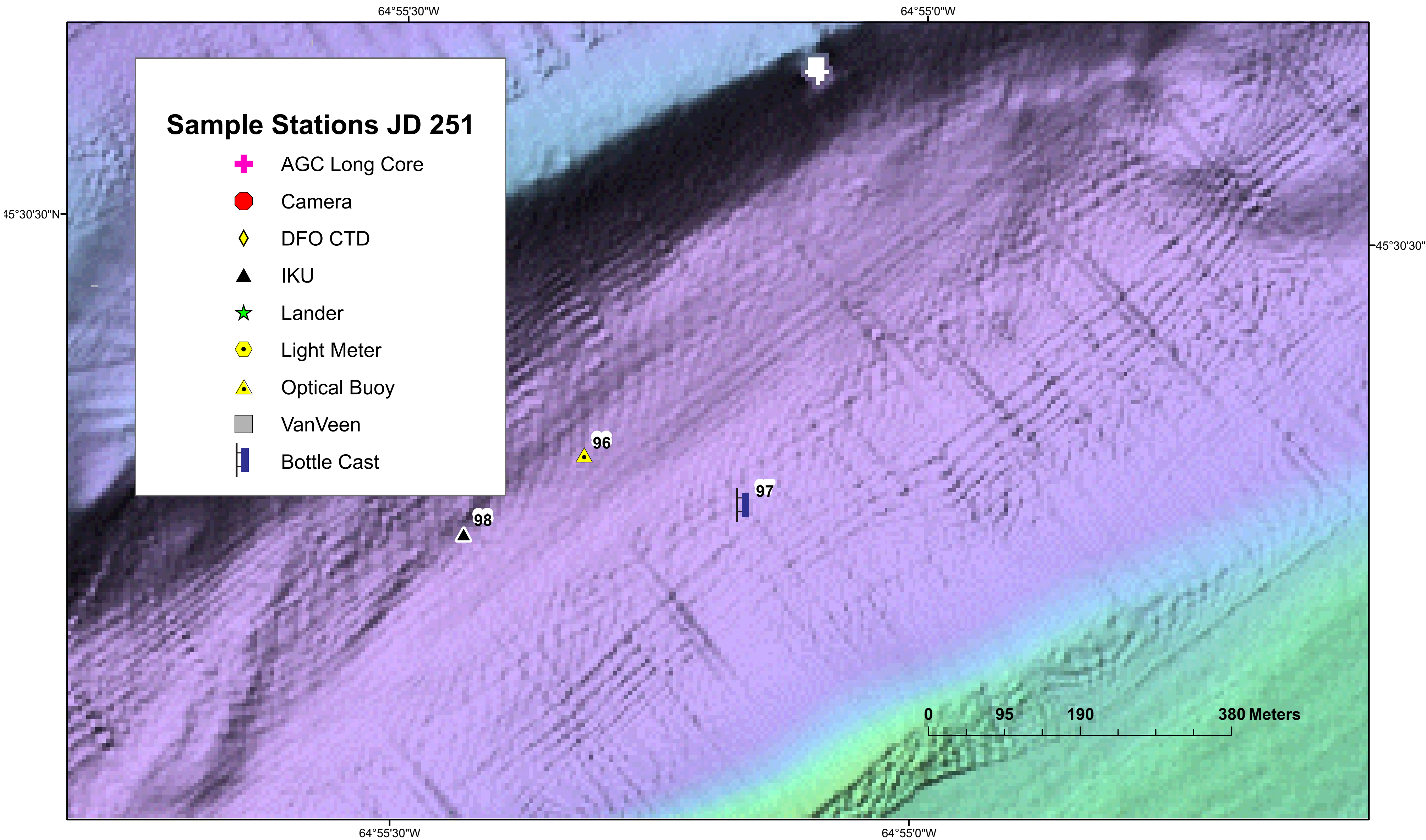


Figure 35. Stations 96 to 98, Chignecto Bay, day 251.

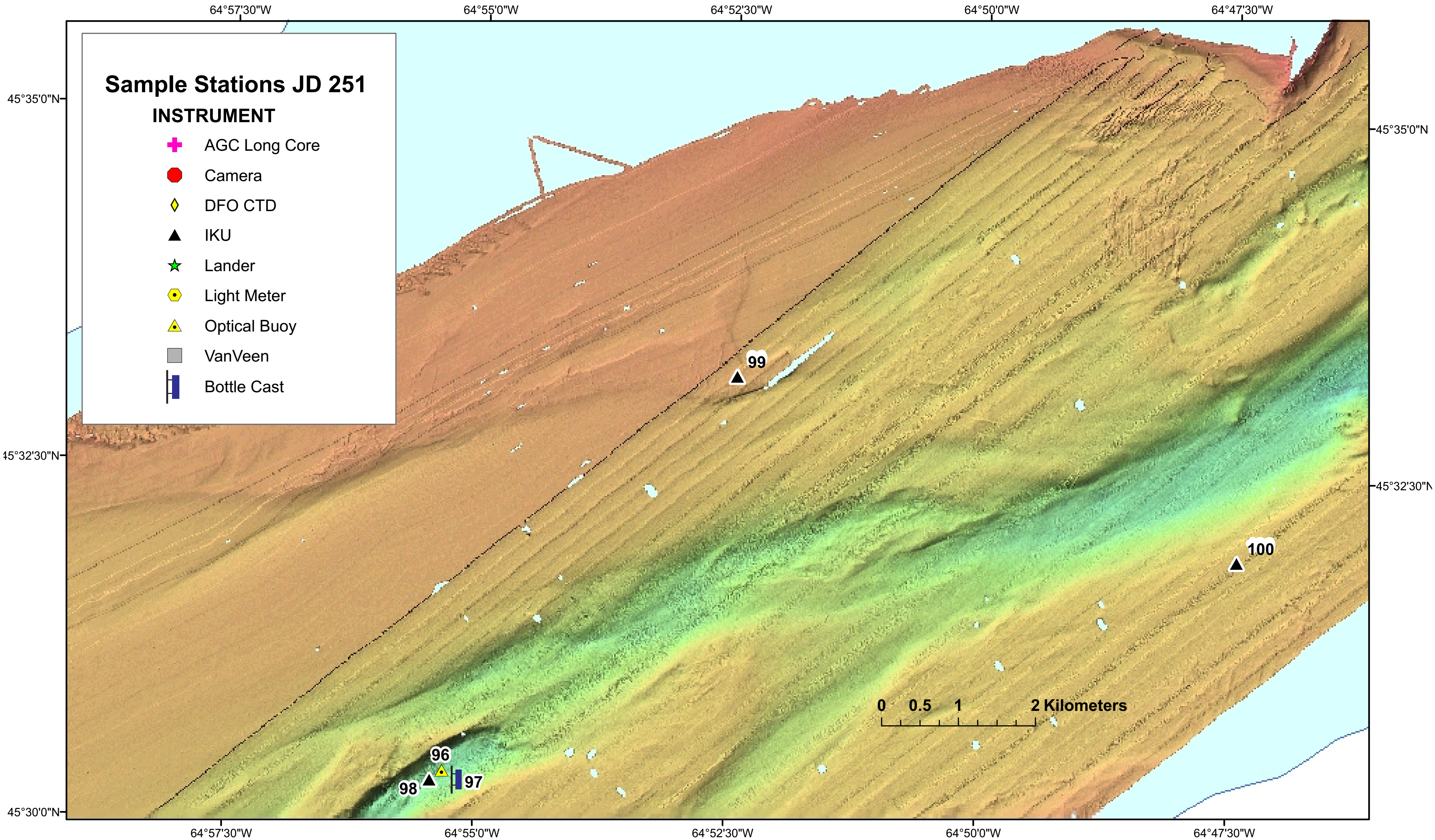


Figure 36. Stations 96 to 100, Chignecto Bay, day 251.

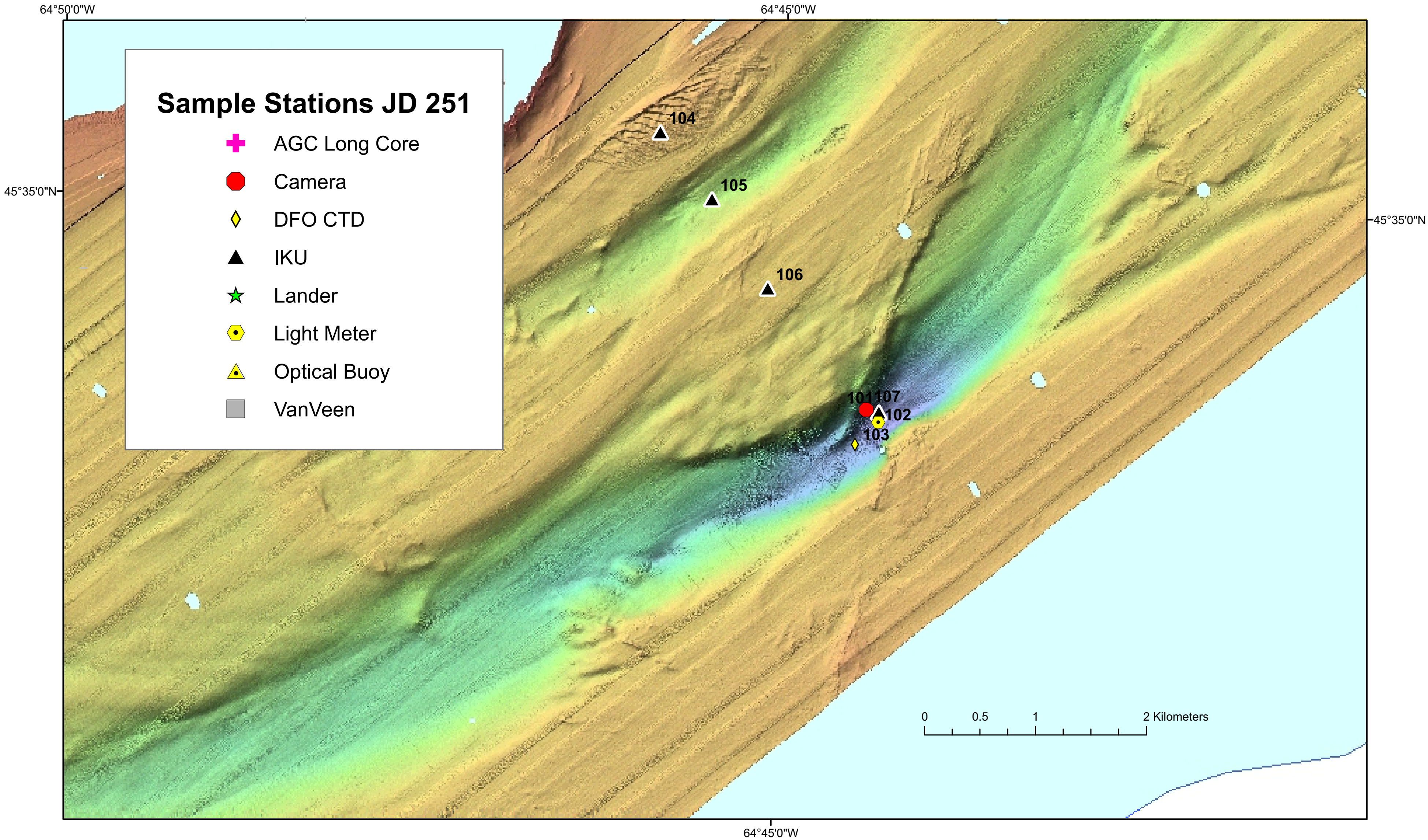


Figure 37. Stations 101 to 107, Chignecto Bay, day 251.

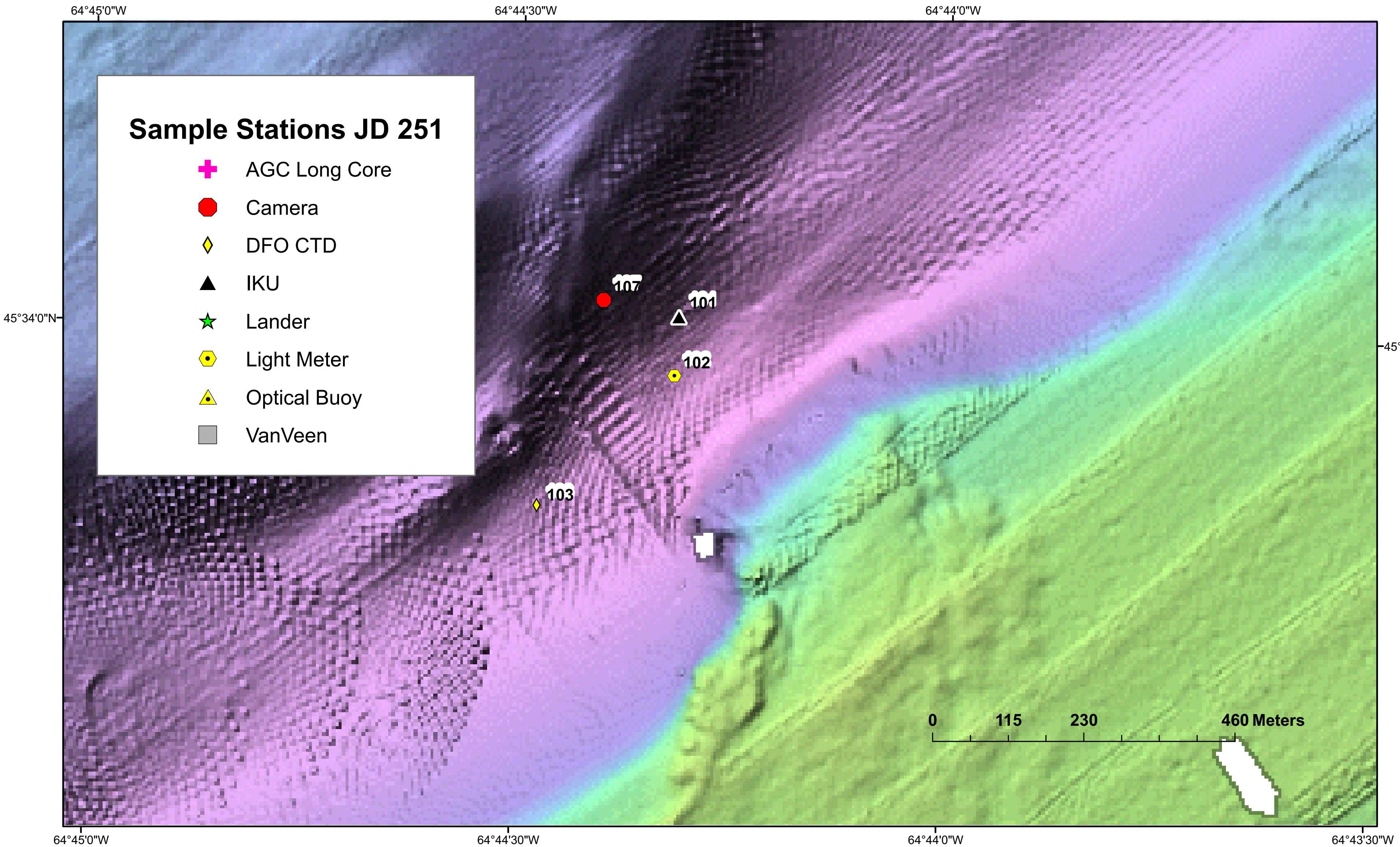


Figure 38. Stations 101 to 103, and 107, Chignecto Bay, day 251.

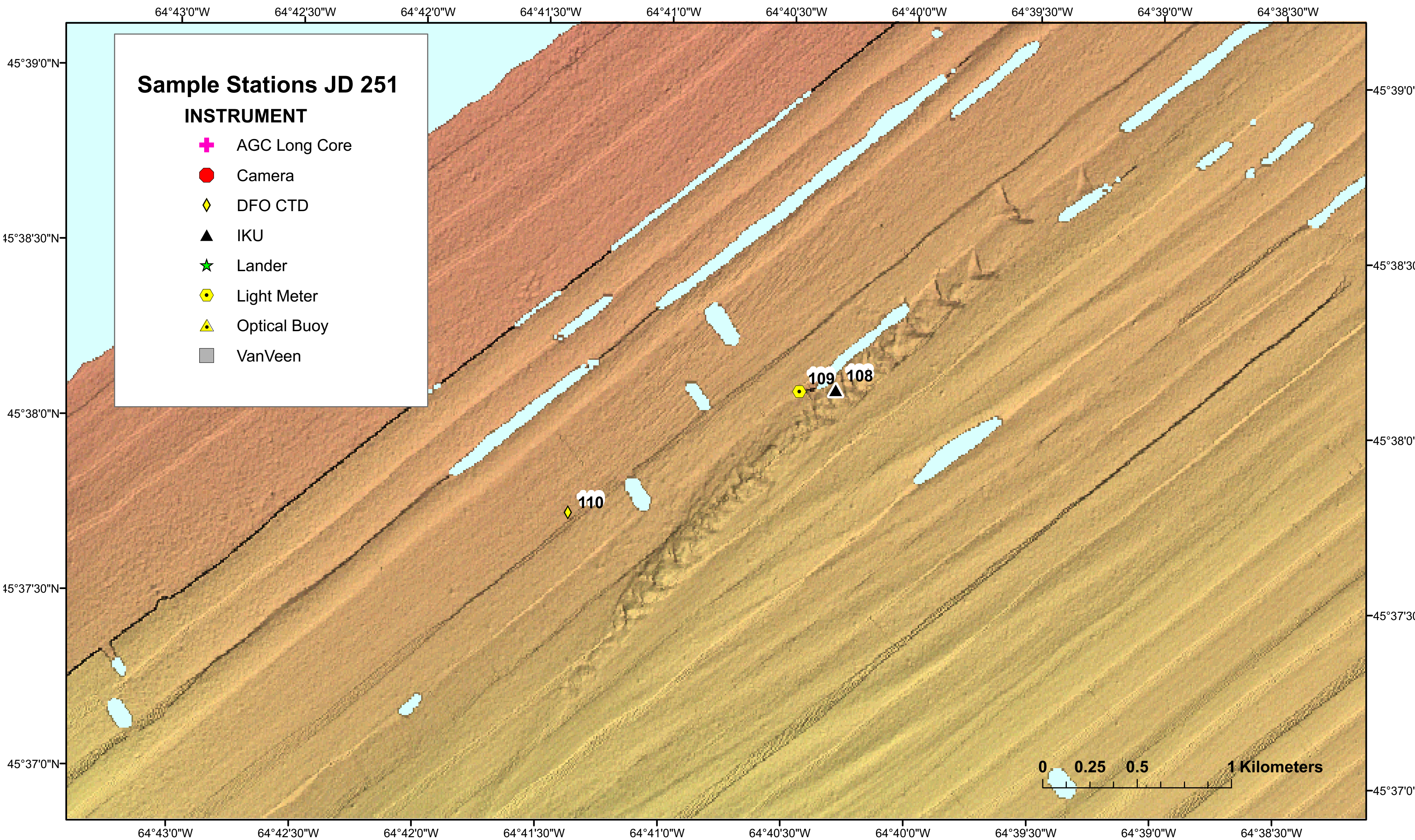


Figure 39. Stations 108 to 110, Chignecto Bay, day 251.

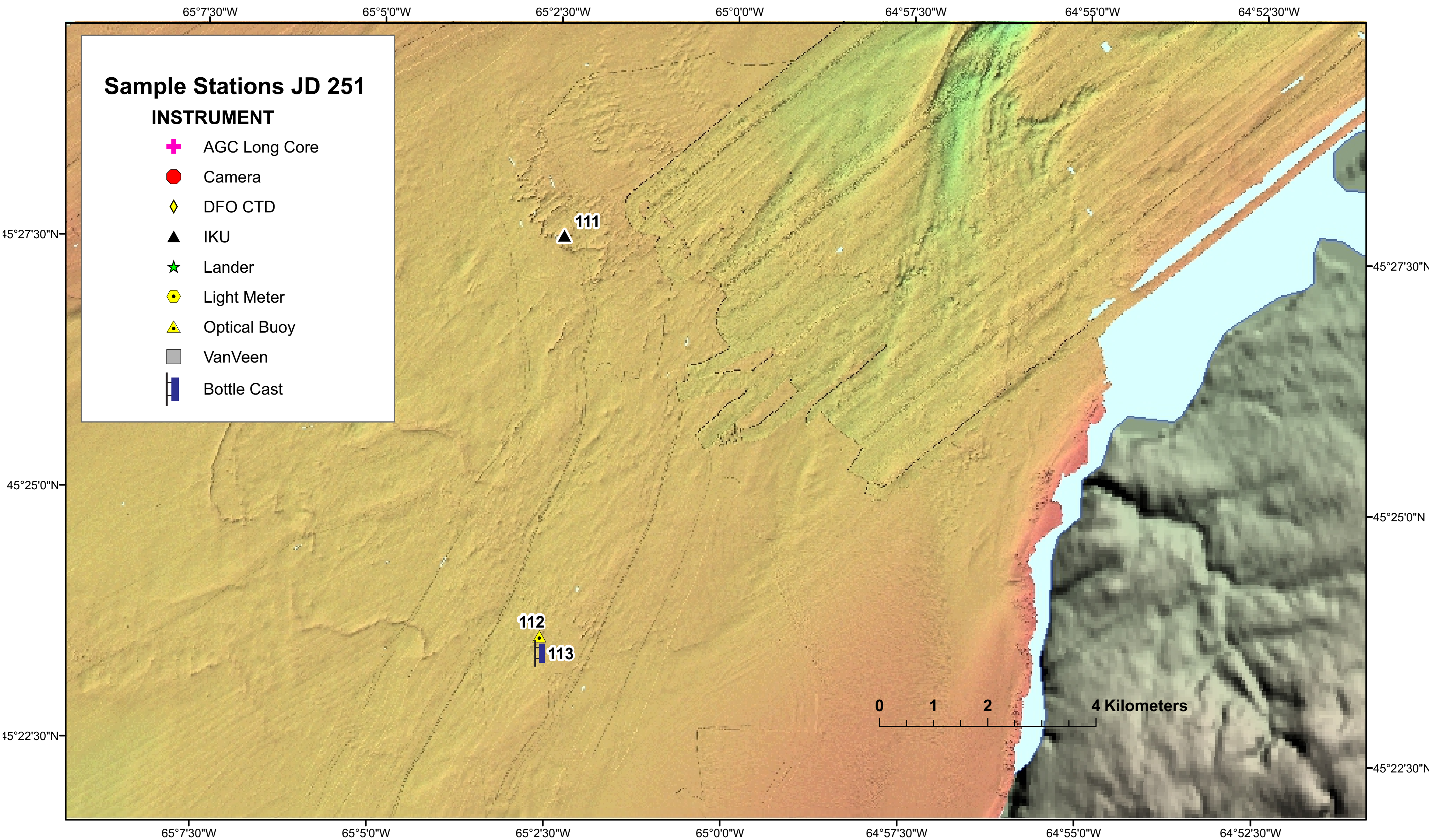


Figure 40. Station 111, mouth of Chignecto Bay, day 251.

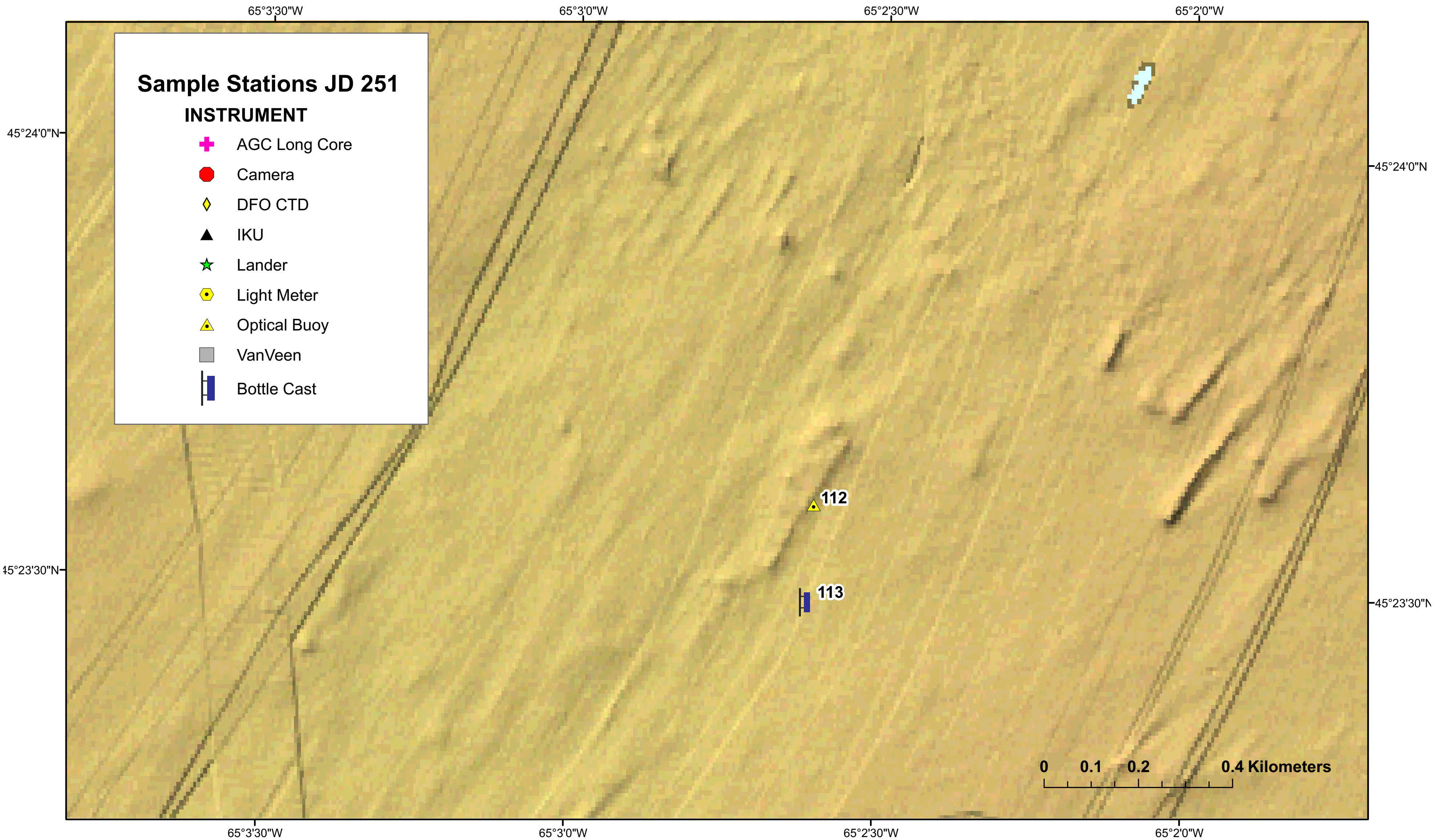


Figure 41. Stations 112 and 113, Chignecto Bay, day 251.

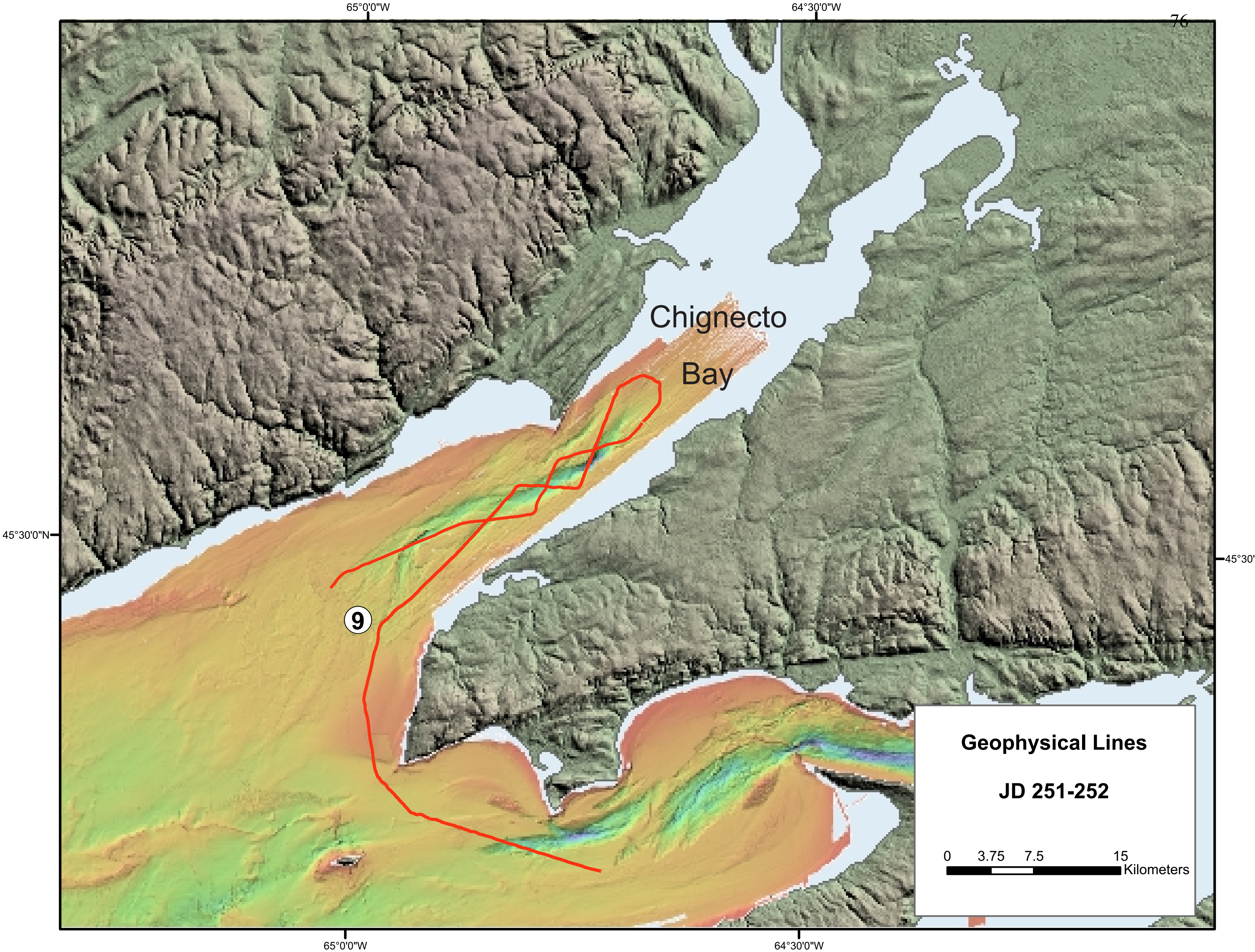


Figure 42. Geophysical survey Line 9, days 251 to 252.

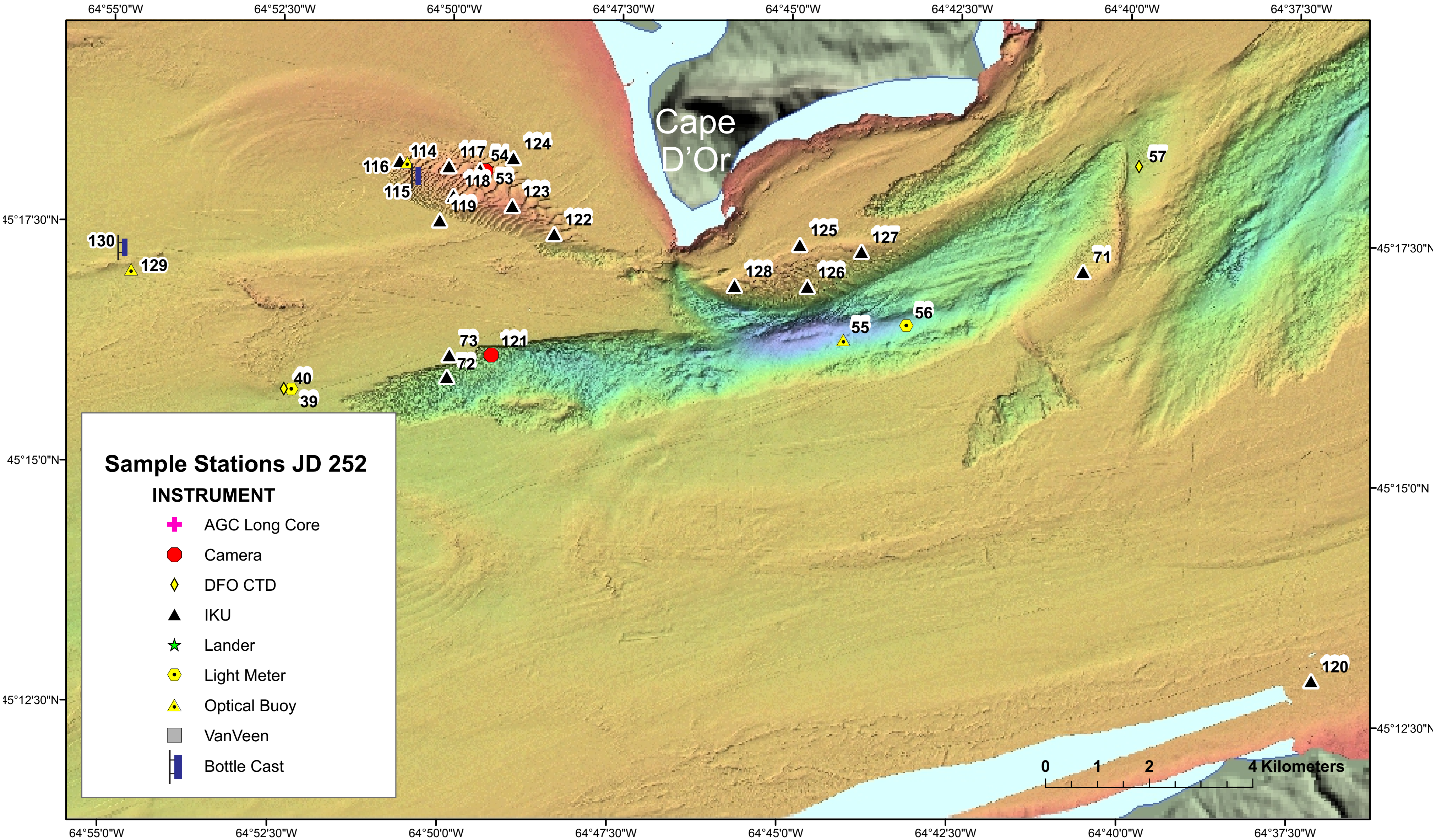


Figure 43. Stations 114 to 128, Cape D'Or banner banks and scour trough, day 252.

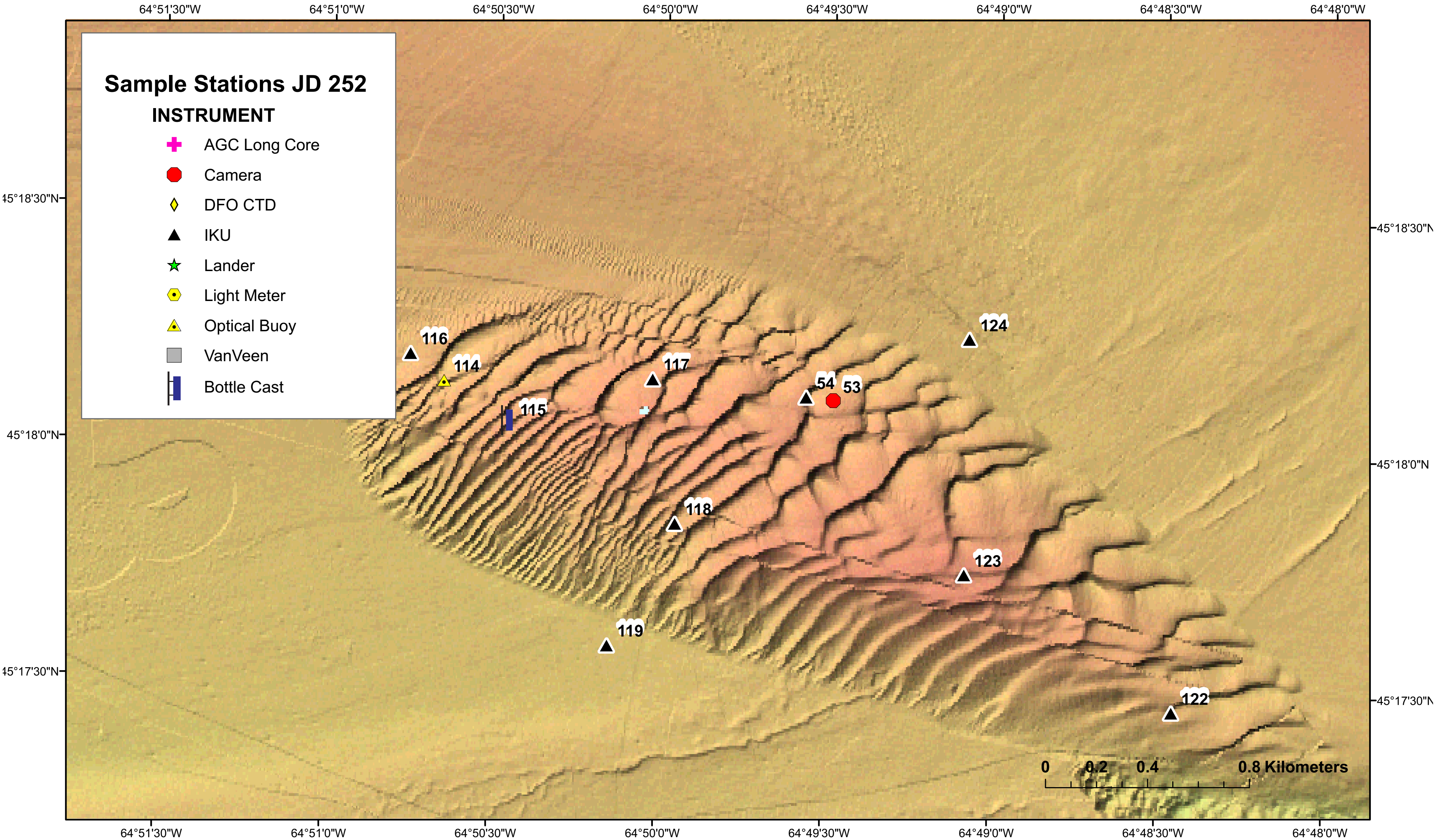


Figure 44. Stations 114 to 124, Cape D'Or west banner bank, day 252.

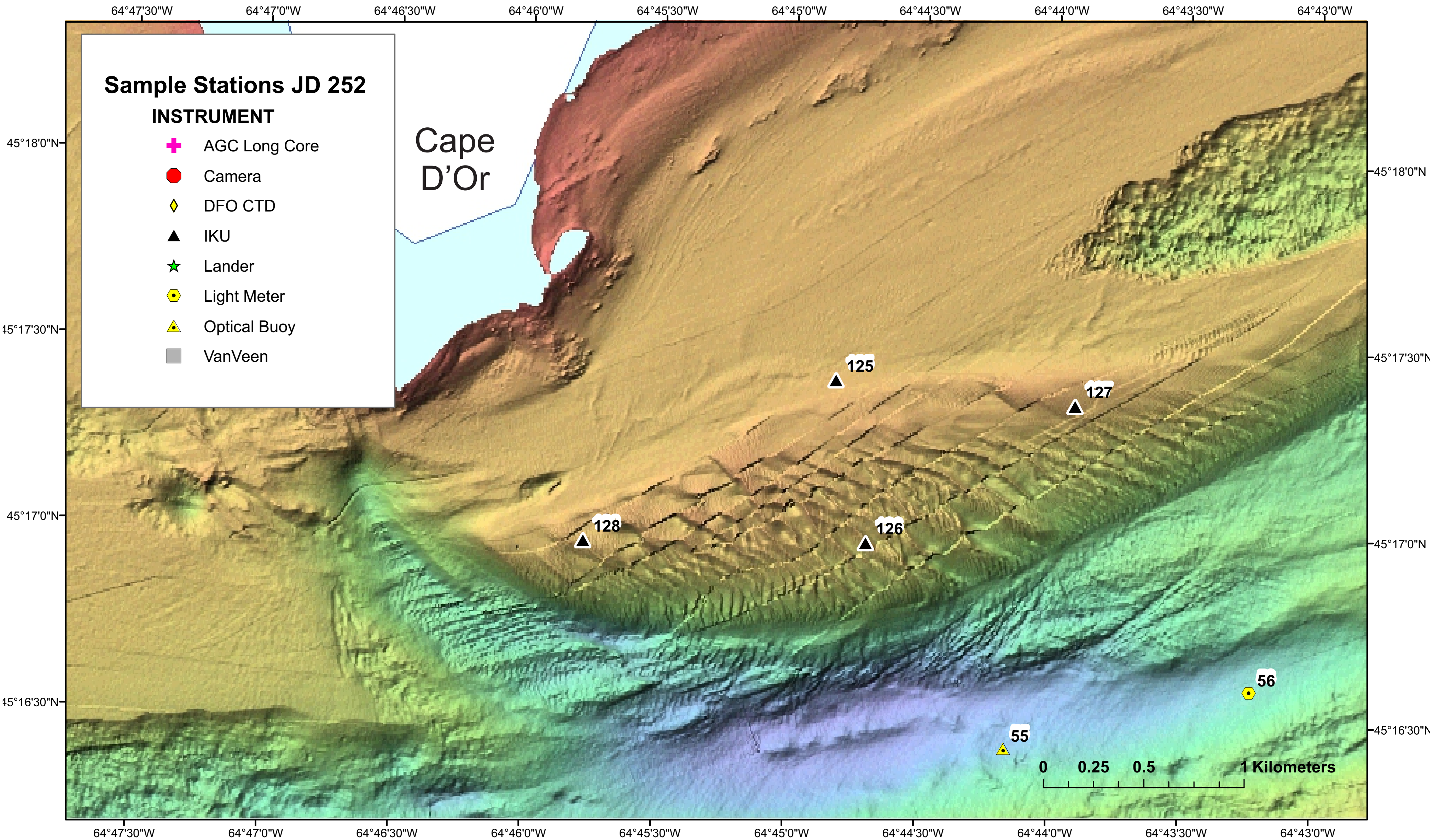


Figure 45. Stations 125 to 128, Cape D'Or east banner bank, day 252.

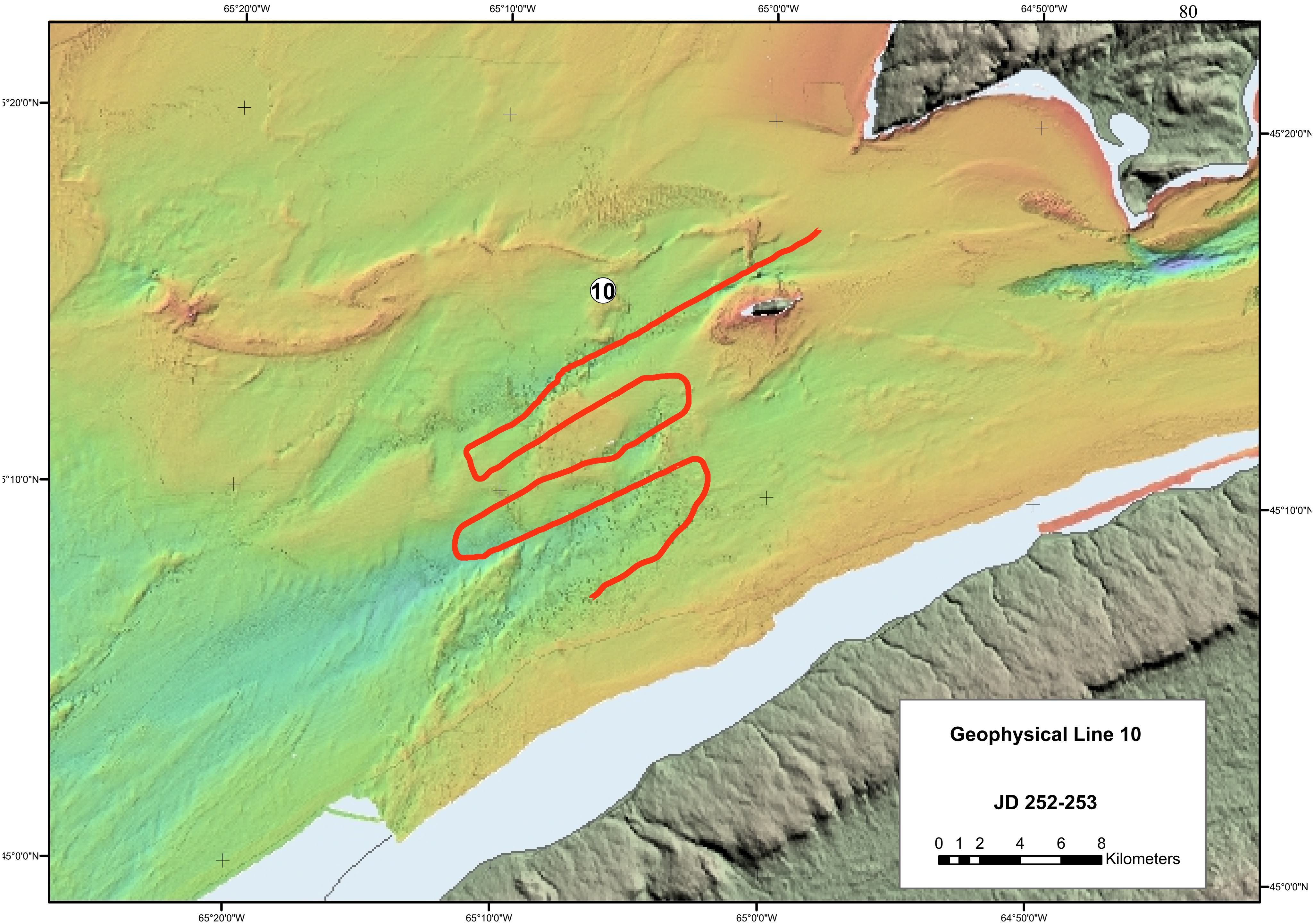


Figure 46. Geophysical survey Line 10, days 252 to 253.

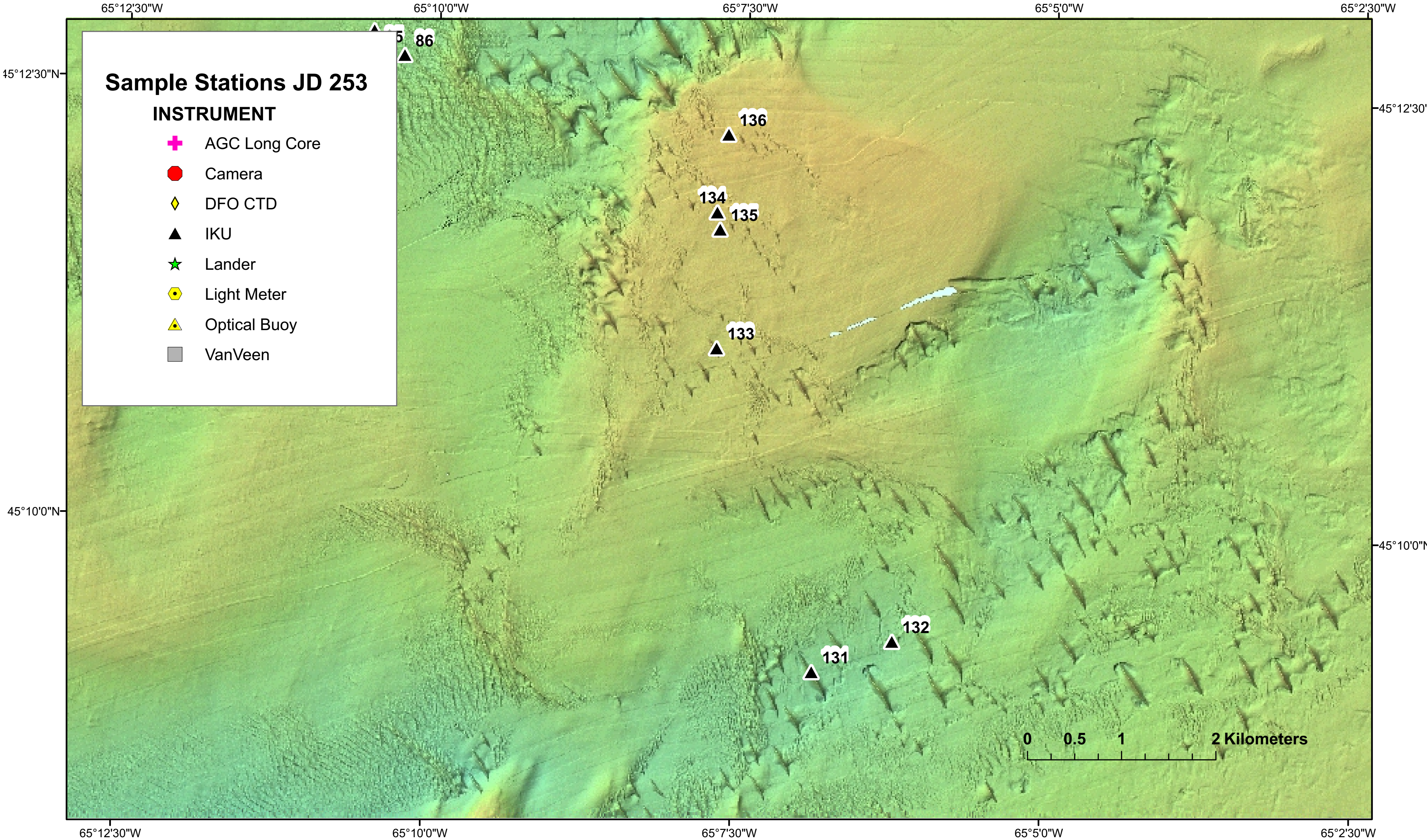


Figure 47. Stations 131 to 136, Margaretsville dune field, day 253.

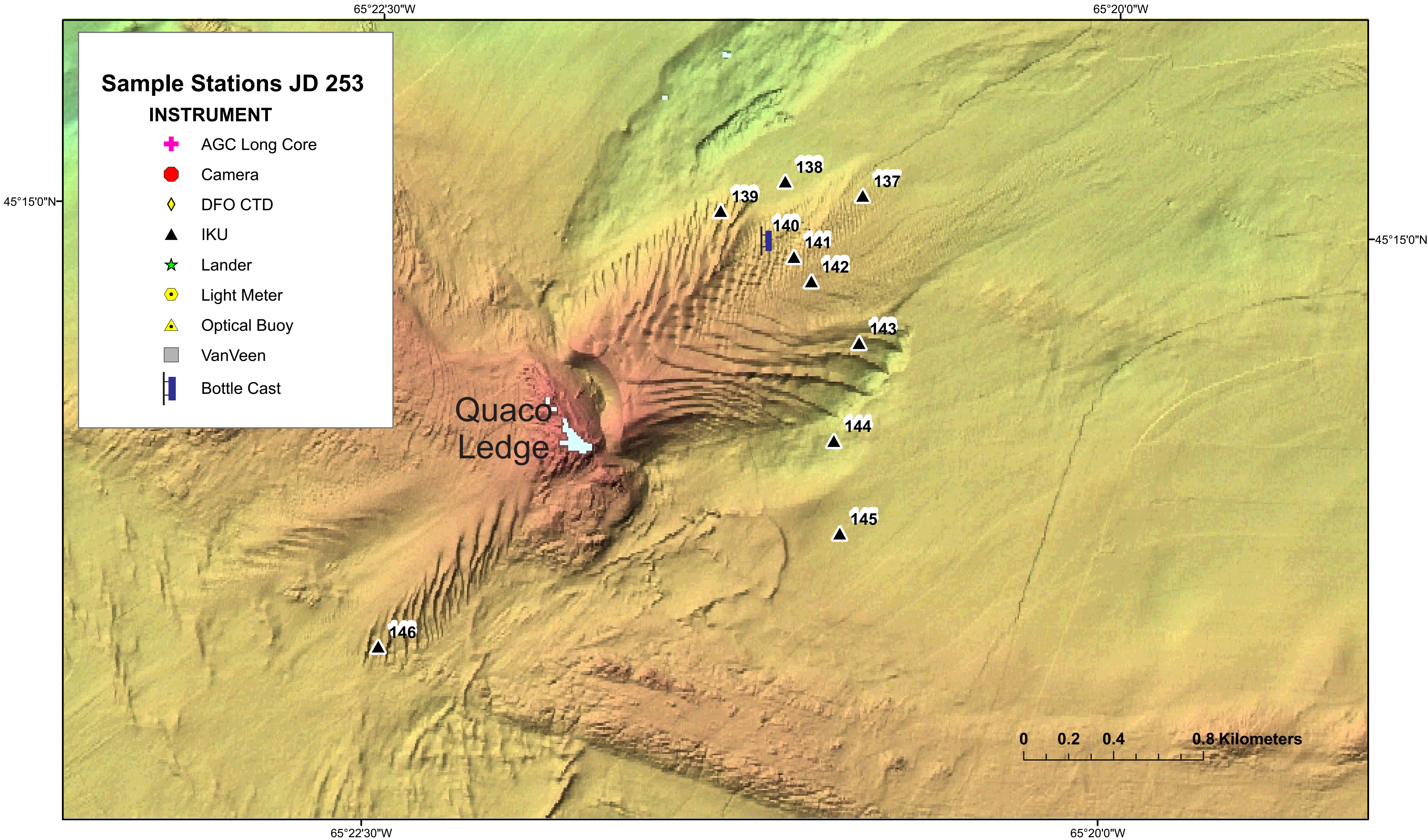


Figure 48. Stations 137 to 146, Quaco Ledge, day 253.

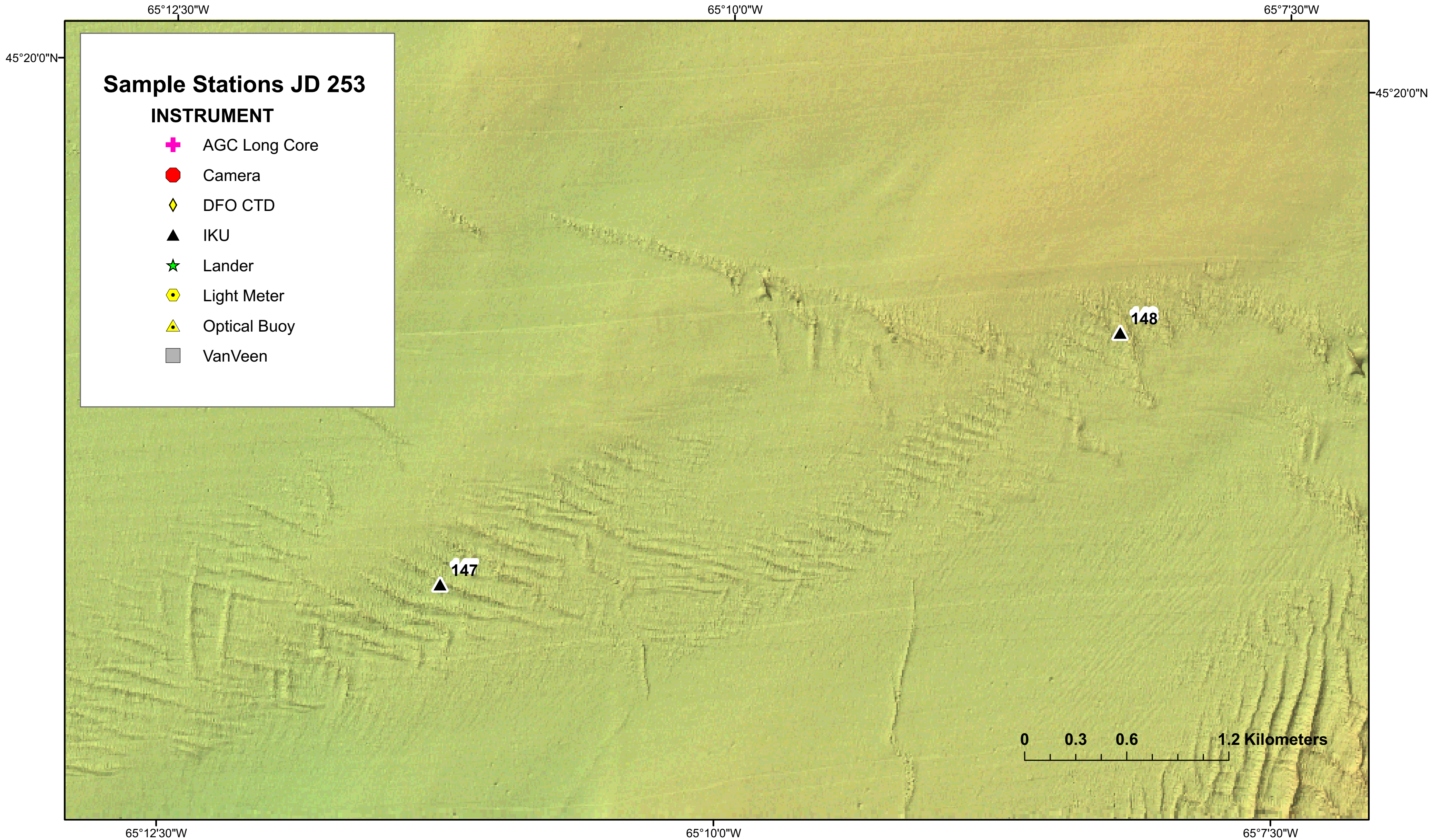


Figure 49. Stations 147 to 148, day 253.

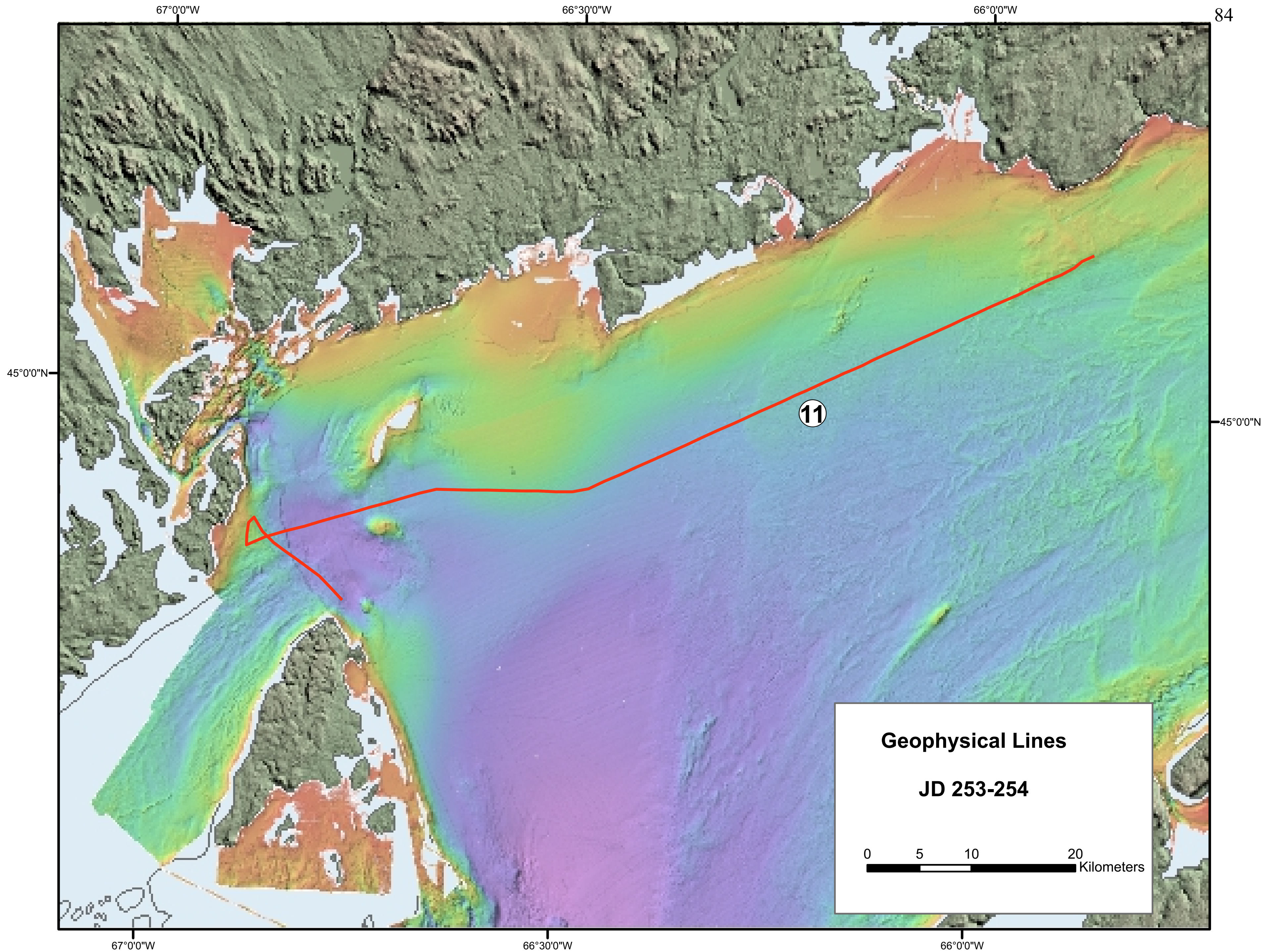


Figure 50. Geophysical survey Line 11, days 253 to 254.

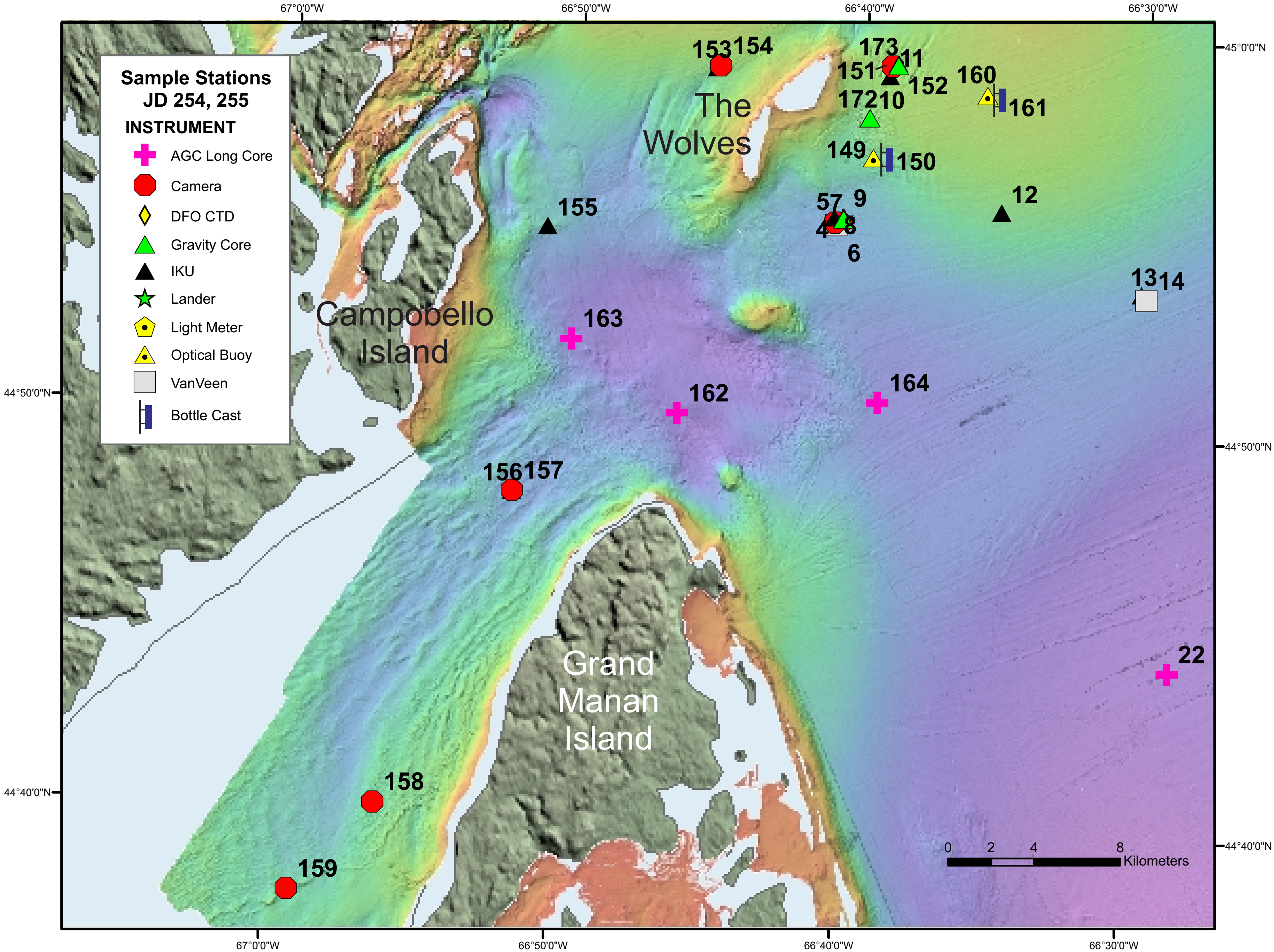


Figure 51. Stations 149 to 164, days 254 and 255.

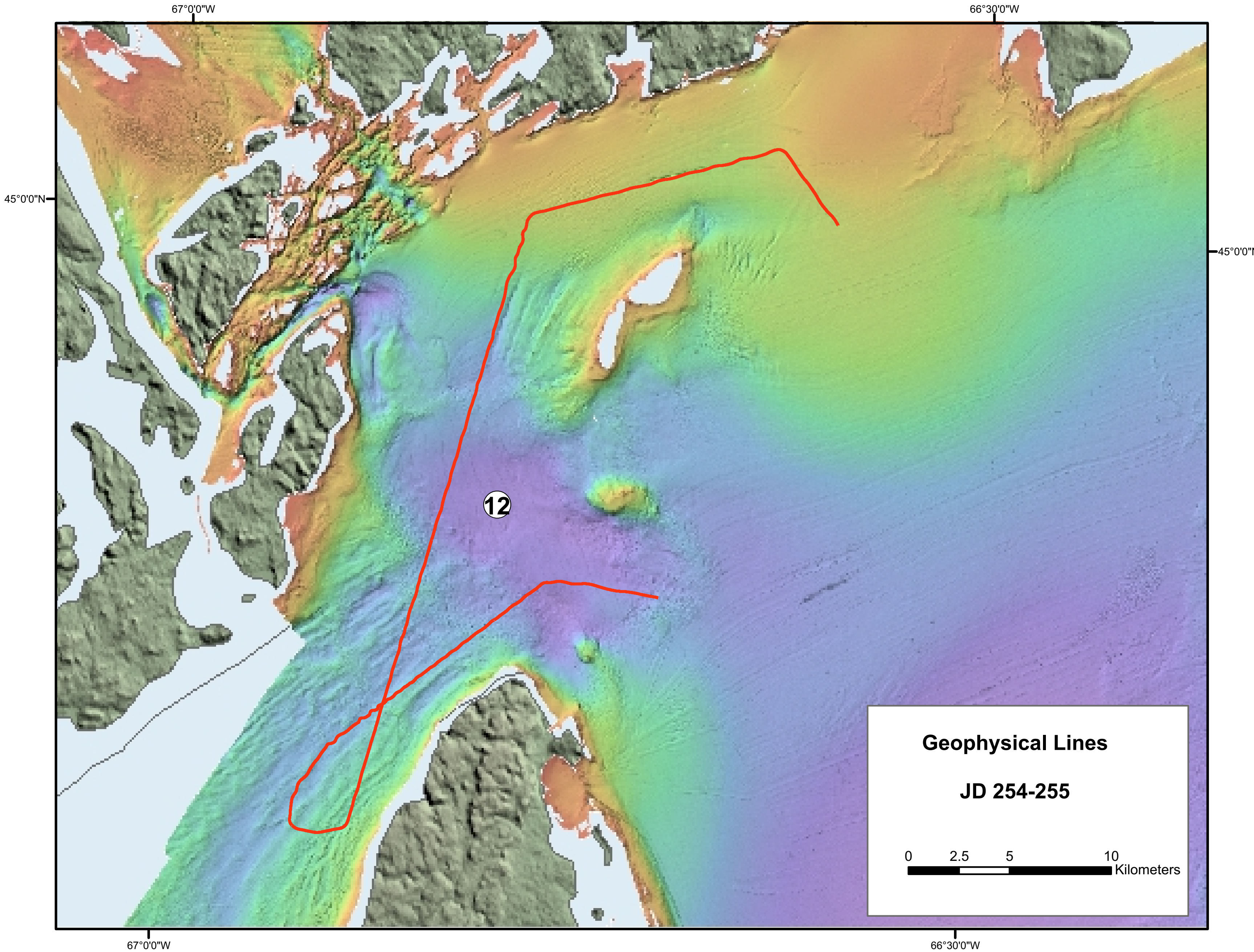
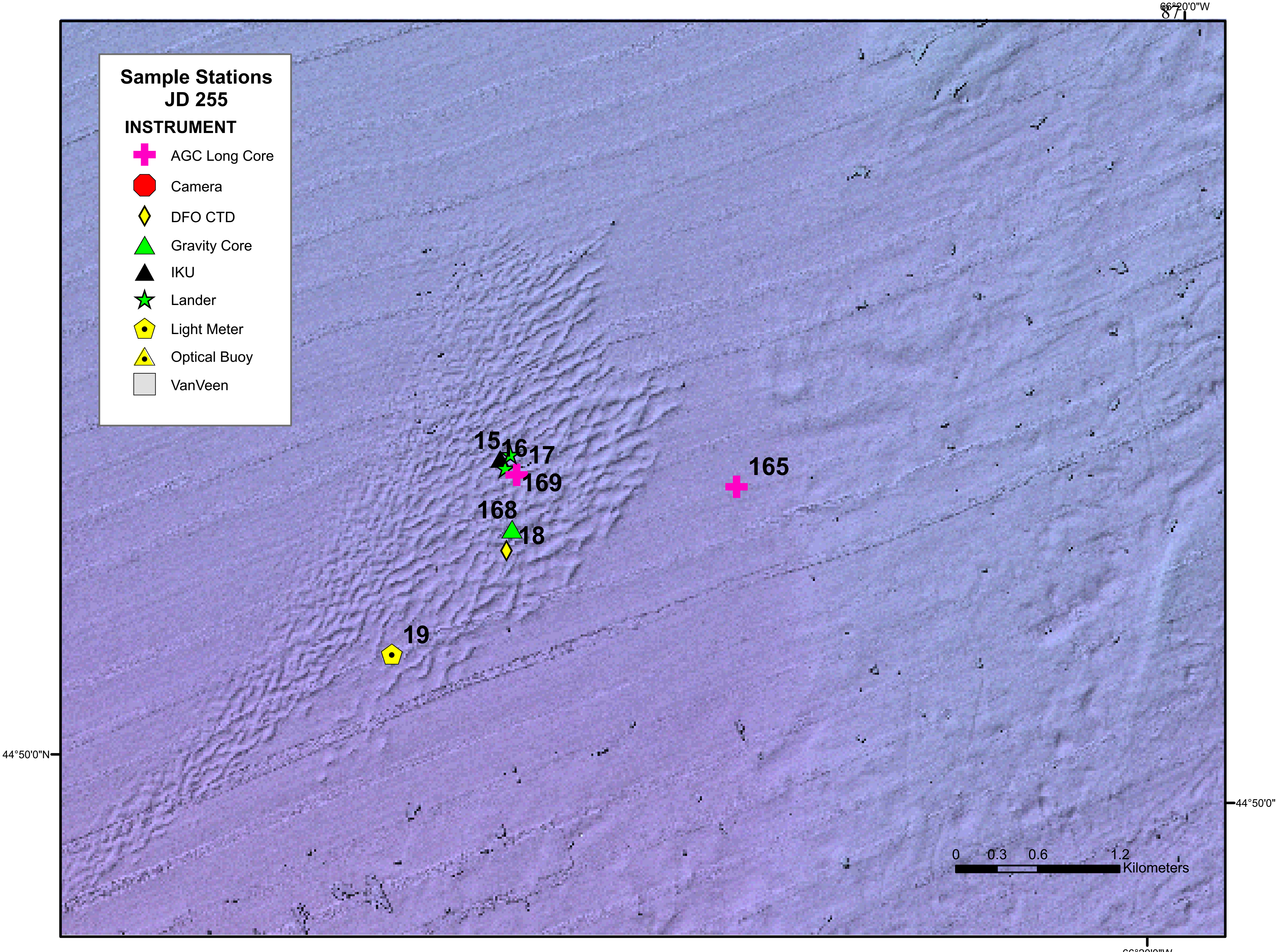


Figure 52. Geophysical survey Line 12, days 254 to 255.



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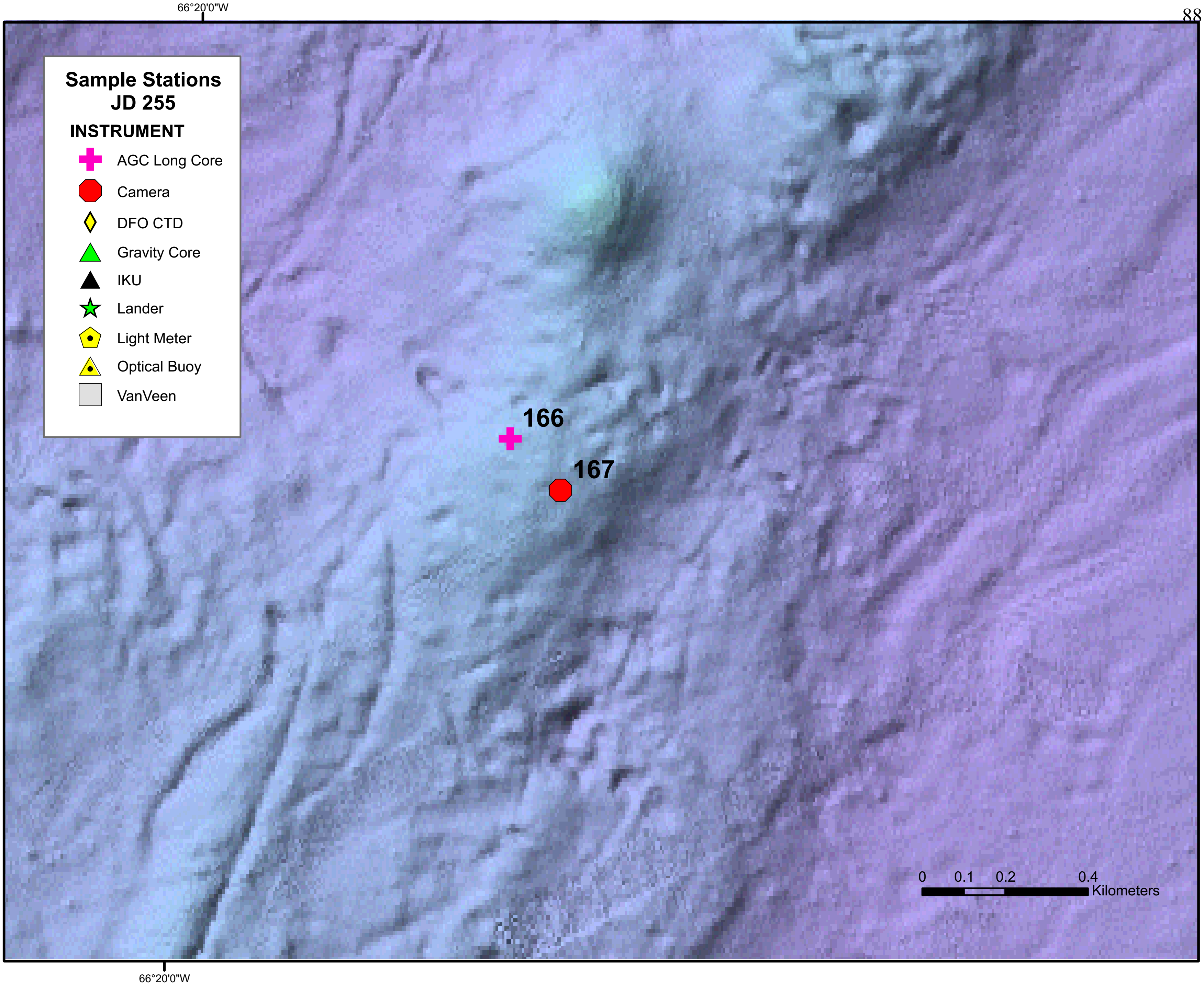


Figure 54. Stations 166 and 167, day 255.

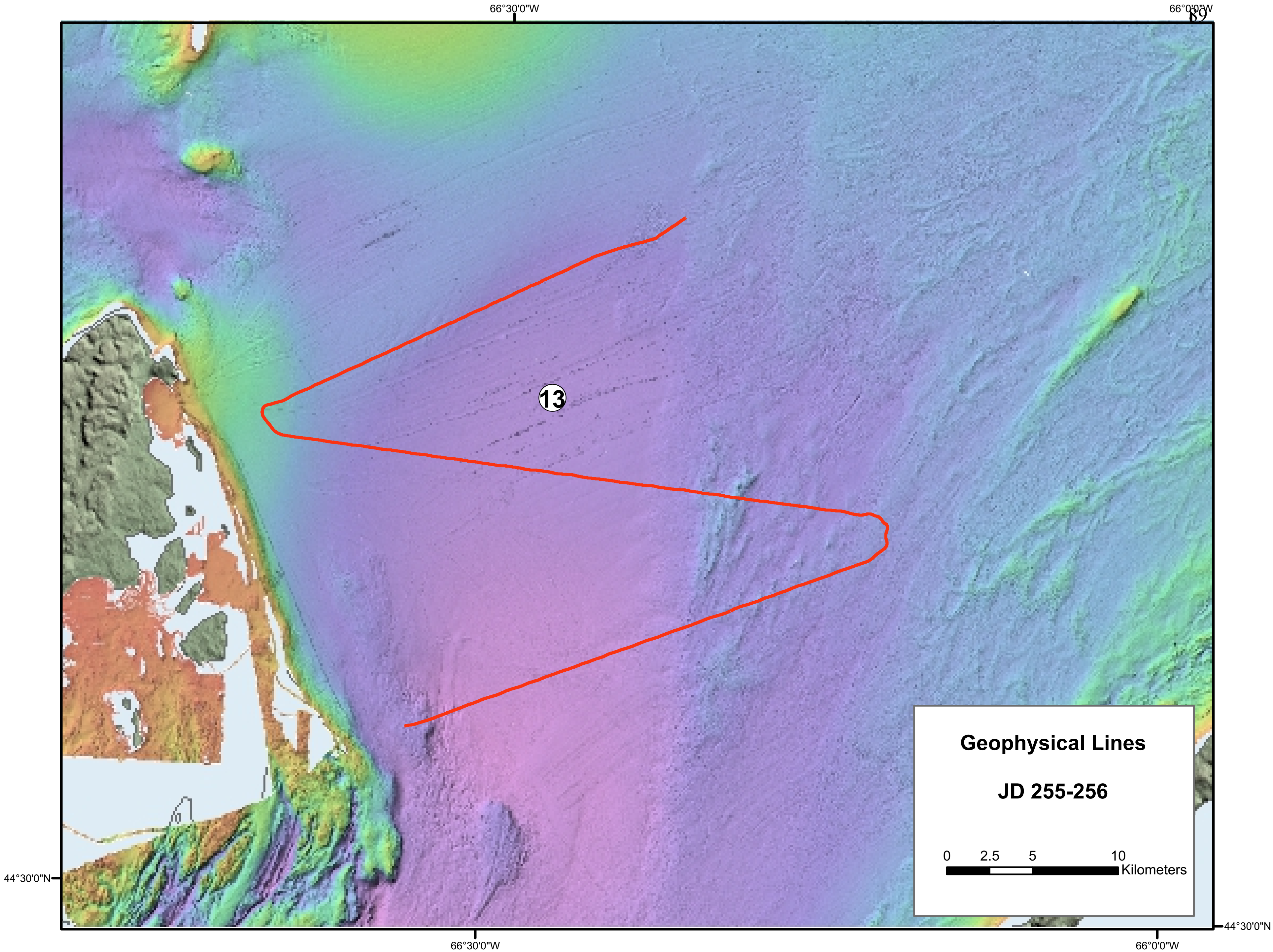
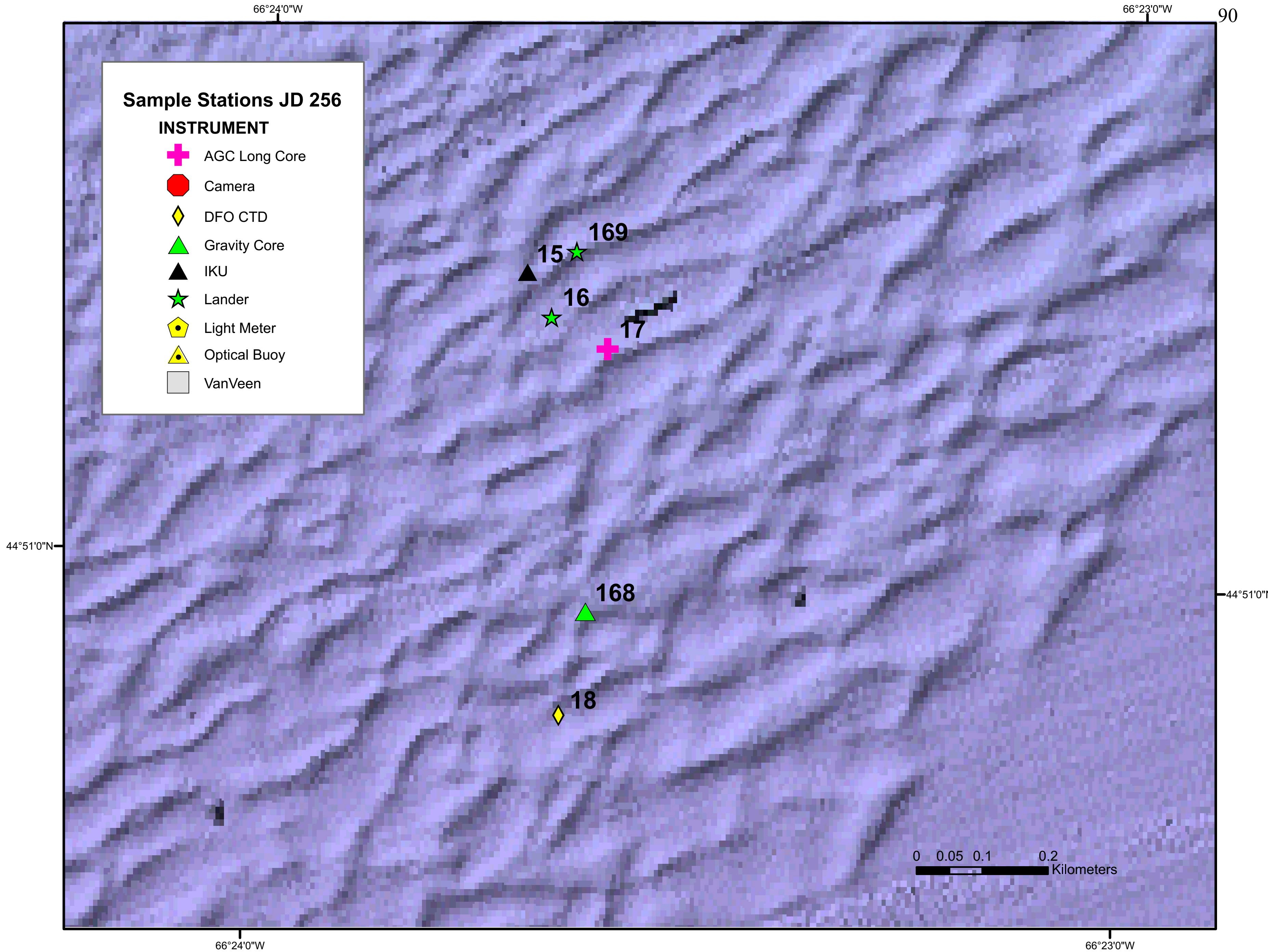


Figure 55. Geophysical survey Line 13, day 255–256.



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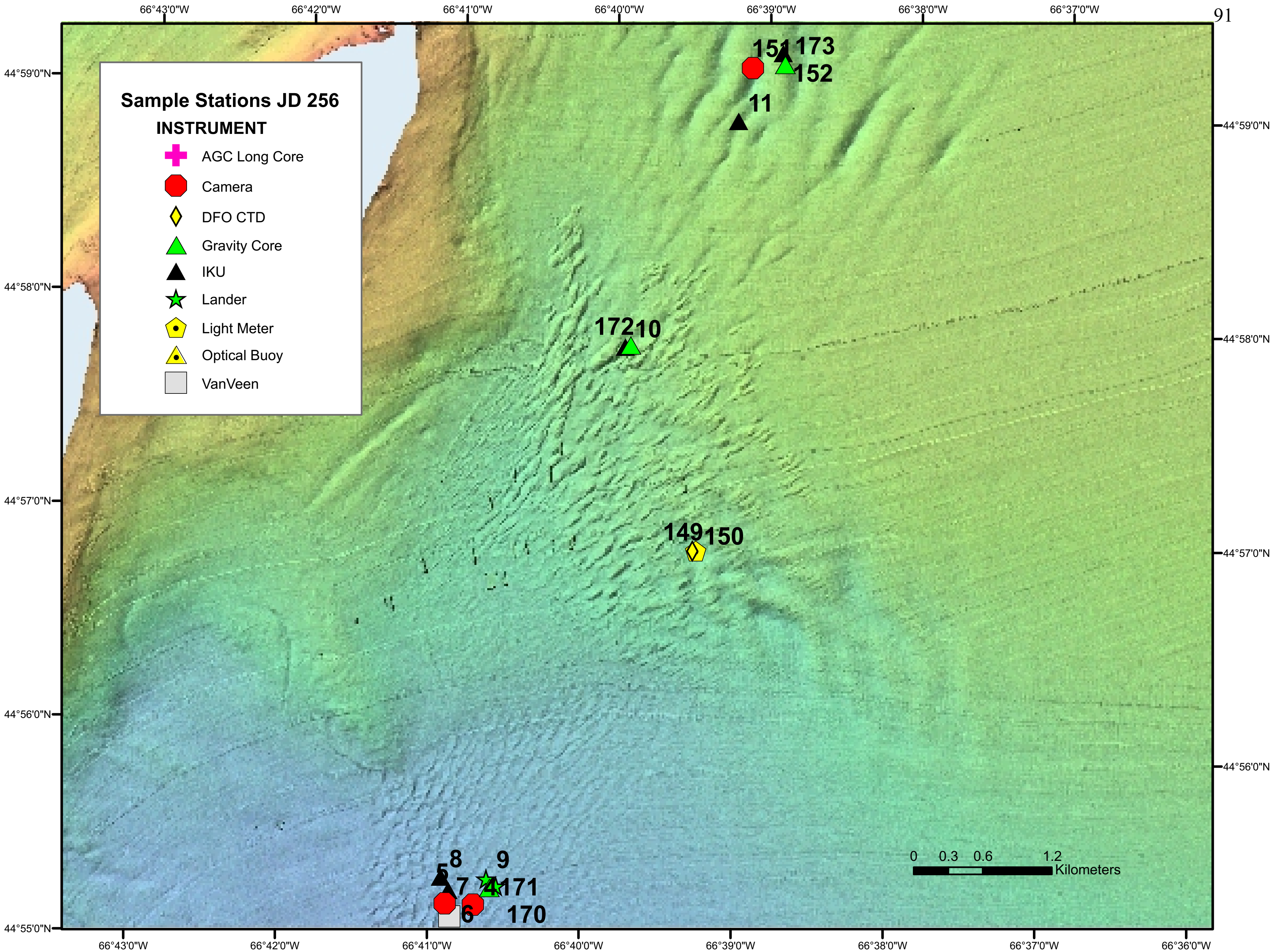

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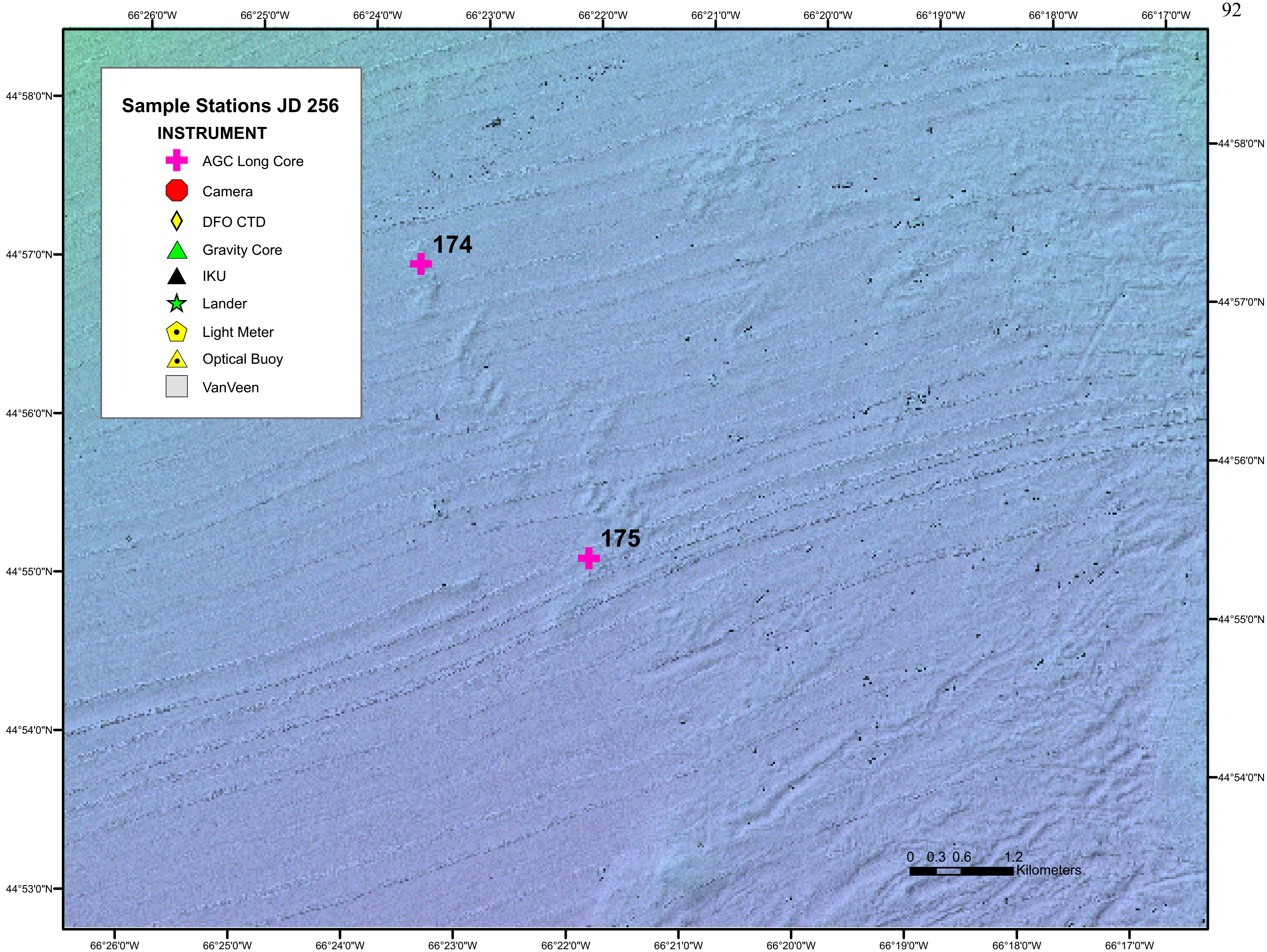

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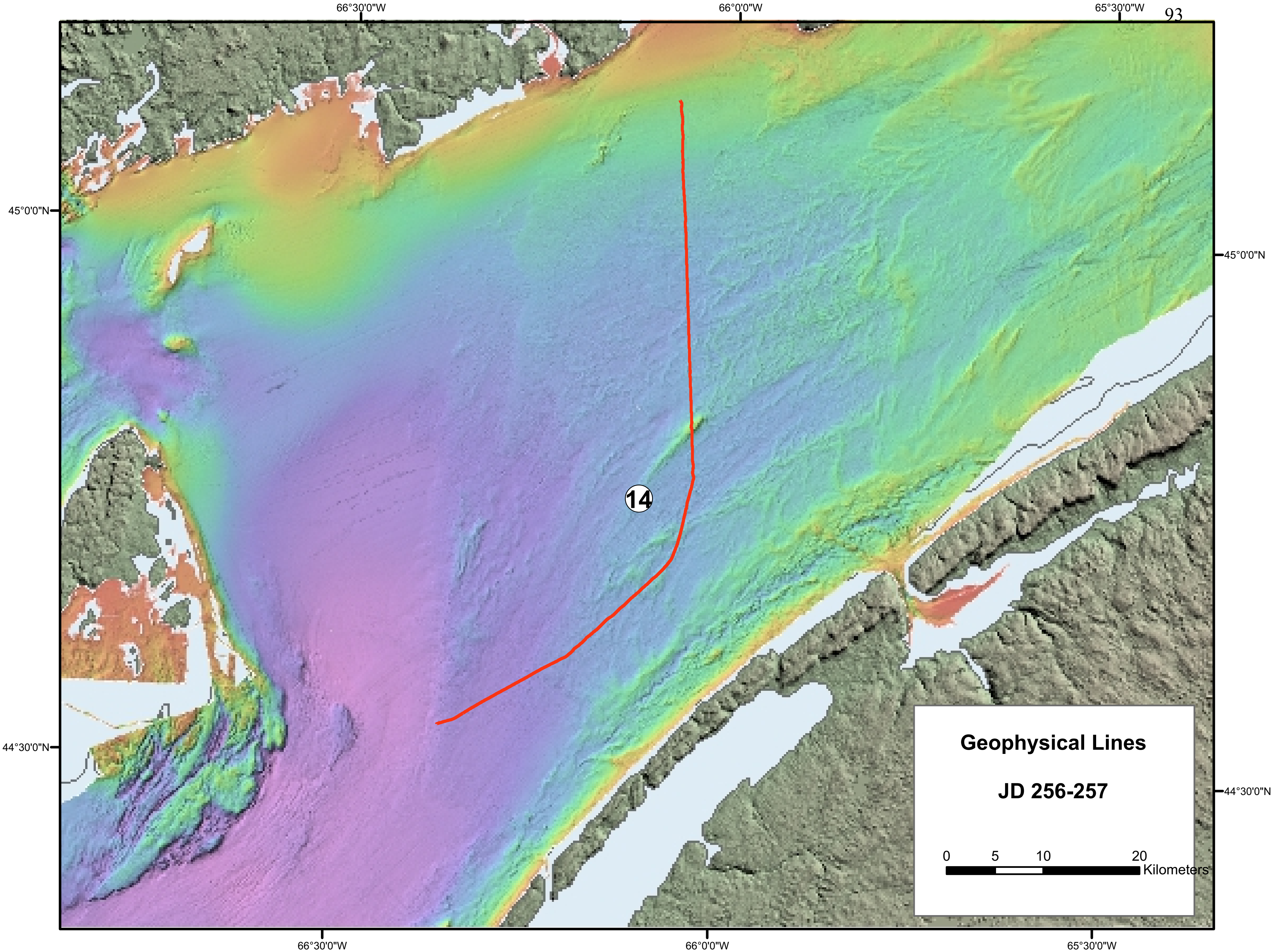

Figure 59. Geophysical survey Line 14, days 256 to 257.

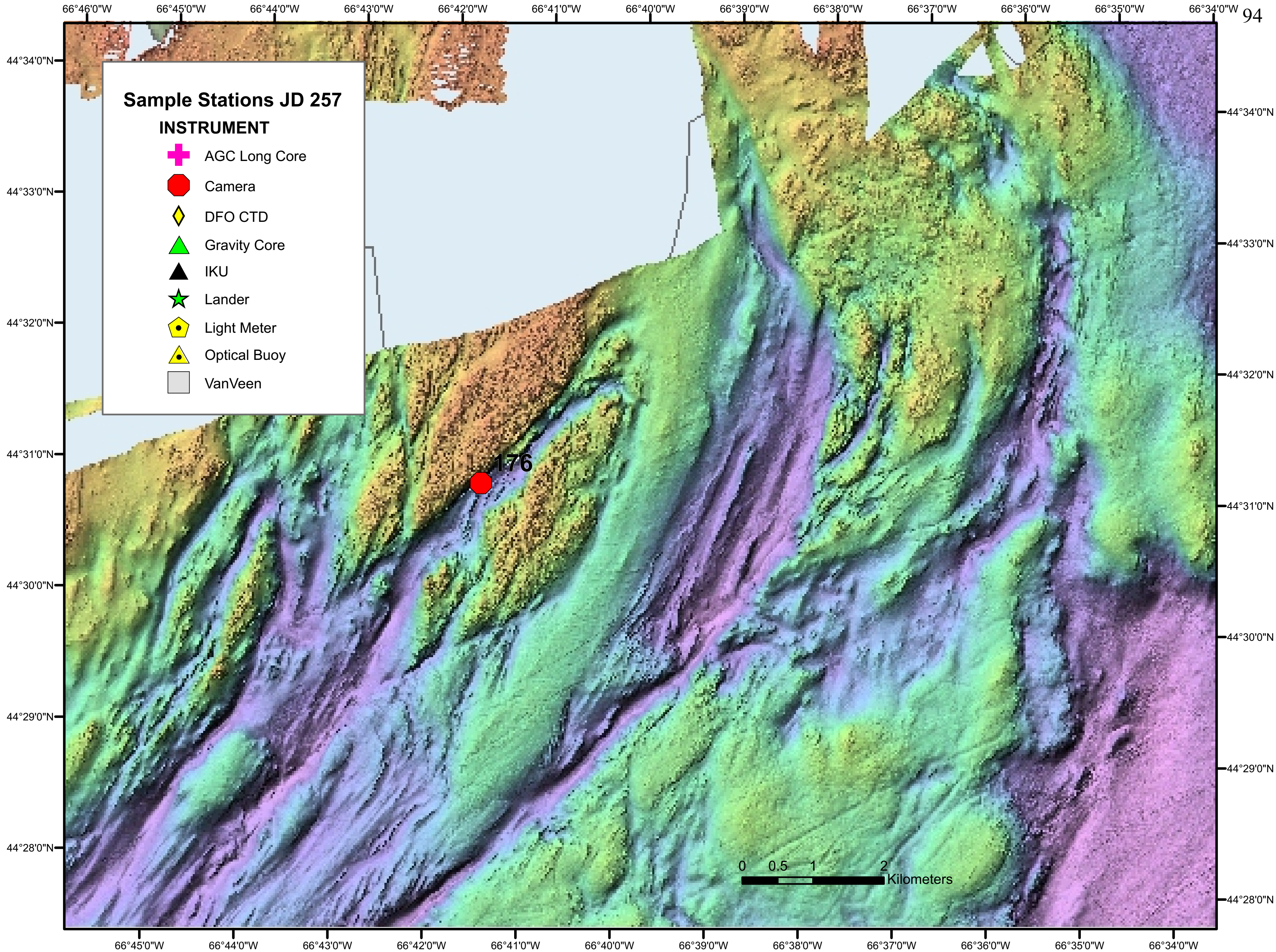

Figure 60. Station 176, day 257.

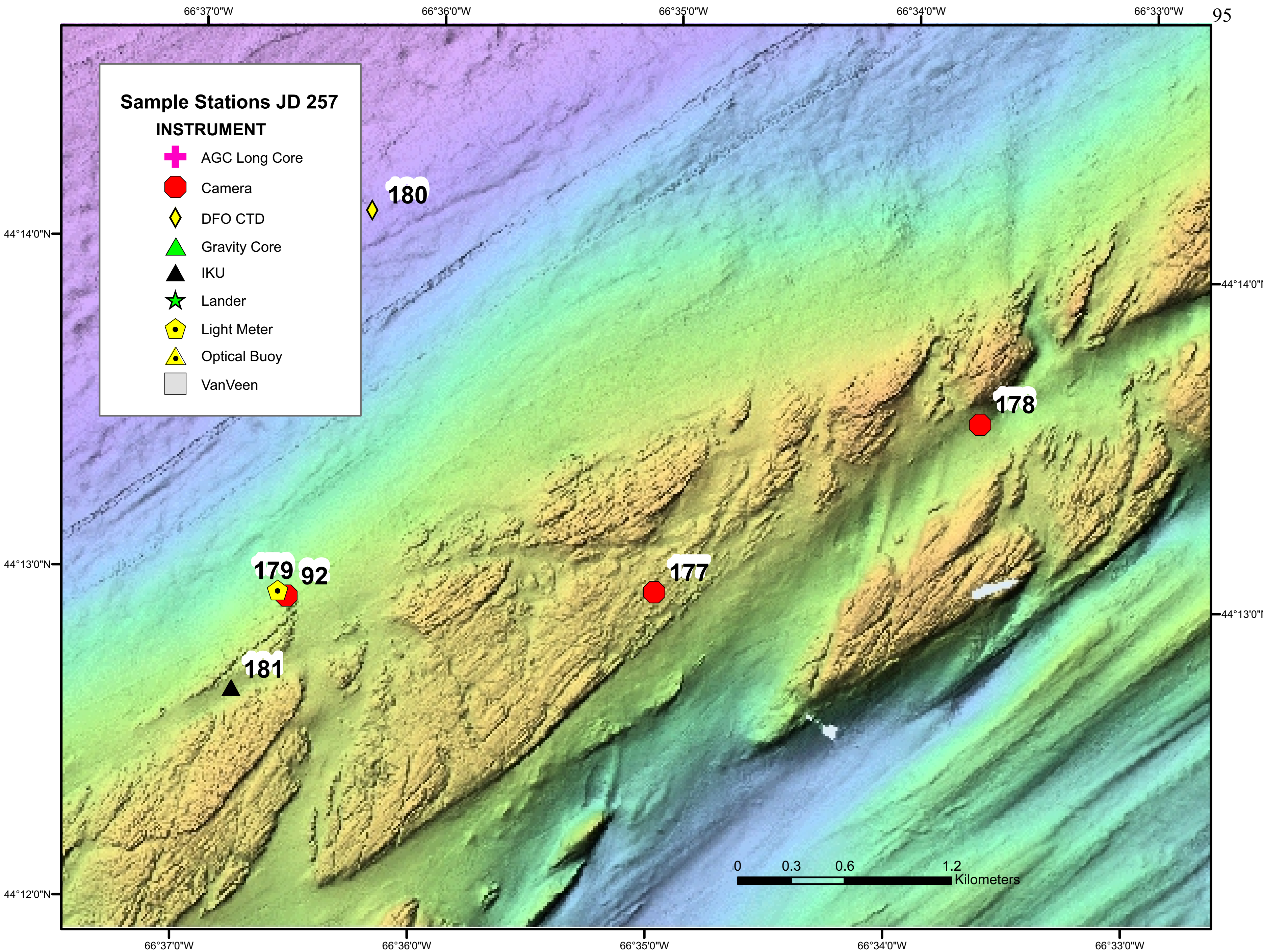

Figure 61. Stations 177 to 181, day 257.

3. Data Management

3.1 Navigation – *S.E. Hayward, P.J. Neelands, D.P. Potter*

Primary GPS information for the expedition was provided by a Thales ADU5 positional and attitude determination system. Real-time differential corrections were received from Canadian Coast Guard radio beacons. A Novatel DL-V3 GPS system was used as a secondary positioning system. NMEA sentences from the primary GPS receiver were combined with NMEA sentences from the Knudsen 12 kHz sounder, the ship's log, the ship's gyro, and the Trackpoint II USBL acoustic positioning system for distribution throughout the ship serially at 9600 baud. Selected sentences were rebroadcast throughout the ship at 4800 baud. In addition to the serial distribution, the GSC Navigation Net system (GSC IO Portal) was used to add metadata and a time stamp to each NMEA sentence. These sentences were rebroadcast as multicast packets over the ship's network. The GSC survey manager software was also used to calculate and broadcast real time offset positions for the ship's central reference point (CRP – centre of stern) and other selected ship locations (e.g., coring location and winch room position). The GSC Navigation Net data was logged using the GSC Nav Net Master Logger. The Dimension4 network time client software was used on all computers that were used for logging or displaying seismic or navigation data to synchronize each computer's clock to the GSC Nav Net *Hudson* Time Server.

All computers that were used for logging seismic or navigation data were running the Dimension4 network time client to synchronize their clocks to the GSC Nav Net *Hudson* Time Server.

Four Regulus systems were used on the ship to view and log the serial navigation data. The systems were set up in the Drawing Office, the Winch Room, the Forward Lab, and the GP Lab. Due to some bugs/issues with the most current Regulus software release; all four systems were running on a previous release, build 28894.

Navigation data were provided to the GSC Dig computers that were used to digitize the to the SEG-Y file trace headers. The sleevegun digitizer received the primary GPS antenna position serially at 4800 baud. The Trackpoint II USBL acoustic positioning system was used to calculate positions for the towfish. The Trackpoint data were cleaned and processed in real time using the GSC USBL RT Processor. GSC Nav Net NMEA formatter was then used to reformat the cleaned Trackpoint data into a simulated GPS NMEA sentence ($GPGGA) and to send the sentence to the sidescan digitizer via a virtual serial port. This allowed the acoustic beacon positions to be written to SEG-Y trace headers.

The Trackpoint II acoustic positioning system was also used to provide positions for the 4k Camera system. The Trackpoint data were again cleaned and processed in real time and the program GSC Nav Net JPEG Merge was then used to write the processed latitudes and longitudes to the JPEG metadata.

Expedition navigation data were cleaned and merged using custom tools in ArcGIS to generate "A" format files and shapefiles from the raw NMEA "E" format files and from the GSC Nav Net real time offset locations file. These files were archived and merged daily.

Chartlets – While on station, bridge officers and station watch-keepers used small, manageable Regulus underlays of multibeam imagery surrounding clusters of stations. These so-called chartlets were generated using Global Mapper in Mercator projection using the WGS84 ellipsoid and were exported as 300 dpi geotiffs. The best method found was to first zoom to the desired view, then click *File/Export Raster and Elevation Data/GeoTIFF*, selecting the *Export Bounds* tab from the GeoTiff Export Options dialog box and clicking the "All Data Visible On Screen" option (Fig. 62).

Offset precision – With offsets now being constantly recorded, the discussion of offsets and accurate locations of equipment and stations evolved. On the second day of operations, the offsets (conning) within Regulus were changed to approximate locations using the CCGS *Hudson* naval architectural plans for best estimates. On the fourth day of operations, an evaluation of the offset.txt files provided the exact location of the various key pieces of equipment (coring winch, antennae, camera winch). These were input into the Conning and Antenna 1 locations in the Regulus configuration module. A location evaluation of STN169 and STN170 was completed using ArcGIS. Comparison of Regulus conning event markers and processed Trackpoint data gave results that matched within ~10m. To ensure event marker accuracy it is recommended that the conning values be changed based on which winch is being used on the ship. A better understanding of this complex issue before sailing is needed to ensure accurate positioning for the various data collection locations.

To assist with this understanding on future expeditions of the CCGS *Hudson* (if she survives much longer), Figure 63 shows a plan view and Figure 64 shows a port elevation view of navigation offsets.

Route creation – Route files for bridge and GP Lab were created using GSCA custom scripts in ArcMAP. The process was as follows: the Chief Scientist selecting points > shp point files > shp line files > export to route. The created shp line files were also imported into Global Mapper.

Waypoint shape files for watchkeepers – Nightly geophysical routes were planned and digitized on-screen by the chief scientist using ArcMap 9.3. These waypoints were labelled and transformed using the GSC waypoint tools, i.e. “convert lines to waypoints” then “convert waypoints to routes”. These routes were input into Regulus *Route Manager/load/import* function.

ArcMap generated shp-lines and shp-points were imported into Global Mapper for providing waypoints to watchkeepers. These were employed to extract bathymetric cross-sections through multibeam data along proposed geophysical lines, helping instrument operators to anticipate rapid changes in bottom topography.

3.2 Subsea positioning – *A.G. Robertson*

Subsea positioning for the two seabed camera systems (4K-VladCam Bullet, DeepImager) was achieved via USBL (ultra short baseline). Each of the camera sleds were equipped with a self powered Applied Acoustics beacon which was turned on manually prior to individual dives. A new Trackpoint III USBL system was used to interrogate and track the subsea beacons. The deck unit for this and the transducer were located in the GP lab at the stern of the vessel. A ram containing the transducer was lowered and raised manually pre- and post-dive through the hull by the navigator or other capable person. Once the camera sleds were in the water column heading down to the seabed the GSCA Master logger and GSCA USBL processing application would be activated remotely to track and acquire the subsea beacon. Filters were set to try and eliminate as much erroneous positioning as possible.

There were several challenges with subsea positioning on this Bay of Fundy mission due to the dynamic nature of the tidal flow and station depths. The bridge would endeavour to maintain a slow drift in a prescribed direction during operations which usually required a fair amount of vessel thrust from the screws and the forward thruster. This would cause cavitation in the water disrupting the subsea acoustics resulting in data gaps. On several of the stations the shallow water depth prevented the camera from comfortably entering the 45° detection cone of the ram transducer again causing data gaps.

As a result of the challenges described, filtered or processed USBL data was often replaced with raw USBL data or a static ship offset position. The 4K-Vladcam Bullet sled was deployed from the winch room so quite often the horizontal offsets for this location would be used if the USBL data did not merge properly with the camera data post dive. The DeepImager was lowered from the forward deck using the coring crane so again a static offset for this location was selected if the subsea positioning was poor.

In future it would be useful to have live subsea tracking over the multibeam imagery with a logging filter so that the operators and scientific investigators could actively watch the track performing quality control prior to significant post-dive processing.

3.3 Station sheets – *P.L. Spencer, A.G. Robertson*

During daytime sampling, a focus was placed on completing the station sheets to be as accurate as possible. The process required recording information on the station sheets which included the details of the current station as well as depth and coordinates captured by an Event Marker in the Regulus interface. This Event Marker was also used by the watchkeeper, which ensured that the time stamp and coordinates recorded in the log book remained in synchronization with the station sheets. In addition, the Event Marker was given a useful name that could later be used to compare with navigation records.

Instruments deployed on this expedition included the IKU grab, long piston corer, van Veen grab, two camera types, and seabed landers. At regular intervals, all essential station data was entered into ED-at-Sea. Subsample data were entered into ED-AT-SEA when an IKU grab or core sample was obtained.

Additional instruments deployed during this expedition were attended to by Fisheries and Oceans Canada scientists. Since this equipment was deployed and retrieved from the deck during the expedition, a station sheet was also created for these events.

On this expedition, an opportunity arose that helped to reduce errors and make the data ready for entry into the Expedition Database. Station sheets were analysed daily and their information entered into the Expedition Database. Thus, quality control was provided and missing entries or inconsistencies were located and corrected. As well, blanks in the station sheets were filled in when the information became available about grab subsamples, core samples or camera station times.

The station sheets for both camera system stations were updated post dive with the first and last bottom image times to improve on estimates. This was relayed to the data team in the drawing room at the close of each day on an updated spreadsheet from which they would extract and modify the individual station sheets.

The seabed lander station sheets were completed by the senior lander technician and included instrument heights and detailed sampling strategies. The deployment and recovery sheets were modified post-recovery to reflect more accurate bottom touchdown times, depths and positions as well as updated liftoff parameters extracted from the various lander instruments.

3.4 Expedition data base (ED) – *P.J. Neelands, J.L. Bryk, P.L. Spencer, A.G. Robertson*

Station sheets were input into ED-AT-SEA on a daily basis in the Drawing Office. A consistent approach for each station's metadata was developed and followed. A map of geographic sub-regions was made and posted at watchkeeper locations. Equipment lists were compiled by scientists for unusual pieces of equipment and this information was added to the comments.

Quality control was conducted by a number of staff during the process, thus detecting many problems before data entry. Once entered, the stations were inspected again by M.Z. Li. Daily "txt" dumps into ArcGIS ensured accurate positional locations.

Where a piston core was obtained based on a seismic profile, the expedition, day and time of the seismic "tie" were provided by the Chief Scientist.

DFO station data (other than CTD stations) were input into "other/water" stations. Each input had a detailed description. An attempt was made for each DFO station to have as detailed a description in comments section as possible including sampling depths, "in water" time and "out of water" time, and any other information provided by DFO scientists.

A seabed still image spreadsheet file was compiled daily and presented to GSCA Curation following the expedition to be uploaded into ED. This file covered all successful camera stations for both camera systems and listed individual JPEG file positions and depths where available. The number of successful seabed photos were calculated and entered as well as various imagery descriptions.

3.5 Curation and data processing – *D.P. Potter, S.E. Hayward, A.G. Robertson*

Paper records – Geophysical lines were run from 2100 to 0900 overnight (1800 to 0600 AST). These paper records consisted of Huntec DTS, sleevegun, and Klein 3000 sidescan sonar. Each morning, upon completion of the previous night's surveys, paper records were trimmed, colour coded (green for Huntec DTS, blue for sleevegun and yellow for sidescan sonar) and annotated with record type, start and end times, sweep, and delays in milliseconds. Table 3 lists survey line numbers and start and end times for each geophysical instrument.

Digital backup files – Digital geophysical data files were backed up daily to the RAID located in the drawing office. Seismic data, digitized using both GSCDIGS and the GSC PortableDIGS, were archived on the RAID along with the sidescan sonar and Knudsen sounder data. In addition, these data were burned to DVDs daily.

Geophysical data processing – Huntec DTS and sleevegun SEG-Y files were converted to JPEG2000 format using R.C. Courtney's *SegyJp2000* software for quality control and verification of start and end times. Parameter (.par) files containing these times were then used to extract navigation for lines of each instrument type.

2011036 SEG-Y to JPEG2000 conversion – Seismic data from the sleevegun and Huntec DTS were digitally recorded in SEG-Y format. The raw SEG-Y files were then concatenated using the GSCA software CombineSEGY. The combined SEG-Y files were then compressed to JPEG2000 format using the SEGYJp2 software. The Huntec DTS external streamer data were converted to a signal power envelope JPEG2000. The external streamer data were filtered from 1000 Hz to 4000 Hz with a taper of 300 Hz. The sleevegun data were also converted to a signal power envelope JPEG2000. In each case, the data were filtered using a low cut of 60 Hz with a taper of 30 Hz. Unfiltered JPEG2000 files were also created from the digitized sleevegun data that had been pre-filtered and recorded on the EPC recorder.

12 kHz/3.5 kHz – Water depth was broadcast through NavNet to all computers. Problems were encountered around running Knudsen software in auto phase versus manual phase. There were some instances in which the range was set at 100 but the water depths went below 50 meters. Auto phase was unable to track the bottom and fixed on multiples. During seismic acquisition, the Knudsen was run in manual phase mode. This required monitoring of the program by the sidescan sonar operator which worked well. During daytime operations, typically run from the Forward Lab, the program was run in auto phase mode. A better understanding by watchkeepers of the operating procedures of this software is needed. Also, there should be a monitor located in the Forward Lab for use by the day-time watchkeepers.

Computers – Computers were found to be extremely slow, with many "not responding" events. Morning shut down and restarts were routine and should be implemented on a daily basis on future cruises. Computer upgrades should be considered in both labs and drawing room. Spare computer parts including mice, USB extensions and video extensions are needed.

Seafloor imagery – All of the seabed imagery (both stills and high definition video) as well as the applicable navigation were stored on two Fantom 1 Tb external Green drives. Post-expedition one of the drives was archived with GSCA Curation while the other was given the Chief Scientist. The data were transferred from the processing laptop via eSATA cables due to the large size of the digital files. Each station folder for the camera sleds included raw imagery, processed imagery and navigation subfolders. For the DeepImager there were two further folders for the forward sector scanning sonar and the multibeam sonar.

There were numerous steps involved in processing the imagery involving GSCA applications and licensed software products. First, the cameras were downloaded and the raw stills, high definition video, navigation and sonar data were saved to disk. A processed folder was created for the stills and all non-seabed images were removed, i.e. deck shots or water column. These stills then had position, and in some cases depth, metadata inserted.

The raw high definition video was viewed in DVMP Pro software allowing the actual seabed touchdown/liftoff running times to be viewed and the elapsed times to be noted. The same raw video was then edited in Sony PMB software and the noted elapsed times were used as the lead in/lead out points for trimming. This then became the processed video M2ts file. DVMP Pro was used to extract the timestamp information from this file as a subtitle file which was set aside for further manipulation in a subsequent step.

The trimmed video file saved from the PMB software was then imported into EMICSoft conversion software so a compressed video file (AVI) could be created from the much larger M2ts files. This was quite taxing on the laptop computer and usually took approximately one to two hours per station. The initial subtitle folder, which only included date and time, was modified using a navigation insertion application by merging the DeepImager logfile in order to extract heading, positioning and sled depth. This final subtitle file was then combined in the processed folder with the AVI so that this vital information could be portrayed while reviewing the video. A few 30 second mosaics were produced but this proved to be too time consuming for the laptop processor.

The forward scanning sonar data was not processed at sea. Some of the multibeam sonar data was processed into P files during the mission, but as time was limited and there were no CARIS processors available, this was abandoned. These processing and imagery mosaics could be produced post-mission if desired by dedicated data processors or done at sea if a dedicated time slot was made available.

Seafloor imagery, curation, and processing were carried out during any slow periods during the day or during the evenings. These tasks could be made more efficient in future with a dedicated powerful multi-core processor laptop with USB-3 or Thunderbolt ports and a dedicated watch schedule timeslot for processing.

List of Figures

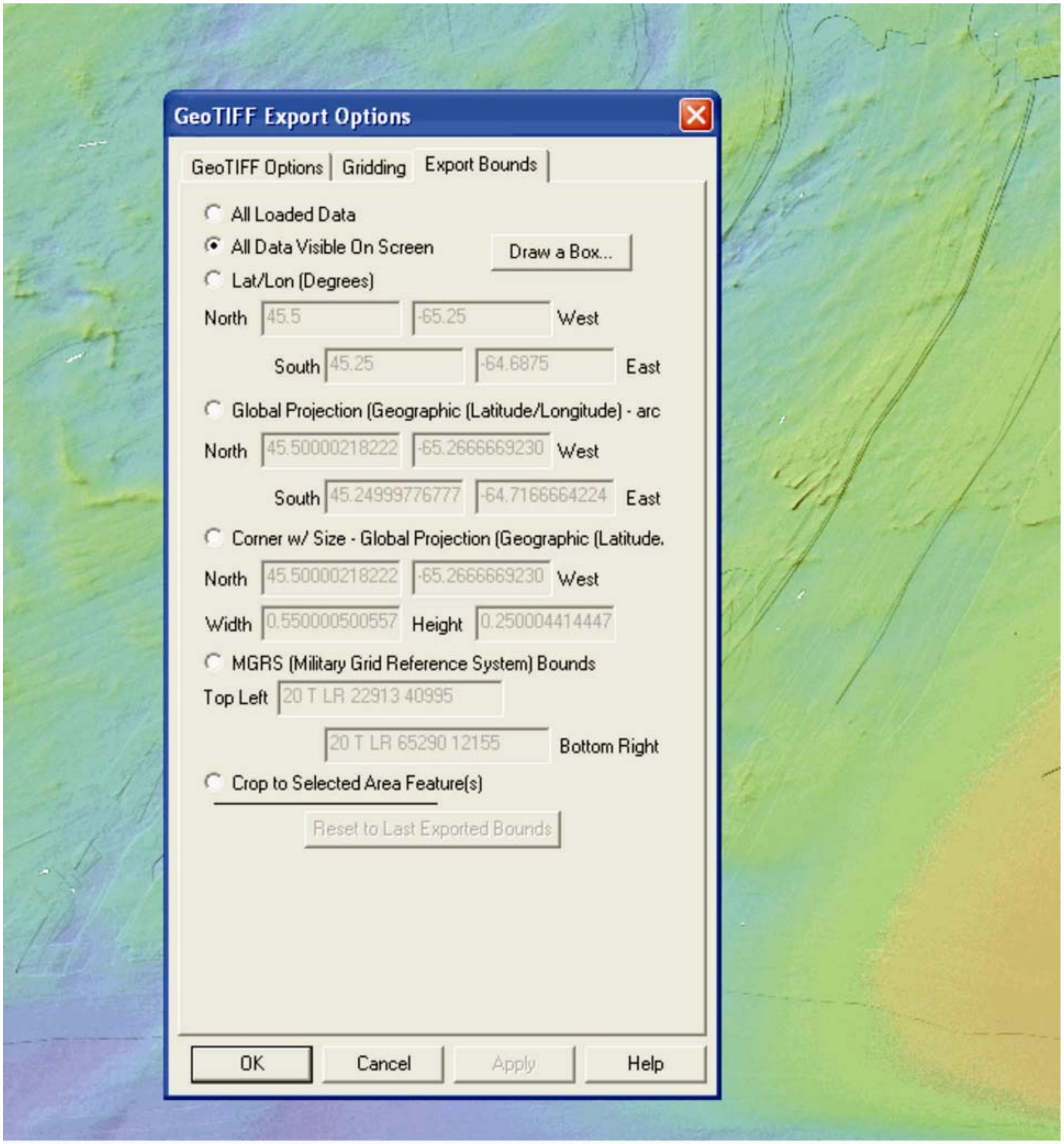

Figure 62. GeoTIFF Export Options dialog box.

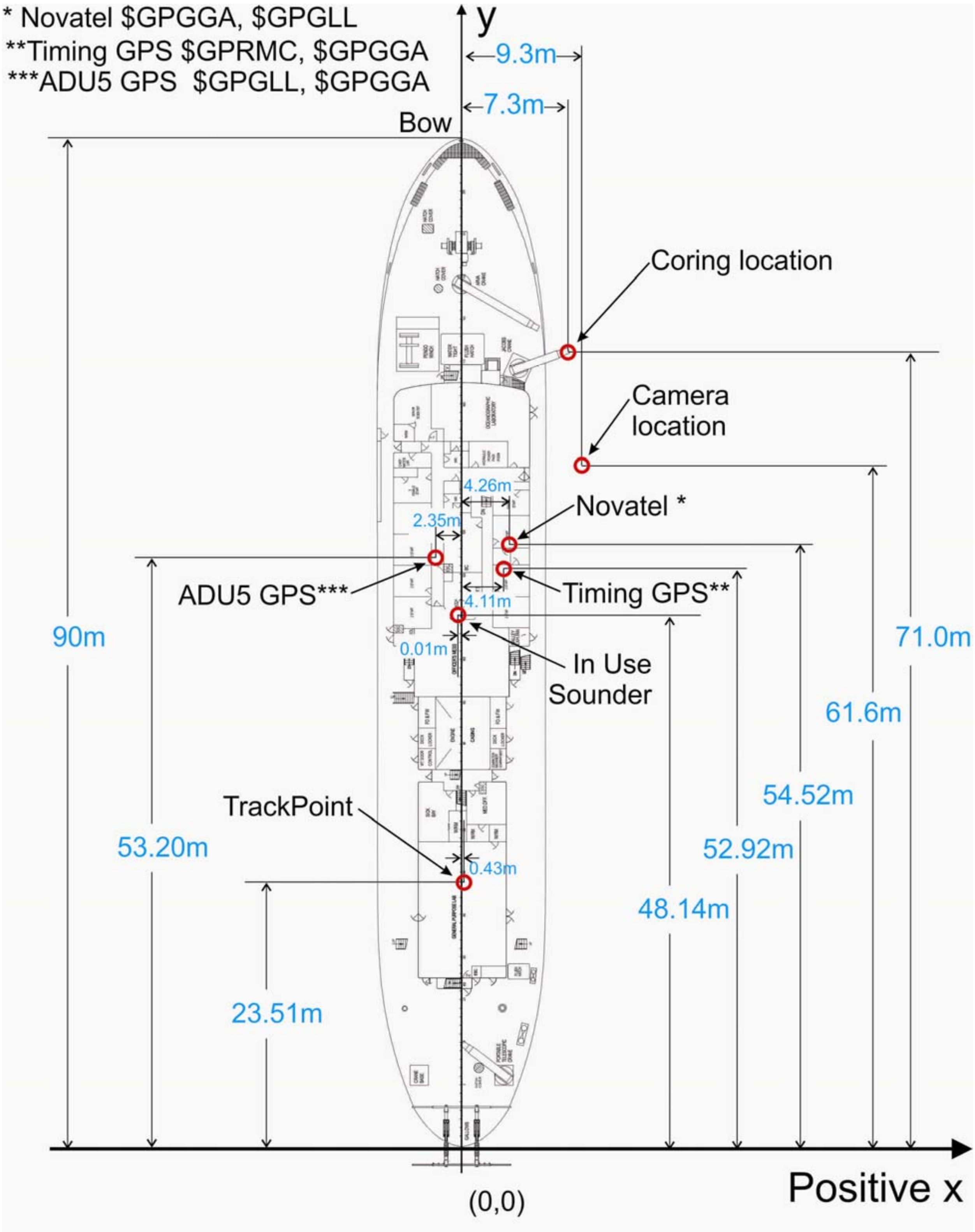

Figure 63. Plan view of navigation offsets on the CCGS *Hudson*.

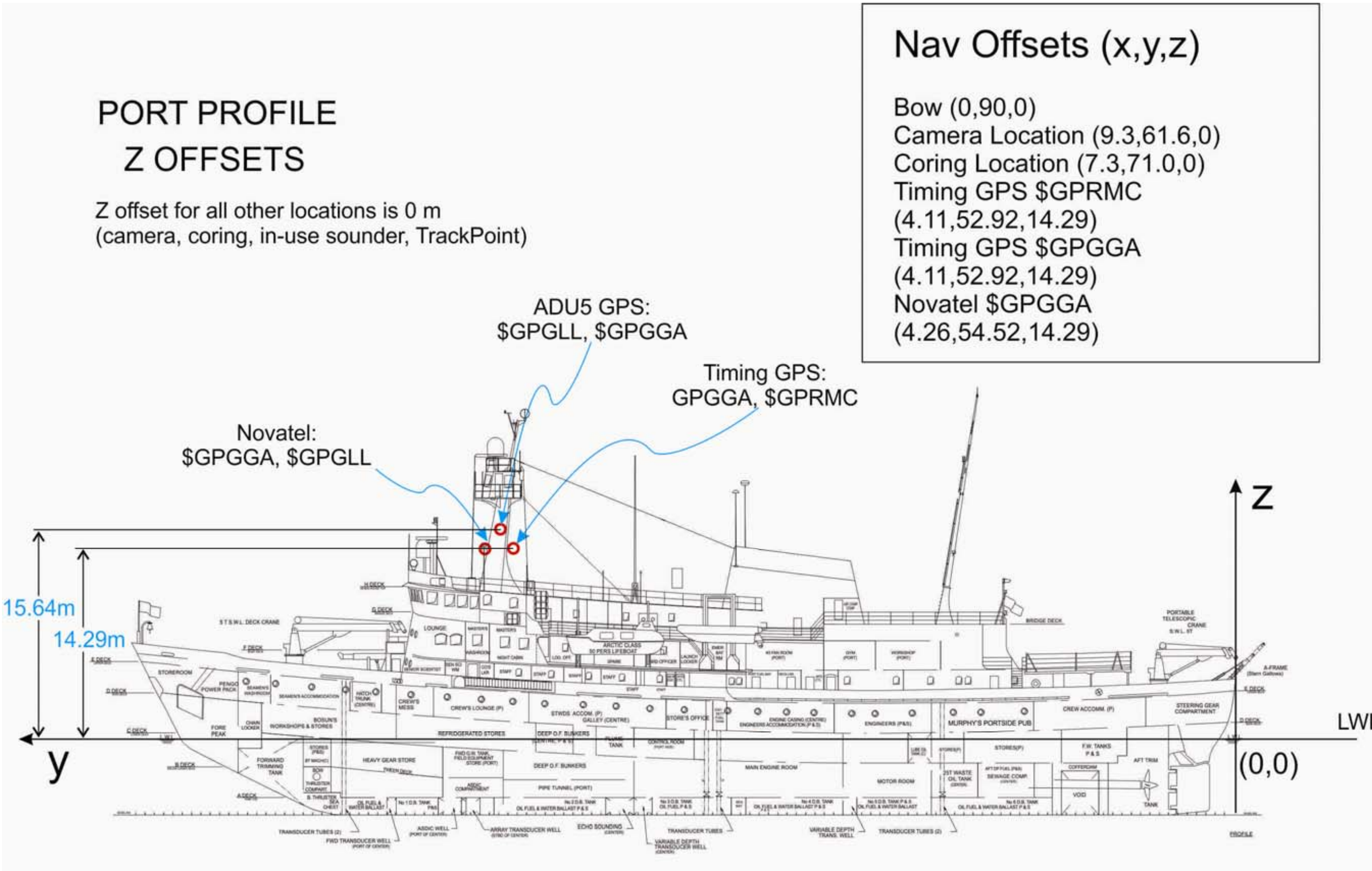

Figure 64. Elevation view of navigation offsets on the CCGS *Hudson*.

4. Watchkeeping – *C.G. Currie, R.R. Boutilier, K.W.G. LeBlanc*

Three eight-hour watches were structured to accommodate a 24 hour expedition schedule. Duties were classed in two main categories of daytime sampling and overnight geophysics.

4.1 Daytime sampling

The daytime sampling watchkeepers performed the following tasks:

1. Maintain a hardcopy expedition log book with general sample station information including parameters Julian day (JD), UTC time, station (STN) number, station water depth, position (latitude and longitude), individual sample details such as the time a device entered the water (in water) or the time the device reached the seabed (on bottom) (or time travelled along the bottom), as well as the time the device arrived at the sea surface (at surface).

2. Enter and maintain "events" corresponding to the items listed in (1) and additional recording requirements in the Regulus II navigation software that accurately recorded time (UTC) and position information when created, and adopted an event naming standard that, when sorted alphabetically, told the logging "story" of events as they unfolded. The event naming convention was Julian day, station number, equipment or equipment sample number for bottom grabs and cores, and wove in various DFO sampling as it took place. An example of an event entry is JD255_STN068_onbottom. Related details were entered into the event record, such as water depth, cable out, etc.

3. Work with the sampling technicians to ensure consistency with the sample sheets being produced for each sample.

4. Meet regularly with navigation and data processing and curation staff to ensure consistency and quality control of station and sample parameters being recorded.

5. Work closely with sampling technical staff and CCGS *Hudson* deck crew to get information about sample deployment accurately transferred to the general log book.

4.2 Overnight geophysics

The overnight geophysics watchkeepers performed the following tasks:

1. Maintain a hardcopy expedition log book which contains general fix information entered at a

regular interval every 15 minutes (UTC time) and in addition record any relevant changes that occur while the geophysical equipment is deployed and recording. Interaction with geophysical staff ensured log book data accuracy.

Information recorded in the expedition log book during geophysical surveying was manually recorded from the Digital General Watchkeepers log displayed in the GP lab. The information was transcribed to the hard copy logbook from the digital log screen by the watchkeepers. It included:

- Julian day (JD)
- UTC time
- position (latitude and longitude)
- geophysical survey line number
- water depth (metres)
- ship’s course (over ground and heading)
- ship’s log speed and speed over ground
- relevant compressor settings, recorder delays
- sidescan sonar information including cable out, fish altitude and sidescan fish water depth
- sleevegun information such as firing rate, delays, etc.
- bathymetry info
- Huntec DTS information

2. Ensure start of line and end of line were recorded and that the Trackpoint ram was taken up at the end of watch and that the bridge was notified of the ram status.

3. Enter watchkeeping information into the digital watchkeepers log when changes were made to the sidescan sonar, Huntec DTS or sleevegun systems. Information such as firing rate, delays, cable length and fish depth were all entered digitally to the general watchkeepers digital and hardcopy logs as the geophysical survey progressed.

4. Keep the seismic technical staff and ship’s crew aware of any system changes, such as drastic changes in bathymetric features, ram up/down status, waypoint alerts, and other relevant information affecting the watch.

4.3 Best practices

1. Overlap of watches: each watchkeeper appeared ready to stand watch 30 minutes early for each shift. This gave enough time for a thorough debriefing of all issues affecting that watch. Watchkeepers shared the Regulus navigation software learning curves from each watch to improve

data input.

2. Regular meetings with the *Hudson* 2011036 curation staff each day helped discover and correct sampling recording errors and improved the way Regulus software was used to acquire and record the data.

4.4 Suggested improvements

GP Lab Digital General Log:
The Digital General log is an exceptionally superior input tool for the GP lab. It is friendly to use as an ongoing watchkeeper's input tool.

1. A real time printout capability while the watch is in progress could eliminate the necessity of the watchkeeper being required to enter data twice: once into digital general log and a second time manually into the hard copy general log. This would be an improvement for several reasons:
i) Transcription errors would be eliminated.
ii) The general watchkeeper is required to make changes to the logging systems to update seismic input parameters. Many times (5 to 10 times per watch) these updates happen at the same time as the regular 15 minute fixes. It is impossible to log them manually at the same time as entering them into the digital general log. The watchkeeper then has to decide which system (the paper or the digital) will he or she enter the data first, at that exact time. Either the paper or the digital system (the one chosen second) will be off by 1 to 2 minutes regardless of how fast and fastidious the watchkeeper is.
iii) With a single input method into the digital general log only, accuracy will be improved. The issue of expedition staff and the chief scientist requiring a hardcopy can be accommodated by report format printouts. This could be accommodated by having the watchkeeper (on a regular basis) do quality control and crate printouts while on watch.

2. The "last data entry" screen in the digital general log requires a scroll button and the capability to scroll back to see the previous entries encompassing at least one hour's worth of data.

3. Regarding the Forward Lab Sample Input log:
i) A thorough briefing on how the Regulus navigation software works before watchkeeping commences would be helpful. This would include an agreement on use of best practices to help ensure the electronic log sampling "story" flows, is consistent, and is understandable, complete and accurate.

ii) Interruptions to the watchkeeper logging procedures are constant because navigation information ("how far to next stop", "distance between stations", etc.) jeopardize accuracy and in the case of one Regulus feature, potentially harmful to data integrity. In this latter case, when an event information record is open, any clicking outside that record box on the map to get distance information replaces the record positional data with those of the distance enquiry. Thus, it would be helpful to either have a second Regulus station shadowing (i.e., seeing the data being captured) for such enquiries, or find some other work-around such as having someone take on the navigator duties in the forward lab during operations there.

iii) An independent program (so as not to tie closely to Regulus software or any successor program) that allowed log entries, including sample information, to be collected, time-stamped, and later merged with other e-logs would be helpful and effective.

5. Sidescan sonar system – *P. Meslin*

The Klein 3000 sidescan sonar was used on the expedition. It is a digital system with paper records provided by a network-connected EPC 1086NT thermal imaging printer. Data were acquired with SonarPro 11.3 and stored in xtf and sdf files.

Upon consultation with the chief scientist and data processing staff, alternate configurations for the EPC 1086NT thermal printer were studied in order to obtain a paper printout of higher quality. The configuration agreed upon was:

- 64 greyscale levels
- no color inversion
- gamma at 1.0
- no range lines

These configuration changes are applied not on the thermal imaging printer but as available options in the SonarPro 11.3 software. The configuration agreed upon for the thermal imaging printer was:

- 240 lpi (200 for the first few nights)
- contrast 80

The Klein internal responder was used with the Trackpoint III system to accurately position the towfish. The Klein responder trigger rate varied between 1/8th and 1/16th of the sidescan ping rate depending on the sidescan's distance from the vessel. The Trackpoint III was set to use an external trigger key in order to interface with the Klein 3000 TPU. The Klein TPU was thus provided with more accurate fish coordinates calculated using data from the Trackpoint III USBL system. After testing the functionality, SonarPro 11.3 was also configured as to provide the Trackpoint III computer with the depth of the sidescan fish in real time. This increased the accuracy of the USBL response over the previously used method of manually entering the fish depth in the Trackpoint interface after notable changes in depth.

Data were acquired at 100 kHz and 500 kHz at a 200 metre range (400 metre swath) or at a 300 metre range (600 metre swath) when conditions warranted it. Paper records were printed for the 100 kHz data. The towfish was deployed with a neutral buoyancy package and one or two depressor weights from a remotely controlled Markey winch fitted with 800 metres of cable. The towfish was towed normally between 15 and 30 metres above the seabed. At times the towfish reached up to 80 metres above the seabed in deeper waters when the maximum depth of the towfish was reached. Due to strong tides, survey speed varied from 1 to 6 knots over ground while trying to maintain an average speed of 4.5 knots in the water.

Following the difficulties observed in 2009 in regard to real-time printing of sidescan sonar data, it was decided to print the sidescan data post-survey instead of real-time. When printing in real-time, any issue which would cause the printer to freeze or interrupt the network feed would cause SonarPro 11.3 to freeze and require a restart, along with the entire sidescan sonar system (TPU and towfish). Printing post-survey has numerous advantages:

- no network conflict (collision) between traffic to the TPU and the thermal printer
- potential printer faults do not cause interrupt acquisition during survey
- it is possible to keep the computer connected to the ship's navigation network during survey. (SonarPro freezes when attempting to print to the 1086NT if said navigation network is connected.)
- the EPC 1086NT printer is capable of high printing speeds, making it possible to print out twelve hours of survey data in slightly over one hour.

As the sidescan sonar computer can now be connected to the ship's navigation network during survey (but not while printing), a secondary computer is no longer required to process the USBL data.

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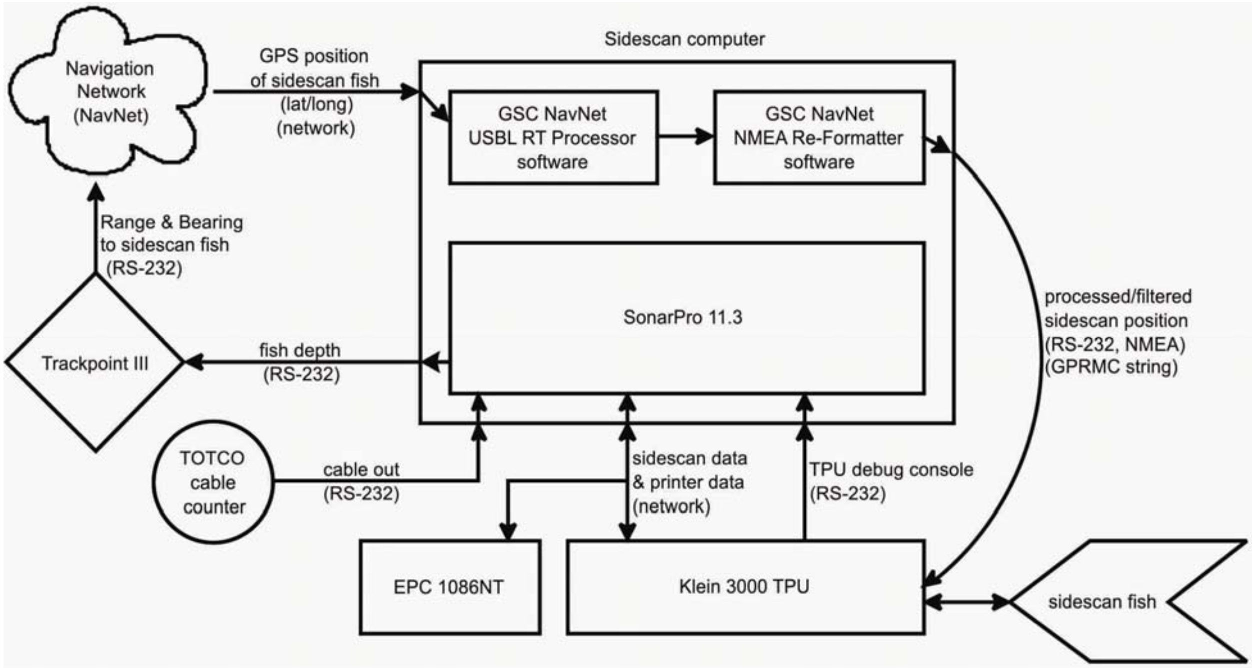

Figure 65. Schematic of sidescan sonar system on *Hudson* 2011036.

6. Sleeve gun seismic reflection system – *D. Manning*

The seismic source for this survey was a 10 cubic inch sleeve gun with inserts to further reduce it to 6 cubic inches. It was towed from an outrigger off the port side of the vessel at a distance of approximately 50 metres from the stern. The single gun was suspended from a Norwegian buoy at a depth of approximately one metre.

Air was supplied to the gun by an enclosed Price W2 Air Gun Master compressor driven by a 200 horsepower electric motor. The frequency of the motor was controlled using a Cutler Hammer SV9000 frequency control unit. Several temperature sensors and a cooling water flow sensor are interfaced to the frequency control unit for automatic shutdown in the event of a high temperature or low flow condition.

Supplied air pressure for this cruise was reduced from 1800 psi to 1400 psi to reduce ringing. The compressor was run at reduced speed (450 hertz) to avoid excessive dumping of unused air.

A Teledyne streamer deployed using hydraulic powered winch and was towed from the starboard side of the ship through a roller block mounted at the stern. Depth of the streamer was controlled to 1 to 2 metres depending on surface conditions using two Digicourse 5010 Digibirds and the new Digicourse Positioning Control System acquired during this cruise.

Streamer analogue data were amplified and logged to two channels of GSCDigs number 8. Channel 1 was used for raw data. Channel 2 was fed through a high pass filter set to 140 HERTZ. Digital data were also logged on the newly developed portable digitizer. Data filtration and annotation were also supplied by the new unit and that signal was printed to an EPC 2086 Graphic Recorder. Only the raw signal is recorded digitally and any filtering or signal gains applied affect only the printed record. This development eliminates the need for the aging TSS annotators previously used.

The 6 cubic inch gun performed well and did not need to be changed for the duration of the cruise. The compressor was down for one hour due to an interruption in the ship supplied cooling water. The ship’s cooling water supply was promptly rerouted by the engineering staff to provide the required flow rate.

Daily maintenance and inspection of the gun, compressor, air lines and winches occurred outside of seismic operational hours. Stress to the equipment was minimal and no lost survey time was incurred due to equipment damage.

The schematic below illustrates the equipment configuration.

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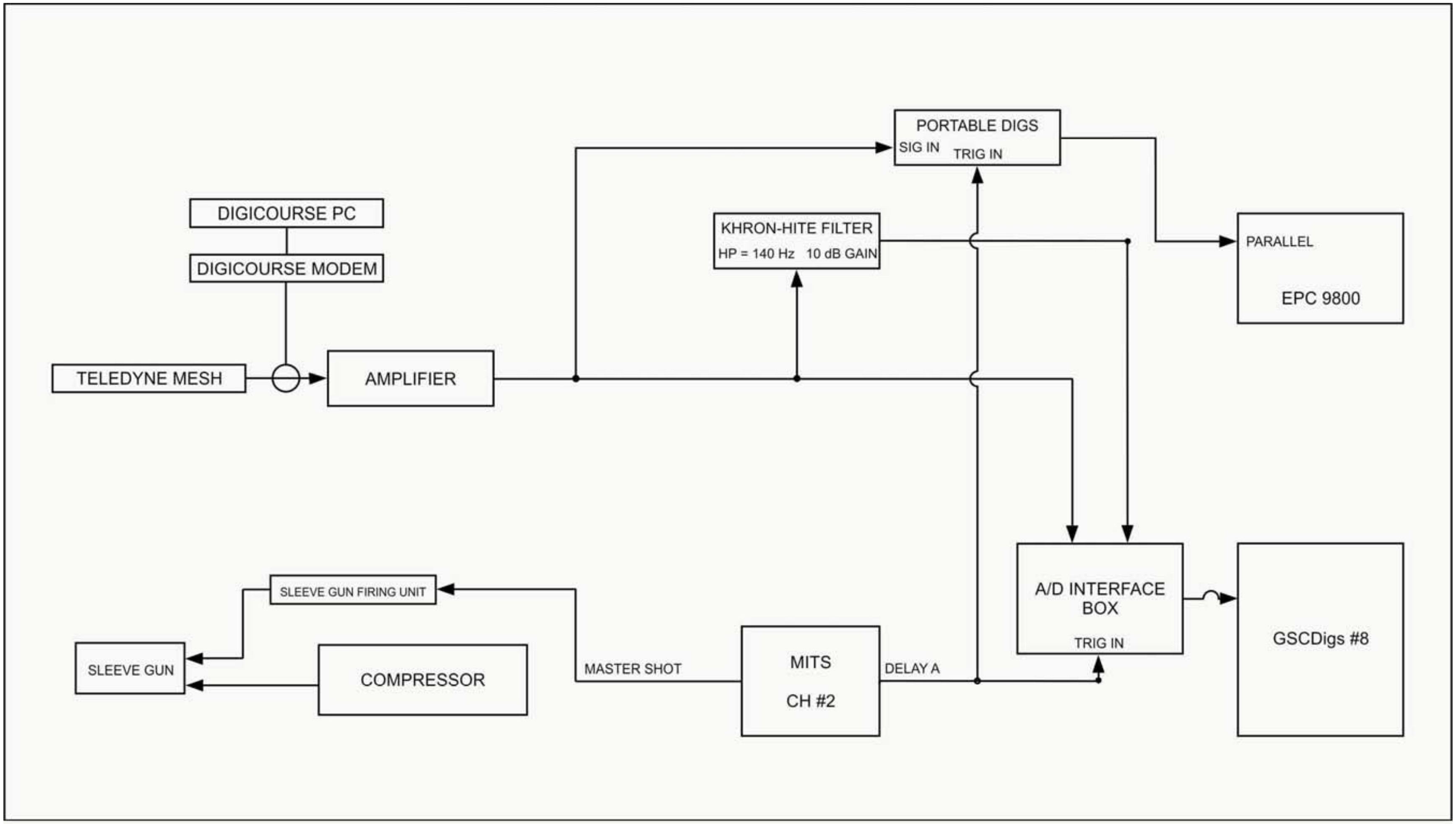

Figure 66. Schematic of sleeve gun seismic reflection system on *Hudson* 2011036.

7. Huntec Deep-Tow-Seismic system – *G. Standen*

7.1 System description

The Huntec Deep-Tow-Seismic (DTS) system, originally manufactured by Huntec (70) Limited, is a high resolution, sub-bottom profiler with the acoustic source, energy supply, motion sensor, and two receiving hydrophones housed in an underwater tow fish. The GSC #3 and #4 DTS systems were used on this expedition, mainly in boomer mode (see below).

The maximum power output of this system is 1000 joules (60 mfd storage capacitance) with an ED10F/C Boomer and a multi-tip sparker source. For *Hudson* 2011036, the internal single element LC10 hydrophone was configured as Seismic #1. The externally-towed Geoforce GF24/24P2i streamer hydrophone was connected as Seismic #2 (overall streamer length 24 feet, two inter-spliced channels with a combined fourteen foot active section, total of twenty-four AQ1 elements with an effective spacing of 12 inches).

The ED10 boomer source is depth-compensated and outputs a highly repeatable broadband pulse, capable of resolving 10 centimetres vertically. Peak output intensity is 118 dB relative to 1 micro bar at 1 metre, with pulse duration of 110 microseconds. The sparker source has twenty, #18 awg, solid core tips. Sparker peak amplitude and pulse width are depth dependant.

The deck equipment consists of a US Geological Survey oceanographic winch, which includes a multi-way slip ring and a 600 metre, twenty-one conductor, armoured tow cable. The winch is powered by a 440 VAC, 50 HP hydraulic pump unit. The tow cable is handled by a 36 inch diameter roller cluster rigged on the centre position of the aft A-frame.

The lab instrumentation consists of the Huntec Systems Console and DC high voltage power supply (PCU). The Systems Console houses the Bottom Motion Compensator circuits, the +24 volt fish supply, and modules for signal processing and tape outputs. The Huntec Mk III PCU provides DC power to the boomer in switchable ranges from 2 to 6 kilovolts.

The new Geoforce/GSC-developed Systems Console was used during the expedition.

7.2 Graphic display, signal processing and system key

The external hydrophone signal was displayed on the EPC 9802 using a 250 ms sweep.

The PC-based MITS system triggered the DTS and seismic systems. The MITS system allows several systems to be run using a common time base. The MITS masking feature significantly reduces acoustic interference by inhibiting the coincidental triggering of interfering system(s). Each source has two independent, adjustable delayed trigger outputs.

7.3 Data recording

The two DTS signal channels were recorded on the PC-based GSC DIG (# 5) digital four-channel logger with hard drive storage and DVD disk writer. The data directory on the hard drive is C:/gscdigdata/hud2011036/day_xxx-xxx. Digital data were also saved to DVDs, ordered by days of survey, e.g., 247–248, and consist of SGY files.

It was also stored and displayed by the new Portable DIGS and a replacement unit for the above which was developed by Peter Pledge of NRCan which allows the data to be displayed by a waterfall image which can then be filtered and processed, and that image is then printed to the EPC 9802.

GSC DIG Inputs	Description
Ch. #1	Seismic #1 - Internal LC10 hydrophone
Ch. #2	Seismic #2 - External GF24/24P2i streamer
Trigger	+5 volt MITS master trigger

7.4 Equipment list

Unit Description	Serial Number
Tow Fish Body	AGC #3 and #4
ED10F/C Boomer Source	
MK5-2 Attitude Sensor Unit	
S1000-4 Energy Storage Unit	
Internal LC10 Hydrophone	
External GF24/24P2i Streamer	103
USGS Winch and Power Pack combined	
Roller Cluster 36" Dia.	
Geoforce Systems Console	001
EPC 9802 Graphic Recorder	134
MK 3 Power Control Unit	105/114

GSC DIG Data Logger	#5

7.5 Equipment settings

The following equipment settings were used for the majority of DTS survey lines.

Parameter	Setting
Fire rate	See daily logs (not in this Open File)
PCU power setting	4 kV 480 joules
ESU power setting	60 microfarad (1000 joules max.)
Geoforce Console-pressure mode	Pressure Mode
Display Gain	Seismic #2
Filter Setting - External	Seismic #2: 500 to 5000 Hz After day 252 channel A 700 Hz to 8000 Hz Channel B 2000 Hz to 8000 Hz After day 256 Channel A 1000 Hz to 9000 Hz
Processor Gain (System Console)	4 KV (both channels)
DTS source	See daily logs (not in this Open File)
GSC DIG trigger	master MITS trigger
GSC DIG sample rate	25 microsecond
GSC DIG samples per channel / range	10000/250 microseconds
EPC 9802 sweep speed	250 msec Channel A external streamer filtered @ 1000–6000 Hz *After day 252 the data were presented using both channels of the recorder to displaying the external signals but with different filter setting
EPC print polarity	positive

7.6 Equipment performance

In general, the DTS system performance was good; however at the beginning of the mission the sparker appeared to have an intermittent problem. This unit had been used successfully on the prior mission with no apparent problems. The tow fish was recovered and the sparker tips were trimmed and the tow fish redeployed. Unfortunately this was not the cause of the problem and after a couple of days of fault finding i.e. changing out to the other tow fish and getting a replacement PCU from Halifax the fault was eventually found to be at the termination point of the cable. It was causing an intermittent break in the trigger line. The cable was re-terminated and no further problems developed.

Systems Console – There appeared to be an anomaly with the depth reading on the system console, with the depth reading on the console showing a depth of 13 meters when in fact the depth was 23 meters. This did not affect the fire point trigger or the compensation aspect of the data collection.

Parts used –

1 94 bushing
1 termination compound packet

8. Seabed landers – *M.Z. Li, A.G. Robertson, S.E. Hayward*

Two instrumented mini-landers were deployed and recovered at strategically selected sites in the lower Bay of Fundy in this expedition to obtain in situ current and sediment transport measurements. The lander data will be analyzed for site-specific assessment of nearbed hydrodynamics, sediment transport processes, and sediment and bedform mobility. The in situ sediment dynamics data will also be used for the calibration of seabed disturbance and sediment transport models.

Mini-lander 1 was deployed at 18:30 UTC on 1 September at Station 16. It was deployed over irregular sediment waves (Fig. 67A) at the northern edge of the Grand Manan Basin. The water depth was 134 m and the IKU sample (Station 15) shows the surficial sediment was silty fine sand. Both landers used small quad frames built with aluminum pipes. Sensors on mini-lander 1 (Fig. 68A) include:

(1) AquaDopp Acoustic Current Profiler (ADCP) with an Optical Backscatter Sensor (OBS) for current profile measurements and suspended sediment concentration (SSC) at a fixed height. ADCP was mounted downward looking at 127 cm above ground and its OBS was at 30 cm height. ADCP was programmed to measure current profiles at 1 Hz for 10 minute duration every half hour but only record the profile averaged over the 10 min duration. At each half hour mark, ADCP then records pressure and current averaged over an 80 cm cell size for 18 min at 2 Hz for wave parameter calculation. The OBS on ADCP recorded for 10 min at 1 Hz every 30 minutes.

(2) ALEC electron-magnetic current meter (EMCM) was mounted at 75 cm above the seabed and programmed to measure current for 3 min burst at 1 Hz every hour (Note: the actual frequency was 0.5 Hz caused by a programming mistake).

(3) Cyclops is a stand alone unit of a single OBS with a data logger. The Cyclops was mounted at 75 cm height to measure SSC for 10 min burst at 1 Hz every hour.

(4) A sediment trap was mounted on the frame to collect accumulation of settling sediment at 75 cm above seabed.

Mini-lander 2 was deployed at 14:02 UTC earlier on 1 September at Station 9. It was deployed on low relief sediment waves to the east of The Wolves in lower Bay of Fundy (Fig. 67B). The water depth was 99 m. The core collected with the long piston corer (Station 171) shows that the surficial sediment was brown mud. Sensors on mini-lander 2 (Fig. 68B) include:

(1) AquaDopp ADCP with an Optical Backscatter Sensor (OBS) for current profile measurements and suspended sediment concentration (SSC) at a fixed height. ADCP was mounted downward looking at 123 cm above ground and its OBS was at 80 cm height. ADCP and its OBS were programmed the same as that on mini-lander 1.

(2) ALEC electron-magnetic current meter (EMCM) was mounted at 80 cm above the seabed and programmed to measure current for 3 min burst at 1 Hz every hour (Note: the actual frequency was 0.5 Hz caused by a programming mistake).

(3) The AquaTec AquaScat system has 3 multi-frequency acoustic backscatter sensors (ABS) for suspended sediment concentration profile measurements and a sidescan sonar for seabed responses and bedform monitoring. The system is also equipped with a tilt sensor, a compass, and a pressure transducer. The three ABS were 100 cm above the seabed while the sidescan sonar was at 85 cm height. The Aquatec unit was programmed to do burst recording for 15 min duration every hour.

(4) A high-definition video camera was mounted 108 cm height and a DSPL matrix LED light at 90 cm height to collect seabed imageries. The camera was programmed in burst mode to take a still photo followed by 58 seconds of video on the hour mark and another identical sequence at 15 minutes past the hour.

(5) A sediment catchment trap was mounted on the frame to collect accumulation of settling sediment at 80 cm above seabed.

Mini-lander 1 was retrieved at 11:38 and mini-lander 2 was retrieved at 14:08 on 13 September. Both seabed landers were recovered in heavy fog conditions. The combination mooring lines and low drag floats worked well with the marker floats at the surface in both cases. The float for the Grand Manan Basin lander (mini-lander 1) was spotted from the bridge while the float of The Wolves lander (mini-lander 2) was spotted by FRC with the position being radioed to the main vessel. The crew performed a safe smooth recovery to deck in both cases.

The Grand Manan Basin lander worked for the duration of the deployment as programmed. The Cyclops logger was left with plenty of memory space and battery power. The ALEC EM current meter was also still running and had memory and battery capacity left for future days. The AquaDopp current profiler was still running upon recovery and probably would have run for approximately one to two additional days before the battery power would have dropped below the operation threshold. On brief investigation there appeared to be no strong energy events during this short deployment

The Wolves lander had problems with several of the instruments. The ALEC EM current meter did not perform any sampling. On investigation it was revealed that it had the correct programming parameters and time/date settings so the small lithium cell was initially suspected as being defective. During numerous tests in the office post mission it was discounted as being the factor. The instrument requires further testing as it appears to be fine with no signs of damage but the programming cable warrants further investigation as shorting could be possible, and if so may have caused a last second error to be sent prior to disconnection.

The AquaScat multi-frequency ABS would not communicate upon recovery so it was disassembled back in the office and found to have leaked a small amount of water that damaged several boards. The path of the water could be seen by salt staining on the inside of the pressure endcap leading down from an underwater connector. The connector in question was a micro series round two pin brass and manufactured by Impulse. This manufacture had produced defective connectors in the past that have leaked so once again we suffered damage. The hard drive was removed from the electronics boards and investigated but could not be read either because of damage or proprietary formatting. Once funding is available the instrument will be sent back to the UK for refurbishment and investigation to determine if the hard drive contains data from this mission.

The AquaDopp current profiler ran well until 0700 UTC on 5 September whereupon the battery pack reached a critical voltage of close to 8 Volts and the instrument could no longer perform a burst. The lithium battery power was carefully logged in the datafiles and it dropped faster than it should have from a brand new pack. The battery (Tadiran brand) was purchased during January 2011 from Nortek USA and manufactured during August of 2008. We had been issued with a notice of defective batteries several years back from this company but would have thought that they would have improved quality control. We will have these lithium packs constructed by a reputable builder in the future probably using the Saft brand of lithium cell.

The GSCA burst HD camera ran exactly as programmed giving 576 seabed stills followed by 576 video clips each 8 seconds long. A few of the pre-deployment deck clips were a few seconds longer than 8 seconds so this is being investigated. The seabed imagery is not of high quality due to the almost constant tidal flow and resulting turbidity. The bed can be discerned in some of the still/video imagery with little sediment reworking evident. In the future the high intensity LED light could be mounted lower to the bed at a shallower angle in order to reduce the light backscatter.

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Figure 67. Location map showing (A) the deployment site of mini-lander 1 on irregular sediment waves in northern Grand Manan Basin, and (B) the deployment site of mini-lander 2 over low relief sediment waves to the east of The Wolves in lower Bay of Fundy.

Figure 68. Photographs of (A) mini-lander 1 and (B) mini-lander 2 deployed in the lower Bay of Fundy on *Hudson* 2011036.

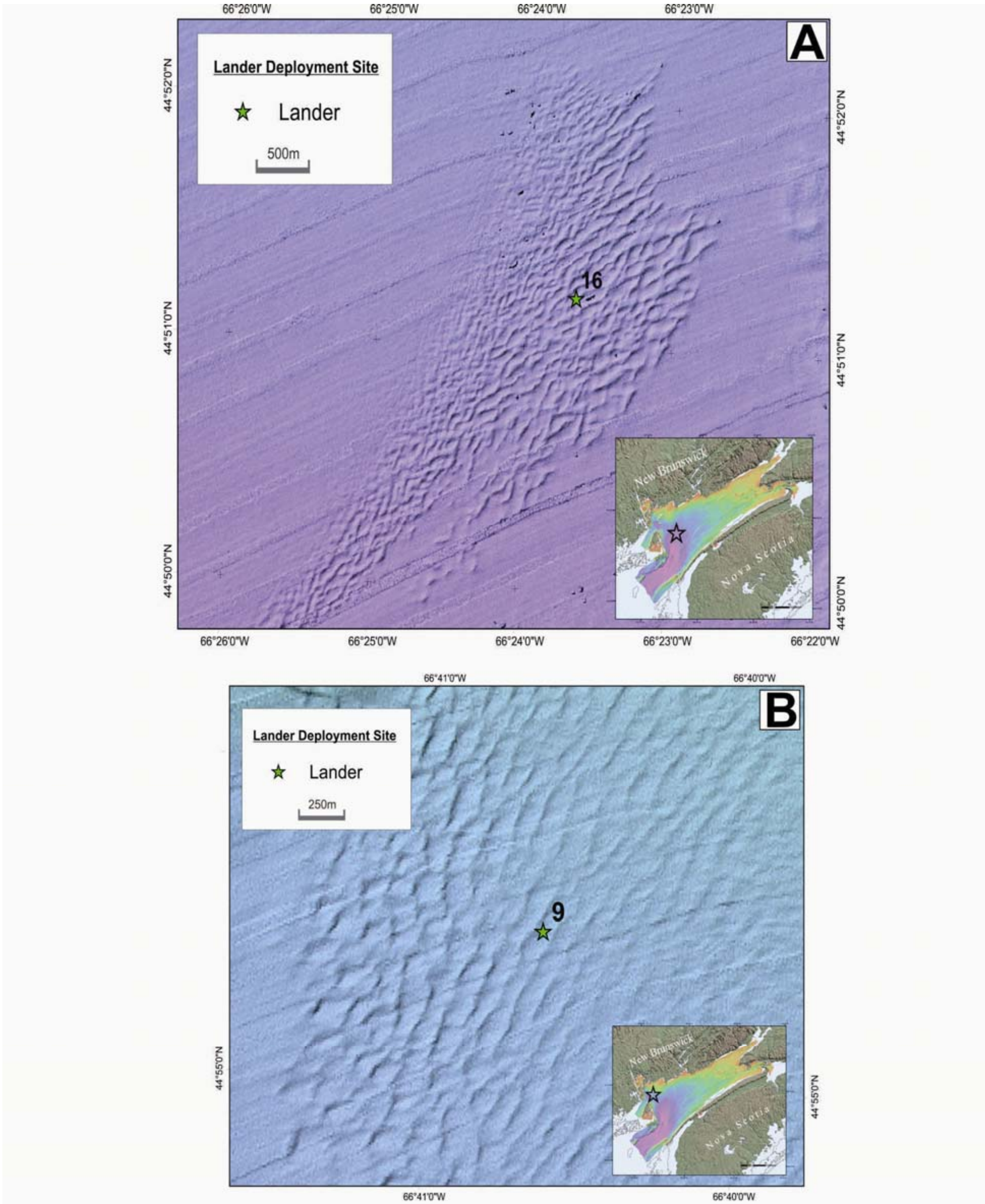

Figure 67. Location map showing (A) the deployment site of mini-lander 1 on irregular sediment waves in northern Grand Manan Basin, and (B) the deployment site of mini-lander 2 over low relief sediment waves to the east of The Wolves in lower Bay of Fundy.

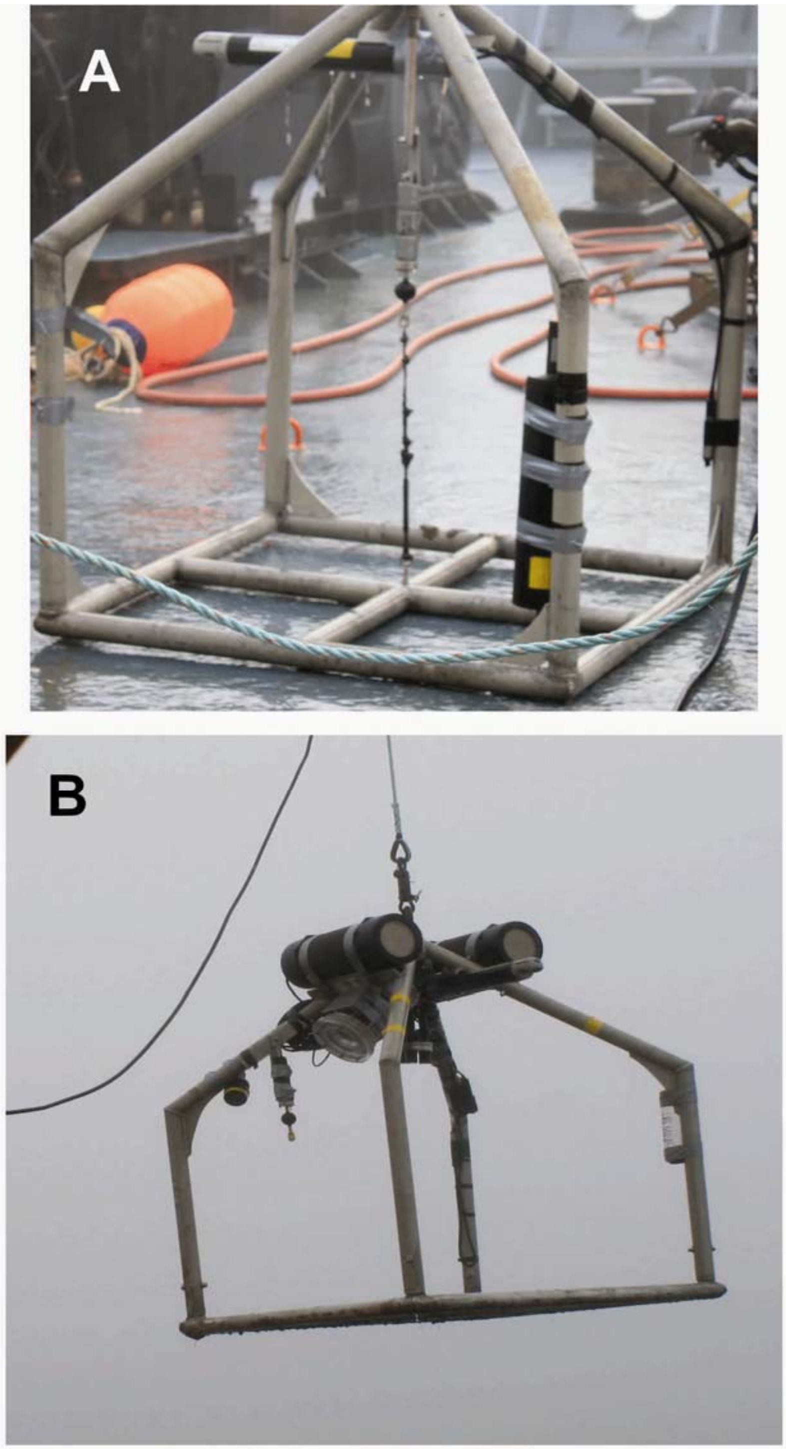

Figure 68. Photographs of (A) mini-lander 1 and (B) mini-lander 2 deployed in the lower Bay of Fundy on *Hudson* 2011036.

9. Seafloor imagery and geological sampling

9.1 WebTide predictions and utilization – *M.Z. Li*

The strong Bay of Fundy tidal currents can cause failures of grab sampling by creating significant wire angles during deployment. Fast tidal currents can also cause the underwater camera to move faster than the low drift speed preferred for optimal seabed images. For these reasons, the WebTide software developed by DFO was used for tidal elevation and current predictions for selected targets during this expedition. These predictions proved useful in planning stations and in discussion with the CCGS *Hudson* officers for optimal conditions for camera and sampling stations. At the time of conducting camera stations, the predicted tidal current speed and direction were used in communications with ship's bridge officers in determining the vessel drift direction and the optimal start location of a transect. This approach worked well and reduced the time needed in positioning the vessel.

9.2 Seafloor imagery – *A.G. Robertson, J.L. Bryk*

Two camera systems were used during the trip with 24 deployments resulting in 22 successful seabed dives: the 4K camera sled with cameras attached, and the DeepImager camera sled. There were 1345 good quality stills taken and 8.19 hours of high definition video running along approximately 10.4 km of transects (Table 5).

The 4K camera sled consisted of a small compact frame and was deployed from the winch room using the hydrocast winch line (Fig. 69). Three successful stations were recorded during the mission. The key camera on the sled was a 10 Megapixel Canon Rebel SLR camera with wide angle lens firing from a bottom weight closure when reaching 1.5 m above the seabed. Two professional Canon flashes were set to synchronize with each touchdown. Bottom drops were timed so that stills could be taken every 30 to 60 seconds. The VladCam Bullet HD video camera was attached to the 4K sled and was self –powered, running autonomously for the entire duration of each dive recording the seabed under continual lighting provided from a Deepsea Power and Light Matrix LED. The SLR, flashes and LED light were all powered from a 12 volt Deepsea Power and light battery. A 12 kHz pinger was attached to provide the audio closure once the camera sled reached the target height above the seabed. A Raytheon 12 kHz sounder was used at the surface with a line scanner to monitor and record each touchdown. An applied acoustics beacon was attached to the sled on a small acetal bracket and activated to provide USBL positioning. Directions were given to the winch operators from two GSCA staff during the transect drifts and this communication ran very smoothly.

The DeepImager camera system (Fig. 70) was deployed from the foredeck of the CCGS *Hudson* using a dedicated DT Marine winch and the main coring crane on 21 stations. Two key GSCA technicians controlled the operations from the foredeck and the forward lab. The camera sled was lowered manually from the winch position on deck to near the seabed and then the lab operator would takeover the operation using a remote joystick. During the recovery operations, winch control would be passed back to the deck with all key steps being broadcast with deck radio boxes.

The system consisted of a Sony 520CX HD video camcorder residing in a solid underwater pressure case. Four Deepsea Power and Light Matrix LED lights were employed to provide seabed illumination. A high resolution Valeport pressure transducer was mounted low on the sled to give very accurate sled depth along with an Imagenix multibeam sonar allowing seabed mapping. Another Imagenix sonar (881 sector scanning) was mounted at the front of the sled to provide a forward scan of the seabed and often showed in fine detail the bedforms ahead. An Applied Acoustics beacon was strapped to the inner part of the sled and provided subsea positioning. A new tailfin was attached to the sled to reduce heading spin and improve attitude parameters, which were logged with a motion reference unit. Data from all these components was sent by modem up the twisted pair cable to be displayed at the surface on the operations laptop. The subsea instruments and lights were powered by a Deepsea Power and Light 24 volt battery.

Both camera systems worked quite well considering the dynamic nature of the Bay of Fundy. The main helmsmen on the bridge were top notch and “at one with the ship” due to their years of experience, so they were a great pleasure to work with. The less sophisticated 4K sled worked fine for the still images considering the turbidity encountered and it is a robust tool. However, high definition video from the piggyback VladCam Bullet was very poor quality as there was an auto focus problem on the first station (7) due to contamination inside the viewport. This contamination unfortunately became the primary focus spot with the seabed only coming into focus override on a few occasions. On the other two stations (69 and 70) turbidity and vessel drift speed were an issue so the video was extremely poor. In a less dynamic body of water, where vessel drift is slower and the water less turbid, the quality of stills is improved and video is often continuous for the whole dive. This was not the case on this mission so there are medium quality stills but very limited seabed video to tell the spatial story.

The DeepImager sled had the advantage of the live view feed and various additional sensors such as sonars, pressure and heading. One disadvantage with the DeepImager was that the still photos were not of the same quality as the 4K system due to the lack of an SLR and flash lighting effectively freezing the image. This could be modified easily in the future. Downloading the high definition video was somewhat clumsy as the entire pressure case had to be removed each time along with eight radial bolts and argon gas replenishment. This task could be simplified with a small memory card jumper pressure case that could be plugged externally into the main housing. The deck winch forward rollers should be modified as the cable jacket was torn during one recovery and the level wind could possibly be adjusted further so less manual input is necessary. The deployment sheave should also be modified so that the side cheek gap tolerance is lessened to prevent cable jam and damage that occurred on an earlier mission. A more powerful operations laptop would be useful in the control lab while flying the camera sled to allow faster application boots and faster post-dive transfer of data.

9.3 IKU and van Veen operation and sampling – *M.Z. Li, A.O. Brown, R.J. Murphy, S.E. Bossey, J.L. Bryk*

The large IKU grab sampler (Fig. 71) was the main sampling tool used to obtain surficial and shallow sub-surface samples. This modified grab is a clam-shell type, capable of collecting 1 m^3 relatively undisturbed sediment. Two scientific staff worked with the ship's deck crew to operate the large IKU sampler. The Grove crane and the Pengo winch were used to deploy and recover the IKU grab. Upon recovering of the sampler, photographs were taken for geological and biological analyses. Visual descriptions were then conducted to describe the recovery condition, penetration depth, sediment type, etc. A surface sample was taken using a 25 dram vial. Because a vial sample could not be representative for samples containing a gravelly surficial lag layer, a bagged bulk sample from the surface (often 0–5 cm) was taken for grain size analysis. A vertical profile was then dug with a shovel. The strata shown by the vertical profile were then described, measured and photographed. Sub-samples sometimes were also taken from strata in question. For stations showing interesting sedimentary structures, peels were collected by pushing wedge-shaped rectangular steel or aluminium trays into the IKU sample. Sand around the trays was dug out to enable the retrieval of the push-tray cores. The peel trays were carried to the GP Lab where they were processed and epoxy resin peels were produced. As the resin penetrates the sample to varying depths due to the porosity and permeability of sediment laminates, the resin peels better show variations of grain size and bedding structures which can be interpreted for mobile layer depth, the type of bedforms and depositional environment of the sample. Since profiles are difficult to produce in muddy samples, a section of piston CAB plastic core liner and vacuum pump were occasionally used to obtain push cores for these stations. The push cores will be analyzed in the lab upon returning to BIO.

A medium size van Veen grab sampler (20 cm maximum sampling depth capacity, Fig. 72) was used occasionally to collect small bulk surface samples. This was deployed from the ship’s winch room with the assistance of two ship’s crew members. After retrieval of the sampler, an undisturbed surface photograph was taken through the inspection port immediately followed by a vial sample of the 0–5 cm surficial sediment. The remaining sample was then dumped on to the sampling tray. A photograph of the bulk sample was first taken, followed by a geological and biological description, and finally a profile photograph. A vial sample of the blended bulk sediment (0–actual recovery depth in cm) was taken.

Both grab tools worked reasonably well during the expedition. Of the two deployments, the van Veen grab failed once due to high tidal currents at sample locations in the upper Bay of Fundy. The IKU grab also failed occasionally due to the same reason. The IKU failed to trip at several stations over muddy seabed in the lower Bay of Fundy. It was speculated that the soft muddy sediment may not generate enough impact force to activate the tripping mechanism of the IKU grab. Through consultation between scientists and the senior sampling technician, it was decided that the gravity trigger weight corer of the piston corer would be an efficient tool to obtain both surface samples and shallow sub-surface cores for these types of stations encountered in the lower Bay of Fundy. This sampling method worked well for three of the four attempts in obtaining short (up to 2 m) cores over the soft mud sediment (Table 6). In future expeditions to Bay of Fundy, box corers should be used for efficient sampling of soft mud sediment.

The on-deck descriptions of the recovery conditions and geology of all grab stations, and biological descriptions for some stations are listed in Table 7. Sample station descriptions concerning sediment type, species composition and recording quality from (up to) five observers (Li, Bossey, Brown, Bryk, Kostylev) are included in the table. Deck photographs were taken by Brown and are in Appendix 1.

9.4 Piston corer – *B.J. Todd, C.A. Jarrett, R.J. Murphy, A.G. Robertson*

Piston cores were obtained at thirteen locations in the Bay of Fundy (Fig. 3, Table 6). Sites were selected on the basis of seismic reflection data collected during *Hudson* 2011036 as well as previous expeditions. Generally, the geological objective of coring was to penetrate the postglacial sediment into the uppermost glacial sediment.

The wide-diameter AGC Long Core was used. This piston corer is designed for recovering relatively long cores and is the tool of choice for sampling sediment sections at several metres depth below the seabed. However, it is not an ideal tool for sampling the upper metre of sediment; in many cases the piston corer will disturb or bypass this interval entirely. The trigger weight corer is the complementary tool to sample the upper one to two metres with a minimum of disturbance or shortening while simultaneously releasing the piston core for its predetermined free-fall distance.

Coring system components

The piston coring system consisted of the following components:

- Corer headweight - modified Alpine corer head (545 kg, 1200 lb) to accept wide-diameter core barrels, described next
- Core barrel – 3.05 m long; 10.8 cm (4.25 inch) inside diameter (ID) with 0.95 cm (0.375 inch) wall thickness
- Couplings - straight for wide-diameter core barrels, secured with set screws
- Core barrel liner – clear cellulose acetate butyrate (commonly known as CAB plastic) of 10.52 cm (4.14 inch) outer diameter (OD) and 9.92 cm (3.904 inch) ID
- Trip arm (trip mechanism)
- Trigger core and trigger cable that attaches to the end of the trip arm
- Pistons, split and solid types
- Coring cable (1.27 cm diameter, wire, anti-torque lay), terminated with a fiege fitting that attaches to the piston, all of which moves inside the core liner during the coring action

Rigging, deployment and recovery of piston corer

At each coring site, the core head and core barrels were rigged along the starboard side of the CCGS *Hudson* on using the long core facility (Fig. 73). Each barrel was installed from the corer headweight downward. A maximum barrel length of 9 m was rigged due to the anticipated penetration through the postglacial sediments. A rope was passed through the corer headweight and each barrel and liner as they were inserted. The rope was then used to pull the wire coring cable with its fiege fitting through to the base of the core pipe. The fitting was attached to the piston and both were pushed back into the end of the lowest core barrel. Finally, the core pipe was completed by inserting a multi-fingered, stainless-steel, core catcher and attaching a cutting shoe or cutter.

At the core site, the trigger weight cable was put through a snatch block on the boom's second runner and the free end shackled to the side of the ship. The boom was lifted up until the trigger weight core cleared the deck, then the weight was lowered over the side. It was left hanging from the side of the ship for later attachment to the trigger arm. The length of the trigger cable was preset to equal the sum of the length of the core pipe, headweight, and the intended freefall distance.

In deploying the piston corer, the boom's second runner was attached to a lifting ring on the side of the corer headweight. The boom was used to gently lift the headweight and slide the attached barrels off the starboard rail. The whole system was boomed up until the corer was near vertical with its lower end in the water and its upper end at deck working level. A loop of coring cable equal to the freefall distance was fashioned and lightly tied at the top of the corer headweight. The trip lever mechanism, with a safety pin engaged, was clamped to the cable just above the freefall loop, and the short arm of the trip lever was slipped into a ring at the top of the corer headweight. The trigger-weight line was then attached to the long arm of the trip lever mechanism. The coring cable was tightened to take up the weight of the corer, and the secondary runner was disconnected from the corer headweight. The trip lever mechanism, clamped to the coring cable, now acted as a large double-armed balance. With its point of attachment to the coring cable serving as a fulcrum, the heavy corer hangs from a short arm on one side of the fulcrum and is balanced by the trigger weight hanging from a long arm on the opposite side of the fulcrum. After removing the trip arm safety pin, the corer was moved with the ship's boom away from the side of the ship. It was then lowered to the sea floor until it triggered. Triggering occurred when the trigger core penetrated the seafloor, unbalancing the trip lever mechanism, so that the long arm moved up and the short arm down. The corer slipped off the short arm of the trip mechanism to begin its freefall. The triggering was automatic and was signalled by recoil in the coring cable as the heavy corer started to fall freely. At this signal the winch and boom operator would stop the downward descent of the coring cable. The system was set up to allow the corer and piston to fall together while gathering downward momentum for penetrating the seabed. Just above the sediment surface, the freefall loop was exhausted and the piston was arrested. The corer continued moving downward, sliding past the piston while coring the sea floor sediment.

Core processing

After the coring drive was completed, the piston was pulled up with the coring cable to a stop at the base of the corer headweight. With continued pulling, the corer and its core were withdrawn from the seafloor and lifted to the ship's side. The reverse order of operation to that described above was used to remove the trigger mechanism and place the core-filled corer alongside the ship on the long core facility.

A total of approximately 46 m of sediment was obtained from 13 Piston (PC), Trigger Weight (TWC) and 4 gravity cores. All cores were processed according to standard GSC Atlantic core procedures (refer to GSC Open File 1044). All cores were identified alphabetically by section at the time of dismantling individual 10 foot core barrels from the bottom to the top, commencing with the bottom-most core barrel and proceeding to the uppermost barrel containing sediment. Each 10 foot length of liner was extruded from the barrel and cut in half, using a modified pipe cutter, in the half height container. The sediment in the liner was cut using a wire saw and the section ends were carefully capped to minimise disturbance to the sediment surface. The top end cap was labelled with the cruise number, station number, section label and top. The base of the core is designated with the letter A and the top of the base section is designated as B. The base section is AB. Each section was brought into the GP Lab and stored horizontally on the benches. Each core, starting with the base section AB, was processed using the following procedure. The core liner was labelled with an up arrow, expedition number, station number, and section label. The top and base of the section were labelled with the appropriate letter. End caps were removed if the sediment was not too fluid, and the section length was recorded.

Undrained shear strength measurements and constant volume samples were taken at the ends of each section if the condition of the sediment allowed (Table 8). The constant volume sampler was inserted into the end of the section, the undrained shear strength measurement was taken, and the constant volume sampler was removed.

The undrained shear strength was measured using a hand-held Hoskin Scientific Torvane according to ASTM Test Method D2573-94 Standard Test Method for Field Vane Shear Test in Cohesive Soil. The dial on the Torvane was zeroed and the fins on the vane were gently pushed into the sediment until they were completely inserted. The dial was rotated at a constant rate until the sediment failed (Fig. 74).

The Torvane dial reading ranges from 0 to 1 and reports values in kg-force/cm^2 units (1 kg/cm^2 = 98.07 kPa). The Torvane has three adapter vanes as described below:

L - Sensitive vane has a range of 0 to 0.2 kg-force/cm^2
Su = dial reading * 0.2 kg-force/cm^2

M - Regular vane has a range of 0 to 1.0 kg-force/cm^2
Su = dial reading * 1 kg-force/cm^2

S - High capacity vane has a range of 0 to 2.5 kg-force/cm^2
Su = dial reading * 2.5 kg-force/cm^2

Constant volume samples for bulk density and water content determinations were taken by inserting stainless steel samplers of a known volume. Prior to insertion, the sampler was lightly sprayed with Pam cooking oil and gently wiped with a small Kimwipe tissue. The bevelled edge of the sampler was placed on the flat sediment surface and the carefully inserted into the sediment at a constant rate using two flat headed spatulas (Fig. 75). The sampler is inserted at a constant rate to minimize compression of the sediment within the sampler. The sampler was then carefully removed and the sediment was trimmed using a wire saw and extruded into a pre-weighed 1 ounce screw-top glass bottle. The bottle cap was then labelled and sealed using electrical tape to prevent the lid from loosening. The constant volume samples will be weighed in the lab at GSCA, dried at 105°C for 24 hours and re-weighed to determine bulk density, dry density and water content according to ASTM Test Method D 2216-90 (revision of 2216-63, 2216-80) for laboratory determination of water (moisture) content of soil and rock. All relevant information for the Torvane measurements and constant volumes was recorded on data sheets and input into spreadsheets to be incorporated into the physical property database.

After measurements were made and samples taken, inert packing was placed in the voids created by the constant volume sampling, and the ends of each core section were re-capped, taped and sealed with wax to prevent drying. The sealed core sections were stored upright in the refrigerated reefer container and maintained at 4°C. All core cutters and catchers were measured, labelled, placed in split liners, waxed and stored upright in buckets in the refrigerated container. All extruded core sections due to sediment expansion or core processing methods were likewise labelled and stored. All samples and subsamples were catalogued and their location information within the container was recorded in a spreadsheet.

When the ship returned to the Bedford Institute of Oceanography, the cores were transferred to the GSC Sample and Core Repository where they are maintained at a constant temperature of about 4°C. The cores will be split, logged, and subsampled.

System performance

The GSCA long core system continued to work well on *Hudson* 2011036, penetrating a variety of seabed sediments. Good dialogue between the Chief Scientist, coring technicians and boatswain allowed for the proper deck setup and split piston orifice to be selected. The initial pilot core barrel and weights were lost early on in the expedition so a spare unit was quickly brought onto the foredeck for the subsequent drops. The main pipe thread connection between the head and barrel was carefully examined on the new system and tightened further as the lost barrel appeared to have unscrewed from the head. Future core assemblies will have a safety bolt through to prevent the head from unscrewing from the barrel.

Core extrusion operations in the half height container were assisted with several tools developed pre-field season. An aluminum core pushing tool (Robertson, Morton, Peters, GSCA-DFO, 2011) was designed and fabricated to slide over the standard diameter core barrel and make contact with the CAB liner circumference within the barrel not disturbing the delicate sediment face. This tool proved to be very effective in the majority of sample extrusions bypassing the need to use the slower hydraulic procedure and was far safer for the operator and sample (Fig. 76).

On the opposite end of the core barrel during the extrusion process another tool was developed (Robertson, Morton, Peters, GSCA-DFO, 2011) that allowed the liner to be held and pulled once an initial push was accomplished as described above. This tool had a secondary feature to allow the core liner to be held firmly while the stainless steel radial cutting tool was used to cut the liner. This tool sped up the extraction process and provided a safer ergonomic method of holding the sample and liner (Fig. 77).

A stationary clamp tool at the prototype stage was also available for this mission allowing the extruded core liner to be clamped while cutting. It had very minor use as there were almost always two core technicians in the container so one could cut while the other used the handheld clamp tool. This was the second year for the core table clamp and vertical cutting ring guide (Robertson and Peters, GSCA-DFO, 2010). These proved very useful in the core processing section of the GP lab effectively allowing one person to safely and accurately cut a core to length (Fig. 78).

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Table 5. *Hudson* 2011036 image data.

Station No.	JD	Date	On bottom time	Off bottom time	Elapsed bottom time (s)	Transect distance (m)	On bottom depth (m)	On bottom latitude	On bottom longitude	Off bottom depth (m)	Off bottom latitude	Off bottom longitude	No. of seabed stills	Tool
2	243	31-Aug	20:44:08	20:55:35	690	868.57	77.69	44.723015	-65.906605	86.28	44.720477	-65.916214	15	DI
7	244	01-Sep	13:13:41	13:28:35	894	305.15	105.3	44.920321	-66.68165	105.13	44.921378	-66.682758	26	4K+VCB
29	246	03-Sep	12:18:39	12:45:24	1605	553.72	47.35	45.259385	-65.660563	47.35	45.259321	-65.660488	55	DI
35	246	03-Sep	17:52:30	18:17:32	1500	326.68	65.59	45.205988	-65.481222	63.89	45.208043	-65.480154	80	DI
52	247	04-Sep	17:04:31	17:34:31	1800	612.77	51.4	45.298320	-65.079280	51.78	45.297946	-65.073808	79	DI
69	248	05-Sep	15:44:41	16:10:50	1569	801.54	39.34	45.317853	-64.548038	77.28	45.326261	-64.553634	38	4K+VCB
70	248	05-Sep	16:37:24	16:44:48	443	253.08	43.3	45.330938	-64.527693	70.69	45.335502	-64.528733	11	4K+VCB
83	249	06-Sep	16:41:36	17:01:04	1168	209.73	62.45	45.200581	-65.202713	63.25	45.200051	-65.204306	65	DI
91	250	07-Sep	12:02:13	12:22:40	1227	544.62	217.85	44.387416	-66.593309	216.73	44.388797	-66.588597	61	DI
92	250	07-Sep	13:49:47	14:19:59	1812	1088	72.75	44.215856	-66.09803	43.69	44.203302	-66.617615	98	DI
93	250	07-Sep	16:18:44	16:38:59	1815	308.33	178.57	44.445658	-66.366792	180.05	44.445518	-66.369544	64	DI
107	251	08-Sep	15:36:26	15:56:11	1184	250.81	102.2	45.566895	-64.739987	104.33	45.564818	-64.741773	58	DI
121	252	09-Sep	15:09:57	15:40:09	1815	853.47	74.3	45.269801	-64.822464	53.25	45.270116	-64.829938	86	DI
151	254	11-Sep	10:53:27	11:09:56	990	198.5	68.09	44.986242	-66.651742	75.05	44.987489	-66.650150	48	DI
154	254	11-Sep	12:39:08	12:51:09	720	168.93	70.82	44.983589	-66.752672	70.58	44.983691	-66.751163	37	DI
157	254	11-Sep	15:11:07	15:31:21	1215	270.59	103.71	44.801908	-66.864292	105.42	44.803382	-66.862005	61	DI
158	254	11-Sep	16:37:57	16:57:57	1200	347.65	81.45	44.669349	-66.936834	82.28	44.666262	-66.935077	68	DI
159	254	11-Sep	17:50:15	18:20:45	1831	168.26	82.19	44.631346	-66.984778	86.37	44.628537	-66.985458	89	DI
167	255	12-Sep	19:55:30	20:05:01	570	173.45	109.96	44.713941	-66.321681	109.77	44.714340	-66.322526	31	DI
176	257	14-Sep	09:33:11	10:04:20	1860	463.78	36.97	44.515630	-66.682707	38.43	44.511224	-66.683882	99	DI
177	257	14-Sep	11:55:44	12:26:00	1815	674.99	48.47	44.216498	-66.583905	57.01	44.226231	-66.581411	93	DI
178	257	14-Sep	12:51:54	13:21:35	1785	933.46	61.1	44.225453	-66.561402	84.98	44.238007	-66.557689	77	DI

DI: DeepImager

4K+VCB: 4K camera with VladCam Bullet attached

Table 6. *Hudson* 2011036 core stations.

Station No.	Sample Type	Subcore	Day/Time (UTC)	Latitude (°N) Longitude (°W)	Water Depth (m)	Corer Length (m)	App. Penn. (cm)	Core Length (cm)	No. of sections	Location	Comments
0017	Piston		244 / 1918	44.852835 66.393283	131.90	610	609.6	22.0	1	Bay of Fundy - North Grand Manan Basin	In water 1912, at surface 1923, on deck 1938. PC recovered 22cm of very fine clay with minor silt and visible catcher grooves and deformation.
		Trigger					213.36	194.5	2		TWC recovered grey homogenous very silty clay with AA' 4cm.
0021	Piston		245 / 1123	44.703343 66.420586	166.00	915	915	280.0	2	Bay of Fundy - North Grand Manan Basin	In water 1114, at surface 1136, on deck 1151. PC recovered brown clay at the base transitioning to a brown and black mottled appearance at base of BC (approx 110 cm from surface). As on board sampling was completed minute gas like fracturing visible at base (40cm), PC cutter/catcher 20cm.
		Trigger					0.0	0.0	0		TWC was spinning in the current as it was lowered in the water and was lost.
0022	Piston		245 / 1336	44.737318 66.475318	163.90	915	850	414.5	3	Bay of Fundy - Grand Manan Basin	In water 1332, at surface 1345, on deck 1359. PC had small gas fracturing throughout; sections AB and BC showed sediment separation up to 4cm and holes were drilled in the liner to allow gas venting. Dark grey at base transitioning to brown closer to sediment surface. PC cutter/catcher 18cm.
		Trigger						0.0	0		TWC fell over and no recovery.
0023	Piston		245 / 1613	44.545873 66.426440	209.90	915	612	266.0	2	Bay of Fundy - Grand Manan Basin	In water 1606, at surface 1620, on deck 1636. PC cutter very stiff plastic clay, mottled brown and black sediment throughout the core with pebbles at the sediment surface. PC cutter/catcher 27cm.
		Trigger					107.0	0.0	0		TWC fell over and approx 30cm observed to fall out as coming on deck, residue of gravelly mud in TWC cutter was retained.
0076	Piston		249 / 1130	45.044005 65.513446	80.50	915	750	199.0	2	Bay of Fundy - Central Bay of Fundy	In water 1127, at surface 1132, 72m of wire out. PC recovered stiff reddish brown mud at the base transitioning to sand and then gravelly sand approx 40 cm below surface. Several pebbles up to 40mm at surface and one 10mm pebble at the top of AB. PC tip 9cm and cutter/catcher 22cm.
		Trigger						0.0	0		Trip arm broken and replaced. No recovery in TWC
0089	Piston		250 / 1031	44.385094 66.592305	218.00	915	609.6	263.5	2	Bay of Fundy - Southern Grand Manan Basin	In water 1028, at surface 1035, 226m of wire out. PC recovered stiff reddish brown mud at the base transitioning to a sandy gravel at approximately 60 cm below surface. PC tip 8cm and cutter/catcher 22cm.
		Trigger					30.0	9.0	1		TWC apparent penetration 30cm, 9cm disturbed gravelly sediment in TWC catcher retained.
0162	Piston		255 / 1034	44.837584 66.769135	140.00	915	760	433.0	3	Bay of Fundy - Owen Basin	In water 1032, at surface 1038, 138m of wire out. PC tip is brown, gray and olive firm plastic mud and sediment surface is dark brown mud with minor fine sand. PC tip 9cm, cutter/catcher 22.5cm and CC' 2cm. Core mislabeled as Station 0161.
		Trigger					130.0	29.0	1		Recovered 10cm AB, 11cm catcher and 8cm cutter of mottled back and brown plastic clay.
0163	Piston		255 / 1243	44.866590 66.833045	129.00	915	910	489.5	4	Bay of Fundy - Owen Basin	In water 1240, at surface at 1246, 126m of wire out. PC contains brown and black mottled sediment which sometimes appears to be speckle-like, pebbles at surface and section breaks. Core mislabeled as Station 0162.
		Trigger					70.0	11.0	1		TWC recovered 11cm with gravel at surface.
0164	Piston		255 / 1533	44.845548 66.651828	129.00	915	914.4	470.5	4	Bay of Fundy - Owen Moraine	In water 1532, 129m of wire out. Core mislabeled as Station 0163.
		Trigger					152.0	125.0	1		
0165	Piston		255 / 1714	44.852834	134.00	915	918	434.5	3	Bay of Fundy -	In water 1711, 137m of wire out. PC cutter/catcher 19.5cm and tip 7cm.

				66.372937						North Grand Manan Basin	
		Trigger					140.0	104.5			
0166	Piston		255 / 1910	44.715374 66.323366	109.00	915	240	73.0	1	Bay of Fundy - Grand Manan Basin	In water 1905, at surface 1912, 115m of wire out. PC 14cm cutter/catcher.
		Trigger					0.0	4.0			Recovered 4cm in the catcher/cutter and small sample from cutter put in vial
0168	Gravity		256 / 1017	44.849401 66.393520	133.00			0.0	0	Bay of Fundy - North Grand Manan Basin	First attempt in water 1007, on bottom 1008, at surface 1011, no recovery. Second attempt, in water 1015, at surface 1011, 142m of wire out, no recovery.
0171	Gravity		256 / 1518	44.921320 66.676545	106.00	274	170.0	168.0	1	Bay of Fundy - The Wolves	In water 1516, at surface 1521, 120m of wire out. Recovered 164cm of brown muddy sediment.
0172	Gravity		256 / 1539	44.964126 66.663718	76.00	274	180.0	139.0	1	Bay of Fundy - The Wolves	In water 1538, at surface 1541, 90m of wire out. Recovered 143cm of brown muddy sediment.
0173	Gravity		256 / 1553	44.986563 66.648152	70.00	274	230	200.5	2	Bay of Fundy - The Wolves	In water 1553, 75m of wire out. Recovered 200.5cm of brown muddy sediment.
0174	Piston		256 / 1722	44.950603 66.392052	107.00	915	0.0	96.0	1	Bay of Fundy - North Grand Manan Basin	In water 1714, at surface 1725, 101m of wire out. PC is brown mud.
		Trigger					335.0	4.0			Approx 4cm disturbed section containing some gravel was bagged.
0175	Piston		256 / 1904	44.920404 66.365385	117.00	915	671.0	4.0	1	Bay of Fundy - North Grand Manan Basin	In water 1847, 11m of wire out, cutter damaged. Recovered 4cm sample of brown mud.
		Trigger					183.0	138.0	1		TWC recovered 138cm, 8cm tip, 17cm cutter/catcher and contained some loose pebbles.

Table 7. *Hudson* 2011036 grab stations.

Station No.	Sample Type	Subcore	Day/Time (UTC)	Latitude (°N) Longitude (°W)	Water Depth (m)	Recovered Length (m)	Location	Comments
0005	IKU		244 / 1148	44.920688 66.681721	99.90	0	Bay of Fundy - The Wolves	Five attempts were made but the IKU did not trip on any attempt, on the third attempt a sample was taken from the exterior surface of the IKU jaws at approx 20cm from the base of the jaws.
0006	Van Veen		244 / 1230	44.918985 66.680895	100.80	0	Bay of Fundy - The Wolves	Two attempts were made but the Van Veen sampler did not trip and no sample was recovered. Second attempt on the bottom 1239.
0008	IKU		244 / 1333	44.921901 66.682006	100.00	0	Bay of Fundy - The Wolves	IKU in water 1333, on surface 1335, IKU did not trip, no sample recovered.
0010	IKU		244 / 1425	44.963715 66.664830	71.80	0	Bay of Fundy - The Wolves	Two attempts but IKU did not trip and no sample recovered. First attempt IKU in water 1424, second attempt in water 1428, on bottom 1429 and on surface 1431.
0011	IKU		244 / 1519	44.982217 66.653000	68.80	0	Bay of Fundy - The Wolves	IKU in water 1518, at surface 1520, IKU did not trip, no sample recovered.
0012	IKU		244 / 1605	44.926970 66.131300	76.70	0	Bay of Fundy - North Grand Manan Basin	84 metres of wire out, two attempts but IKU did not trip and no sample recovered. First attempt IKU in water 1601, on bottom 1602, at surface 1603. Second attempt on bottom 1605 and at surface 1607.
0013	IKU		244 / 1646	44.895200 66.498800	99.00	0	Bay of Fundy - North Grand Manan Basin	IKU in water 1644, on surface 1648, IKU did not trip, no sample recovered.
0014	Van Veen		244 / 1658	44.893400 66.496600	108.70	20	Bay of Fundy - The Wolves	In water at 1655, at surface at 1700, sampler full and 20cm sample recovered. Reddish brown mud on the surface with biology of 0phiuroids and shrimp-like crustaceans. 3 vials of sample taken, 0-5cm of grey coloured layer with organic content, 0-20cm of blended mixed sample and 15-20cm.
0015	IKU		244 / 1759	44.854000 66.394900	131.90	30	Bay of Fundy - North Grand Manan Basin	IKU in water 1757, on surface 1802, partial wash out on the sides of the IKU. Recovered 30cm of brown muddy silt to very fine sand on the surface, and fine to very fine sand at the base. Biology includes brittle stars, 3 different types of molluscs, tooth shells, polychaetes, caprilid amphipods and shrimp-like crustaceans. Samples taken at E include bagged bulk sample 0-5cm for OBS calibration, profile sample 20-25cm and at EE a DFO surface subsample 0-2cm was taken.
0024	IKU		245 / 1858	44.689261 65.888343	106.00	30	Bay of Fundy - Grand Manan Basin	IKU in water 1855, at surface 1901, on deck 1904, 109m of wire out. IKU jaws held open by shells so may have lost most of sample; recovered 30cm of grey well sorted medium sand with shell fragments and gravel ranging from a few mm to 5cm and one boulder 23cm by 12cm. Biology in the IKU includes bryozoans and asterias seastar. Samples taken at B include 0-5cm, profile samples of sand at 5-10cm and 15-20cm. In addition a bucket bulk sample was taken and a DFO surface subsample was taken at BB.
0025	IKU		245 / 1946	44.690195 65.894720	160.00	50	Bay of Fundy - Digby Drumlin Field	IKU taken on the flank of a drumlin, 91m of wire out but acoustic depth is 160m. Partial wash out as pebbles caught in the jaws. Recovered 50cm of sorted gravelly coarse sand with shell fragments, sediment fining with depth, pebbles ranging in size from a few mm to 5cm. Biology includes bryozoans, molluscs, barnacles and polychaetes. At F a 0-5cm surface sample and 0-10cm bagged bulk sample were taken.
0027	IKU		246 / 1053	45.258777 65.666574	52.00	23.0	Bay of Fundy - East Red Head	IKU in water 1051, at surface 1054, 45m of wire out at approx angle of 15 degrees. IKU hit bottom at an angle and recovered small sample (23cm) of gravelly fairly sorted medium to coarse sand with shell hash, sediment becomes coarser at approx. 20cm. 19-24cm sample taken at B, 0-5cm surface sample taken at A and a DFO surface subsample was taken at BB.
0028	IKU		246 / 1133	45.257958 65.662046	41.00	70.0	Bay of Fundy - East Red Head	IKU in water 1131, at surface 1135. Recovered 70cm of very coarse sand to granules (semi rounded) with abundant shell hash. Samples taken at E include 0-5cm, 5-10cm and 55-60cm with a DFO surface subsample taken at DD.
0032	IKU		246 / 1421	45.261293 65.717514	26.90	88.0	Bay of Fundy - McCoy Head	IKU in water 1420, at surface 1421, on deck 1423, 23m of wire out. Recovered 88cm reddish-brown, well sorted, medium sand with fine shell hash, shell hash abundance increases below 15cm and at 15 to 18cm is an anoxic layer. 0-5cm surface sample taken at G, 10-12cm sample taken at H and a DFO surface subsample was taken at GG.
0033	IKU		246 / 1535	45.358119 65.431600	38.60	50.0	Bay of Fundy - Fownes Head	IKU in water 1534 and at surface 1536. IKU hit bottom at an angle and some sample wash out. Recovered 50cm reddish-brown, well sorted fine to medium sand with minor amount of fine shell hash. 0-5cm surface sample taken at G and a DFO surface subsample was taken at GG.

0034	IKU		246 / 1706	45.206857 65.481857	70.00	60.0	Bay of Fundy - SW Quaco Ledge	IKU in water 1703 and at surface 1707. IKU taken at gas site and recovered 60cm gravelly coarse sand with shell fragments, gravel ranges in size from a few mm to 3-5cm, red clay clast on the surface, at approx 12cm layer of mixed mud, coarse sand and shell. In the profile the texture is uniform but several mud clasts noted. At E a 6-21cm sample and a sand clast sample (approx 35cm) were taken. A 0-5cm surface sample was taken at G and a DFO surface subsample was taken at GG.
0038	IKU		246 / 1956	45.309075 65.540439	43.00	90.0	Bay of Fundy - Quaco Head	43m of wire out. Recovered 90cm of well sorted, medium sand with occasional shell hash throughout. 0-5cm surface sample taken at G and a DFO surface subsample taken at GG.
0041	IKU		247 / 1029	45.295315 65.034004	58.00	55.0	Bay of Fundy - NW Ile Haute	IKU in water 1028 (58m), at surface 1031 (58.3m), 64 m of wire out. Full bucket and recovered 55cm of well sorted, fine to medium sand with shell hash with shell hash layers at 10 to 15cm and 23 to 30cm. 0-5cm surface sample taken at D and a DFO surface subsample was taken at DD.
0042	IKU		247 / 1101	45.298824 65.061903	52.00	50.0	Bay of Fundy - NW Ile Haute	IKU in water 1100 (54m), at surface 1103 (57m), 65 m of wire out. Recovered 50cm of well sorted, fine to medium sand with fine shell hash, shell hash content increases at 12cm. 0-5cm surface sample taken at D and a DFO surface subsample taken at DD.
0043	IKU		247 / 1139	45.309865 65.091086	51.00	30.0	Bay of Fundy - NW Ile Haute	IKU in water 1138, at surface 1140, 57m of wire out. Recovered 30cm of well sorted, medium sand with abundant whole shells and shell fragments (scallops, mussels and sand dollars), minor gravel on the surface and several pebbles and cobbles down section, red mud clasts at 13cm and shell concentration increases at approx. 10cm. 0-5cm surface sample taken at F, 15-20cm sample taken at I and a DFO surface subsample was taken.
0044	IKU		247 / 1225	45.307070 65.090228	48.00	30.0	Bay of Fundy - NW Ile Haute	First attempt in water 1212, on bottom 1213, at surface 1215, IKU did not trip and no sample recovery. Second attempt in water 1225, at surface 1226, 53m of wire out. IKU full and recovered 30cm of well sorted gravelly medium sand with abundant whole shells and shell fragments (scallop and mussel), shell concentration increases at approx 13cm. 0-5cm surface sample taken at G and a DFO surface subsample taken at GG.
0045	IKU		247 / 1304	45.302846 65.089242	45.00	50.0	Bay of Fundy - NW Ile Haute	IKU in water 1304, at surface 1306, 50m of wire out. Recovered 50cm of homogeneous well sorted fine to medium sand with fine shell hash and a few whole shells. 0-5cm surface sample taken at C and a DFO surface subsample taken at CC.
0048	IKU		247 / 1414	45.295569 65.087451	42.00	65.0	Bay of Fundy - NW Ile Haute	IKU in water 1413 (42m), at surface 1416 (46m), 47m of wire out. Recovered 65cm of well sorted fine to medium sand with minor amounts of fine shell hash, at approx 10cm is a 5cm layer with more abundant shells. 0-5cm surface sample taken at E, 10-15cm sample taken at H and a DFO surface subsample taken at EE.
0049	IKU		247 / 1508	45.288454 65.086411	51.00	80.0	Bay of Fundy - NW Ile Haute	IKU in water 1507, at surface 1509, 52m of wire out. Recovered 80cm of well sorted medium sand with multiple shell hash layers (1 to 2cm thick) in the top 20cm, and biology included worms. 0-5cm surface sample taken at C and a DFO surface subsample taken at CC.
0050	IKU		247 / 1542	45.284174 65.086357	53.00	35.0	Bay of Fundy - NW Ile Haute	First attempt on bottom 1533, at surface 1535, IKU jaws held open by a rock and no sample recovered. Second attempt in water 1541, at surface 1543, on deck 1545, 52m of wire out, jaws slightly open and partial washout of sediment. Recovered 35cm with a 3 to 5cm surface gravel lag layer (gravel a few mm to 10cm) over silty fine to medium sand with increasing gravel content with depth. Granules and pebbles are semi to well rounded and shell fragments are present. Biology includes sand dollars. 0-5cm bagged bulk sample and 15-18cm sample taken at H.
0051	IKU		247 / 1621	45.292981 65.133363	52.00	50.0	Bay of Fundy - NW Ile Haute	First attempt in water 1614, on bottom 1615, at surface 1616, no sample recovered. Second attempt in water 1621, at surface 1623, partial washout of sediment. Recovered 50cm of homogeneous well sorted medium sand with fine shell hash. 0-5cm surface sample taken at D.
0054	IKU		247 / 1916	45.301892 64.826121	30.00	65.0	Bay of Fundy - West Cape D'Or	First attempt on bottom 1912, at surface 1913, no sample recovered. Second attempt in water 1916, at surface 1917, 30m of wire out, surface layer washed out due to strong currents. Recovered 65cm with a 7cm surface layer of well sorted medium sand with minor fine shell hash over 14cm of weakly stratified well sorted medium sand with abundant shell hash over 12cm of well sorted, medium sand with minor fine shell hash. Peel taken at A-B and labeled as A and a 0-5cm surface sample taken at D.
0054A		Peel				51.0		
0058	IKU		248 / 1039	45.308609 64.557794	32.00	80.0	Bay of Fundy - Scots Bay Banner Bank	First attempt in water 1025, on bottom 1026, at surface 1027, did not trip. Second attempt in water 1027, on bottom 1028, at surface 1029, did not trip. Third attempt on bottom 1030, at surface 1031, did not trip. Fourth attempt at surface 1040, 33m of wire out. Recovered 80cm of gravelly coarse sand with some shell hash, granules and pebbles are semi angular to semi rounded, from 10cm to 20cm the shell hash becomes coarser and more abundant and below this the grain size becomes finer. 0-5cm sample taken at G and a

								15-45cm sample taken at E.
0059	IKU		248 / 1059	45.320214 64.557646	72.00	90.0	Bay of Fundy - Scots Bay Banner Bank	IKU in water 1058, at surface 1101, 80 m of wire out, bungee cord for the IKU trip mechanism broke and was repaired. Recovered 90cm of well sorted very coarse sand with pebbles and granules and minor shell hash. The lag layer is 6cm below surface and the profile is uniform. 0-5cm sample taken at I.
0060	IKU		248 / 1136	45.316673 64.547494	23.60	50.0	Bay of Fundy - Scots Bay Banner Bank	IKU in water 1136 (22.5m), at surface 1137, 26m of wire out, sample washed out due to the strong currents. Recovered 50cm of homogeneous well sorted, medium sand with shell hash and some gravel, shell hash content increases at 10cm below surface. 0-5cm sample taken at A.
0061	IKU		248 / 1157	45.312728 64.535365	39.00	30.0	Bay of Fundy - Scots Bay Banner Bank	IKU in water 1156, at surface 1158, 41m of wire out, one side partially washed out due to the strong currents. Recovered 30cm of well sorted medium to coarse sand with granules (up to approx. 4mm), shell hash and occasional pebbles. At approx. 6cm shell hash content increases and sediment becomes more gravelly. 0-5cm sample taken at G.
0062	IKU		248 / 1215	45.311608 64.532515	41.00	30.0	Bay of Fundy - Scots Bay Banner Bank	IKU at surface 1217, 44m of wire out, jaws held open by rocks and partial wash out of sample. Recovered 30cm with a lag layer of pebbles (approx. 3cm) and cobbles (30 x 18cm) with some fine shell hash and whole shells, over a fine sand with occasional red mud clasts. One 11.5l bucket of lag layer (estimated depth of 0-5cm) taken at C, mud clast sample (unknown depth) taken at H and a 0-5cm sample taken at I.
0063	IKU		248 / 1248	45.323253 64.538050	32.40	55.0	Bay of Fundy - Scots Bay Banner Bank	First attempt in water 1236, on bottom 1237, at surface 1238, did not trip. Second attempt in water 1240, on bottom 1241, at surface 1242, did not trip. Third attempt in water 1243, on bottom 1243, at surface 1244, did not trip. Fourth attempt at surface 1249, partial wash out, 33m of wire out. Recovered 55cm of homogeneous well sorted clean medium sand with fine shell hash. 0-5cm sample taken at A.
0064	IKU		248 / 1314	45.329991 64.52849	43.00	30.0	Bay of Fundy - Scots Bay Banner Bank	First attempt on bottom 1306, at surface 1307, cobbles stuck in jaw, no recovery. Second attempt in water 1313, 48m of wire out, rocks in jaw but only partial wash out of sample. Recovered mostly pebble and cobble lag with some medium to coarse sand, the gravels are semi to well rounded and range in size from a few cm to 33cm x 14cm. Sand suspected to be underneath the gravel lag and mud was attached to the bottom half of some of the cobbles. No samples were taken.
0065	IKU		248 / 1353	45.289148 64.544255	35.00	20.0	Bay of Fundy - Scots Bay Barchan Dunes	First attempt in water 1347, on bottom 1348, at surface 1349, rocks holding jaws open, no recovery. Second attempt at surface 1355, 40m of wire out, rocks in jaw but only partial wash out of sample. Recovered 20cm of lag layer of cobbles and boulders on top of gravelly medium sand, shell hash and whole shells, some boulders have sand sediment underneath and seem to be cemented by biological activities. Sample of boulders (40x22cm, 40x26 and 15x25cm) photographed and bagged.
0066	IKU		248 / 1421	45.286241 64.539916	32.00	45.0	Bay of Fundy - Scots Bay Barchan Dunes	First attempt in water 1412, on bottom 1413, at surface 1414, rocks stuck in jaws, no recovery. Second attempt at surface 1422, 35m of wire out, rocks in jaw but only partial wash out of sample. Recovered 45cm of well sorted medium sand with shell hash and whole shells, 8cm surface sand layer on top of 3cm sandy shell hash layer with a second 10cm shell hash layer at 20cm depth, base of IKU included shell hash and pebbles. 0-5cm sample taken at G.
0071	IKU		248 / 1740	45.286485 64.677430	47.00	25.0	Bay of Fundy - Minas Channel	IKU in water 1739, at surface 1741, 60m of wire out. Recovered 25cm of sediment with a gravel lag (semi to well rounded and ranging in size from 1-5cm) surface layer over very coarse sand. Bagged sample (unknown depth) taken at G.
0072	IKU		248 / 1901	45.265892 64.833166	75.00	35.0	Bay of Fundy - SW Cape D'Or	First attempt in water 1842, on bottom 1843, at surface 1844, no recovery. Second attempt in water 1854, on bottom 1855, at surface 1857, no recovery. Third attempt at surface 1903, 87m of wire out. Recovered 35cm of compact reddish clay, surface layer has a grayish colour, visible worm burrows and one semi rounded pebble, mud occurs as mud clasts possibly due to grabbing impact. Biology includes Anemone and crustaceans. Push core labeled A but taken at D and 5 litre bucket bulk sample taken at C.
0072A		Push				24.0		
0073	IKU		248 / 2008	45.269617 64.832676	55.00	00.0	Bay of Fundy - SW Cape D'Or	First attempt in water 1954, on bottom 1955, at surface 1956, rock caught in jaws, photographed but not retained. Second attempt in water 1957, on bottom 1958, at surface 1959, rock caught in jaws, cobble (31x6cm) with biological growth on it was photographed but not retained. Third attempt at surface 2009, 62m of wire out, rock caught in jaws, no recovery.
0077	IKU		249 / 1305	45.105548 65.281055	85.00	60.0	Bay of Fundy - Central Bay of Fundy	IKU in water 1304 (85m), at surface at 1307, 91m of wire out. Recovered 60cm of well sorted medium sand with shell hash and whole shells. 5cm thick shell hash layer at 8cm, 3cm thick shell has layer at 24cm, 15cm layer with abundant whole shells at 38cm and a few individual shells were encountered in the profile. 0-5cm sample taken at C.
0078	IKU		249 / 1350	45.111327 65.288042	83.00	45.0	Bay of Fundy - Central Bay of Fundy	First attempt in water 1340, on bottom 1349, at surface 1343, rocks caught in jaws and sample washed out. Second attempt in water 1349, at surface 1351, 88m of wire out, sample half washed out. Recovered 45cm

								of well sorted, fine to medium sand with fine shell hash and whole shells, with some granules on surface. Approx. 3-5cm surface sand layer over a 2-3cm thick shell hash layer with another 15cm thick shell hash layer at approx. 20cm. 0-5cm sample taken at H.
0079	IKU		249 / 1435	45.183006 65.244985	68.00	55.0	Bay of Fundy - Central Bay of Fundy	IKU in water 1434, at surface 1437, 75m of wire out. Recovered 55cm of well sorted fine to medium sand with shell hash and shell fragments, semi angular to semi rounded granules on surface. Profile shows a 7cm thick sand layer over a 8cm thick shell hash layer over a 15cm thick sand layer over a 15cm shell fragment hash layer to the base. Biology includes clams and bryozoans. 0-5cm sample taken at C.
0082	IKU		249 / 1618	45.201553 65.202226	58.00	20.0	Bay of Fundy - Central Bay of Fundy	IKU in water 1618, at surface 1620, 61m of wire out, gravel caught in the jaws and partial wash out of sample. Recovered 20cm sample of a gravel lag layer overlaying gravelly, medium sand with some shell fragments, red muddy sand also found in the matrix, gravels are semi angular to semi rounded and range from a few mm to 15cm. Mud sample (unknown depth) taken at B and sand sample (unknown depth) taken at G.
0084	IKU		249 / 1725	45.204529 65.181582	68.00	70.0	Bay of Fundy - Central Bay of Fundy	IKU in water 1724, at surface 1726, 71m of wire out, partial wash out of sample. Recovered 70cm sample of well sorted fine to medium sand with small shell fragments. 0-5cm sample taken at D.
0085	IKU		249 / 1758	45.213268 65.175578	70.00	20.0	Bay of Fundy - Central Bay of Fundy	First attempt in water 1747, on bottom 1748, at surface 1750, no sample recovery. Second attempt in water 1757, at surface 1759, 75m of wire out, rocks caught in the jaws and partial wash out of sample. Recovered 20cm of well sorted fine to medium sand with minor shell hash, semi rounded to rounded pebbles (a few cm to 16x8cm, some have mud clasts attached to them) and one boulder (42x23x18cm). Biology includes two whole clam shells. 0-5cm sample taken at I.
0086	IKU		249 / 1813	45.210975 65.171398	72.00	50.0	Bay of Fundy - Central Bay of Fundy	IKU in water 1812, at surface 1815, 76m of wire out, partial wash out on one side. Recovered 50cm sample of well sorted medium sand some granules, shell fragments and whole shells, shell hash abundance increases at approx 40cm. No sample retained.
0090	IKU		250 / 1135	44.385204 66.592296	219.00	70.0	Bay of Fundy - Southern Grand Manan Basin	IKU in water 1133, at surface 1141, 236m of wire out. Recovered 70cm sample with a 3cm surface gravel lag over red sandy mud, gravels angular to well rounded and range in size from a few mm to 15cm, a 5cm thick layer of red clay mixed with small pebbles at the base. Biology includes sponges, brittle stars, bryozoans, anemones, and brachiopods. Push core labeled A taken at D and a bagged bulk sample taken at E.
0090A		Push				57.0		
0094	IKU		250 / 1718	44.446272 66.366172	177.00	45.0	Bay of Fundy - Grand Manan Basin	IKU in water 1716, at surface 1722, 189m of wire out. Recovered 45cm sample with a surface layer of gravelly (semi rounded to semi angular, ranging in size from 0.5cm to 18cm) muddy fine sand with a few shell fragments overlaying a grey clay. Biology includes barnacles on a cobble. No sample retained.
0095	IKU		250 / 1814	44.531065 66.484644	151.00	100.0	Bay of Fundy - Grand Manan Basin	IKU in water 1813, at surface 1818, 162m of wire out. Recovered 100cm with a surface lag layer of pebbles and cobbles (semi angular to semi rounded) and muddy sand matrix, overlying red clay. Push core labeled A but taken at B.
0095A		Push				46.0		
0098	IKU		251 / 1039	45.504822 64.923868	80.00	70.0	Bay of Fundy - Chignecto Bay	First attempt in water 1033, on bottom 1034, at surface 1036, did not trip. Second attempt in water 1037, at surface 1042, 87m of wire out, pebbles caught in the jaws and partial wash out of sample. Recovered 70cm with a 5cm surface gravel (pebbles semi rounded, cobbles semi angular) lag layer with a muddy medium sand matrix, overlying 10cm of red sandy mud with grey sandy mud at the base. Samples taken at E include 25-30cm of reddish mud and 38-43cm of grey mud. Bagged bulk sample taken at H.
0099	IKU		251 / 1137	45.552736 64.874220	36.00	60.0	Bay of Fundy - Chignecto Bay	IKU in water 1136, at surface 1139, 37m of wire out. Recovered 60cm sample with a 3-5cm surface lag layer of muddy medium to coarse sand with gravel, over a 5cm reddish sandy mud, over gray silty mud to the base. Samples taken at E include 0-5cm bagged bulk sample, 8-13cm of reddish mud and 20-25cm of grey mud.
0100	IKU		251 / 1216	45.532204 64.790529	44.00	105.0	Bay of Fundy - Chignecto Bay	First attempt on bottom 1214, at surface 1215, no recovery. Second attempt in water 1215, at surface 1218, 48m of wire out. Full bucket and recovered 105cm with a 3-5cm surface lag layer of gravelly sandy mud (gravels are semi angular to semi rounded and range in size from a few mm to 15cm) with a few shell fragments. Below lag is a uniform reddish brown sandy mud with occasional pebbles. 0-5cm bagged sample taken at H and 25-30cm sample taken at B.
0101	IKU		251 / 1252	45.566855 64.738499	123.00	50.0	Bay of Fundy - Chignecto Bay	IKU in water 1251, at surface at 1255, 133m of wire out, 50cm boulder caught in the jaws and sample washed out. Recovered 50cm of gravelly (pebbles and cobbles) sandy sediment with the one boulder. Photos taken of IKU but no sample retained.

0104	IKU		251 / 1412	45.589173 64.764455	37.00	70.0	Bay of Fundy - Chignecto Bay	IKU in water 1411, at surface at 1413, 41m of wire out. Recovered 70cm of well sorted medium sand with shell fragments and whole shells with a few granules on the surface. 2-3cm lag layer of coarse sand at approx. 8cm and shell fragment abundance increases from 20cm to the base. 0-5cm sample taken at E.
0105	IKU		251 / 1442	45.583832 64.758315	63.00	65.0	Bay of Fundy - Chignecto Bay	66m of wire out, jaws open upon recovery of IKU. Recovered 65cm of pebbles and cobble lag with a muddy sand matrix and several boulders, gravels are semi angular to semi rounded and some red mud clasts also found. No sample retained.
0106	IKU		251 / 1505	45.576695 64.751631	42.00	70.0	Bay of Fundy - Chignecto Bay	IKU at surface 1506, 44m of wire out. Recovered 70cm with an approx. 7cm surface lag layer of granules to cobbles with a sandy mud matrix and minor shell fragments and whole shells. Pebbles and cobbles are mostly semi rounded, but some are semi angular. Biology includes bryozoans. No sample retained.
0108	IKU		251 / 1656	45.635200 64.671773	30.00	70.0	Bay of Fundy - Chignecto Bay	IKU in water 1655, at surface 1657, 35m of wire out. Recovered 70cm of gravelly coarse sand with some shell fragments, granules and small pebbles are semi angular to semi rounded. 11cm surface layer of coarse sand overlaying very coarse sand. Vague cross stratifications can be seen throughout the profile. 0-5cm sample taken at D.
0111	IKU		251 / 1916	45.460168 65.040042	37.00	40.0	Bay of Fundy - Mouth Chignecto Bay	First attempt in water 1907, on bottom 1908, at surface 1909, very little recovery, photographed but no sample retained. Second attempt in water 1915, at surface 1917, 38m of wire out, cobbles caught in jaws and partial wash out. Recovered 40cm with a thin layer of gravelly sand over brown sandy mud with pebbles throughout the profile. Several cobbles (majority semi rounded and 10-15cm in size, a few are semi angular) and boulders (largest boulder semi rounded and 45 x 24cm in size). No sample retained.
0116	IKU		252 / 1040	45.303147 64.845912	36.00	65.0	Bay of Fundy - West Cape D'Or	IKU in water 1040, at surface 1041, 42m of wire out. Recovered 65cm of well sorted, medium to coarse sand with semi rounded granules and shell hash. At 6cm there is a layer of coarser sand with more abundant shell hash and also observed a 5cm thick low angle lamination layer. Three 2-3cm layers of more abundant shell hash at 15cm, 21cm and 30cm depth. 0-5cm sample taken at A.
0117	IKU		252 / 1111	45.302417 64.833794	27.00	65.0	Bay of Fundy - West Cape D'Or	IKU at surface 1112, 29m of wire out. Recovered 65cm of well sorted, medium to coarse sand with shell hash and occasional granules. At 12cm there is a layer of coarser sand with low angle lamination that is approx. 12cm thick. 0-5cm sample taken at F.
0118	IKU		252 / 1131	45.297340 64.832538	36.00	70.0	Bay of Fundy - West Cape D'Or	IKU at surface 1133, 42m of wire out. Recovered 70cm of well sorted medium to fine sand with abundant shell hash, fragments and whole shells. At 8cm depth a 8cm layer of coarser sand with more abundant shell hash with a medium to high angle of stratification. At 18cm depth a 10cm layer with more abundant shell hash with medium to high stratification. At 30cm depth a 8cm layer with more abundant shell hash with a moderate angle of stratification. Shell hash abundance increases to the base. 0-5cm sample taken at A.
0119	IKU		252 / 1159	45.292366 64.832658	48.00	1.0	Bay of Fundy - West Cape D'Or	First attempt on bottom 1153, at surface 1155, sample washed out and no recovery. Second attempt in water 1158, at surface 1200, 55m of wire out, sample washed out and recovered a very small sample that was photographed but not retained.
0120	IKU		252 / 1318	45.216268 64.619364	44.00	45.0	Bay of Fundy - Halls Harbour	IKU at surface 1318, 48m of wire out. Recovered 45cm of a surface pebble and cobble lag layer (covered by abundant mussel growth) overlying a muddy gravel with some black anoxic layering below the surface. 0-5cm bagged bulk sample taken at C.
0122	IKU		252 / 1615	45.291046 64.807562	38.00	10.0	Bay of Fundy - West Cape D'Or	IKU in water 1614, at surface 1616, 45m of wire out. Recovered only 10cm of well sorted medium clean sand with fine shell hash and no visible stratigraphy. 0-5cm sample taken at A.
0123	IKU		252 / 1636	45.295753 64.818046	37.00	60.0	Bay of Fundy - West Cape D'Or	IKU at surface 1637, 27m of wire out, partial wash out occurred on one side. Recovered 60cm of well sorted fine to medium sand with fine shell hash. Surface is 5cm thick and there are two layers with more abundant shell hash and low angle stratification at depths of 10cm and 16cm. 0-5cm sample taken at F and peel taken at A to B.
0123A		Peel				28.0		
0124	IKU		252 / 1715	45.304061 64.818015	40.50	20.0	Bay of Fundy - West Cape D'Or	First attempt in water 1707, on bottom 1708, at surface 1709, boulder caught in jaws and no recovery. Second attempt at surface 1717, 41m of wire out. Recovered 20cm with a thin surface layer of reddish silty very fine sand (with abundant whole shells and shell fragments on the surface) overlying a mixed fine sand with gravel. The gravels are semi to well rounded, range in size from 1cm to 22cm have muddy sand stuck on the base. 0-5cm bagged bulk sample taken from G and 12-17cm sample taken at H.
0125	IKU		252 / 1815	45.290125 64.747146	37.00	10.0	Bay of Fundy - East Cape D'Or	First attempt in water 1806, on bottom 1807, at surface 1807, no recovery. Second attempt at surface 1816, 37m of wire out, IKU landed on an angle but the jaws closed properly. Estimated recovery of 10cm. Suspect that there was a lag layer of pebbles. Coarse sand found below the lag layer may be the matrix of the lag. Pebbles are semi angular to semi rounded. Entire sample bagged.
0126	IKU		252 / 1834	45.282053	45.00	45.0	Bay of Fundy - East	First attempt in water 1830, on bottom 1831, at surface 1832, did not trip, no recovery. Second attempt in

				64.747063			Cape D'Or	water 1833, at surface 1835, 50m of wire out. Recovered 45cm of well sorted coarse sand with granules, shell fragments and whole shells. Upper 10cm shows low angle stratification with coarser material at the base and profile below this is structureless. 0-5cm sample taken at B.
0127	IKU		252 / 1854	45.289168 64.731957	36.00	50.0	Bay of Fundy - East Cape D'Or	First attempt on bottom 1852, at surface 1853, did not trip, no recovery. Second attempt at surface 1855, 40m of wire out. Recovered 50cm of granules and semi rounded to well rounded pebbles ranging in size from 1cm to 5cm, with a trace of silt in the matrix. Gravel lag layer at the surface and the profile is structureless with pebbles throughout. 0-5cm bagged bulk sample taken at E.
0128	IKU		252 / 1913	45.282727 64.762976	38.00	75.0	Bay of Fundy - East Cape D'Or	IKU in water 1912, at surface 1914, 42m of wire out. Recovered 75cm of very coarse sand with pebbles and shell fragments. At 6cm depth there is a 5cm stratified layer (at a moderate angle) of coarser sediment with more abundant shell fragments. At 23cm another layer of coarser sediment with more abundant shell fragments and the abundance of pebbles increases towards the base. 0-5cm sample taken at H.
0131	IKU		253 / 1001	45.153201 65.114441	72.00	65.0	Bay of Fundy - Margaretsville Dune Field	IKU at surface 1003, 75m of wire out. Recovered 65cm of well sorted, medium sand with granules and shell fragments. At approx. 5cm depth is a 5cm stratified layer with more abundant shell fragments. From 35cm to base shell fragment abundance increases. 0-5cm sample taken at A.
0132	IKU		253 / 1037	45.156295 65.103719	76.00	65.0	Bay of Fundy - Margaretsville Dune Field	First attempt in water 1027, on bottom 1029, at surface 1030, did not trip, no recovery. Second attempt in water 1031, on bottom 1032, at surface 1034, did not trip, no recovery. Third attempt in water 1036, at surface 1038, 82m of wire out. Recovered 65cm of medium to coarse sand with shell hash, granules and pebbles. 10cm surface layer over 10cm layer of coarser sediment with less abundant shells. Shell abundance increase below this layer. 0-5cm sample taken at B.
0133	IKU		253 / 1201	45.183829 65.128329	56.00	70.0	Bay of Fundy - Margaretsville Dune Field	IKU at surface 1202, 61m of wire out. Recovered 70cm of gravelly coarse sand with shell fragments. 3cm surface layer overlying 12cm of coarse sand with less abundant shell fragments. Beneath this is a 10cm stratified layer of coarse sediment with more abundant shell fragments. 0-5cm sample taken at D.
0134	IKU		253 / 1219	45.196782 65.128697	52.00	45.0	Bay of Fundy - Margaretsville Dune Field	IKU at surface 1221, 57m of wire out, recovery not recorded on deck sheet so estimated as 45cm based on the description. Recovered medium sand with gravel and shell fragments. Surface 5cm has low angle stratification with increased shell and grain size to the base. 5 to 25cm has low to medium angle stratification and 25-45cm has medium angle stratification. Small pebbles observed throughout profile. 0-5cm sample taken at B.
0135	IKU		253 / 1235	45.195138 65.128279	54.00	10.0	Bay of Fundy - Margaretsville Dune Field	IKU in water 1234, at surface 1236, 58m of wire out, cobbles caught in jaws, partial wash out sample. Recovered approx 10cm of sediment with a lag layer of cobbles and pebbles over gravelly medium sand with occasional red sandy mud clasts. Cobbles are well rounded and range in size from 10 to 30cm. 0-5cm bagged bulk sample taken at C and a 3-7cm sample taken at B.
0136	IKU		253 / 1257	45.204207 65.127440	51.00	60.0	Bay of Fundy - Margaretsville Dune Field	IKU in water 1256, at surface 1258, 55m of wire out. Recovered 60cm with a 5cm lag layer of fine gravel with shell fragments, 5 to 20cm a layer of brownish sand with low-medium angle stratification, 20cm to base shelly sand layer with low angle stratification. 0-5cm sample taken at I.
0137	IKU		253 / 1408	45.251153 65.347637	52.00	55.0	Bay of Fundy - Quaco Ledge	IKU in water 1407, at surface 1409, 52m of wire out. Recovered 55cm well sorted, fine to medium sand with fine shell hash and occasional granules. 8cm thick surface layer with low to medium angle lamination. 3cm shell layer at 8cm and a 2-3cm shell layer at 13cm. Below is structureless with shell hash. 0-5cm sample taken at H.
0138	IKU		253 / 1426	45.251635 65.352059	56.00	30.0	Bay of Fundy - Quaco Ledge	IKU in water 1425, at surface 1427, 60m of wire out, cobbles caught in the jaws, partial wash out. Recovered 30cm with a lag layer of cobbles and pebbles with shells over a fine to medium sand with shell hash and a few red mud clasts. Cobbles are rounded with sizes 10-40cm (minor axis 20cm). 0-10cm bagged bulk sample taken at I.
0139	IKU		253 / 1443	45.250380 65.355657	48.00	70.0	Bay of Fundy - Quaco Ledge	IKU in water 1442, 51m of wire out. Recovered 70cm of medium to coarse sand with some pebbles, shell hash throughout and no visible structure. 0-5cm sample taken at H.
0141	IKU		253 / 1459	45.248626 65.351444	45.00	60.0	Bay of Fundy - Quaco Ledge	IKU in water 1458, at surface 1500, 50m of wire out, partial washout. Recovered 60cm of well sorted, fine to medium sand with some shell hash. At approx. 15cm is a 0-5cm thick shell hash band at a 30 degree angle, 5 to 7 similar layers below but otherwise no visible structure. 0-5cm sample taken at F.
0142	IKU		253 / 1517	45.247667 65.350417	32.00	60.0	Bay of Fundy - Quaco Ledge	IKU at surface 1518, 47m of wire out. Recovered 60cm of well sorted fine sand with shell hash and a few whole shells. 2cm shell lag layer at approx 8cm, 1cm shell layer at approx 20 cm, shell hash abundance increases at 27cm. 0-5cm sample taken at G.
0143	IKU		253 / 1534	45.245253 65.347615	51.00	55.0	Bay of Fundy - Quaco Ledge	IKU in water 1533, at surface 1535, 53m of wire out, rocks caught in jaws, partial wash out. Recovered 55cm of gravelly coarse sand with pebbles (semi to well rounded, 1cm to 10cm) and shell fragments, pebbles throughout the profile. 0-5cm sample taken at F.

0144	IKU		253 / 1558	45.241317 65.348879	56.00	70.0	Bay of Fundy - Quaco Ledge	IKU in water 1557, 57m of wire out, pebbles caught in jaws, partial wash out. Recovered 70cm of pebbly coarse sand with shell fragments, scattered cobbles and boulders (up to 38cm) on surface. Below lag layer is a layer of red mud mixed with granules. 0-10cm bagged bulk sample taken at I.
0145	IKU		253 / 1620	45.237610 65.348390	50.00	25.0	Bay of Fundy - Quaco Ledge	IKU in water 1619, at surface 1621, 50m of wire out, partial wash out due to strong currents. Recovered 25cm of gravelly coarse to very coarse sand with shell fragments and whole shells. Cobbles up to 12cm and very fine sand in the matrix. 0-5cm bagged bulk sample taken at C.
0146	IKU		253 / 1654	45.232545 65.374315	47.00	9.0	Bay of Fundy - Quaco Ledge	First attempt in water 1647, on bottom 1648, at surface 1649. Second attempt in water 1653, at surface 1655, 47m of wire out, cobbles (18cm) caught in jaws and most of the sample washed out. Recovered 9cm of clean coarse sand with shell fragments. 0-5cm sample taken at G.
0147	IKU		253 / 1817	45.306033 65.187568	56.00	15.0	Bay of Fundy - NW Ile Haute	First attempt in water 1810, on bottom 1811, at surface 1812. Second attempt in water 1817, at surface 1819, 58m of wire out, IKU may have landed on an angle. Recovered 15cm of well sorted fine sand with shell fragments. 0-5cm sample taken at F.
0148	IKU		253 / 1845	45.320299 65.137190	50.00	20.0	Bay of Fundy - NW Ile Haute	IKU in water 1844, at surface 1847, 53m of wire out, IKU may have landed on an angle. Recovered 20cm of fine to medium sand with shell hash. 0-5cm sample taken at G.
0152	IKU		254 / 1136	44.987421 66.648404	66.00	0.0	Bay of Fundy - The Wolves	First attempt in water 1132, on bottom 1133, at surface 1135, did not trip. Second attempt at surface 1137, 76m of wire out, did not trip, approx. apparent penetration 30cm in soft clay. Sample taken from the exterior surface of the grab.
0153	IKU		254 / 1216	44.982270 66.754793	70.00	0.0	Bay of Fundy - The Wolves	First attempt in water 1212, on bottom 1213, at surface 1215, did not trip. Second attempt in water 1215, at surface 1219, 80m of wire out, did not trip, approx. apparent penetration 30cm in mud. Sample taken from the interior surface of the grab.
0155	IKU		254 / 1402	44.913273 66.850070	96.00	0.0	Bay of Fundy - Owen Basin	First attempt in water 1357, on bottom 1358, at surface 1400, did not trip. Second attempt in water 1401, at surface 1404, 108m of wire out, did not trip. Sample taken from the interior surface of the grab.
0156	IKU		254 / 1452	44.802041 66.863904	108.00	70.0	Bay of Fundy - Grand Manan Channel	IKU in water 1451, at surface 1455, 122m of wire out. Recovered 70cm of brown silty mud with pebbles, live and whole shells, approx. 42cm of brownish mud overlying grey mud, in the profile compact grey mud clasts are found in the brown mud layer. Samples from 13-18cm (red mud) and 40cm (grey mud) taken at B and a bagged sample of gray mud clast taken at H just below the surface.
0181	IKU		257 / 1540	44.210818 66.613048	60.70	10.0	Bay of Fundy - Northwest Ledge	IKU in water 1525, at surface 1543, 66m of wire out. Recovered 10cm of subangular gravel ranging from pebbles to cobbles with a matrix of coarse sand. Entire sample put in an 11.5 litre bucket.

Table 8. Summary of *Hudson* 2011036 physical property sampling.

Station Number	Sample Type	Number of constant volume samples	Number of Torvane measurements
17	TWC	2	2
	PC	0	0
21	TWC	-	-
	PC	2	2
22	TWC	-	-
	PC	3	3
23	TWC	-	-
	PC	1	1
76	TWC	-	-
	PC	2	2
89	TWC	0	0
	PC	2	2
162	TWC	0	0
	PC	2	2
163	TWC	0	0
	PC	3	4
164	TWC	0	0
	PC	4	5
165	TWC	0	0
	PC	4	3
166	TWC	-	-
	PC	0	0
168	Gravity	0	0
171	Gravity	0	0
172	Gravity	0	0
173	Gravity	2	2
174	TWC	0	0
	PC	0	0
175	TWC	0	0
	PC	0	0

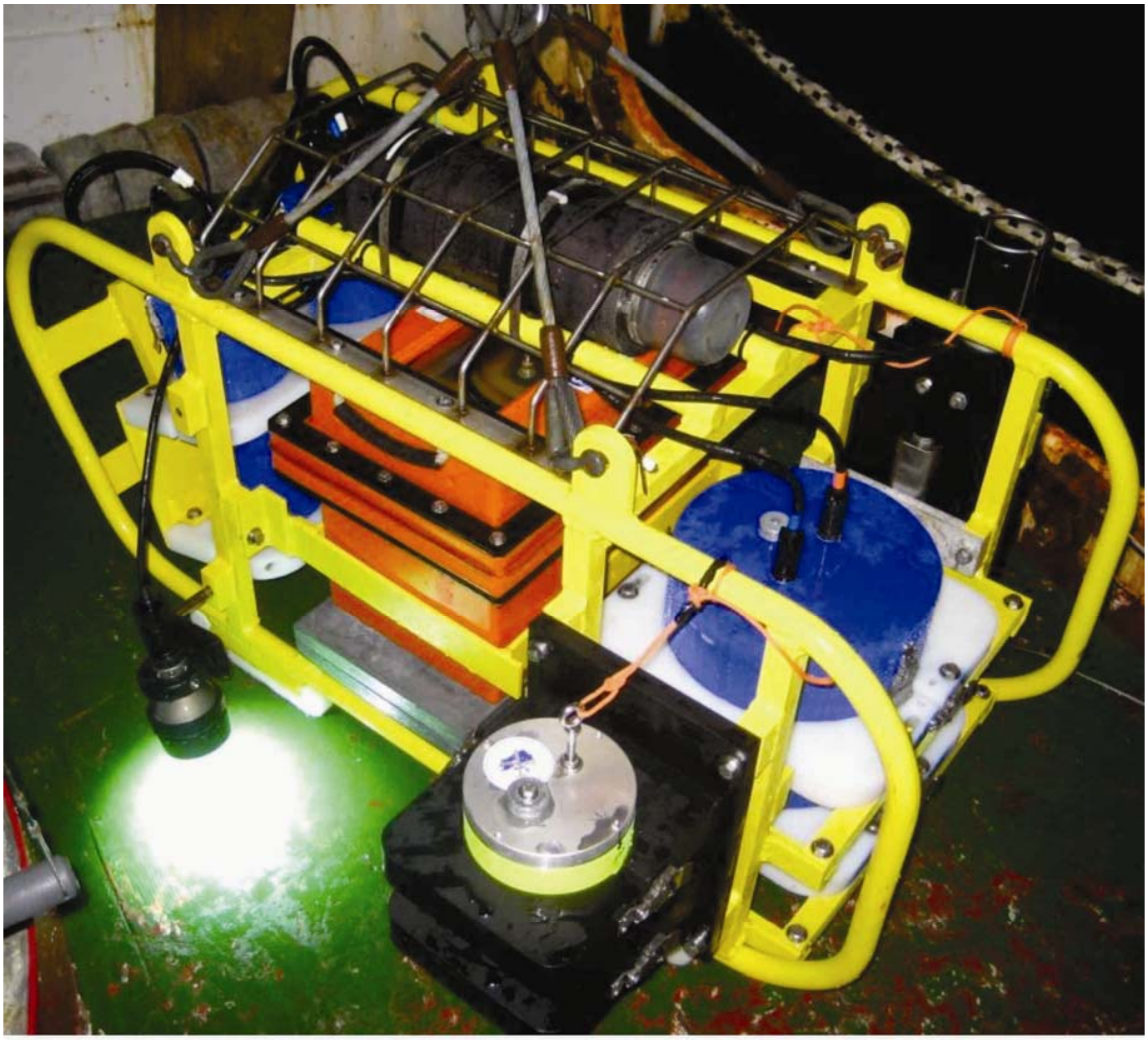


Figure 69. 4K-VladCam Bullet combination camera system.

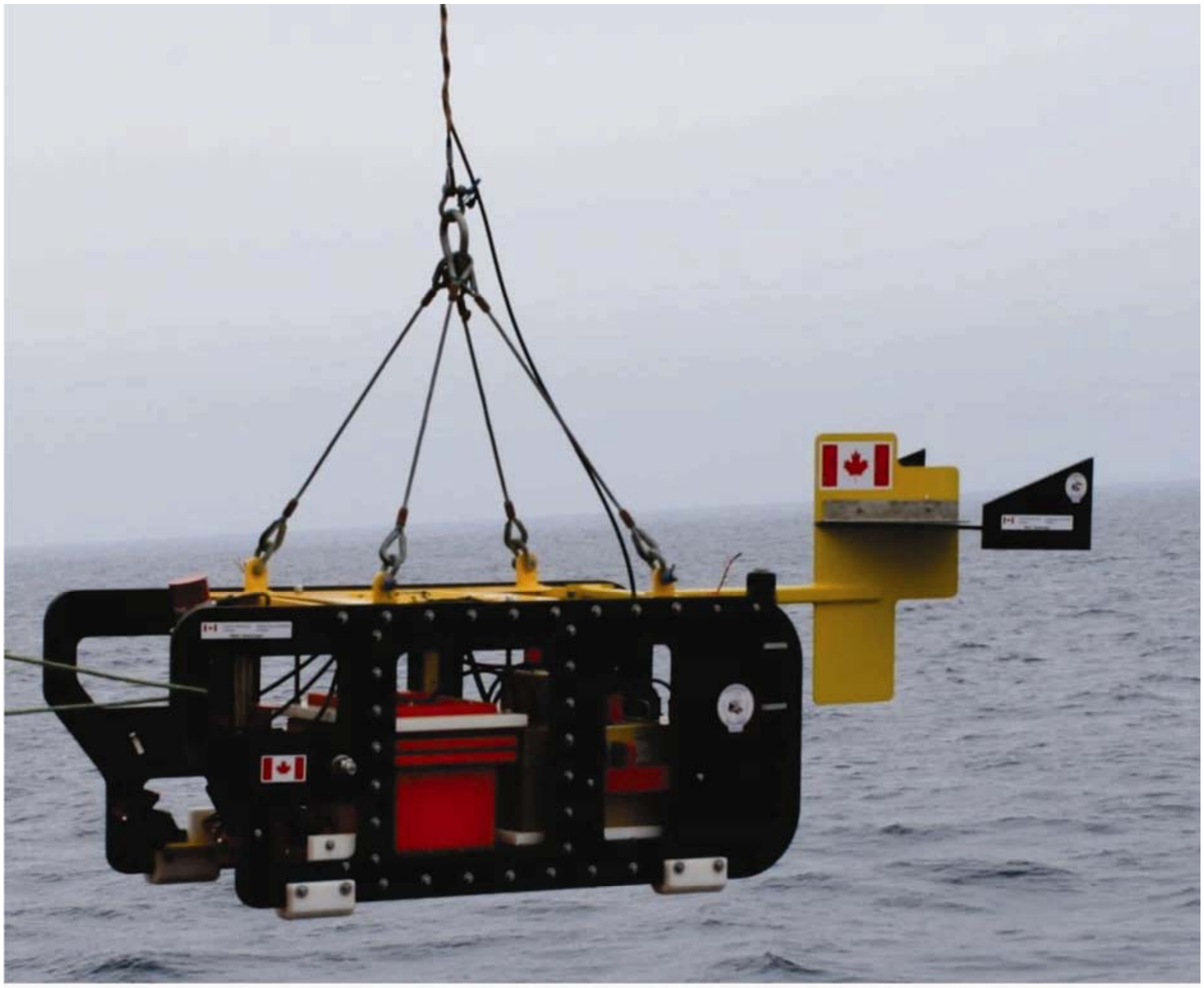


Figure 70. DeepImager camera system.

Figure 71. Large IKU grab sampler used for surface and shallow sub-surface sampling.

Figure 72. Medium size van Veen grab sampler.

Figure 73. Piston corer being deployed off the starboard bow of the CCGS *Hudson*.

Figure 74. Taking a Torvane measurement.

Figure 75. Inserting the constant volume sampler.

Figure 76. Core extrusion pusher.

Figure 77. Core extrusion puller.

Figure 78. Core holder and cutting alignment ring.

10. Oceanographic measurements – *E.P. Horne, G.L. Bugden, C.A. Jarrett*

The following instruments were deployed during the expedition:

1) Profiling Hyperspectral radiometer: This device measures downwelling and upwelling light over the whole visual band every two nanometres as it falls to the bottom. It also has a fluorometer and light scattering sensors as well as a surface light sensor which stay at the surface while the instrument profiles.

2) Optics buoy: This buoy is equipped with the same sensors as item #1 but they are mounted on a buoy at stay at one metre depth while the buoy drifts around freely. The buoy has a McLane water sampler underneath it which filters water on 24 filters at different times which are analysed for chlorophyll or suspended sediment concentrations.

3) Profiling camera: This camera takes pictures of the water column as it is lowered. The images are later analysed to give particle size.

4) Laser In-Situ Scattering and Transmissometery (LISST): This instrument measures particle size by using laser light scattering. It measures smaller particles than does the camera. Both the LISST and camera are both lowered together on the same frame.

5) CTD: This instrument measures the conductivity and temperature of the water as it is lowered. It also has sensors to measure chlorophyll, oxygen, and sediment concentration.

6) Niskin Bottles: These 5 litre bottles are fastened to the hydro wire and collect water which is then filtered to analyse for chlorophyll, sediment concentration and CDOM (coloured dissolved organic matter).

During *Hudson* 2011036 there were 44 DFO stations. On the deck sheets and in ED these stations were described as DFO CTD, DFO light meter, DFO optical buoy and DFO bottle cast (Table 9). The instrument configuration for each of the stations types is described below.

DFO CTD stations comprised a Seabird model 25 CTD with a Wetlabs flow through fluorometer, YSI oxygen sensor, a PAR light sensor and an optical back scatter sensor. The CTD was lowered at the same time as a floc camera and a LISST particle size measuring instrument. Water samples were also collected at 1 and 5 m depths with 5 litre Niskin bottles.

DFO light meter stations comprised a hyperspectral light profile collected with a Satlantic HyperPro radiometer equipped with upwelling and downwelling light sensors as well as a surface reference sensor.

DFO optical buoy stations comprised a drifting buoy equipped with a surface hyperspectral light sensor as well as upwelling light sensors at 1 and 3 m depths and a Wetlabs triplet fluorometer/backscatter sensor. The buoy was also equipped with a McLane water sampler which filtered water through 24 different filters as programmed.

The DFO bottle cast 5 litre bottles were fastened to the hydro wire.

List of Tables

Table 9. *Hudson* 2011036 DFO stations.

Station No.	Sample Type	Day/Time (UTC)	Latitude (°N) Longitude (°W)	Water Depth (m)	Location	Comments
0001	DFO Light Meter	243 / 2014	44.727816 65.886635	72.00	Bay of Fundy - Digby Esker	DFO Light Meter. In the water 2006 and 2013, on the surface 2018.
0003	DFO CTD	243 / 2134	44.709195 65.949868	81.00	Bay of Fundy - Digby Drumlin Field	DFO CTD. In water at 2123, lowered to 60m at 2128, messenger away at 2134, CTD turned off and on deck at 2140. Water samples collected at 1m (DFO ID 373752) and 5m (DFO ID 373751) with 5 litre Niskin bottles.
0018	DFO CTD	244 / 2004	44.847976 66.393956	134.00	Bay of Fundy - North Grand Manan Basin	DFO CTD. Over side at 2004, messenger away at 2014, CTD turned off and on deck at 2017, position recorded in general cruise log. Water samples collected at 1m (DFO ID 373754) and 5m (DFO ID 373753) with 5 litre Niskin bottles.
0019	DFO Light Meter	244 / 2024	44.840847 66.404161	136.80	Bay of Fundy - North Grand Manan Basin	DFO Light Meter. In water at 2024, on surface at 2042 at 44.835755N and 66.410352W.
0020	DFO Optical Buoy	245 / 1038	44.701096 66.42039	168.80	Bay of Fundy - Grand Manan Basin	DFO Optical Buoy. Deployed and left for later pick up near Grand Manan Island. On surface and away at 1038 and water depth of 168.8m. Refer to Station 0026 for retrieval.
0026	DFO Optical Buoy	245 / 2216	44.660483 66.365135	155.00	Bay of Fundy - Grand Manan Basin	DFO Optical Buoy. Deployed at Station 0020, successfully retrieved JD245 2216 hours.
0030	DFO Light Meter	246 / 1257	45.259456 65.659559	42.00	Bay of Fundy - East Red Head	DFO Light Meter. Run 1 in water 1258, pulling up 1301 and on surface 1302. Run 2, lowered to 41m at 1302, pulling up 1304 and on surface 1305. Run 3 lowered to 42m at 1305, pulling up 1306 and on surface 1307.
0031	DFO CTD	246 / 1320	45.259972 65.661963	42.50	Bay of Fundy - East Red Head	DFO CTD. In water 1320 and out of water 1325. Water samples collected at 1m (DFO ID 373780) and 5m (DFO ID 373779) with 5 litre Niskin bottles.
0036	DFO Light Meter	246 / 1832	45.209181 65.470349	66.00	Bay of Fundy - SW Quaco Ledge	DFO Light Meter. At Gas Site. Run 1 in water 1832, drop 1833 and on surface 1836. Run 2, lowered at 1837, on surface 1840. Run 3 lowered at 1840 and out of water 1844.
0037	DFO CTD	246 / 1856	45.218928 65.453718	60.00	Bay of Fundy - SW Quaco Ledge	DFO CTD. On at 1851, in water at 1856, messenger away at 1903, CTD turned off at 1906. Water samples collected at 1m (DFO ID 373782) and 5m (DFO ID 373781) with 5 litre Niskin bottles.
0039	DFO Optical Buoy	247 / 0935	45.263169 64.871304	56.00	Bay of Fundy - SW Cape D'Or	DFO Optical Buoy. Deployed and refer to Station 0055 for retrieval info.
0040	DFO Bottle cast	247 / 0937	45.263211 64.873122	56.40	Bay of Fundy - SW Cape D'Or	DFO Bottle cast. Water samples collected at 1m (DFO ID 373784) and 5m (DFO ID 373783) with 5 litre Niskin bottles.
0046	DFO Light Meter	247 / 1319	45.298026 65.097429	46.00	Bay of Fundy - NW Ile Haute	DFO Light Meter. Run 1 in water 1317, mark 1319 and back up 1320. Run 2 lowered at 1322, mark 1324, at surface 1325. Run 3 lowered at 1325, mark 1327, end 1844.
0047	DFO CTD	247 / 1341	45.294091 65.107826	45.00	Bay of Fundy - NW Ile Haute	DFO CTD. In water at 1338, mark at 1341, at surface at 1345. Water samples collected at 1m (DFO ID 373786) and 5m (DFO ID 373785) with 5 litre Niskin bottles.
0055	DFO Optical Buoy	247 / 1944	45.27381 64.736108	45.00	Bay of Fundy - East Cape D'Or	DFO Optical Buoy. Deployed at Station 0039, successfully retrieved JD247 1944.
0056	DFO Light Meter	247 / 1954	45.276523 64.720561	99.00	Bay of Fundy - West Cape D'Or	DFO Light Meter. Run 1 in water 1954 and at surface 1958. Run 2 lowered at 2001, at surface 2005 and on deck 2009.
0057	DFO CTD	247 / 2046	45.305009 64.664172	65.00	Bay of Fundy - Minas Channel	DFO CTD. Problems with the winch hydraulics. In water at 1935, mark at 2046, in winch room at 1345. Water samples collected at 1m (DFO ID 373788) and 5m (DFO ID 373787) with 5 litre Niskin bottles.
0067	DFO Light Meter	248 / 1437	45.28778 64.540087	31.60	Bay of Fundy - Scots Bay	DFO Light Meter. On a Banner Bank. Run 1 in water 1437 and at surface 1440. Run 2 lowered at 1440 and at surface 1442. Run 3 lowered at 1442, at surface 1444.

					Barchan Dunes	
0068	DFO CTD	248 / 1455	45.294549 64.54047	33.40	Bay of Fundy - Scots Bay Barchan Dunes	DFO CTD. On a Banner Bank. In water at 1455 and out of water at 1502. Water samples collected at 1m (DFO ID 373790) and 5m (DFO ID 373789) with 5 litre Niskin bottles.
0074	DFO Optical Buoy	249 / 1042	45.043410 65.513169	81.00	Bay of Fundy - Central Bay of Fundy	DFO Optical Buoy. Deployed at 1042 and refer to Station 0087 for retrieval info.
0075	DFO Bottle cast	249 / 1046	45.043798 65.513142	81.00	Bay of Fundy - Central Bay of Fundy	DFO Bottle cast. Water samples collected at 1m (DFO ID 373792) and 5m (DFO ID 373791) with 5 litre Niskin bottles.
0080	DFO Light Meter	249 / 1534	45.200168 65.205855	60.00	Bay of Fundy - Central Bay of Fundy	DFO Light Meter. Run 1 in water 1533 and at surface 1536. Run 2 lowered at 1536 and at surface 1540. Run 3 lowered at 1540, at surface 1544.
0081	DFO CTD	249 / 1559	45.200563 65.212403	60.00	Bay of Fundy - Central Bay of Fundy	DFO CTD. In water at 1555 and out of water at 1602. Water samples collected at 1m (DFO ID 373794) and 5m (DFO ID 373793) with 5 litre Niskin bottles.
0087	DFO Optical Buoy	249 / 2024	45.038678 65.636705	86.00	Bay of Fundy - Central Bay of Fundy	DFO Optical Buoy. Deployed at Station 0074, successfully retrieved JD249 2024.
0088	DFO Bottle cast	249 / 2029	45.039942 65.635159	85.00	Bay of Fundy - Central Bay of Fundy	DFO Bottle cast. Water samples collected at 1m (DFO ID 373796) and 5m (DFO ID 373795) with 5 litre Niskin bottles.
0096	DFO Optical Buoy	251 / 1018	45.505744 64.921959	80.00	Bay of Fundy - Chignecto Bay	DFO Optical Buoy. Deployed at 101827 and refer to Station 0112 for retrieval info.
0097	DFO Bottle cast	251 / 1022	45.505278 64.919346	74.00	Bay of Fundy - Chignecto Bay	DFO Bottle cast. Water samples collected at 1m (DFO ID 373798) and 5m (DFO ID 373797) with 5 litre Niskin bottles.
0102	DFO Light Meter	251 / 1310	45.566053 64.738563	126.00	Bay of Fundy - Chignecto Bay	DFO Light Meter. Run 1 in water 1310 and at surface 1312. Run 2 lowered at 1313 and at surface 1316. Run 3 lowered at 1316, at surface 1321.
0103	DFO CTD	251 / 1339	45.564243 64.741194	113.00	Bay of Fundy - Chignecto Bay	DFO CTD. In water at 1336 and at surface at 1348. Water samples collected at 1m (DFO ID 373800) and 5m (DFO ID 373799) with 5 litre Niskin bottles.
0109	DFO Light Meter	251 / 1703	45.635095 64.674231	30.00	Bay of Fundy - Chignecto Bay	DFO Light Meter. Run 1 in water 1701, on way down 1703 and at surface 1705. Run 2 lowered at 1707 and at surface 1709.
0110	DFO CTD	251 / 1721	45.629125 64.68976	26.00	Bay of Fundy - Chignecto Bay	DFO CTD. In water at 1718, event at 1721 and at surface at 1724. Water samples collected at 1m (DFO ID 373802) and 5m (DFO ID 373801) with 5 litre Niskin bottles.
0112	DFO Optical Buoy	251 / 1956	45.393262 65.043358	43.00	Bay of Fundy - Mouth Chignecto Bay	DFO Optical Buoy. Deployed at Station 0096, successfully retrieved JD251 1956.
0113	DFO Bottle cast	251 / 2008	45.391414 65.043499	41.00	Bay of Fundy - Mouth Chignecto Bay	DFO Bottle cast on West Banner Bank. Water samples collected at 1m (DFO ID 373804) and 5m (DFO ID 373803) with 5 litre Niskin bottles.
0114	DFO Optical Buoy	252 / 1026	45.302265 64.844183	36.00	Bay of Fundy - West Cape D'Or	DFO Optical Buoy deployed at 1026. Refer to Station 0129 for retrieval info.
0115	DFO Bottle cast	252 / 1029	45.300863 64.840882	27.00	Bay of Fundy - West Cape D'Or	DFO Bottle Cast. Water samples collected at 1m (DFO ID 373806) and 5m (DFO ID 373805) with 5 litre Niskin bottles.
0129	DFO Optical Buoy	252 / 2005	45.283211 64.910782	30.00	Bay of Fundy - Advocate Bay	DFO Optical Buoy. Deployed at Station 0114. First attempt unsuccessful but circled around and successfully retrieved JD252 2005.
0130	DFO Bottle cast	252 / 2020	45.287097 64.91287	45.00	Bay of Fundy - Advocate Bay	DFO Bottle cast. Water samples collected at 1m (DFO ID 373808) and 5m (DFO ID 373807) with 5 litre Niskin bottles.
0140	DFO Bottle cast	253 / 1452	45.249497 65.350595	46.00	Bay of Fundy - Quaco Ledge	DFO Bottle cast. Water samples collected at 1m (DFO ID 373810) and 5m (DFO ID 373809) with 5 litre Niskin bottles.
0149	DFO Optical Buoy	254 / 1014	44.94832 66.655567	80.00	Bay of Fundy - The Wolves	DFO Optical Buoy. Deployed at 1014. Refer to Station 0160 for retrieval info.
0150	DFO Bottle	254 / 1017	44.948309	80.00	Bay of Fundy -	DFO Bottle cast. Water samples collected at 1m (DFO ID 373812) and 5m (DFO ID 373811)

	cast		66.655963		The Wolves	with 5 litre Niskin bottles.
0160	DFO Optical Buoy	254 / 2053	44.975760 66.593334	56.00	Bay of Fundy - North Grand Manan Basin	DFO Optical Buoy. Deployed at Station 0149 and successfully retrieved JD254 2053.
0161	DFO Bottle cast	254 / 2059	44.975733 66.593649	56.00	Bay of Fundy - North Grand Manan Basin	DFO Bottle cast. Water samples collected at 1m (DFO ID 373814) and 5m (DFO ID 373813) with 5 litre Niskin bottles.
0179	DFO Light Meter	257 / 1414	44.215845 66.610076	60.00	Bay of Fundy - Northwest Ledge	DFO Light Meter. Run 1 in water 1415 and at surface 1417. Run 2 lowered at 1418 and at surface 1423.
0180	DFO CTD	257 / 1451	44.235245 66.604604	140.00	Bay of Fundy - Northwest Ledge	DFO CTD. In water at 1437 and event at 1444. Water samples collected at 1m (DFO ID 373816) and 5m (DFO ID 373815) with 5 litre Niskin bottles.

Appendix 1

Hudson 2011036 deck photographs

2011036 Van Veen Grab Station 14

20011036 IKU Grab Station 15

2011036 IKU Grab Station 24

2011036 IKU Grab Station 25

2011036 IKU Grab Station 27

2011036 IKU Grab Station 28

2011036 IKU Grab Station 32

2011036 IKU Grab Station 33

2011036 IKU Grab Station 34

2011036 IKU Grab Station 38

2011036 IKU Grab Station 41

2011036 IKU Grab Station 42

2011036 IKU Grab Station 43

2011036 IKU Grab Station 44

2011036 IKU Grab Station 45

2011036 IKU Grab Station 48

2011036 IKU Grab Station 49

2011036 IKU Grab Station 50

2011036 IKU Grab Station 51

2011036 IKU Grab Station 54

2011036 IKU Grab Station 58

2011036 IKU Grab Station 59

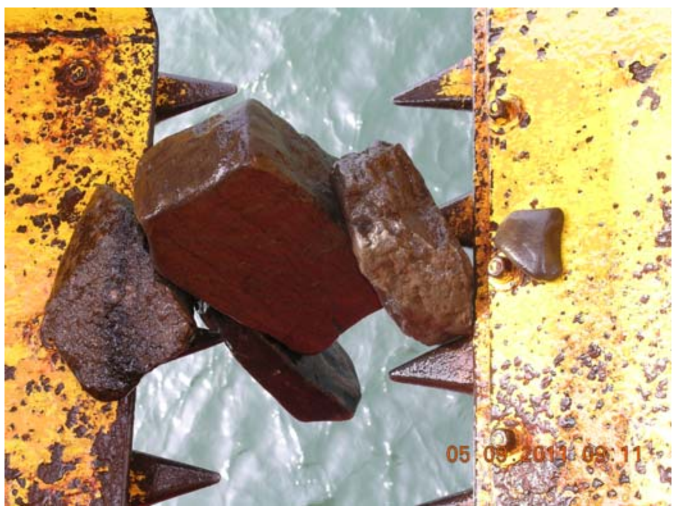
2011036 IKU Grab Station 60

2011036 IKU Grab Station 61

2011036 IKU Grab Station 62

2011036 IKU Grab Station 63

2011036 IKU Grab Station 64 first attempt



2011036 IKU Grab Station 64 second attempt

2011036 IKU Grab Station 64 second attempt

2011036 IKU Grab Station 65

2011036 IKU Grab Station 65

2011036 IKU Grab Station 66

2011036 IKU Grab Station 71

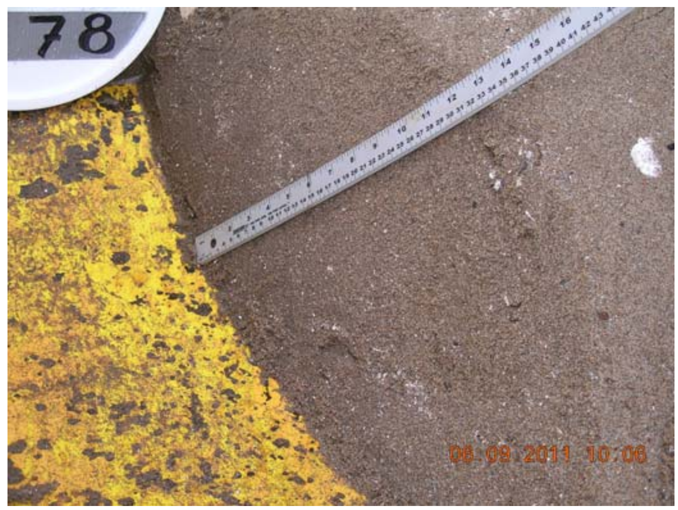
2011036 IKU Grab Station 72

2011036 IKU Grab Station 73 first attempt

2011036 IKU Grab Station 73 second attempt

2011036 IKU Grab Station 77

2011036 IKU Grab Station 78



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2011036 IKU Grab Station 82

2011036 IKU Grab Station 84

2011036 IKU Grab Station 85

2011036 IKU Grab Station 86

2011036 IKU Grab Station 90

2011036 IKU Grab Station 94

2011036 IKU Grab Station 94

2011036 IKU Grab Station 95

2011036 IKU Grab Station 98

2011036 IKU Grab Station 99

2011036 IKU Grab Station 0100

2011036 IKU Grab Station 101

2011036 IKU Grab Station 104

2011036 IKU Grab Station 105

2011036 IKU Grab Station 106

2011036 IKU Grab Station 106

2011036 IKU Grab Station 108

2011036 IKU Grab Station 111 first attempt

2011036 IKU Grab Station 111 second attempt

2011036 IKU Grab Station 116

2011036 IKU Grab Station 117

2011036 IKU Grab Station 118

2011036 IKU Grab Station 119

2011036 IKU Grab Station 120

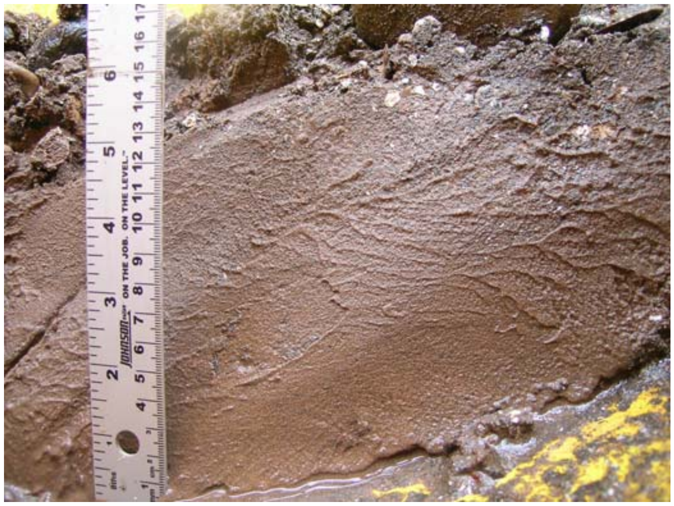
2011036 IKU Grab Station 122

2011036 IKU Grab Station 123

2011036 IKU Grab Station 124 first attempt

2011036 IKU Grab Station 124 second attempt

2011036 IKU Grab Station 124 second attempt



2011036 IKU Grab Station 125

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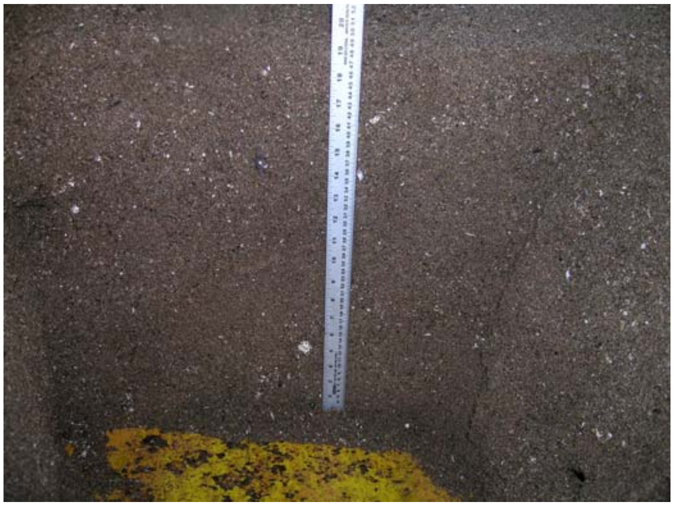
2011036 IKU Grab Station 128

2011036 IKU Grab Station 131



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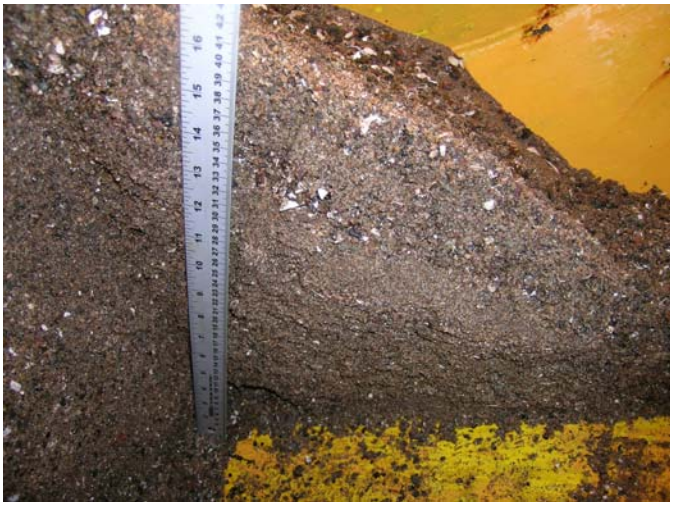
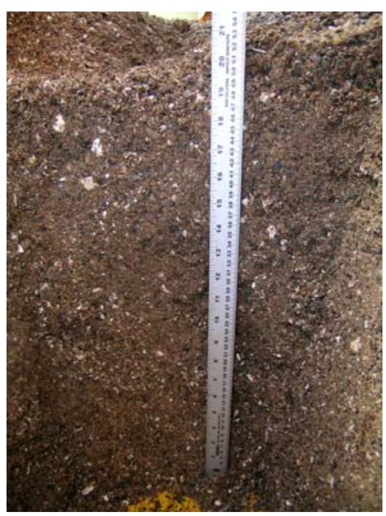


2011036 IKU Grab Station 132

2011036 IKU Grab Station 133



2011036 IKU Grab Station 134

2011036 IKU Grab Station 135

2011036 IKU Grab Station 136

2011036 IKU Grab Station 137

2011036 IKU Grab Station 138

2011036 IKU Grab Station 139

2011036 IKU Grab Station 141

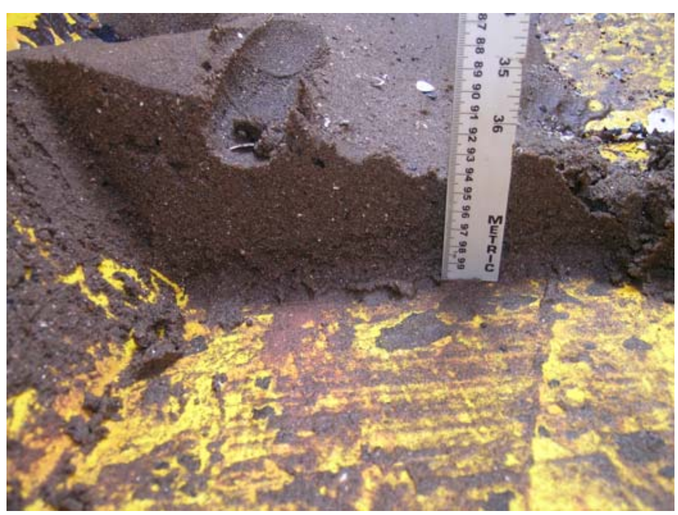
2011036 IKU Grab Station 142

2011036 IKU Grab Station 143

2011036 IKU Grab Station 144

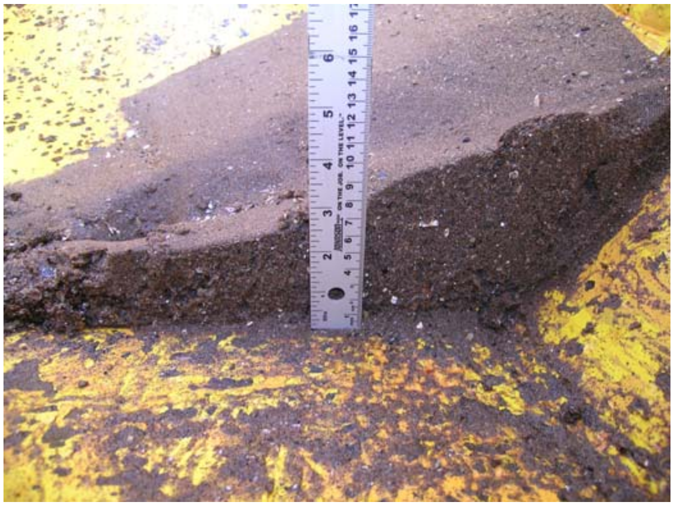
2011036 IKU Grab Station 145

2011036 IKU Grab Station 146



2011036 IKU Grab Station 147

2011036 IKU Grab Station 148



2011036 IKU Grab Station 152 second attempt

2011036 IKU Grab Station 153 second attempt

2011036 IKU Grab Station 155

2011036 IKU Grab Station 156

2011036 IKU Grab Station 156

2011036 IKU Grab Station 181