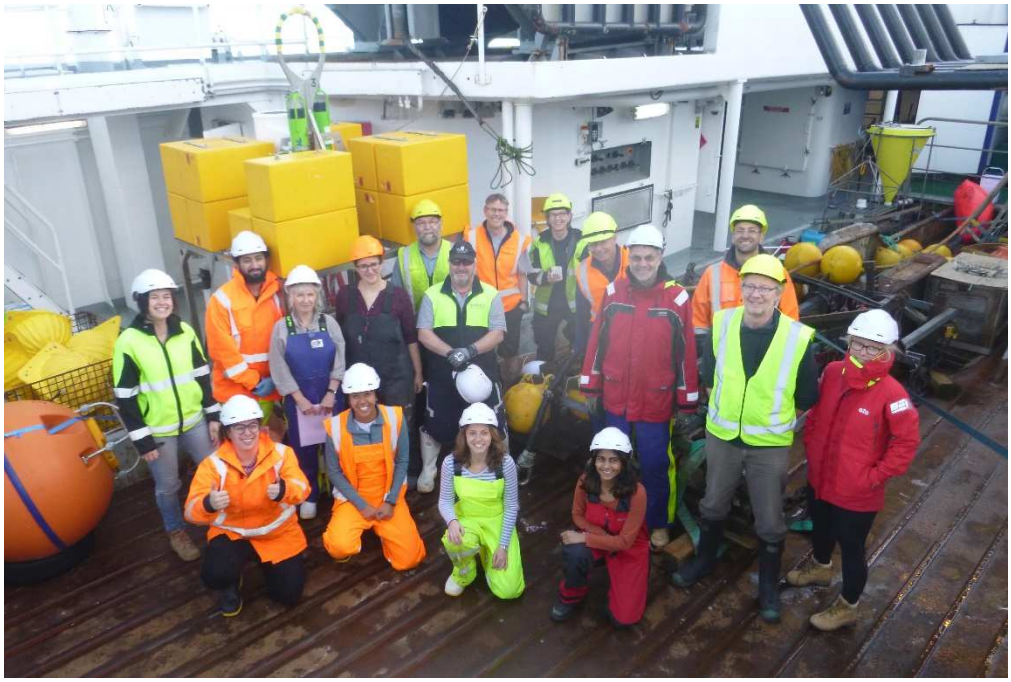
Resilience of deep-sea benthic communities to the effects of sedimentation ("ROBES")

Voyage report of Survey 2: June 2019

November 2019



Prepared by:
Malcolm R Clark, Scott Nodder, Joanne O'Callaghan, Rima Browne, Apirana Daymond, Peter de Joux, Steve George, Rachel Hale, Alan Hart, Khushboo Jhugroo, Daniel Leduc, Valeria Mobilia, Olivia Price, Sarah Searson, Cassidy Solomon, Rob Stewart, Di Tracey,

For any information regarding this report please contact:

Malcolm Clark
Principal Scientist - Fisheries

+64-4-386 0523
Malcolm.Clark@niwa.co.nz

National Institute of Water & Atmospheric Research Ltd
Private Bag 14901
Kilbirnie
Wellington 6241

Phone +64 4 386 0300

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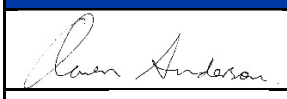	Reviewed by:	Owen Anderson
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1 Voyage background

Uncertainty about the potential environmental effects of deep-sea mining is a major impediment to development of the off-shore mining sector in New Zealand. Two recent applications for seabed mining were declined by the EPA, a key reason being uncertainty about the effects of sediment plumes created by disturbance to the seafloor and discharge of processed waters. Sedimentation effects from bottom trawl fisheries is also an environmental issue of concern for sustainable fisheries certification. Understanding such impacts in the deep ocean is challenging, but in 2016 MBIE funded a NIWA-led programme to investigate the effects of sedimentation from such seabed disturbance using a combination of field survey experimentation with *in situ* observations, and laboratory-based experiments. In combination, the two approaches will provide information on the concentrations and distances over which impacts of suspended sediment on faunal communities become 'ecologically significant'. The work is designed to determine the extent and persistence of sediment plumes, the immediate impact and subsequent recovery of seafloor exposed to these plumes, and the sedimentation effect on the functioning of ecologically significant species.

This survey was the second of a series of three surveys in a seabed disturbance experiment on the Chatham Rise. Building on experience gained during the first survey in 2018, a ploughing type operation over an area of up to 0.5 km^2 in 2019 was designed to generate a low sediment cloud 2-3 m high at seabed depths of 400-500m. The overall plan was for benthic communities to be surveyed across the wide area sampled in 2018 to monitor changes over the year; then to survey in a smaller area in 2019 before disturbance as well as immediately afterwards; and then to survey again 1 year later (the third survey in 2020) to monitor recovery and resilience of the seabed communities.

2 Objectives:

The main aim of the voyage was:

1) To undertake a sediment disturbance experiment to investigate the impacts of a sediment plume on deep-sea benthic communities.

This objective had the following sub-components:

a) To repeat sample monitoring sites from 2018

b) To carry out a new baseline survey of benthic communities near the "Butterknife" feature;

c) To disturb an area of seabed near the "Butterknife", creating a sediment cloud above the seafloor;

d) To monitor the dispersal of the sediment cloud;

e) To determine the characteristics of the suspended and settled sediment;

f) To survey benthic communities, post-disturbance; and

g) To collect animals for experimental sedimentation threshold studies onshore.

3 Voyage summary

3.1 Voyage Personnel

Name	Organisation	Role
Malcolm Clark	NIWA	Voyage-Watch Leader/Biology lead/OFOP
Joanne O'Callaghan	NIWA	Watch Leader/Physics lead/glider
Scott Nodder	NIWA	Sedimentation lead
Steve George	NIWA	DTIS/ CTD
Rob Stewart	NIWA	DTIS/Deck Safety Officer
Di Tracey	NIWA	Biology/OFOP/Live capture
Daniel Leduc	NIWA	Biology/OFOP/ Chemicals Safety Officer
Alan Hart	NIWA	Biology/OFOP/MBES
Olivia Price	NIWA	Moorings/landers/CTD
Sarah Searson	NIWA	Moorings/landers/CTD
Pete de Joux	NIWA	Cameras/transponders/acoustics
Khushboo Jhugroo	Victoria University/NIWA	Glider/ADCP
Valeria Mobilia	Victoria University/NIWA	Live capture/ general biology support
Rachel Hale	NIWA	Sedimentation/biogeochemistry
Rima Browne	Cook Islands Seabed Minerals Authority	GIS/general biology support
Cassidy Solomon	Hokotehi Moriori Trust	Iwi representative/general support
Apirana Daymond	Te Aitanga o ngā uri o Wharekauri	Iwi representative/general support

3.2 Voyage time-line

The voyage duration was from 9 June (mobilisation in Wellington) to 29 June (return to Wellington. Testing of some gear occurred in transit (11 June) to the main survey area, where sampling was undertaken 12 – 27 June, before heading back towards Wellington with further sample collection on 28 June. Details of daily events are given in Appendix A.

3.3 Voyage and survey area

The research occurred in the central part of the Chatham Rise, on the northern slope at depths of 400-500 m.

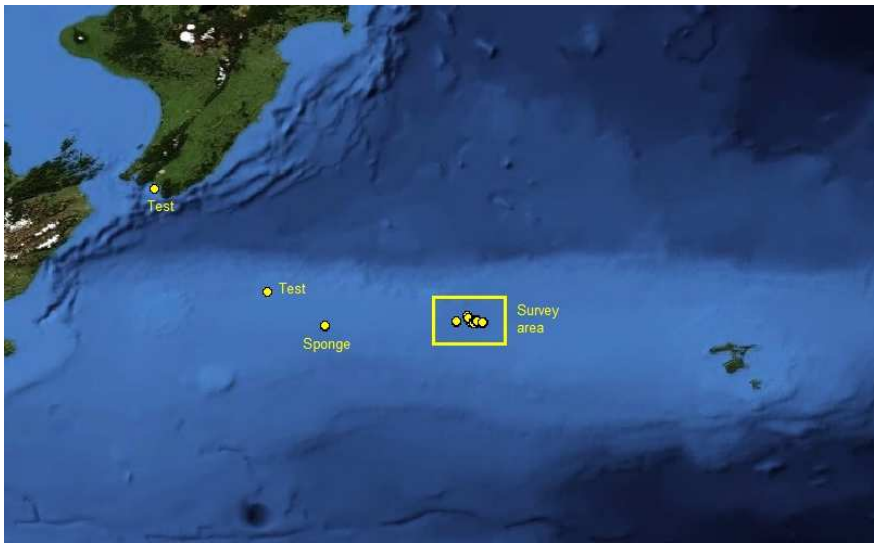


Figure 3-1: The survey area, showing general location of the main survey (yellow box, Fig. 3-2) and test and sponge collection sites.

The survey area was the same as covered in 2018 (Figure 3-2), with monitoring over the extent of the area surveyed then, and more concentrated work around the "Butterknife" feature.

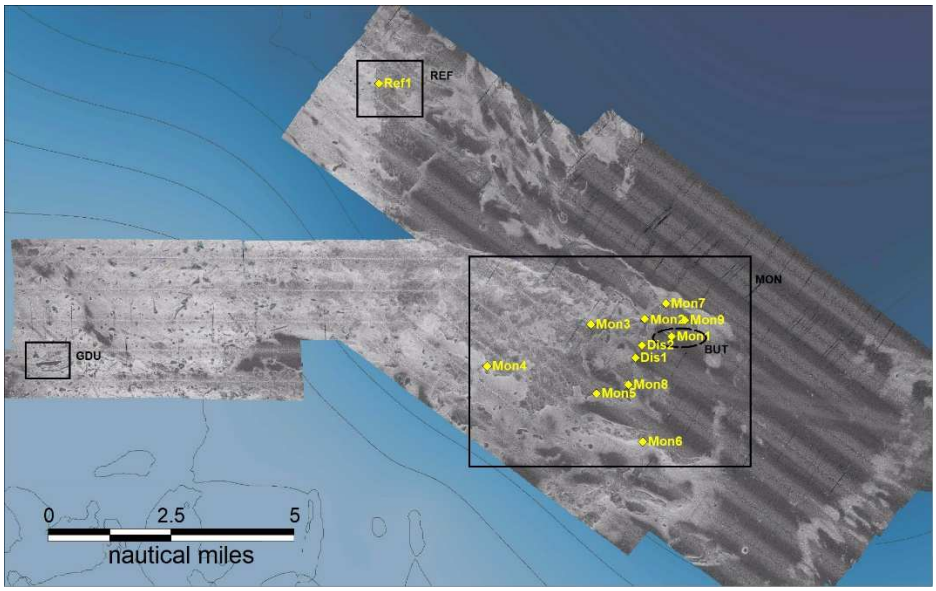


Figure 3-2: The survey area, with multibeam backscatter mosaic and regional bathymetry, showing Monitoring (MON) and Reference (REF) areas (black boxes, sites from 2018 (yellow diamonds), planned disturbance area (Butterknife, BUT) and coral collection area (GDU).

4 Research components

4.1 Survey approach

The survey approach and design was developed taking into account some previous disturbance experiments (Jones et al. 2017) as well as our survey results from 2018. The key components of the survey plan were to:

1) Recover two moorings recording oceanographic data from 2018.
2) The glider to measure physical oceanographic conditions is deployed and programmed to survey the area we plan to disturb.
3) A survey of the Monitoring stations from 2018 with camera and multicorer to describe benthic communities is carried out.
4) Benthic landers are deployed to measure oceanographic and sedimentological conditions near the area we plan to disturb to then measure the plume deposition during and following disturbance.
5) A more detailed pre-disturbance survey of the area to be disturbed is then carried out with towed camera, multicorer, and several CTDs to record water characteristics and benthic communities. An acoustic grid utilising MBES and Fisheries sounders to record backscatter in the water column is completed.
6) The seafloor is disturbed over a small area (repeated coverage of lines about 1 km long), creating a cloud of fine sediment, that disperses down-current.
7) The pre-disturbance survey with towed camera and multicorer and acoustics is repeated post-disturbance to monitor changes caused by the BD. CTD stations also sample water from various heights in the water column to measure particle density and composition in and around the sediment cloud. The glider also is programmed to work through the expected area of the plume to help detect and track it.
8) Landers and glider are recovered, one mooring re-deployed for the coming year.

4.2 Details of sampling locations

The main Monitoring (MON) sites from 2018 were repeated, together with a Reference Site (REF), and a Disturbance site (DIS). Camera (Deep Towed Imaging System, DTIS) and multicorer sampling was undertaken at each of these locations.

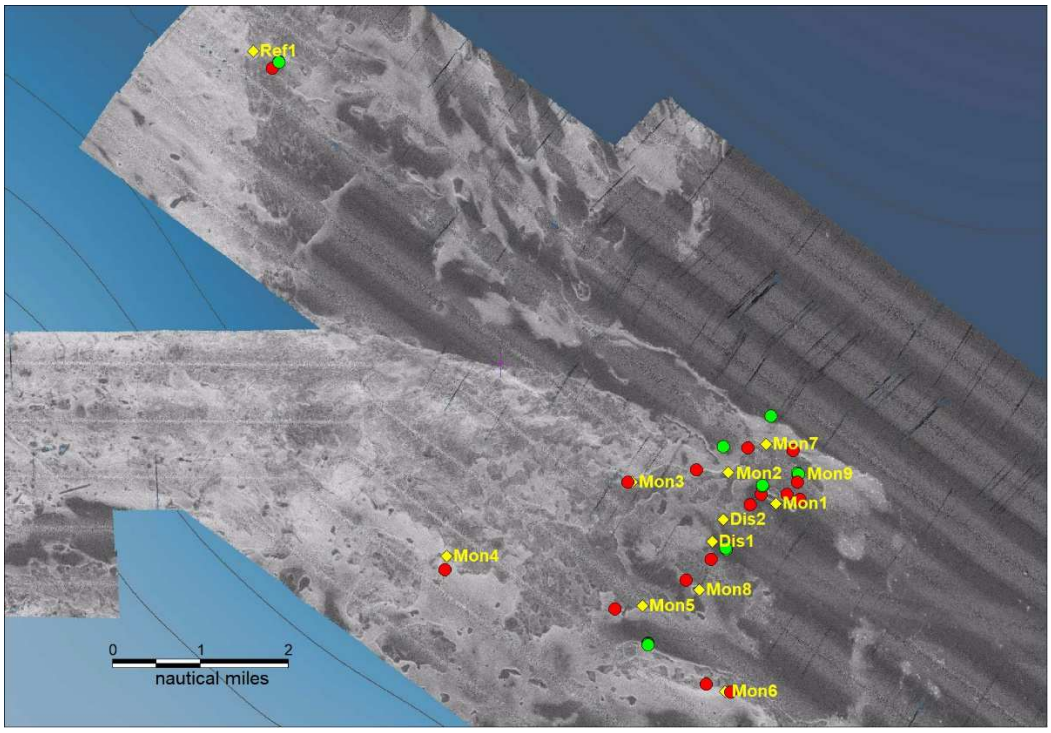


Figure 4-1: The sampling sites (MON, DIS, REF) for camera (red) and multicorer (green) from 2018, repeated on TAN1903.

More detailed sampling was carried out in the region of the Butterknife (see below) with DTIS, multicorer, acoustics, Conductivity-Temperature-Depth (CTD) and benthic lander deployments. These are covered in more detail in the sections below. The Butterknife was chosen to be a more detailed study area because it had relatively dense coral communities on the rims, and soft sediment that could be disturbed in close proximity on different sides.

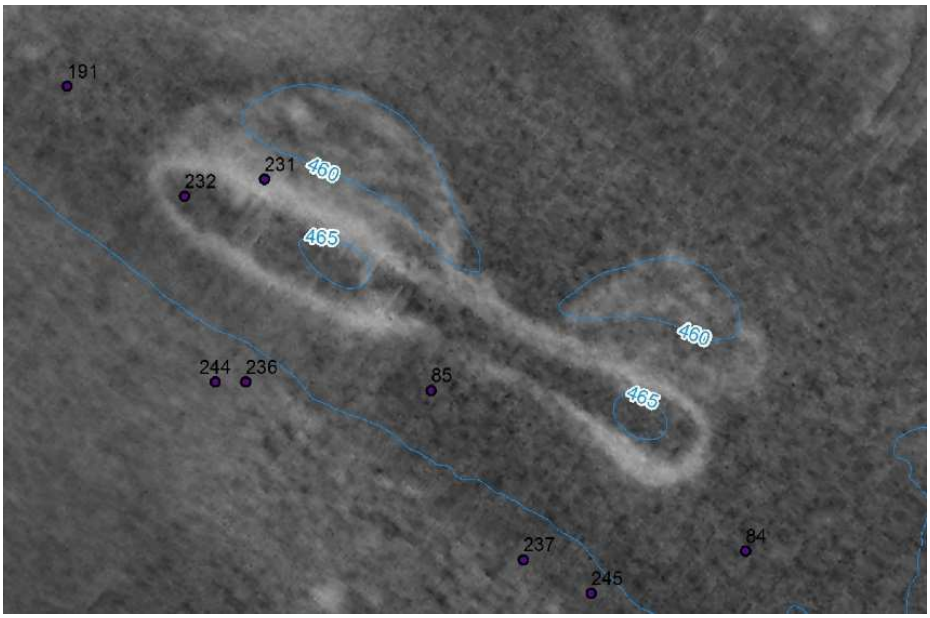


Figure 4-2: The "Butterknife" feature. The white colour is high reflectivity from MBES backscatter (i.e. hard substrate), dark grey is softer sediment.

The total number of stations completed was 172 (Table 4-1). Of these38 were repeat sampling of 2018 monitoring stations using DTIS and/or the multicorer (Table 4-2). There were19 and 50 camera and multicorer deployments respectively around the Butterknife feature (Table 4-2).

Table 4-1: Number of deployments by sampling gear type. CAM = Deep Towed Imaging System (DTIS); MUC = multicorer; CTD = Conductivity-Temperature-Depth; LAN = Benthic Lander; MOOR = Mooring; ACO = Acoustics; SLED = Epibenthic Sled; SCIP = Sediment Cloud Induction Plough; GLR = Glider; BEAM = Beam Trawl.

CAM	**MUC**	CTD	LAN	MOOR	ACO	SLED	SCIP	GLR	BEAM
44	**73**	12	4	4	4	5	20	1	5

Table 4-2: Number of sampling stations of the main gear types during the different phases of the survey. CAM = Deep Towed Imaging System (DTIS); MUC = multicorer; SCIP = Sediment Cloud Induction Plough.

Phase	**CAM**	**MUC**	**SCIP**
Testing	7		8
2018 repeat	17*	21	
Pre-disturbance	7	25	
Disturbance phase			12
Post disturbance	12	25	

*Includes 5 used for pre-disturbance baseline

Details of all stations are given in Appendix B.

4.3 Physical Oceanography

4.3.1 Methods

A number of gear types and instruments were deployed or used to measure and characterise the oceanographic conditions in the area, as well as the sediment plume composition (solid and dissolved phases).

CTD (Conductivity-Temperature-Depth)

The CTD-rosette system was a Seabird Electronics Inc. (SBE) 911plus CTD with a 24 by 10-litre SBE 32 Carousel water sampler. The CTD sensor configuration consisted of primary temperature, primary conductivity, and primary dissolved-oxygen; secondary temperature, secondary conductivity, and secondary dissolved-oxygen; pressure; primary and secondary fluorescence; primary and secondary transmissivity; solar photosynthetically active radiation (PAR); Seapoint turbidity, and sonar altitude. The water sampler carried 24 10-litre external-spring Niskin-type bottles. On selected casts, a Wetlabs Ecotriplet was attached to the CTD frame to measure Coloured Dissolved Organic Matter (CDOM), 660 nm fluorescence and particle back-scatter, as a proxy for turbidity.

Water samples were collected from selected depths for processing onboard. Primary sampling depths were surface (nominally ~10 m), 200, 400, 435, 450 and nominally ~455 (i.e., at the bottom of the CTD cast, typically 10 m above the seafloor) metres, with additional sampling undertaken at 300 m as required, depending on profile structure. The seawater was transferred into 10 litre carboys, except

for those samples that are taken directly off the Niskin bottles (see below). Details of the methods used for the water column measurements are summarised here.

The water column parameters were:

1) Total Suspended Solids (TSS) – ~2 litres filtered through pre-weighed 0.4 µm polycarbonate filter, rinsed with 0.2 µm filtered seawater and Milli-Q distilled water; dried in dark.
2) Particulate Organic Carbon-Particulate Nitrogen (POCPN) and Total Carbon-Total Nitrogen (TCTN) – 1 litre filtered through pre-combusted GFF filter, rinsed with 4 ml 0.4 M H_2SO_4 acid and 0.2 µm filtered seawater (POCPN) and 0.2 µm filtered seawater only (TCTN); filter folded, placed in Secol envelope and frozen (-20°C)
3) Chlorophyll a (Chla) - 1 litre filtered through GFF filter, rinsed with 0.2 µm filtered seawater; filter folded, placed in Secol envelope and frozen (-20°C)
4) Nutrients – seawater filtered through GFF filter (used for Chla) into 250 ml polyethylene bottle and frozen (-20°C)
5) Dissolved organic carbon (DOC) – filtered directly from Niskin through pre-combusted GFC into 50 ml glass Schott bottle and frozen (-20°C)
6) Dissolved inorganic carbon/alkalinity (DIC/alk) – seawater taken directly from Niskin, collected in 1 litre glass Schott bottle, poisoned with 1 drop of $HgCl_2$
7) Coloured dissolved organic matter (CDOM) – seawater collected into a 60 ml polycarbonate bottle and refrigerated until analysis onboard using a spectrophotometer
8) Trace gases (methane, CH_4; nitrous oxide, N_2O) – seawater taken directly from Niskin, collected in 150 ml glass bottle, poisoned with 1 drop of $HgCl_2$, capped and sealed.

Moorings

Three moorings were deployed during TAN1805 and left for the 12 month period between surveys. These consisted of:

- RD Instruments 600kHz Acoustic Doppler Current Profiler (ADCP)
- McLane PARFLUX Mark 78HW-13 sediment trap (S/N: ML14441-01), with additional instrumentation attached to the frame (Aqualogger x 2, Ecotriplet, MicroCAT CTD sensor)
- McLane Remote Access Sampler (RAS), with 48 x 500 ml water sample bags.

The configuration of these was plotted in the Voyage Report from TAN1805 (Clark et al. 2018).

These were retrieved during TAN1903, with the sediment trap and RAS samples removed and refrigerated for analysis on land. Additional samples of encrusting animals from bio-fouling on the moorings were bagged and frozen (-20°C) onboard.

Near the conclusion of TAN1903 a single mooring was redeployed that comprised:

- PARFLUX Mark 78H Sediment trap (21 bottles)
- Aqualogger x 2
- Ecotriplet
- MicroCAT CTD sensor
- ADP Current meter

This mooring will be retrieved in June 2020.

Shipborne acoustic sensors

Three acoustic sources, including the EK60 Split-beam Echosounder (SpBES), EM302 Multibeam Echosounder (MBES) and Acoustic Doppler Current Profiler (ADCP), were utilized during the survey.

MBES

The Kongsberg EM302 is a mid- to deep water MBES using frequencies centred on 30 kHz. The system emits 288 beams generating up to 432 soundings per swath and has dual-swath. The system can record bathymetry (water depth), seafloor and water-column backscatter data.

EK60

The keel mounted EK60 system on RV *Tangaroa* comprises five frequencies (18, 38, 70, 120, 200 kHz).

ADCP

Tangaroa is fitted with a 75kHz RDI ADCP, which uses acoustics to measure ocean current speed and direction at depth intervals ("bins") through the water column below the ship. The transducer is housed in an acoustic pod, located on the hull slightly port and forward from the ship centre, at a depth of 5m. A blanking distance of 8m applies to all data collected, meaning the first measured depth range starts at 13m.

Glider

The glider used in the voyage was NIWAs 1000m rated underwater Slocum Glider 'Betty'. Slocum gliders are buoyancy driven, autonomous underwater vehicles that move through the ocean in a saw-tooth pattern at a top speed of $0.3ms^{-1}$ (0.5 knots) and a descent/ascent rate of $0.2ms^{-1}$. Science sensors were sampled every 4 seconds during the dive from the sea surface to 13m above the seabed, and the return to the surface.

The glider carried a suite of sensors:

- SeaBird CTD - temperature, conductivity, pressure
- WetLabs FLBBCD - chlorophyll, coloured dissolved organic matter, scattering at 700nm
- WetLabs BB3 - scattering at 470, 532, 660nm
- Biospherical QSP2155 - photosynthetically active radiation
- AADI OXY4831 - dissolved oxygen concentration

4.3.2 Results

CTD

A total of 12 CTD casts was completed over the duration of the voyage. Most were carried out in the vicinity of the Butterknife immediately after a disturbance event, to detect and take water samples of the near-bed plume and water column.

Three CTD casts were made towards the end of the voyage (station numbers 158, 159 and 160) directly over the Butterknife (#158), 0.25 n.mile (#159) and 1.0 n.mile (#160) to the north to collect a gradient of data on CDOM and a final CTD was undertaken at station 172 to collect water for DIC/alkalinity analysis near the coral collection site.

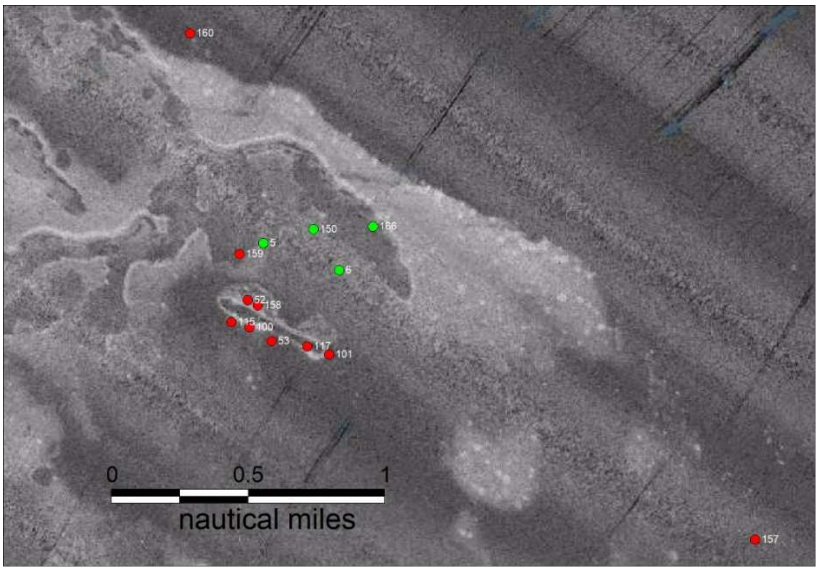


Figure 4-3: The distribution of CTD (red) and Mooring (green) sites near the Butterknife to collect water sample data.

Temperatures spanned 8° to 14° C and salinity ranged from 34.45 to 34.75 psu from the T-S plot. An example CTD profile prior to any benthic disturbance showed the presence of several oceanographic features: (1) an upper well-mixed water column with high fluorescence, and (2) a homogeneous bottom boundary layer that had lower transmission (down to 94% light transmission). The lower light transmission is indicative of higher turbidity in the bottom boundary layer, which during TAN1805 and TAN1903 was up to 100 m above the seafloor.

Moorings

Three moorings were recovered after having been deployed at the end of TAN1805. These were station numbers 5 (RAS mooring), 6 (Sediment mooring) and 150 (ADCP mooring) (see Figure 4-3). All were covered with some extensive hydroid growth, with associated fauna that included nudibranchs, anemones, and polychaetes.

Figure 4-4: An acoustic release from the ADCP mooring, showing the extensive growth of hydroids after 12 months in the water.

A mooring with a current meter and sediment trap (Figure 4-5), with various instrumentation attached to the frame, was deployed (station #166), which will be recovered in June 2020

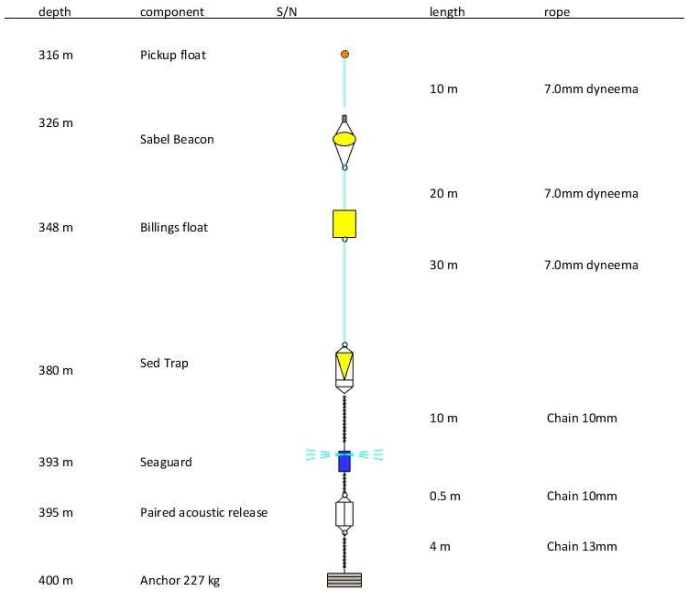


Figure 4-5: Details of the sediment-trap/current meter mooring configuration deployed on TAN1903.

Mooring (and lander) positions were determined after settling to the seabed by triangulation fixes based on distance and bearing from the ship to the acoustic release transponders mounted on the equipment.

MBES-Acoustics

After the disturbance areas around the Butterknife were selected, acoustic lines were run pre- and post-disturbance. The EK60 SpBES, and the ADCP were run on both occasions, while the MBES was only run post-disturbance. The number of systems meant a reduced ship speed of 6 knots, allowing sufficiently small distances between pings of each system.

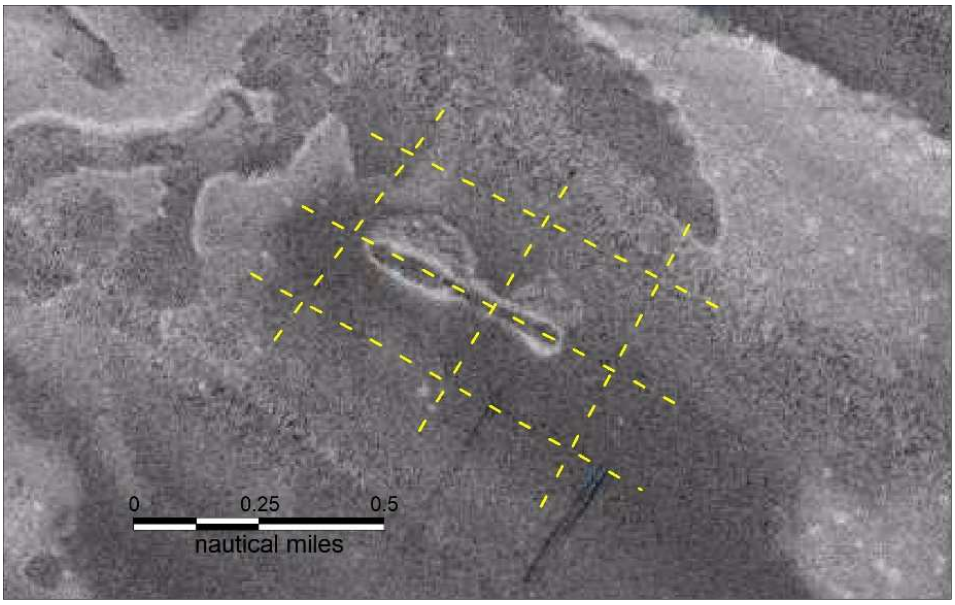


Figure 4-6: Distribution of acoustic transect lines in the main survey region.

Glider

NIWAs ocean glider "Betty" was deployed on 12 June and recovered on 25 June, a period of two weeks monitoring conditions in the Butterknife survey area. Over this time, the glider covered 260 km and completed 465 vertical profiles. The figure below shows the glider track, and surface locations, during the survey.

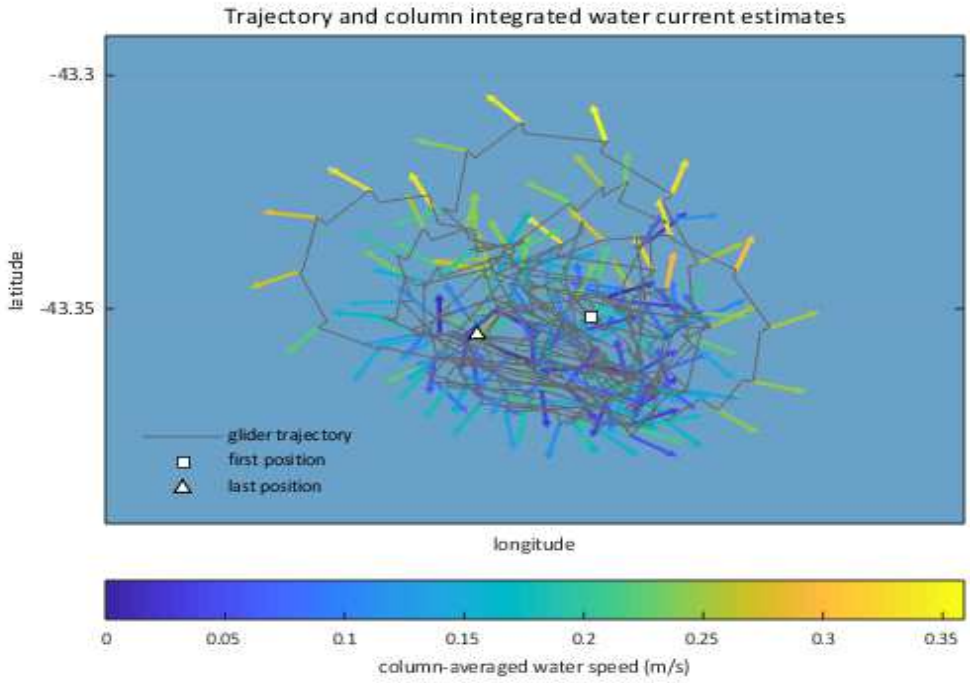


Figure 4-7: Glider track over the 13-days with depth averaged currents from each segment.

The glider collected data of several parameters, but here we illustrate contour profiles of temperature, salinity and coloured dissolved organic matter (CDOM).

Temperatures tended to decrease linearly with depth to a minimum of 8 C at 350 m down to the seabed. Salinity structure was more complicated with subsurface peaks in salinity occurring below the mixed layer depth. Subsurface salinity maxima of 34.7 psu were persistent over the 13 day glider deployment. This is likely due to horizontal advection of eddies at around 100m. Tidal fluctuations were seen in both temperature and salinity as twice daily 'wiggles' most noticeable at the base of the pycnocline. Prior to any disturbance experiments, salinity maxima were observed above the bottom boundary layer at 300m. These coincided with spring tide at the winter solstice.

The time series of CDOM showed near constant CDOM observations from 12 to 22 June, typically around 1ppb. Increases in CDOM occurred at the end of the glider mission to around 1.2-1.5ppb for the last four days of the deployment. Elevated CDOM was observed above the bottom boundary layer, with instances of higher CDOM to the surface. It is unclear if these changes were related to the SCIP disturbance.

Signals in optical backscatter or turbidity to indicate a plume from the disturbance experiment were limited from glider profiles. However, relationships between the four optical wavelengths (470, 532, 660 and 700 nm) require further investigation to determine if a plume can be detected in the lower water column.

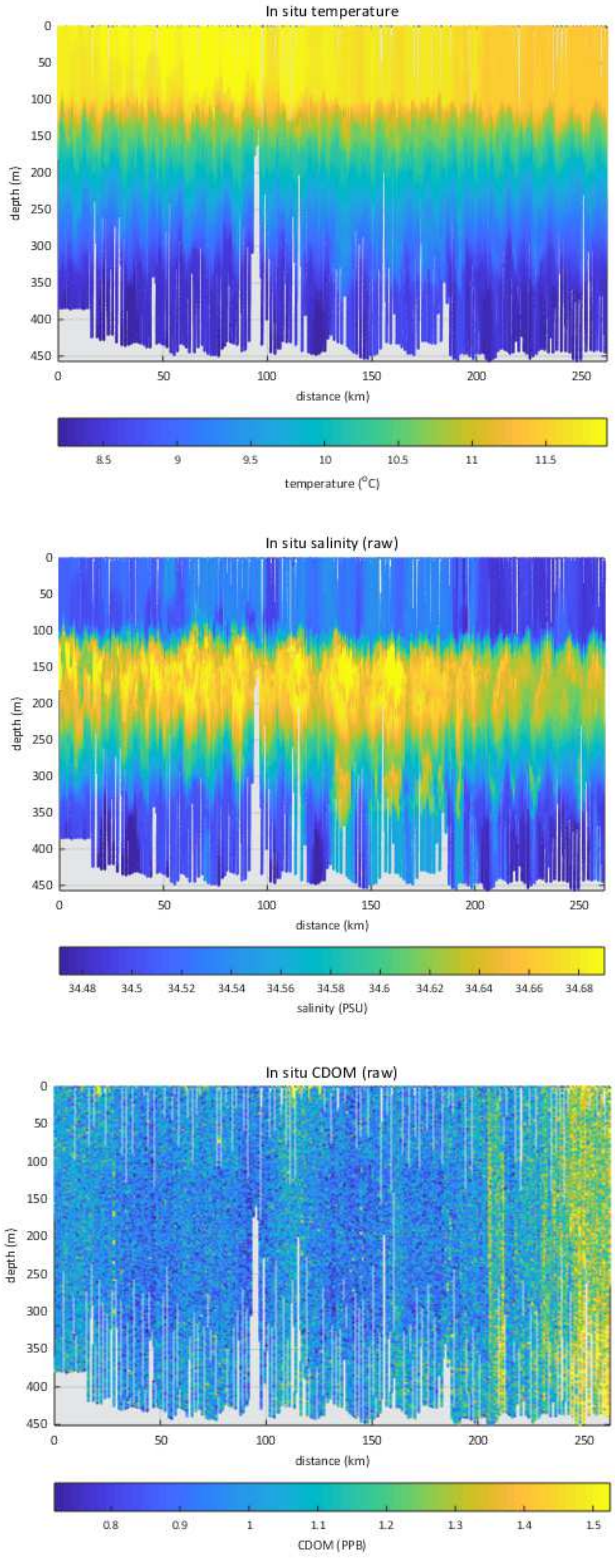


Figure 4-8: Temperature, salinity and Coloured Dissolved Organic Matter (CDOM) observations from ocean glider 'Betty' during the survey. Grey areas and spikes represent areas of no data (e.g., seabed, or when glider is diving or returning to surface).

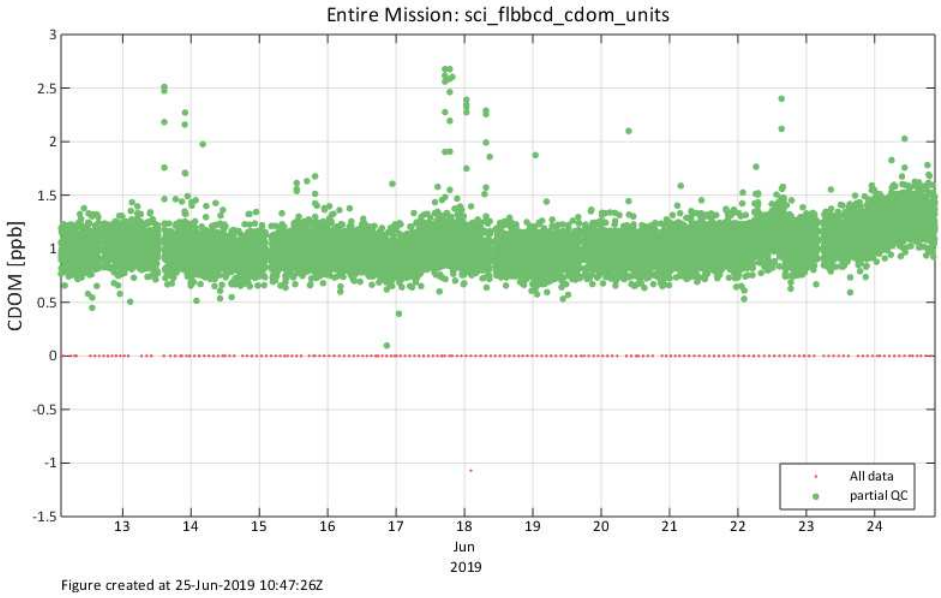


Figure 4-9: Time series of CDOM for the duration of the glider deployment.

4.4 Seabed disturbance

4.4.1 Methods

Benthic Disturber

The physical disturbance in the 2018 survey was done with a specially designed "Benthic Disturber" that had previously been used at abyssal plain depths. However, its fluidising system did not mobilise deeper than a few cm and it didn't lift the heavier sand components of the Chatham Rise sediments. Attempts to fund improvements were unsuccessful, and so plans changed to the concept of using an agricultural plough and disturbing just the area close to the Butterknife where a sediment cloud had more chance of settling on epifaunal communities.

A second-hand Hooper "flexi-tyne" was purchased and modified for our purposes by adding skids to control the depth of penetration of the tynes, plates to direct sediment vertically, options for a harrow mat instead of the roller, and attachment plates for cameras and a position-beacon. The configurations of SCIP ("Sediment Cloud Induction Plough") are shown below.

Figure 4-10: Images of SCIP, showing the roller configuration (left) and final harrow mat configuration (right).

Initial trials

There were several initial trials with SCIP, where paired lines of SCIP followed by the DTIS towed camera were run (station numbers 03-04, 38-39, 85-86, 88&89-90, 91-92-refer Appendix B) to evaluate the performance before starting the disturbance survey. On a separate trial run (#55) the roller hit the bottom of the stern ramp hard upon retrieval, and this sheared one of the housing brackets of the roller, which was lost. Thereafter, SCIP was used with a harrow mat behind the tynes. During these trials, the removal of the central leg/foot and some strengthening of cross-members were required, as well as the addition of extra weight. Various speeds were trialled, and results assessed by the DTIS runs as well as viewing video cameras mounted in two places on SCIPs frame.

Figure 4-11: Images from the video cameras mounted on SCIP showing the tyne penetration (and roller) (left) and the sediment cloud being generated (right).

Tynes were set at a depth of 15cm, and towing speed was 1.5 – 2.0 knots. The towing procedure was to shoot SCIP to the seafloor, note landing position based on the c-node beacon attached to the frame, haul back to the trawl block at the end of a line, then turn around and reshoot. Every 4-5 lines SCIP was retrieved on deck to tighten and repair damaged tynes, and check towing point, chain and harrow mat links.

4.4.2 Results

Disturbance area

There were three disturbance areas at the Butterknife site:

- Southern zone: just to the south of the southern rim
- Middle zone: “inside” the Butterknife rim, shorter tows to land and haul clear of the west and east rims
- Northern zone: to the north of the Butterknife, clear of the medium backscatter which extended north of the northern rim.

Where possible, the location of the disturbance was matched to current direction throughout the tidal cycle-so that when the currents were heading NE, we worked the South Zone. Most effort was concentrated in the Middle zone where direction of sediment drift would cover the northern or southern rim irrespective of tidal cycle stage.

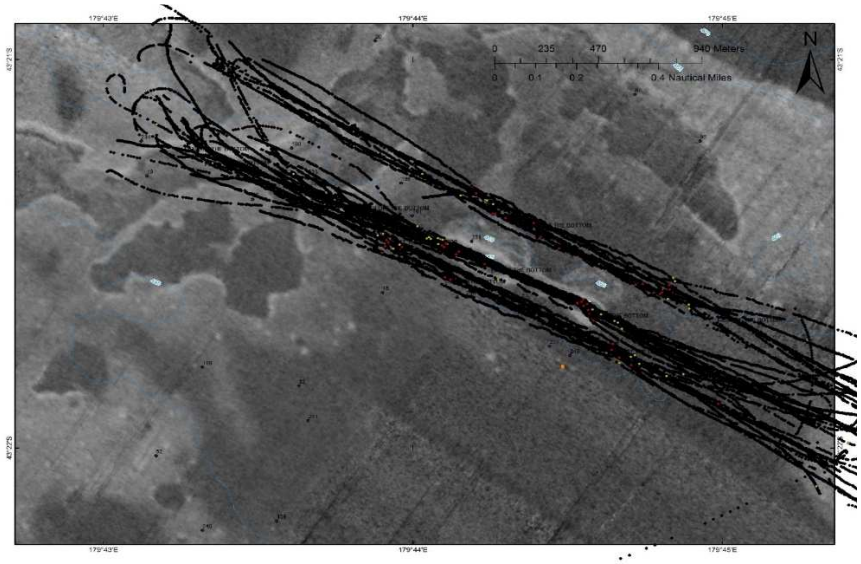


Figure 4-12: A view of the Butterknife region showing SCIP lines covering the three disturbance zones (black lines). Note the lines include when SCIP was off the bottom, and actual tow lines are much shorter than represented.

The table below summarises the duration and distance of each deployment of SCIP.

Table 4-3: The distance and area swept of each deployment of the SCIP.

Stn_no		Distance (nm)	Area (km^2)
3		2.5	0.0162
38		1.85	0.0119
55		1.75	0.0113
85		1.39	0.0090
87		1.18	0.0076
88		1.14	0.0073
89		1.17	0.0075
91		1.7	0.0110
93		6.14	0.0398
94		3.7	0.0239
95		4.51	0.0292
96		1.38	0.0089
97		1.09	0.0071
98		1.88	0.0122
110		5.60	0.0363
111		5.17	0.0335
112		1.54	0.0099
113		1.96	0.0127
114		2.07	0.0134
156		1.06	0.0069
TOTAL		**48.78**	**0.316**

The main disturbance event occurred over the period 19 – 23 June. This consisted of tows 93-98 and then after a spell of bad weather stopped operations, stations 110-114.

Figure 4-13: Images from DTIS of SCIP tracks following disturbance events.

4.5 Sedimentation characteristics

4.5.1 Methods

Benthic landers

Three Benthic Landers (the same as developed for the 2018 survey) were deployed. They carried a variety of instrumentation, as follows:

- Acoustic doppler current profiler (Nortek Aquadopp 2 MHz)
- Turbidity sensors (an AQUAscat and Aquatec AQUAloggers)
- Temperature-salinity-dissolved oxygen sensor (Seabird MicroCAT)
- Camera and light
- Niskin water bottle (5 litre)
- Sediment trap (Technicap, 12 sample bottles) to measure particle deposition.

One lander had a full suite of instrumentation (Lander 1), while the other two did not have an AQUAscat.

The lander deployment was tested in shallow water in Palliser Bay after sailing on 10 June (station #001), and to ensure the amount of buoyancy was appropriate.

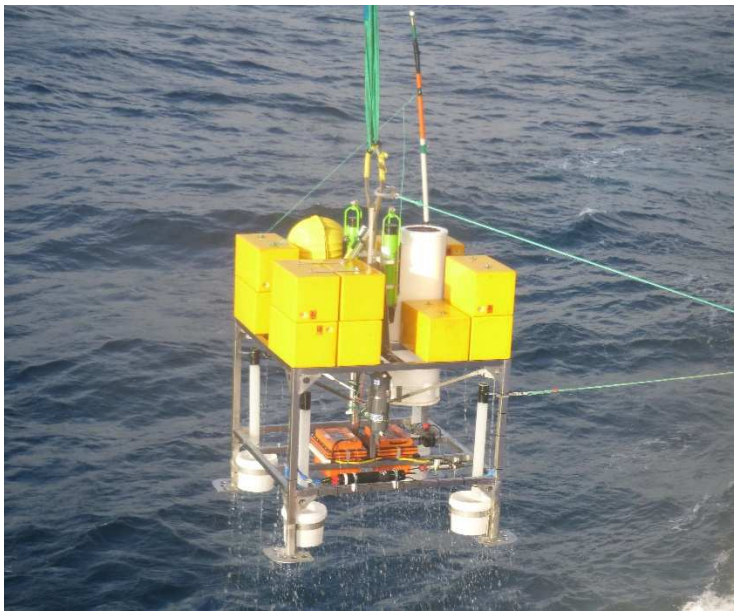


Figure 4-14: Image from the cut-away on RV Tangaroa while deploying a benthic lander.

Multicoring operations

The Ocean Instruments MC-800 multicorer consists of a metal frame with a number of short 10 cm-diameter core barrels and a coring weight assembly. The weights are triggered when the frame contacts the seabed, pressing the barrels down into the sediment, ensuring that the sediment-water interface is largely preserved. During the voyage, 4 or 6 tubes were mounted onto the frame and most deployments were successful.

A set of idealised sampling schemes was developed for the voyage and employed where practicable at each site to ensure sufficient sediment samples were collected for the range of parameters being measured. This differed between the MON, REF and DIS sites, where three casts were done at each site, and the disturbance grid sites, where one cast was done at each site. The scheme for repeating the 2018 sites is shown below.

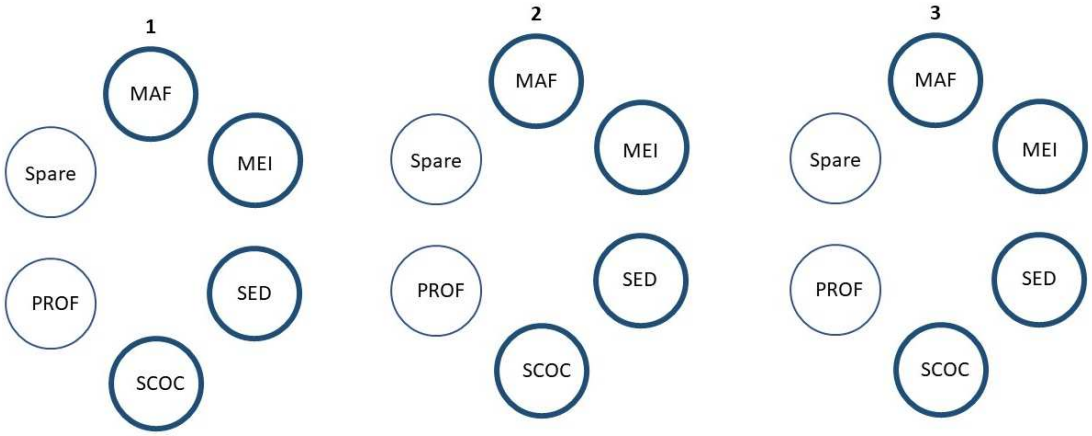


Figure 4-15: Sampling scheme for the 2018 repeat DIS, REF and MON sites, where three multicore deployments (each with 6 cores) took place at each site. MUC = multicorer. MAF = macrofaunal, MEI = meiofauna (sub-core), bacteria (surface) and stable isotope/fatty acids (rest of 0-5 cm core), SED = sediment parameters, SCOC = sediment oxygen consumption, PROF = profiling.

Macrofauna (MAF) were sampled by sectioning the core at 0-5, 5-10 and 10-15 cm sediment depth intervals, wet-sieving at 300 µm, and fixation in 10% formalin. Meiofauna (MEI) were sampled by taking a 2.9 cm-diameter sub-core, sectioning at 0-1, 1-2 and 2-5 cm sediment depth intervals and preserving with 10% buffered formalin. Bacteria samples were collected as a surface scrape using a sterilised stainless steel spoon, with sediment placed in a 50 ml Falcon tube and frozen at -80°C. The remaining sediment from around the meiofauna sub-core was placed in a plastic bag and frozen at -20°C for later stable isotope/fatty acid analyses. Sediment (SED) parameter samples were sliced at 0.5 cm intervals to 2 cm, then the following layers were sectioned: 2-5 cm, 5-10, 10-15, 15-20, and so on at 5 cm intervals to the bottom of the core. Sediment samples were placed in Whirlpak or Twirl'Em bags, sealed and frozen at -20°C for later analysis for particle grain-size, water content, total organic matter, pigments (chlorophyll a/phaeopigments) and carbonate content.

Three multicore drops were made at seven of the 2018 DIS, REF and MON sites:

DIS 1, REF 1, MON 1 (2 deployments), MON 2, MON 5, MON 7, MON 9 (refer Clark et al. 2018)

A regular grid of sampling sites was designed to cover the area of the Butterknife. These were regularly spaced in a 5 x 5 station grid to span the range of disturbance and non-disturbance conditions.

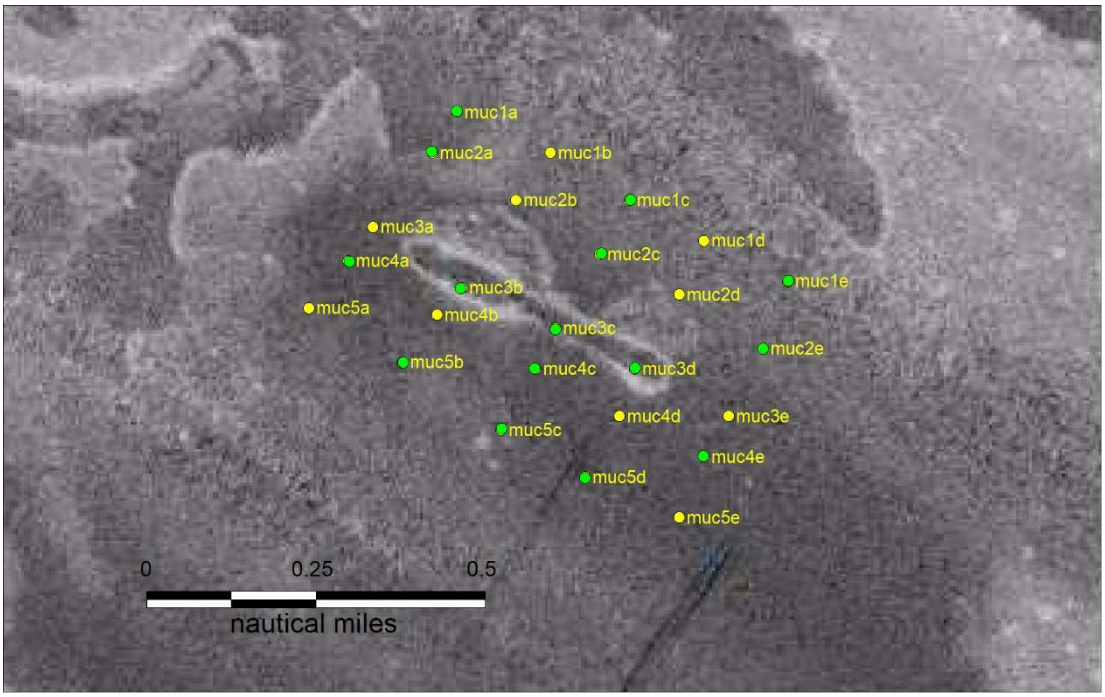


Figure 4-16: The grid of Multicorer stations across the Butterknife area (green = SCOC sites, see text).

These sites were sampled before disturbance, and then post-disturbance. There was single drop at each site, with six cores.

A subset of these sites (15 of the 25) was selected for more detailed experimental measurements in the onboard laboratories (see next section).

Experimental work

Additional cores from three sites along each multicore transect were set aside for profile and respiration experiments on board (green in Figure 4-16):

Transect 1: a, c, e

Transect 2: a, c, e

Transect 3: b, c, d

Transect 4: a, c, e

Transect 5: b, c, d

Biogeochemistry of sediments (profile cores)

Micro-probes were used for measurement of dissolved oxygen (DO) and pH profiles in the surficial 50 mm, and pore waters removed (using a Rhizome sampler) for chemical analysis and pH, DO and redox measurements at a range of depths down to 20-30 cm sub-surface.

Sediment cores were sectioned for later chemical and particle size analysis.

Sediment Community Oxygen Consumption (SCOC cores)

Sediment incubations were undertaken in order to estimate sediment community oxygen consumption. The upper 13–15 cm of sediment and the overlying water from undisturbed multicore tubes were carefully extruded into incubation chambers (total volume = 2.0 L) with the same internal diameter. Overlying water was sampled for dissolved nutrients. Incubation chambers were then sealed and placed in water baths at ambient bottom water temperature (± 0.1 °C) where they were held in the dark for 26–48 h. An additional chamber containing only near-bottom water was incubated to account for water column respiration. A magnetically driven impeller (60–80 rpm) fitted to the chamber lids gently circulated water during the incubations. Approximately 6 h after chambers were placed in the water bath, O_2 concentrations were measured with a PreSens FIBOX 3 PSt3 optode O_2 sensor inserted through a sampling port in the chamber lid. Further O_2 measurements were made during the incubation period, (6hr increments) which was terminated when the initial concentrations had decreased by 10%–20%. Upon termination of core incubations dissolved nutrients were sampled. SCOC was estimated from the decline in O_2 concentration with time (linear regression $r^2 > 0.9$) after correcting for water column respiration. Once the incubation was completed, all of the sediments in the core were processed for macrofauna (sieved on 300 micron mesh and fixed in formalin).

4.5.2 Results

Landers

The landers were deployed across an area we expected would cover the sediment plume gradient and measure the size, density and biochemical composition of the particles. Lander 1 was deployed just north of the northern Butterknife rim, with Landers 2 and 3 to the south and east (see figure below). The landers were deployed on 15 June (stations 45, 46, and 47). There were issues during the deployment of Lander 1, where a controlled deployment using a rope was attempted and it was found that this put the instrumentation (HiPAP beacon and acoustic release) attached by the rope to the top of the lander under severe strain and threat of breakage. Upon aborting this deployment and its recovery, all landers were subsequently deployed using the traditional free-fall method. The landers were successfully recovered on 25 June.

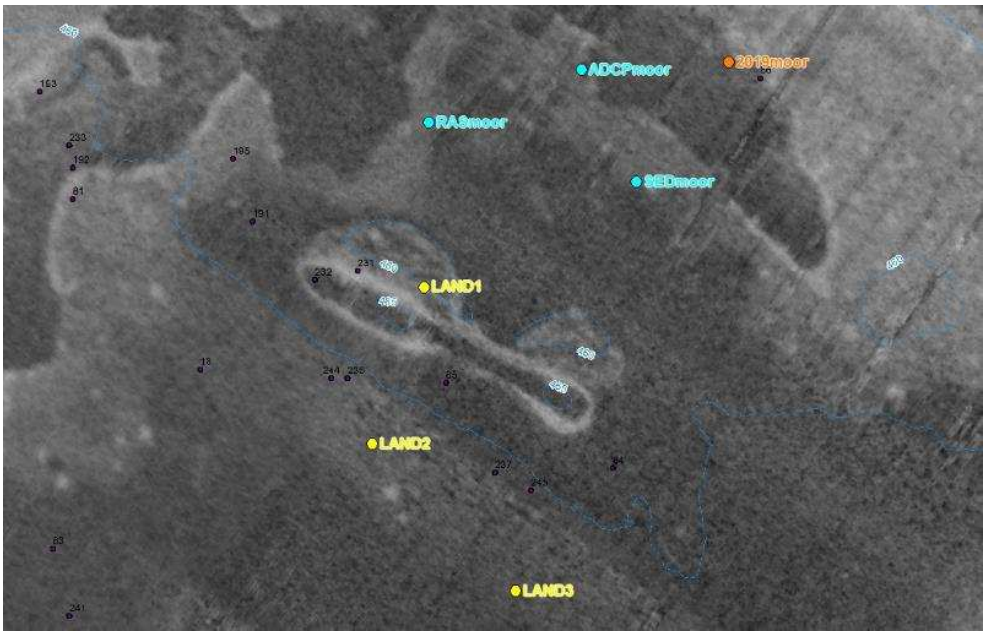


Figure 4-17: The position of the landers and moorings deployed/retrieved during the voyage.

All instruments were removed from the frames and data downloaded. The sediment traps on Landers 1, 2 and 3 provided samples with ~1-day resolution for the duration of the deployment. The Niskin bottle on Lander 2 didn't shut properly with the top still open upon recovery. The water samples from the remaining Niskin bottles were transferred into 10 litre carboys and then subsampled for total suspended solids and Particulate Organic Carbon-Particulate Nitrogen (POCPN) using the methods for processing CTD water samples (see above).

Multicorer

The distribution of stations is shown below for the repeated 2018 sites, and the 2019 Butterknife survey.

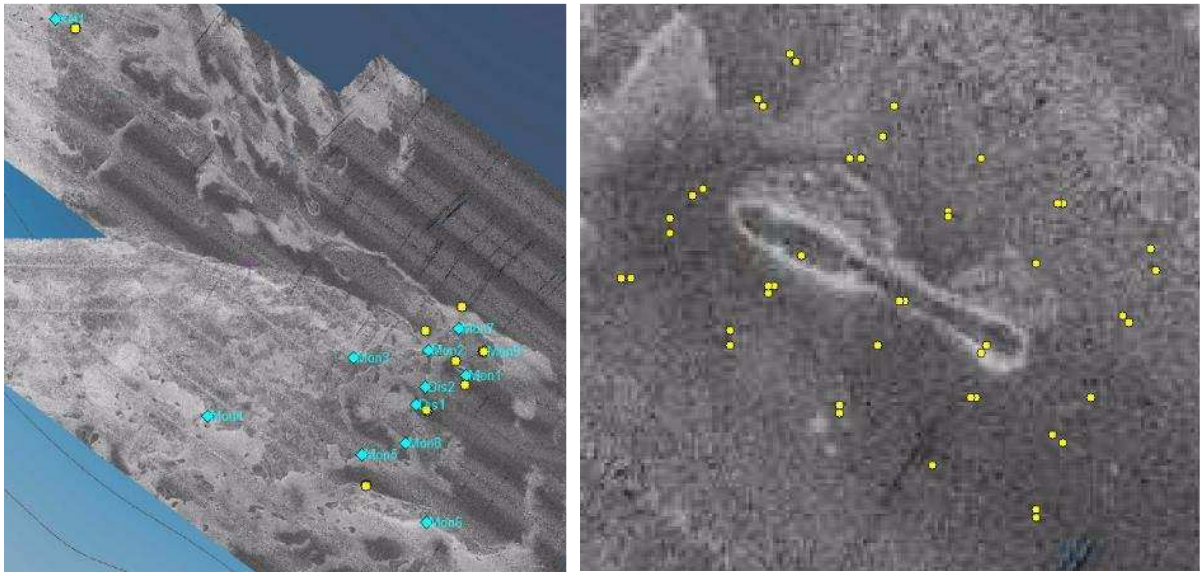


Figure 4-18: The distribution of MUC stations (yellow dots) over the 2018 wide area (left), and 2019 Butterknife survey area (right).

There were 21 deployments (3 at each site) at the 2018 repeat sites, and 25 both pre- and post-disturbance for the Butterknife grid.

Cores were also obtained from a number of sites to provide sediments for sedimentation experiments on land using sponges and corals (Valeria Mobilia, PhD) and for calibration of the instruments measuring water column turbidity, deployed on the CTD and benthic landers.

4.6 Seabed habitats and fauna

4.6.1 Methods

Photographic survey

The camera gear used was NIWAs "Deep Towed Imaging System" (DTIS). DTIS is a battery-powered towed camera frame which records continuous high definition (HD) digital video and simultaneously takes high definition (10 megapixel) still images at 15 second intervals. Full resolution video and still images were recorded at the seabed and downloaded on return to the surface. A low-resolution video image was transmitted to the surface in real time enabling control of camera altitude and initial evaluation of seabed substratum types and biological assemblages. The seabed position of DTIS was monitored by an acoustic ultra-short baseline (USBL) transponder system and plotted in real time using OFOP (Ocean Floor Observation Protocol) system.

During all deployments, spatially-referenced observations on the occurrence of biological assemblages (at relatively coarse taxonomic resolution) and substratum types were recorded by observers using the OFOP system. These initial observations were logged directly to an onboard database. All data were subsequently transferred to the ship's server for storage.

All DTIS transects were run using *Tangaroa*'s Dynamic Positioning System to maintain course and speed and help ensure the winch operator could maintain the optimal height above the seabed. This was successfully done using the main azimuth thruster, and minimising use of bow or stern thrusters. DTIS was towed at 0.5 knots, at a height of 2–3 m above the seafloor.

A small CTD unit was attached to DTIS, recording conductivity, temperature, and depth data for the first camera transects. Unfortunately, the unit became flooded from station 53. For subsequent tows, an Aqualogger was mounted on the DTIS frame recording data on turbidity.

Catch sampling

Coral specimens were collected at several sites with an epibenthic sled, but the main gear used to sample live corals and sponges was the beam trawl. This trawl is a net attached to a 4m wide beam, with a vertical opening of about 30 cm.

4.6.2 Results

Photographic sampling

A total of 44 DTIS tows was completed. The nature of these varied between "activity" and site depending on weather angles that were possible. There were five paired SCIP-DTIS trials where DTIS was used to evaluate the performance of the plough and assess the effectiveness of modifications. There were seven DTIS runs pre-disturbance, and 12 post-disturbance, along the same lines as much as possible.

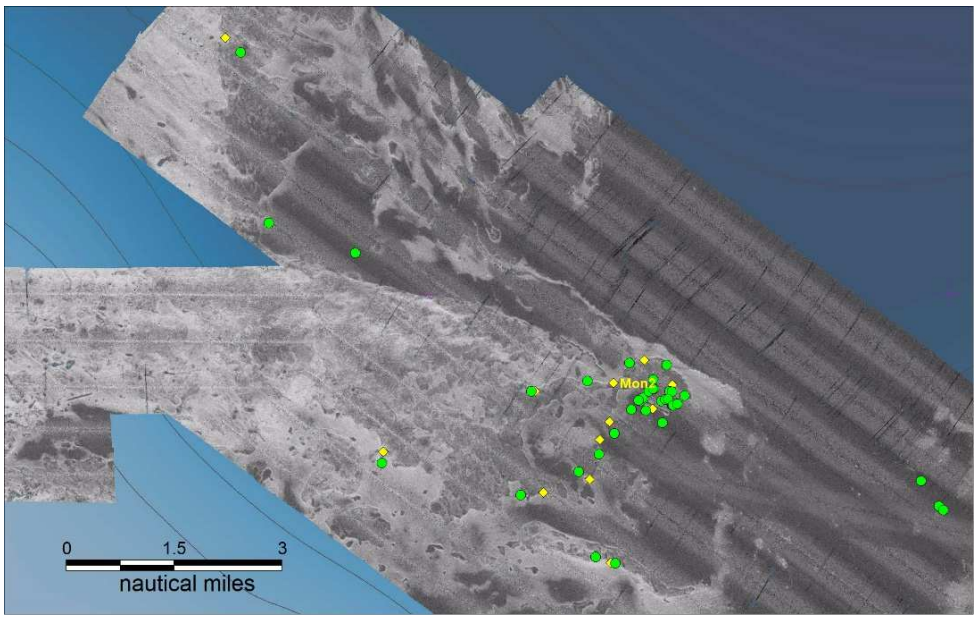


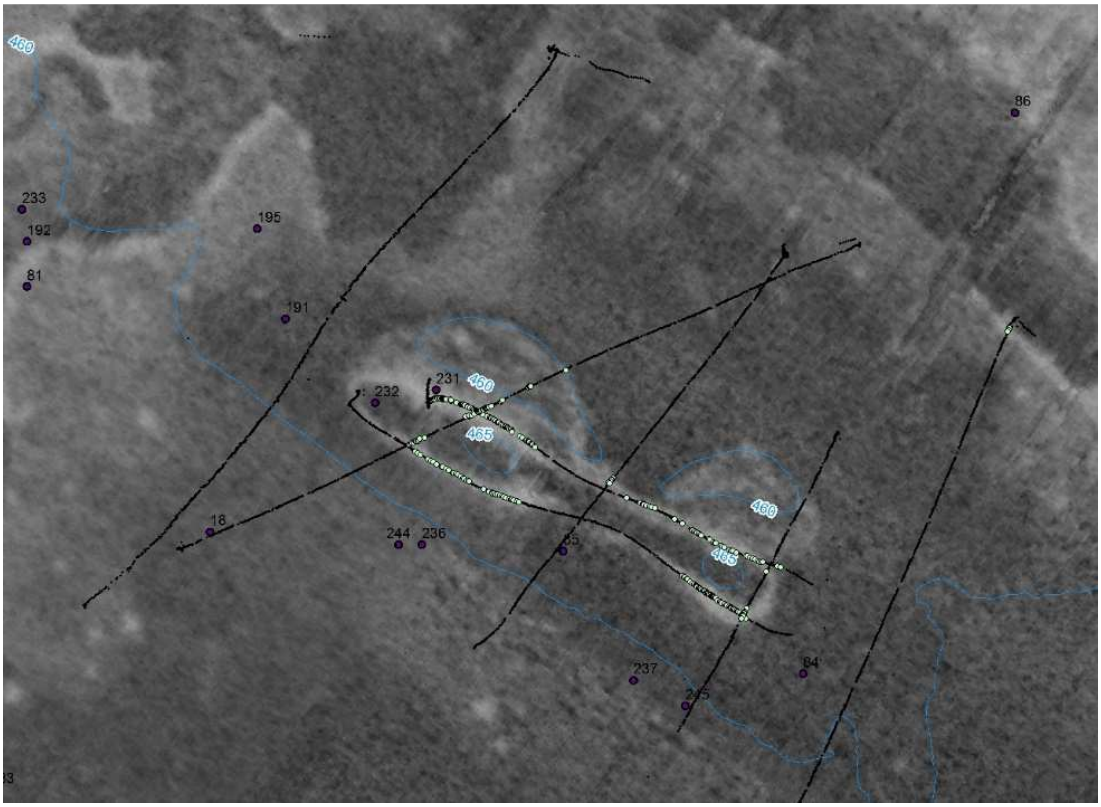
Figure 4-19: Distribution of DTIS tows over the survey area.

Over 38 hours of high definition video were recorded, and over 9 000 still images were taken (240 frames per 1 hr of transect -see the table below). Image quality for both video and stills was generally high, and the use of the *Tangaroa*'s Dynamic Positioning was an important element in this, as it controlled the speed of the ship and enabled a reasonably consistent height above the seafloor to be maintained. DTIS was operated successfully in a range of wind conditions, and swells up to 4–5 m.

Table 4-4: Summary of DTIS data. Duration of video and number of still images for the survey.

Site	No. Stations	No. Stills	Video (HH:MM:SS)
All	44	9 247	38:22:59

The pre- and post-disturbance DTIS lines across the Butterknife differed slightly, with more post-disturbance lines as more fine-scale examination of sedimentation was required.



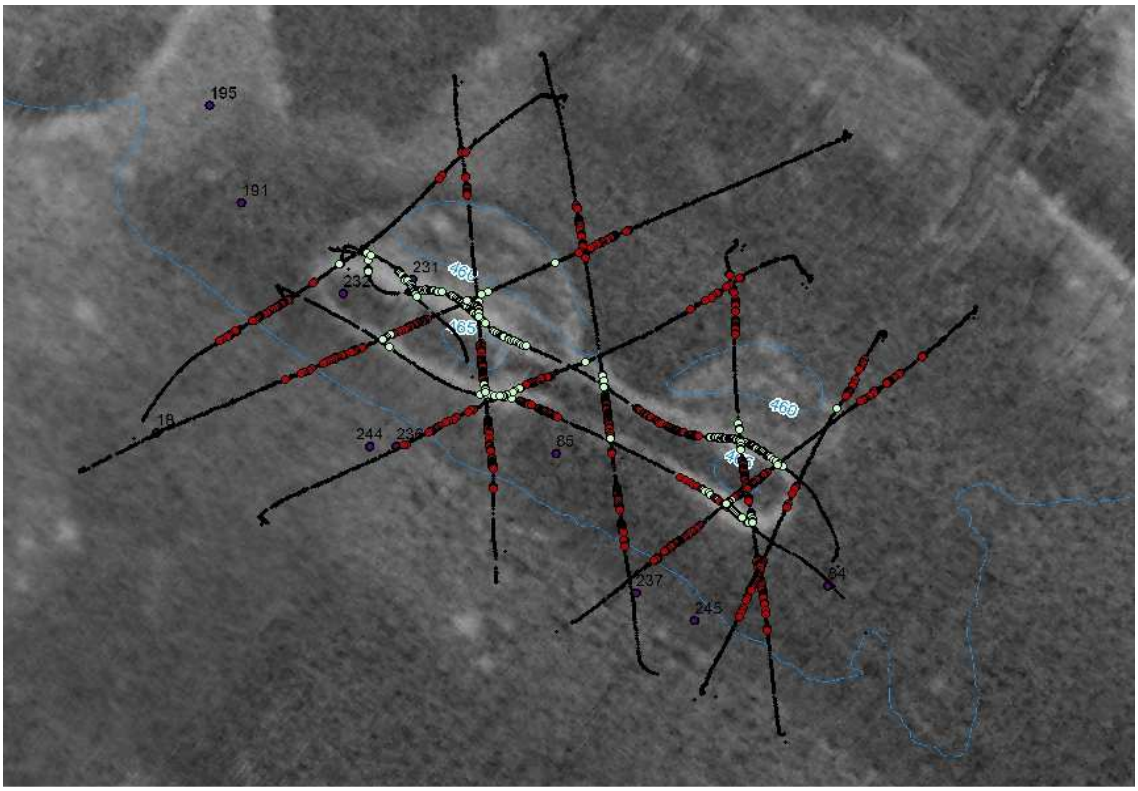


Figure 4-20: DTIS lines pre-disturbance (top panel) and post-disturbance (bottom panel). White dots indicate records of coral communities, red dots show observations of SCIP marks.

The pre-disturbance survey recorded no remaining disturbance marks from the previous survey, despite the intensive lines run with the Benthic Disturber on the southern side of the Butterknife in 2018. The post-disturbance survey, however, shows very clearly the widespread distribution of SCIP marks.

DTIS station descriptions

An account of each DTIS station, highlighting the main characteristics of the tow, with images of representative or notable fauna or substrate, is given in Appendix C.

Live capture aquarium samples

Live deep-sea corals and sponges were sampled by beam trawl or epibenthic sled.

Five sleds were carried out on a small feature targeting the stony coral *Goniocorella dumosa*. The catch from these tows amounted to about 300 kg of mud, boulders, pebbles, and small amounts of coral, galatheids, worms and crabs (the total biological catch was about 20 kg). Three subsequent beam trawls on Hart's Hillock yielded more mud (about 80 kg) but also several good samples of coral (10 kg) and also samples of *Thenea novaezealandiae* (yoyo sponge).

Two further beam trawls (#170, 171) were done west of the main survey area targeting *Ecionemia novaezelandiae*, a sponge known from this area from work in TAN1805. Following a DTIS run, the trawls successfully caught 25 kg of biological samples, which included 20 kg of sponge.

These were held in an aquaria cold-water flow through system on board *Tangaroa*. On collection the animals were kept in closed containers with chilled and recirculating sea-water in a dark environment. Daily checks were made to ensure the water temperatures and current flow in the tanks reflected in

situ conditions. In port, the specimens were transferred to NIWA's aquaria containment facility (Marine Environmental Manipulation Facility - MEMF), at Greta Point.

A count by species of the number of individuals collected at-sea held in the MEMF is summarised below. There were 71 individual *Thenea novaezealandiae* sponges; 20 *Ecionemia novaezealandiae* sponges, several of which due to their size had been cut at sea to fit into the aquarium containers; and 241 small colonies or colony branchlets of *Goniocorella dumosa*.

Table 4-5: Counts of deep-sea sponge and coral samples returned from sea and held in the MEMF.

Holding tank	Species	Count
1	*Goniocorella dumosa*	56
2	*Thenea novaezealandiae*	33
3	*Thenea novaezealandiae*	38
4	*Ecionemia novaezealandiae*	6
5	*Ecionemia novaezealandiae*	6
6	*Ecionemia novaezealandiae*	8
7	*Goniocorella dumosa*	14
8	*Goniocorella dumosa*	88
9	*Goniocorella dumosa*	83

Figure 4-21: Aquaria samples (clockwise): Thenea, Ecionemia, Ecionemia in situ, and Goniocorella.

5 Acknowledgements

Thanks to all the scientific staff, officers and crew of RV *Tangaroa* for their enthusiasm and hard work onboard in coping with challenges of new equipment and the wide variety of gear deployments.

We appreciate the efforts made by Vessels shore staff, especially David Hogan, in helping facilitate the modifications required for SCIP. The ship's engineers are thanked for their help during the voyage in helping sort out various equipment problems.

The support and advice of members of the project End-User Advisory Group (comprising representatives from MfE, DOC, MPI, MBIE, STRATERRA, Chatham Rock Phosphate, ECO) was appreciated. Discussions were also held prior to the survey at a half-day seminar with several stakeholder, NGOs and tangata whenua groups. Further engagement occurred with Hokotehi Moriori Trust, Ngāti Mutunga, and members of Te Aitanga o ngā uri o Wharekauri on the Chatham Islands, and we acknowledge the assistance of Lee Rauhina-August (NIWA Te Kuwaha). Input and assistance in the survey design and preparations from Ashley Rowden, Chris Hickey (both NIWA) and Conrad Pilditch (University of Waikato) were appreciated.

Ship time for the *Tangaroa* for the voyage was awarded by the Tangaroa Reference Group (TRG) and funded by the Ministry for Business, Innovation and Employment (MBIE) (MBIE contract CO1X1614).

6 References

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https://niwa.co.nz/sites/niwa.co.nz/files/ROBES_VoyageReport_1Nov2018-web.pdf

Appendix A Summary of daily events during the voyage.

Date	Activity
9 June	Mobilisation
10 June	Mobilisation completed. Delay sailing for replacement ship's officer. Sail 1600. Short lander deployment test in Palliser Bay. Head for Chatham Rise.
11 June	Transit, stream warp. Do DTIS run (#2) over test area for SCIP trial. SCIP tow (#3) at various speeds. DTIS tow post trial. More tests needed, but no major issues. Continue steam towards survey area.
12 June	Arrive in ROBES survey area 0800. Recover RAS and SED moorings (#5, 6), deploy glider to survey Butterknife area (#7). Weather good, so begin repeat sampling of 2018 sites. Two DTIS runs along N and S rims of Butterknife (#8,9). Multicorer (MUC) sampling at MON1, MON9, DIS1 with 3 good drops at each site (#010-018). DTIS at DIS1 (#019).
13 June	Continue with DTIS tows from 2018 survey, at DIS2 (#20), MON1 (#21), MON9 (#23). Complete MUC sites MON7 (#24-26), MON2 (#27-29).
14 June	DTIS MON2 (#30), MON3 (#31), REF1 (#33). MUC at REF1 (#34-36). Then retrial SCIP. Do DTIS beforehand (#37), then trial SCIP at various speeds again (2-4 knots) (#38). Poor HiPap signal. Post DTIS run along line (#39).
15 June	DTIS to repeat MON6, MON5, and MON8 (#40, 41, 43, 44). CTD cast for bottom water for sediment traps (#42). Deploy 3 benthic landers. Method of lowering and releasing was unsuccessful, so deploy from surface. Box their locations (#45, 46, 47). Complete two further DTIS on Butterknife (=MON1) (#48, 49). Weather marginal, no MUC.
16 June	Acoustic transect survey completed over Butterknife feature (pre-disturbance phase). Do two CTDs with full water (#52, 53). Weather delays progress (SW 30-35 knots). Further DTIS (#54) on Butterknife. Then SCIP trial (#55). Damage to roller. Start Butterknife MUC grid, 7 core sites (#56-62).
17 June	Continue with MUC grid (#63,64), a further DTIS on Butterknife (#65) to complete the pre-disturbance DTIS, then finish remaining MUC grid core sites (#66-81), and coring at MON5 (#82-84). SCIP test with harrow mat fitted (#85, no beacon signal). DTIS follow-up (#86).
18 June	Further SCIP trial. Weather deteriorating, stop operations at 0530. Dodging throughout much of the day.
19 June	Resume operations 0400. Two SCIP trials (#88,89) then DTIS (#90). Modify SCIP, then further test (#91) and DTIS run over line (#92). Short transect runs over Butterknife for ADCP data, then start SCIP Disturbance survey in South (SOTH) and north (NORT) boxes (#93)
20 June	Continue SCIP survey. Complete #93 in NORT, #94 (SOTH), #95 in middle box (MIDD), #96 (MIDD), #97 (SOTH).
21 June	Continue SCIP disturbance survey (NORT). Weather comes away and suspend disturbance, do acoustics lines (#99), two CTDs (#100, 101) over centre of Butterknife, two DTIS over Butterknife (#102, 103). Weather still marginal, so head west to sample for live corals (DTIS #104), and sled tows (#105-109).
22 June	Resume SCIP disturbance survey: #110 (MIDD) and #111 (SOTH).
23 June	Continue Disturbance survey (#112, 113, 114 (MIDD). Glider close. Finish disturbance survey and do two CTDs (#115, 117), acoustics survey (#116),

	begin post-disturbance sampling with DTIS on north and south rims (#118, 119, 120) and multicore grid (4 drops, #121-124).
24 June	Continue DTIS stations across the Butterknife (#125, 126, 127). Short delay with wind freshening and moving multicorer. Multicore grid continues, 18 corer drops (#128-145).
25 June	Complete last 4 stations of MUC grid. Weather window suitable for recovery operations, ADCP mooring from TAN1805, glider, Benthic Landers 1, 2, and 3. Steam to west (Harts hillock) for three beam trawls (#153, 154, 155) catching *Goniocorella dumosa* and *Thenea* yoyo sponges. Head back to Butterknife for DTIS, but swell too heavy. Wait for swell to ease and daylight.
26 June	Swell and wind easing slowly, but too large for DTIS. Deploy SCIP for experimental runs to characterise the cloud (#156) with CTD (#157). Three further CTDs for cdom samples (#158-160). Weather eases, resume DTIS operations on Butterknife (#161, 162).
27 June	Complete DTIS tows on Butterknife (#163-165). Deploy SED and current meter mooring (#166) and box position. Steam to west for two DTIS runs over the previous beam trawl shots (#167, 168) and then onto “ANZ site” to sample sponges.
28 June	DTIS run over potential tow line (#169) and then two short beam trawls to sample sponges for experimental work (#170, 171). CTD to collect bottom water for temperature and pH determination. Begin transit to Wellington.
29 June	Arrive back in Wellington

Appendix B TAN1903 station summary.

CAM=DTIS, CTD=conductivity-temperature-depth unit, MUC=multicorer, SLED=epibenthic sled, LAN=benthic lander, SCIP=benthic disturber, GLR=glider, MOOR=mooring, BEAM=beam trawl. Perf=gear performance (1,2=good; 3=poor), depths (s_dep, f_dep) in m.

Stn	Area	Method	Date	Time	lat_d	lat_min	lon_d	lon_min	lon	s_dep	f_dep	n.mile	dir	Perf	Comments
1	Test	LAN	10/06/19	1915	41	26.36	175	5.01	E	28	29	0		2	Test of tethered lander deployment and instruments
2	Test	CAM	11/06/19	1118	42	56.49	176	42.98	E	408	409	0.7	11	1	DTIS run over test area of SCIP.
3	Test	SCIP	11/06/19	1503	42	56.66	176	42.92	E	414	422	2.5		2	Test of benthic disturber (SCIP)
4	Test	CAM	11/06/19	1734	42	56.61	176	42.93	E	405	408	1.56		1	DTIS run over test area post SCIP.
5	MON1	MOOR	12/06/19	825	43	21.27	179	44.32	E	456	456	0		2	Retrieval of RAS mooring from 2018. Extensive hydroid growth.
6	MON1	MOOR	12/06/19	915	43	21.35	179	44.7	E	460	460	0		1	Retrieval of SED mooring from 2018. Extensive hydroid growth
7	SURVEY	GLR	12/06/19	1301	43	21.97	179	44.64	E	0	0	0	315	0	Glider deployment near Butterknife, retrieval after 2 weeks
8	MON1	CAM	12/06/19	1605	43	21.48	179	44.08	E	458	458	0.44		1	DTIS run repeat of TAN1805/232 south side. Good GDU start and end of line.
9	MON1	CAM	12/06/19	1830	43	21.48	179	44.48	E	464	456	0.2	144	1	DTIS run repeat of TAN1805/231 north side
10	MON1	MUC	12/06/19	2016	43	21.39	179	44.1	E	452	452	0		1	MON1muc, 6 good cores
11	MON1	MUC	12/06/19	2041	43	21.39	179	44.1	E	460	460	0		1	MON1muc, 6 good cores
12	MON1	MUC	12/06/19	2204	43	21.38	179	44.1	E	465	465	0		1	MON1muc, 6 good cores
13	MON9	MUC	12/06/19	2335	43	21.25	179	44.66	E	465	465	0		1	MON9muc, 6 good cores
14	MON9	MUC	13/06/19	23	43	21.24	179	44.64	E	458	458	0		1	MON9muc, 6 good cores
15	MON9	MUC	13/06/19	55	43	21.25	179	44.66	E	465	465	0		1	MON9muc, 6 good cores
16	DIS1	MUC	13/06/19	156	43	22.11	179	43.53	E	461	461	0		1	DIS1muc, 6 good cores
17	DIS1	MUC	13/06/19	227	43	22.11	179	43.53	E	455	455	0		1	DIS1muc, 6 good cores
18	DIS1	MUC	13/06/19	254	43	22.1	179	43.52	E	459	459	0		1	DIS1muc, 5 good cores
19	DIS1	CAM	13/06/19	443	43	22.22	179	43.29	E	451	454	0.57	51	1	DTIS repeat of TAN1805/240). Muddy, no BDR marks.
20	DIS2	CAM	13/06/19	748	43	21.93	179	43.58	E	453	456	0.66	21	1	DTIS, repeat of TAN1805/241 in DIS 2 site. Muddy sediment, possible BDR mark

21	MON1	CAM	13/06/19	1037	43	21.6	179	43.91	E	457	458	0.61	66	1	NE tow across previous BDR and across Butterknife. Muddy sediment outside rims of Butterknife, GDU communities on rims, no BDR marks evident.
22	MON7	CAM	13/06/19	1345	43	20.95	179	43.87	E	458	465	0.59	78	1	MON7 site following high reflectivity edge. Mainly mud, some pebbles, few GDU.
23	MON7	CAM	13/06/19	1635	43	20.98	179	44.58	E	461	460	0.18	124	2	DTIS camera issues mid-run. Two files on OFOP, 23A + 23B
24	MON7	MUC	13/06/19	1906	43	20.59	179	44.23	E	475	475	0		1	6 good cores
25	MON7	MUC	13/06/19	1936	43	20.59	179	44.23	E	468	468	0		2	5 good cores
26	MON7	MUC	13/06/19	2010	43	20.59	179	44.23	E	467	467	0		1	6 good cores
27	MON2	MUC	13/06/19	2129	43	20.94	179	43.49	E	460	460	0		2	4 good cores
28	MON2	MUC	13/06/19	2157	43	20.94	179	43.49	E	460	460	0		1	5 good cores
29	MON2	MUC	13/06/19	2224	43	20.94	179	43.49	E	460	460	0		1	5 good cores
30	MON2	CAM	14/06/19	7	43	21.2	179	43.06	E	459	435	0.41	90	1	DTIS, repeat of TAN1805/234 at MON2
31	MON3	CAM	14/06/19	214	43	21.34	179	41.99	E	447	436	0.4	68	1	Run along reflective rim, muddy with pebble and cobbles, sponges, few corals
32	MON4	CAM	14/06/19	557	43	22.34	179	39.13	E	426	423	0.37	327	1	Mud with scattered areas of pebbles and cobbles. Some GDU, STY, heart urchins.
33	REF1	CAM	14/06/19	901	43	16.62	179	36.43	E	446	437	0.67	312	1	Mostly mud-pebbles, some GDU. Sponges, Hyalascus, asteroids, heart urchins.
34	REF1	MUC	14/06/19	1113	43	16.54	179	36.54	E	454	454	0		2	4 good cores
35	REF1	MUC	14/06/19	1145	43	16.54	179	36.54	E	453	453	0		1	6 good cores
36	REF1	MUC	14/06/19	1233	43	16.55	179	36.54	E	462	462	0		2	4 good cores
37	TEST	CAM	14/06/19	1444	43	19.42	179	38.62	E	458	459	0.49	106	1	DTIS before SCIP test#2 mainly mud as expected
38	TEST	SCIP	14/06/19	1719	43	19.99	179	37.32	E	434	455	1.85	67	2	SCIP test. Beacon failed. 15min @ 2kts, 15min @ 3 kts, 10min @ 4 kts
39	TEST	CAM	14/06/19	1925	43	19	179	36.97	E	434	452	1.22	90	2	DTIS after SCIP. Visible tracks in 2-3 knots section, and 4 knots section for first 2-3 mins. Very hard to see any tracks
40	MON6	CAM	15/06/19	2	43	23.65	179	43.22	E	441	435	0.27	109	2	DTIS. Issues with camera partway through MON6.
41	MON6	CAM	15/06/19	152	43	23.74	179	43.6	E	440	438	0.2	109	2	DTIS. This was the second half of MON6 after issues with cable.
42	TEST	CTD	15/06/19	441	43	22.72	179	41.64	E	0	419	0		2	Water collection cast for sediment traps on landers

43	MON5	CAM	15/06/19	636	43	22.79	179	41.79	E	439	444	0.5	125	1	Muddy sediment, few fauna, small coral area.
44	MON8	CAM	15/06/19	1009	43	22.46	179	42.9	E	448	447	0.59	131	1	Mostly muddy sediment, GDU on cobbles at W rim of depression
45	BUTT	LAN	15/06/19	1519	43	21.54	179	44.31	E	465	465	0		0	Benthic Lander 1. Released + let drift to bottom position. Recovered after 2 weeks.
46	BUTT	LAN	15/06/19	1710	43	21.732	179	44.268	E	454	454	0		0	Benthic Lander 2. Deployed from surface.
47	BUTT	LAN	15/06/19	1845	43	21.871	179	44.547	E	454	454	0		0	Benthic Lander 3. Deployed from surface.
48	MON1	CAM	15/06/19	2050	43	21.54	179	44.68	E	454	452	0	209	1	DTIS, MON1 repeat from TAN1805
49	MON1	CAM	15/06/19	2247	43	21.34	179	44.64	E	455	454	0	218	1	DTIS, MON1 new baseline. LAN 2 at end of line so stopped early
50	BUTT	ACO	16/06/19	20	43	21.49	179	43.8	E	461	461	0	97	2	Acoustic Survey, E-W outside of MUC stations. 3 lines
51	BUTT	ACO	16/06/19	124	43	21.41	179	44.98	E	456	456	0	254	2	Acoustic Survey, N-S outside of MUC stations. 3 lines
52	BUTT	CTD	16/06/19	355	43	21.46	179	44.24	E	0	0	0	242	2	CTD south of Butterknife, full water sampling.
53	BUTT	CTD	16/06/19	804	43	21.61	179	44.36	E	0	0	0	178	1	CTD central Butterknife, full water sampling
54	BUTT	CAM	16/06/19	1155	43	21.18	179	44.32	E	460	456	0.52	220	2	West end of Butterknife. Muddy sediment, few fauna.
55	TEST	SCIP	16/06/19	1625	43	22.47	179	50.4	E	447	434	1.75	212	3	SCIP test, 3.5kts, 4.5kts. Lost Beacon halfway through. Turned turtle. SCIP roller lost on recovery
56	BUTT	MUC	16/06/19	1857	43	21.51	179	44.86	E	463	463	0		1	MUC1e, 6 good cores
57	BUTT	MUC	16/06/19	1929	43	21.61	179	44.82	E	463	463	0		1	MUC2e, 6 good cores
58	BUTT	MUC	16/06/19	2005	43	21.77	179	44.7	E	458	458	0		1	MUC4e, 6 good cores
59	BUTT	MUC	16/06/19	2116	43	21.8	179	44.46	E	460	460	0		1	MUC5d, 6 good cores
60	BUTT	MUC	16/06/19	2159	43	21.64	179	44.56	E	470	470	0		2	MUC3d, 5 good cores
61	BUTT	MUC	16/06/19	2248	43	21.39	179	44.55	E	460	460	0		2	MUC1c, 4 good cores. 1 lost tube
62	BUTT	MUC	16/06/19	2357	43	21.46	179	44.49	E	458	458	0		1	MUC 2c, 6 good cores
63	BUTT	MUC	17/06/19	41	43	21.58	179	44.41	E	460	460	0		2	MUC 3c. 5 good cores
64	BUTT	MUC	17/06/19	120	43	21.64	179	44.36	E	460	460	0		1	MUC 4c, 6 good cores
65	BUTT	CAM	17/06/19	243	43	21.4	179	44.92	E	456	455	0.58	204	1	Run along eastern MUC line. Muddy sediment.
66	BUTT	MUC	17/06/19	434	43	21.86	179	44.65	E	465	465	0		1	MUC5e, 6 good cores
67	BUTT	MUC	17/06/19	508	43	21.71	179	44.75	E	461	461	0		1	MUC3e, 5 good cores
68	BUTT	MUC	17/06/19	549	43	21.45	179	44.7	E	460	460	0		1	MUC1d, 6 good cores
69	BUTT	MUC	17/06/19	619	43	21.53	179	44.65	E	472	472	0		2	MUC2d, 6 good cores

70	BUTT	MUC	17/06/19	731	43	21.32	179	44.39	E	467	467	0		1	MUC1b, 6 good cores
71	BUTT	MUC	17/06/19	804	43	21.39	179	44.33	E	451	451	0		1	MUC2b, 5 good cores
72	BUTT	MUC	17/06/19	848	43	21.43	179	44.04	E	451	451	0		1	MUC3a, 6 good cores
73	BUTT	MUC	17/06/19	931	43	21.56	179	44.17	E	460	460	0		1	MUC4b, 4 good cores
74	BUTT	MUC	17/06/19	1030	43	21.55	179	43.91	E	466	466	0		1	MUC5a, 6 good cores
75	BUTT	MUC	17/06/19	1140	43	21.71	179	44.54	E	460	460	0		1	MUC4d, 6 good cores
76	BUTT	MUC	17/06/19	1227	43	21.26	179	44.21	E	461	461	0		1	MUC1a, 6 good cores (27-37cm)
77	BUTT	MUC	17/06/19	1311	43	21.52	179	44.22	E	461	461	0		1	MUC3b, 6 good cores (13-40cm)
78	BUTT	MUC	17/06/19	1355	43	21.72	179	44.29	E	460	460	0		1	MUC5c, 6 good cores
79	BUTT	MUC	17/06/19	1443	43	21.62	179	44.09	E	458	458	0		2	MUC5b, 4 good cores
80	BUTT	MUC	17/06/19	1547	43	21.47	179	43.981	E	461	461	0	270	1	MUC4a, 6 good cores
81	BUTT	MUC	17/06/19	1635	43	21.31	179	44.14	E	459	459	0		1	MUC2a, 6 good cores
82	MON5	MUC	17/06/19	1746	43	23.18	179	42.31	E	442	442	0		1	MON5, 6/6 cores
83	MON5	MUC	17/06/19	1811	43	23.19	179	42.31	E	445	445	0		1	MON5, 5/6 cores
84	MON5	MUC	17/06/19	1838	43	23.2	179	42.31	E	442	442	0		1	MON5, 4/4 cores
85	TEST	SCIP	17/06/19	2000	43	22.91	179	49.62	E	450	446	1.39	270	2	SCIP test with harrow mat. Deployment and recovery went well. 2kts (15 mins), 3 kts (10 mins). No positional data.
86	TEST	CAM	17/06/19	2230	43	22.94	179	49.79	E	443	451	1.56	272	2	Tow along and across inferred SCIP line. Difficult to locate, some disturbance marks.
87	TEST	SCIP	18/06/19	440	43	22.89	179	49.5	E	453	438	1.18	232	2	Further SCIP trial. Change beacon.
88	TEST	SCIP	19/06/19	449	43	23.06	179	49.86	E	450	439	1.14	201	2	Further SCIP trial. Chain and float changes.
89	TEST	SCIP	19/06/19	626	43	23.07	179	49.8	E	458	455	1.17	200	2	Further SCIP trial as per #88
90	TEST	CAM	19/06/19	842	43	23	179	49.87	E	443	440	1.06	199	1	Run over tows 88 and 89.
91	TEST	SCIP	19/06/19	1159	43	22.68	179	49.39	E	462	442	1.7	200	2	SCIP test. More chain added.
92	TEST	CAM	19/06/19	1345	43	22.59	179	49.45	E	449	445	1.94	203	1	DTIS over SCIP test. Chain marks pushed sediment. Less harrow marks
93	BUTT	SCIP	19/06/19	1803	43	21.46	179	43.91	E	465	450	6.14	107	2	Disturbance NORT-6 lines, SOTH -5 lines
94	BUTT	SCIP	20/06/19	455	43	21.75	179	44.64	E	465	455	3.7	118	1	Disturbance SOTH-4 lines
95	BUTT	SCIP	20/06/19	847	43	21.61	179	44.49	E	472	452	4.51	117	1	Disturbance MIDD-11 lines
96	BUTT	SCIP	20/06/19	1902	43	21.53	179	44.23	E	470	450	1.38	124	2	Disturbance MIDD-4 lines
97	BUTT	SCIP	20/06/19	2210	43	21.56	179	44.1	E	465	452	1.09	309	1	Disturbance SOTH- 2 lines
98	BUTT	SCIP	21/06/19	14	43	21.41	179	44.36	E	464	464	1.88	117	2	Disturbance NORT-5 lines
99	BUTT	ACO	21/06/19	400	43	21.51	179	44.92	E	0	0	0	262	2	Acoustic survey post disturbance
100	BUTT	CTD	21/06/19	613	43	21.56	179	44.25	E	0	0	0	308	1	CTD to 457m. Turbidity elevated.
101	BUTT	CTD	21/06/19	835	43	21.66	179	44.65	E	0	0	0	293	1	CTD to 450m. No turbidity.

102	BUTT	CAM	21/06/19	1142	43	21.78	179	44.5	E	456	458	0.44	31	1	N-S DTIS over SCIP at NW end of butterknife
103	BUTT	CAM	21/06/19	1405	43	21.61	179	44.18	E	458	458	0.31	28	1	DTIS over Hart Hillock, GDU in moderate amounts along track
104	HART	CAM	21/06/19	1701	43	22.35	179	27.17	E	392	393	0.48	351	1	DTIS over Hart Hillock, GDU in moderate amounts along track
105	HART	SLED	21/06/19	1837	43	22.06	179	27.07	E	395	395	0.15	12	3	Sled, Hart Hillock DTIS #104 track where most GDU seen. 0.034 kg shell hash; dead coral fragments.
106	HART	SLED	21/06/19	1938	43	22.06	179	27.08	E	396	396	0.18	358	3	Sled, Hart Hillock DTIS #104 track. 114 kg. Mud. Polychaetes, plexaurid.
107	HART	SLED	21/06/19	2040	43	22.27	179	27.15	E	391	384	0.23	336	2	Sled,southern DTIS #104 track. 56 kg. Small sample live GDU in aquarium ~ 50 g. Crab, Munida, Thouarella, polychaetes.
108	HART	SLED	21/06/19	2202	43	22.09	179	27.05	E	387	380	0.33	13	3	Sled, midway DTIS #104 track. 58 kg. Phosphate nodules. I small live GDU. Munida.
109	HART	SLED	21/06/19	2302	43	22.4	179	27.4	E	392	392	0.39	339	3	Sled, southern DTIS #104 track. 300 kg. Mud, boulder, cobbles, pebbles, Phosphate, dead coral, fossil Desmophyllum, T. Tauhou
110	BUTT	SCIP	22/06/19	226	43	21.64	179	44.54	E	461	450	5.6	297	2	Disturbance MIDD-15 lines
111	BUTT	SCIP	22/06/19	1559	43	21.47	179	43.99	E	460	459	5.17	215	1	Disturbance SOTH- 9 lines
112	BUTT	SCIP	23/06/19	125	43	21.58	179	44.77	E	467	466	2.1	299	1	Disturbance NORT-3 lines
113	BUTT	SCIP	23/06/19	404	43	21.5	179	44.15	E	469	456	1.96	115	2	Disturbance MIDD-5 lines
114	BUTT	SCIP	23/06/19	902	43	21.64	179	44.58	E	470	472	2.07	293	2	Disturbance MIDD-5 lines
115	BUTT	CTD	23/06/19	1410	43	21.54	179	44.16	E	0	0	0	75	1	CTD over Butterknife, to 456m.
116	BUTT	ACO	23/06/19	1453	43	21.59	179	45.02	E	0	0	0	350	1	Acoustic Survey over Butterknife
117	BUTT	CTD	23/06/19	1632	43	21.63	179	44.54	E	0	0	0	142	1	CTD over Butterknife, to 456m.
118	BUTT	CAM	23/06/19	1918	43	21.45	179	44.14	E	455	455	0.43	82	2	DTIS, N rim of butterknife. Visible tracks at times. Limited visible covering of GDU by disturbance. Missed a section of rim on NW side and will capture in #119
119	BUTT	CAM	23/06/19	2103	43	21.44	179	44.12	E	457	460	0.1	131	2	Short tow to better sample NW section of N rim.
120	BUTT	CAM	23/06/19	2254	43	21.47	179	44.04	E	456	456	0.44	118	2	South rim. GDU dense at SE end
121	BUTT	MUC	24/06/19	27	43	21.76	179	44.68	E	460	460	0		1	MUC4e, 6 good cores
122	BUTT	MUC	24/06/19	112	43	21.6	179	44.81	E	463	463	0		1	MUC2e, 6 good cores

123	BUTT	MUC	24/06/19	155	43	21.54	179	44.87	E	465	465	0		1	MUC1e, 6 good cores
124	BUTT	MUC	24/06/19	242	43	21.65	179	44.55	E	465	465	0		1	MUC3d, 6 good cores
125	BUTT	CAM	24/06/19	355	43	21.46	179	44.55	E	458	456	0.37	173	1	Eastern side of Butterknife, corals on rims, numerous SCIP marks.
126	BUTT	CAM	24/06/19	603	43	21.34	179	44.24	E	457	455	0.35	175	1	Western side of Butterknife, corals on northern rim, SCIP marks.
127	BUTT	CAM	24/06/19	836	43	21.31	179	44.34	E	158	456	0.46	166	1	Central region of Butterknife.
128	BUTT	MUC	24/06/19	1040	43	21.87	179	44.65	E	451	451	0		2	MUC5e, 5 good cores
129	BUTT	MUC	24/06/19	1127	43	21.71	179	44.53	E	458	458	0		1	MUC4d, 6 good cores
130	BUTT	MUC	24/06/19	1230	43	21.71	179	44.75	E	461	461	0		1	MUC3e, 4 good cores
131	BUTT	MUC	24/06/19	1327	43	21.53	179	44.65	E	460	460	0		1	MUC2d, 4 good cores
132	BUTT	MUC	24/06/19	1414	43	21.39	179	44.31	E	460	460	0		1	MUC2b, 4 good cores
133	BUTT	MUC	24/06/19	1500	43	21.49	179	43.98	E	455	455	0		1	MUC4a, 6 good cores
134	BUTT	MUC	24/06/19	1558	43	21.64	179	44.09	E	456	456	0		1	MUC5b, 6 good cores
135	BUTT	MUC	24/06/19	1640	43	21.52	179	44.21	E	462	462	0		1	MUC3b, 6 good cores
136	BUTT	MUC	24/06/19	1745	43	21.32	179	44.15	E	462	462	0		2	MUC2a, 6/6 1 poor-mid quality
137	BUTT	MUC	24/06/19	1813	43	21.25	179	44.2	E	457	463	0		2	MUC1a, 6/6 2 poor-mid quality
138	BUTT	MUC	24/06/19	1856	43	21.39	179	44.55	E	460	460	0		1	MUC1c 6/6 poor-fair quality
139	BUTT	MUC	24/06/19	1959	43	21.468	179	44.49	E	458	463	0		1	MUC2c 6/6 fair- good (21-31 cm)
140	BUTT	MUC	24/06/19	2034	43	21.58	179	44.4	E	456	456	0		1	MUC3c 6 good cores
141	BUTT	MUC	24/06/19	2102	43	21.64	179	44.36	E	457	457	0		1	MUC4c 6 cores
142	BUTT	MUC	24/06/19	2130	43	21.73	179	44.29	E	460	460	0		2	MUC5c 5 fair cores
143	BUTT	MUC	24/06/19	2158	43	21.73	179	44.29	E	457	457	0		1	MUC5c repeat 4/6 good cores
144	BUTT	MUC	24/06/19	2248	43	21.8	179	44.46	E	460	459	0		2	MUC5d 5 cores fair -good quality
145	BUTT	MUC	24/06/19	2334	43	21.45	179	44.69	E	457	454	0		1	MUC1d 5/6 cores fair-good cores (13-28cm)
146	BUTT	MUC	25/06/19	28	43	21.36	179	44.37	E	460	460	0		1	MUC1b, 3 good cores
147	BUTT	MUC	25/06/19	114	43	21.44	179	44.02	E	462	462	0		1	MUC3a. 3 good cores
148	BUTT	MUC	25/06/19	159	43	21.55	179	43.89	E	461	461	0		1	MUC5a, 3 good cores
149	BUTT	CAM	25/06/19	419	43	21.54	179	44.69	E	457	456	0.28	205	3	Swell high, considerable heave and DTIS high at times.
150	BUTT	MOOR	25/06/19	740	43	21.2	179	44.57	E	427	427	0		2	Recovery of ADCP mooring from TAN1805
151	BUTT	MUC	25/06/19	1544	43	21.57	179	44.16	E	454	454	0		1	MUC4b, 6 good cores
152	BUTT	MUC	25/06/19	1610	43	21.56	179	44.16	E	454	454	0		1	MUC for sediment experiments
153	HART	BEAM	25/06/19	1853	43	21.92	179	27.03	E	390	390	0.11	169	1	Trawl for GDU for lab expts. Good number of live corals. Some large GDU

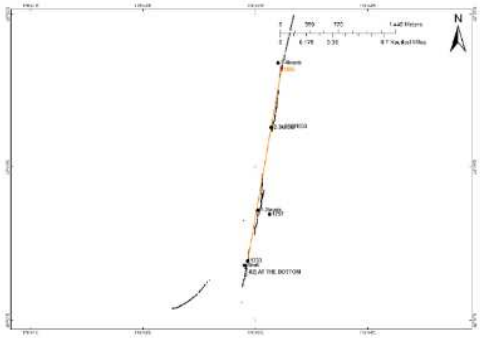
154	HART	BEAM	25/06/19	2018	43	21.93	179	27.09	E	389	396	0.05	196	2	Trawl for GDU for lab expts. Large rock. Small broken GDU
155	HART	BEAM	25/06/19	2152	43	21.94	179	27.01	E	395	395	0.06	173	2	Trawl for GDU for lab expts. Slightly to the West of #153. Small GDU
156	TEST	SCIP	26/06/19	1021	43	22.35	179	46.64	E	464	464	1.06	148	1	SCIP test prior to CTD.
157	TEST	CTD	26/06/19	1229	43	22.34	179	46.79	E	0	0	0	212	1	CTD over SCIP, to 450m
158	BUTT	CTD	26/06/19	1541	43	21.48	179	44.29	E	0	0	0	216	1	CTD, CDOM water sampling,to 458m. Butterknife
159	BUTT	CTD	26/06/19	1633	43	21.29	179	44.2	E	0	0	0	285	1	CTD, CDOM water sampling to 450m, 0.25nm to NW from Butterknife
160	BUTT	CTD	26/06/19	1747	43	20.48	179	43.95	E	0	0	0	220	1	CTD, CDOM water sampling to 450m, 1nm to NW from Butterknife
161	BUTT	CAM	26/06/19	1943	43	21.35	179	44.68	E	456	455	0.61	247	1	DTIS #20 repeat NE - SW direction. Lots of tracks N, Centre + S of Butterknife. Marginal weather. DTIS surge 5m seas at times
162	BUTT	CAM	26/06/19	2243	43	21.31	179	44.32	E	457	451	0.5	116	1	DTIS #west of Butterknife visible tracks at NW end of butterknife and many deep tracks to SW end
163	BUTT	CAM	27/06/19	130	43	21.45	179	44.61	E	460	457	0.46	243	1	Central Butterknife
164	BUTT	CAM	27/06/19	416	43	21.54	179	44.7	E	458	456	0.28	206	1	Eastern side of Butterknife, corals on rims, numerous SCIP marks.
165	BUTT	CAM	27/06/19	603	43	21.52	179	44.78	E	458	455	0.35	231	1	Eastern side of Butterknife, repeat TAN1805/237
166	BUTT	MOOR	27/06/19	1012	43	21.19	179	44.87	E	457	457	0		0	Mooring deployed: SED trap and current meters.
167	HART	CAM	27/06/19	1318	43	21.87	179	27.23	E	393	390	0.22	243	1	Tow over beam trawl area.
168	HART	CAM	27/06/19	1414	43	21.98	179	27.18	E	395	390	0.18	244	1	Tow over beam trawl area.
169	ANZ	CAM	28/06/19	27	43	25.75	177	33.16	E	311	307	0.36	233	1	Tow over beam trawl option for sponges
170	ANZ	BEAM	28/06/19	219	43	25.85	177	32.99	E	305	307	0.33	220	1	Good small catch of ANZ.
171	ANZ	BEAM	28/06/19	335	43	25.74	177	33.12	E	305	305	0.29	235	1	Good small catch of ANZ.
172	ANZ	CTD	28/06/19	443	43	25.81	177	32.83	E	0	0	0	56	1	CTD to 313m for water sample

Appendix C DTIS station descriptions

Station 2

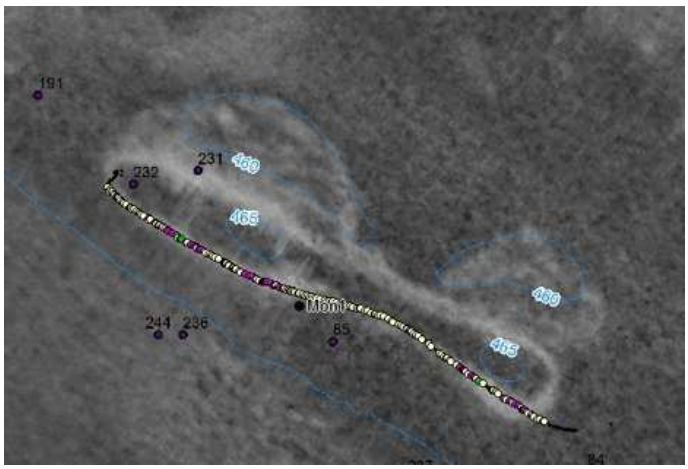
DTIS transect prior to the trial of Sediment Cloud Induction Plough (SCIP) in test location of flat muddy seafloor on route to the survey area. Muddy sediment with pits and burrows. Fauna includes anemones, sea pens and scampi.


Station 4

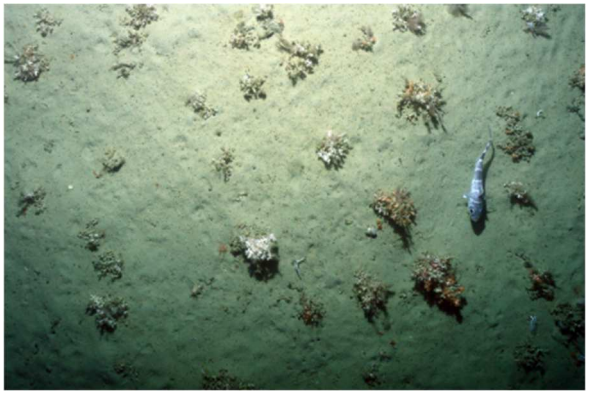


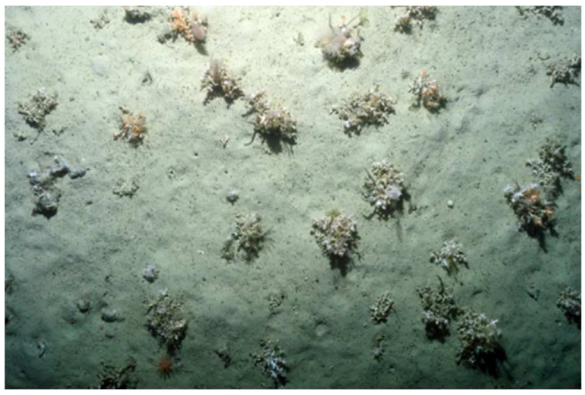
Deployment post disturber trial. SCIP tracks are detected along the SCIP transect line (above) that includes time stamps indicating trial changes of towing speed from 1 to 4 knots. SCIP configuration includes rear roller, the effects of which are clear from stills where the DTIS crosses the SCIP track. Still images are obscured by suspended sediment over large portions of the transect.


Station 8, MON1.

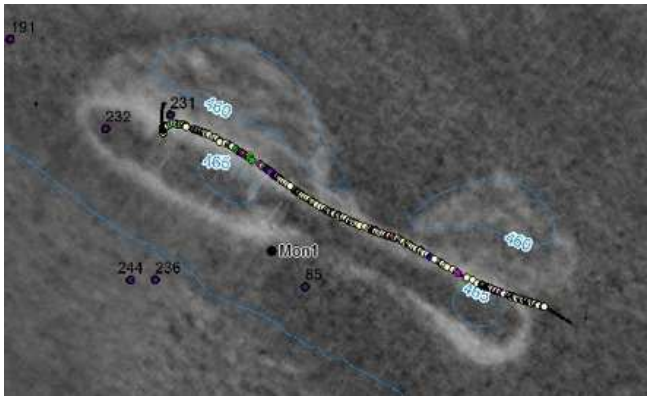


Southern rim of Butterknife, 450m. Muddy sediment, burrows, mounds start transitions to pebbles and cobbles. Clumps of *Goniocorella dumosa* (GDU) in two locations on high reflectivity backscatter - near the beginning of the line and covering about one third from northern end, as well as at southern end. Often the clumps were very dense. Stylasterid hydrocorals often attached to the GDU, as well as several small demosponges, one very large demosponge observed, possibly a *Corallistes*. Some cidarids, a sea star, sea pen, and anemones. Fish were in low densities, species included various rattails, a sea perch, and eels.

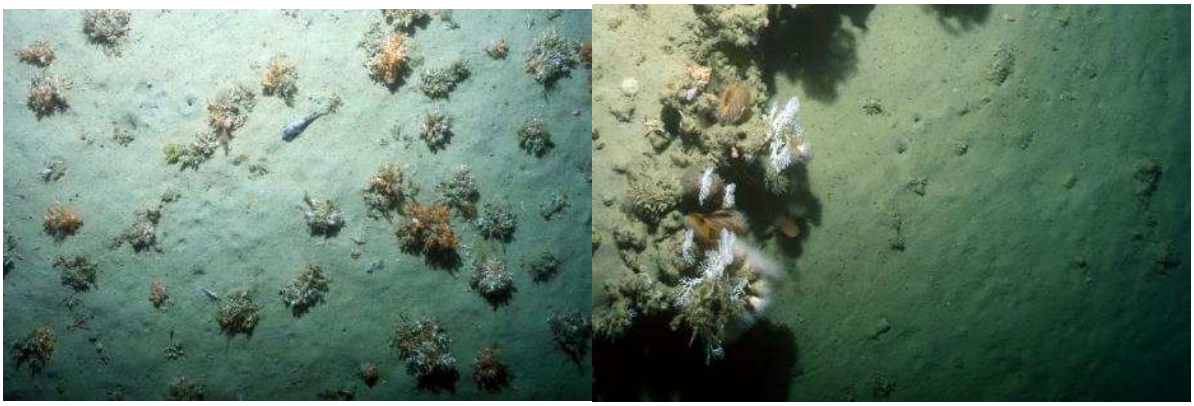




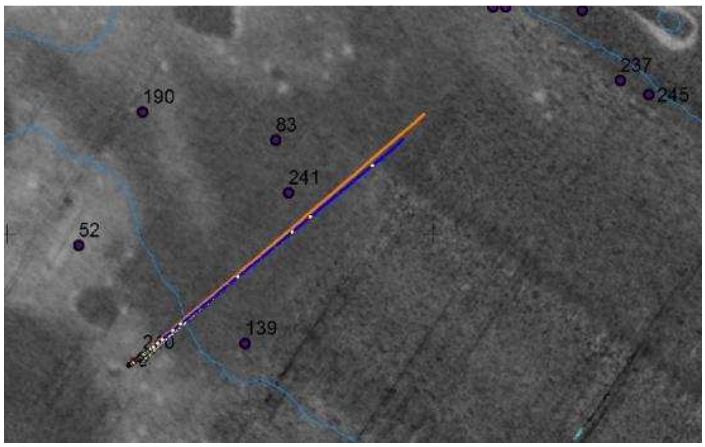
Station 9, MON1.



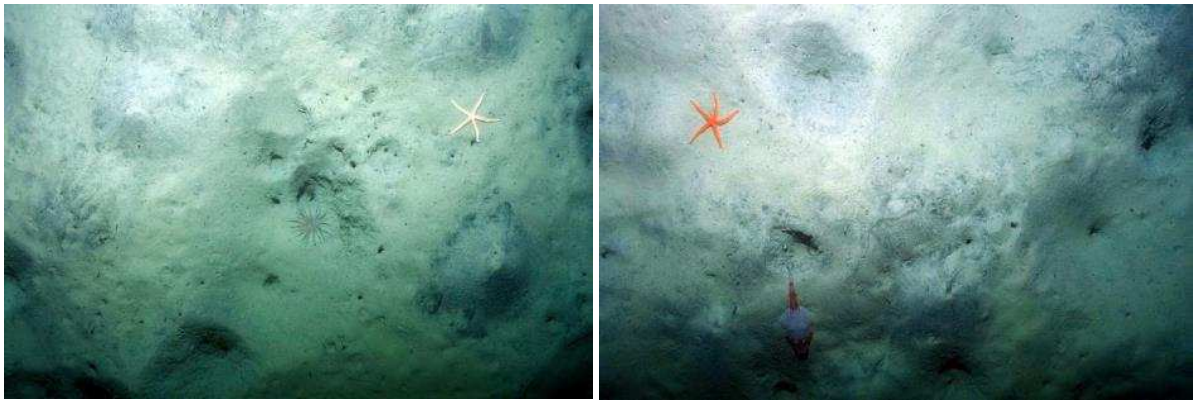
Butterknife north rim, tow ESE. Muddy sediment, burrows, mounds, cobbles, gravel and bedrock. Clumps of GDU and along ridge of the outcrop a lot of diversity, brisingids, cup corals, stylasterids, soft coral (*Anthomastus*), and GDU. The GDU more extensive than previous run. Animals away from outcrop included sea stars, sea pens, small sponges, some cidarids. Fish were in low densities, some rattails, a sea perch, eels.



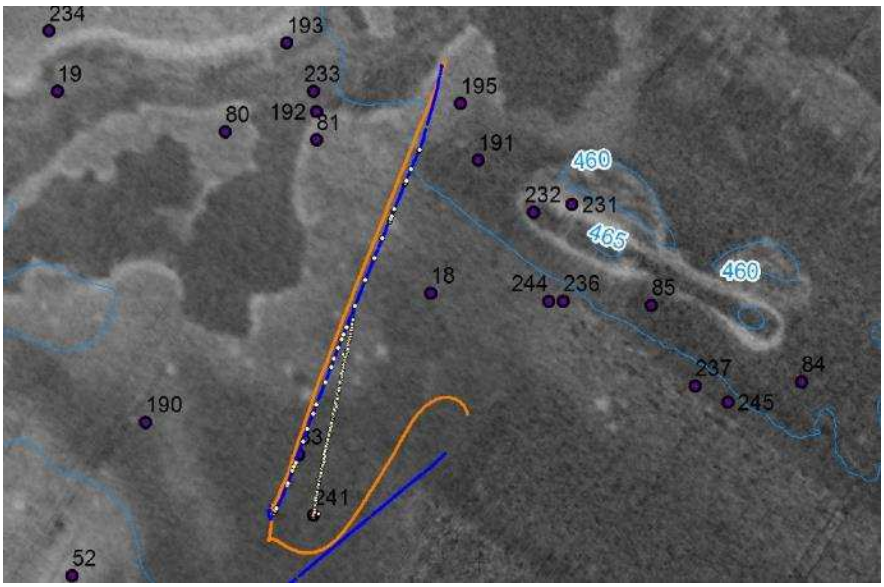
Station 19, DIS1



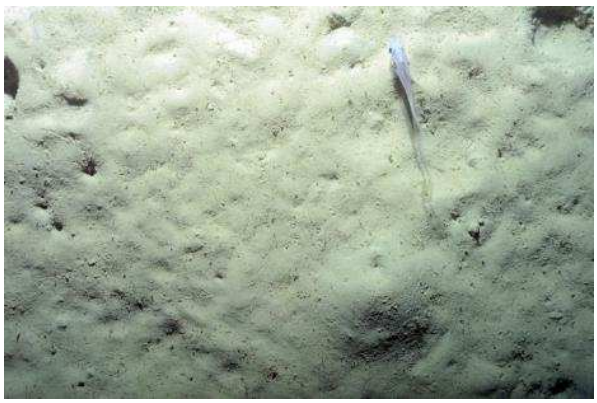
This was in the main Benthic disturber (BDR) area from the 2018 survey. There was uniform muddy sediment, with mounds, pits and burrows. Occasional anemones, demosponges, and echinoderms. There was little sign of any 2018 BDR tracks, possibly the odd “edge” from the BDR skids.



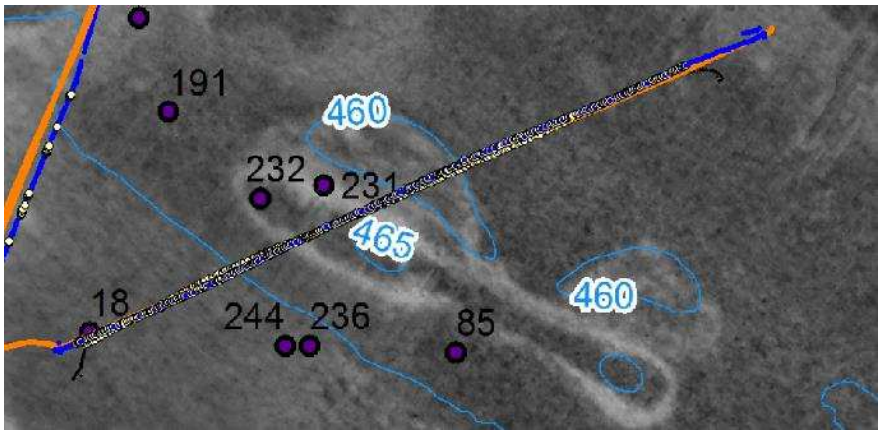
Station 20, DIS2



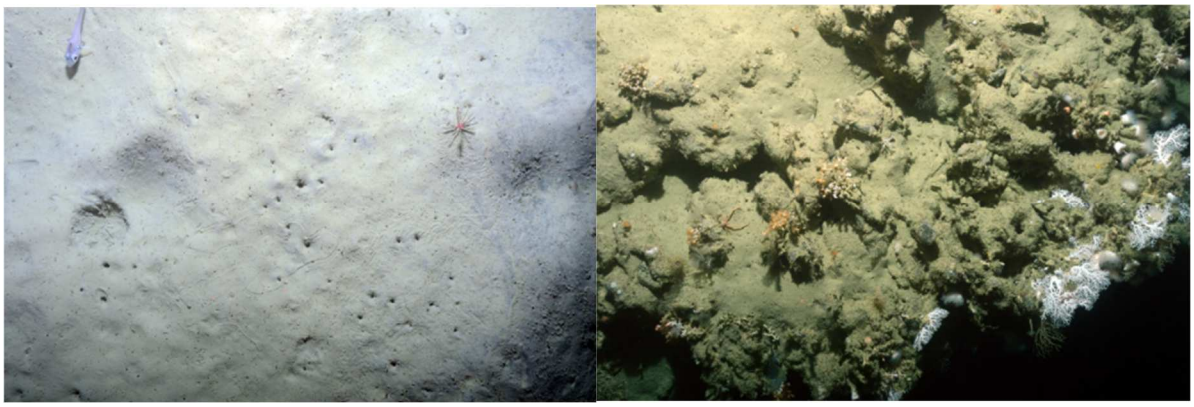
This tow was a repeat of TAN1805/241. Flat muddy bottom, 452-454m, with mounds, pits and burrows. Sparse fauna, javelin fish, some tam-o-shanters, ophiuroids, cidarid urchins, and anemones. A single possible BDR mark was seen.



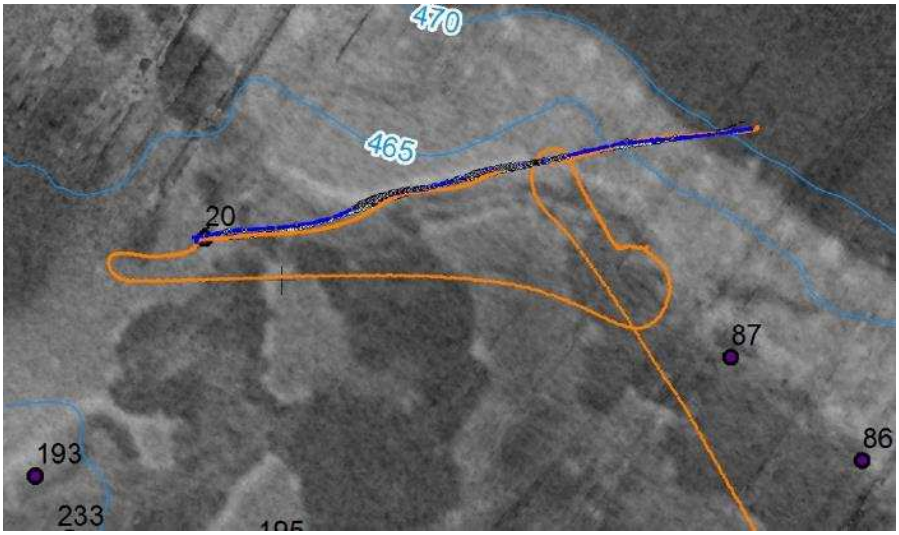
Station 021, MON1



A NE direction across the western end, repeat of TAN1805/018. Started in muddy substrate and ran across the area of previous intensive BDR lines-with no sign of previous disturbance. The S and N rims had GDU thickets and communities with stylasterids and sponges. Between the rims was muddy sediment, a good area to deploy the Sediment Cloud Induction Plough (SCIP). There were scattered areas of pebbles and some GDU on the speckly backscatter to the north of N rim, possibly suitable for SCIP deployments. Depth was steady, at 455-458m. There were occasional rattails and eels, a lookdown dory, and hoki.

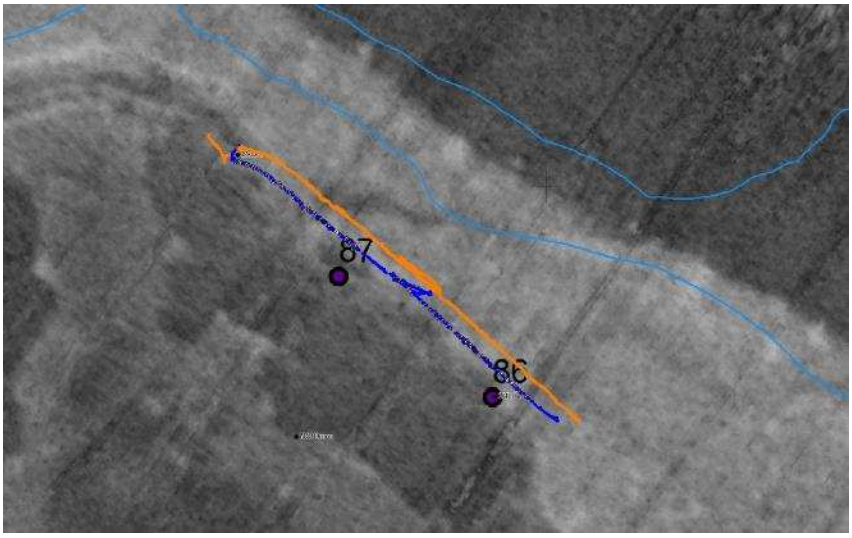


Station 22, MON7



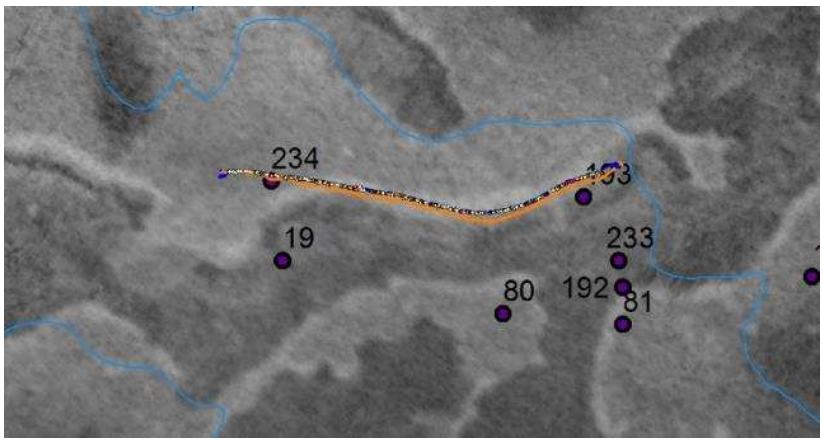
The transect skirts a ribbon of high reflectivity backscatter, starting in muddy soft sediment with mounds, pits and burrow, ascending (slightly) to a region with pebbles and cobbles with encrusting fauna (not easily identified in low resolution video feed), ends in soft mud with pits and burrows. Invertebrates included a crab, anemones, asteroids, echinoids, holothurian, bryozoan, stylasterids, small corals and a sea pen. Small soft corals and pale purple anemones are commonly observed from high resolution stills. Several fish including rattails, dwarf cod, eels and a shark.

Station 23, MON9



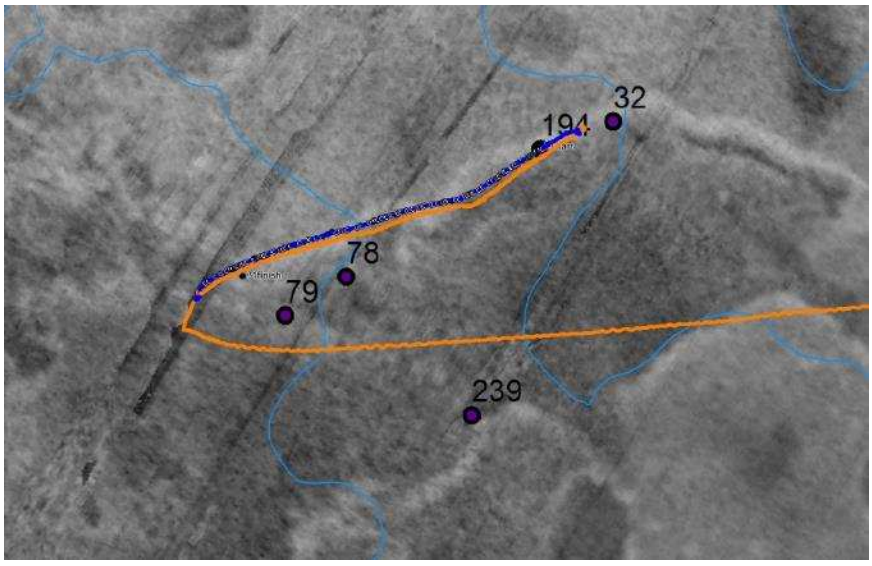
Camera lights failed at ~17 mins into transect– restarted and resumed line after moving back to point where lights failed without bringing DTIS back on board. Muddy sediment, burrows, gravel and pebbles. Anemones, GDU, sponges including two large *Corallistes* sponges, and echinoids. Fish included rattails, banded bellowsfish, and one large ling.

Station 30, MON2



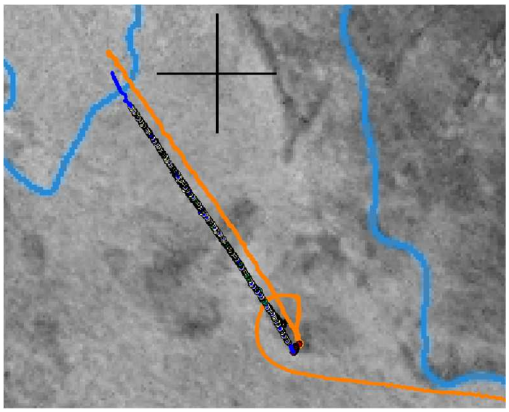
This was a repeat of TAN1805/234. Heading east along curvy ridge of high reflectivity. Transect mainly mud and pebbles with burrows, some gravel patches. Quite a few small sponges and ascidians plus one *Corallistes* and a large *Hyalascus* sponge. Possibly one clump of GDU, otherwise very sparse fauna. Asteroids, sea perch, rattails, and eels. More gravel toward the end of transect.

Station 31, MON3



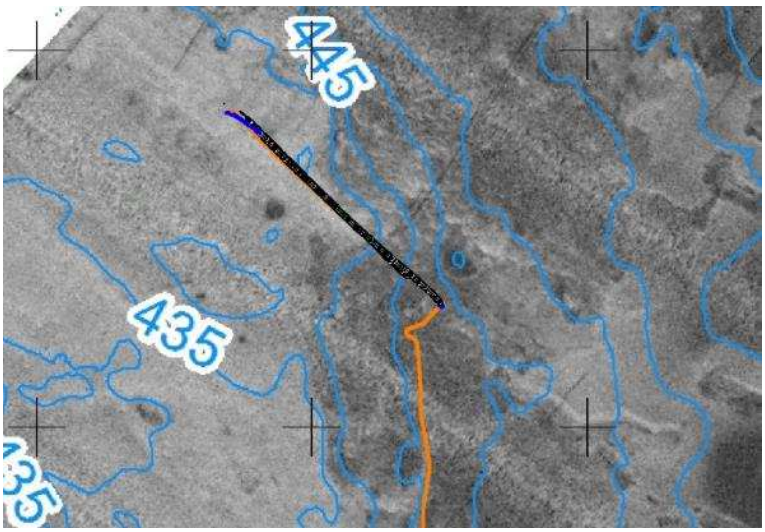
Repeat of TAN1805/194 DTIS transect along ridge of high reflectivity. SW to NE. Mud burrows, mounds, pebbles, cobbles. Outcrop of GDU & several small sponges close to the beginning and half way along transect. Pebbles with GDU, stylasterids, sponges near end. Epizoanthid and numerous asteroids and spatangid urchins.


Station 32, MON4

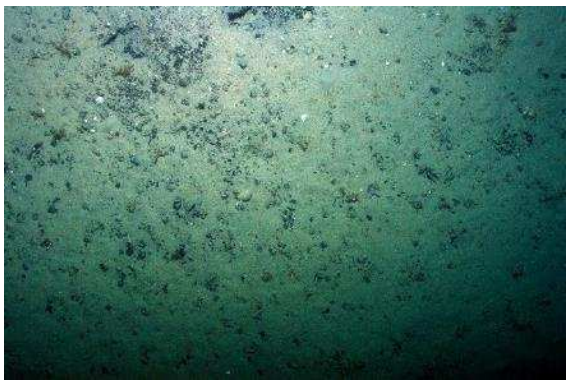


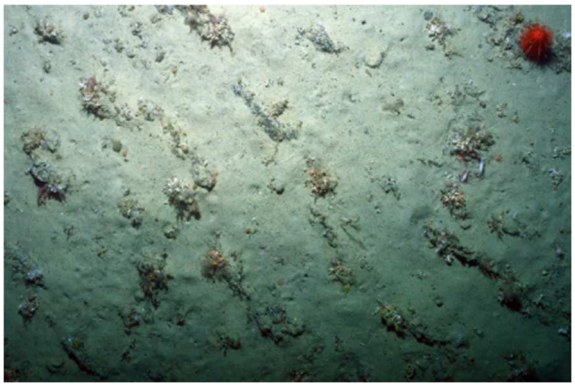
The transect starts in low BS with moundy pitted muddy sediment, transitions to pebbles and small cobbles with encrusting fauna difficult to define in low res but including some small fragments of *Goniocorella*, sponges, stylasterids, brisingids and galatheids, soft sediment fauna included asteroids and heart urchins, fish included bellowsfish, rattails and conger eels.


Station 33, REF 1

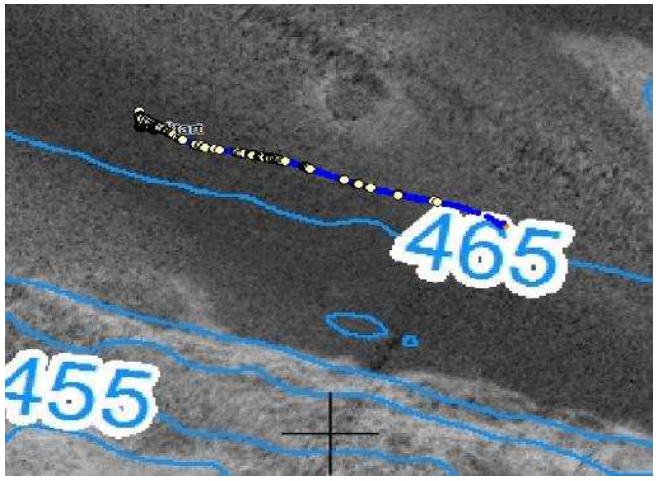


Repeat of tan1805/050. Towed NW from soft mud in the low reflectivity slightly upslope to mixed muds-pebble-gravel with some cobbles. Patches of heart urchins, other fauna scattered-some stylasterids, GDU, demosponge and ascidians on the cobbles, asteroids on the mud. Several large *Hyalascus* glass sponges. Rattails occurred along the transect, with occasional bellowsfish and a deep-sea flathead.



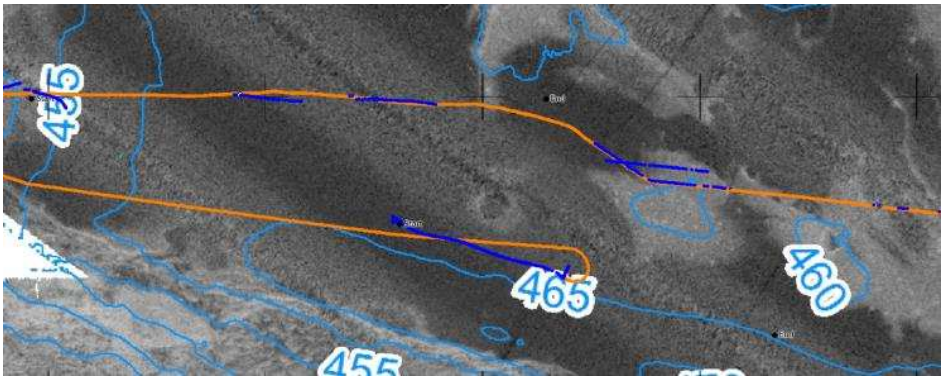


Station 37, SCIP test

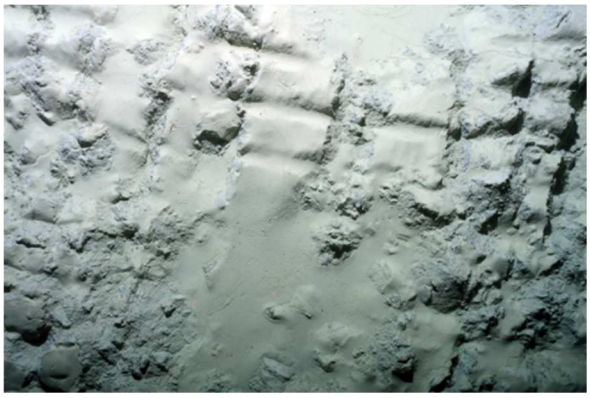


Towed camera run along track intended for SCIP trial. Muddy sediments throughout with burrows, mounds, pits, burrowing urchins common, some asteroids, anemones, otherwise fairly barren of mega-fauna. Several rattails including *C. oliverianus* and eels. One small octopod.

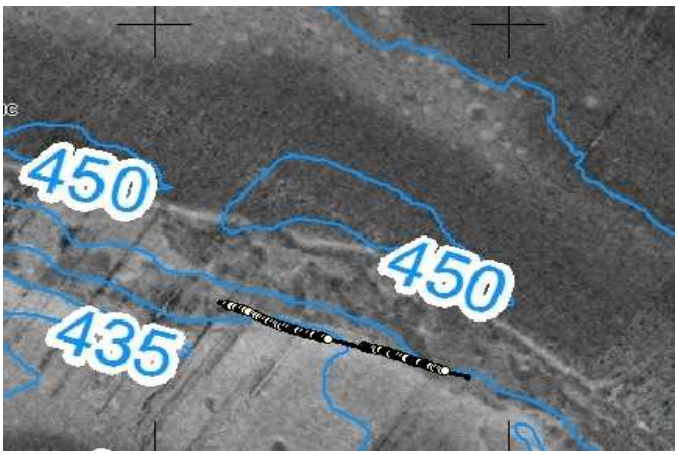

Station 39, SCIP Test



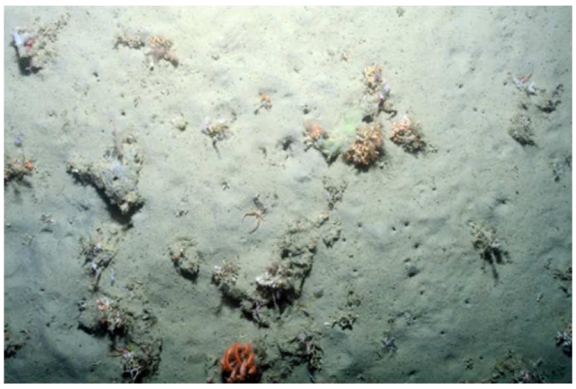
Re-ran the 2nd SCIP test line to assess signs of disturbance from SCIP – at 2, 3, and 4 knots. Substrate consisted of muddy sediments, burrows, mounds. Fauna included Spatangidae, anemones, rattails, eels. First encountered SCIP tracks half hour into the transect (1 knot zone), SCIP track well defined and relatively deep indentations in mud. Followed track for ~18 minutes including into the 3 knot zone without noticing any changes in track make-up. Then lost track marks. Located about 15 minutes later, into the 4 knot zone. Lost track twice more, some evidence of track but less pronounced than in 2 and 3 knot zone. High incidence of rattails seen in track zones.

Station 40, MON6

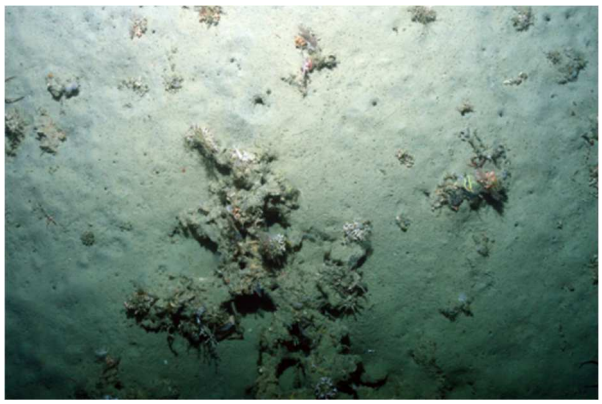


Transect skirts a region of high reflectivity but began with muddy sediments and burrows, which transitioned to muddy sediment with pebbles and occasional cobble. Fauna included GDU, sponge, asteroids, a single *Hyalascus* sponge, and a *Corallistes* sponge, among others. GDU clumps got progressively bigger as we progressed through the transect. Aborted transect at around halfway.

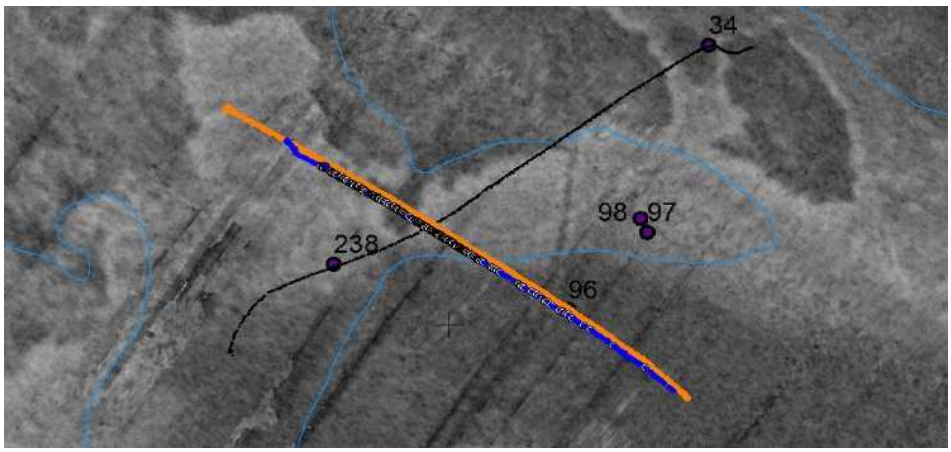


Station 41, MON6 (2nd Section)

Second half of station 40 transect repeating TAN1805/88. Transect began with rocky outcrops with medium dense GDU and sponge on muddy-pebbly-cobbly substrate. Substrate later turned to soft sediment with burrows and mounds without sessile fauna. Impressive *Hyalascus* glass sponge.

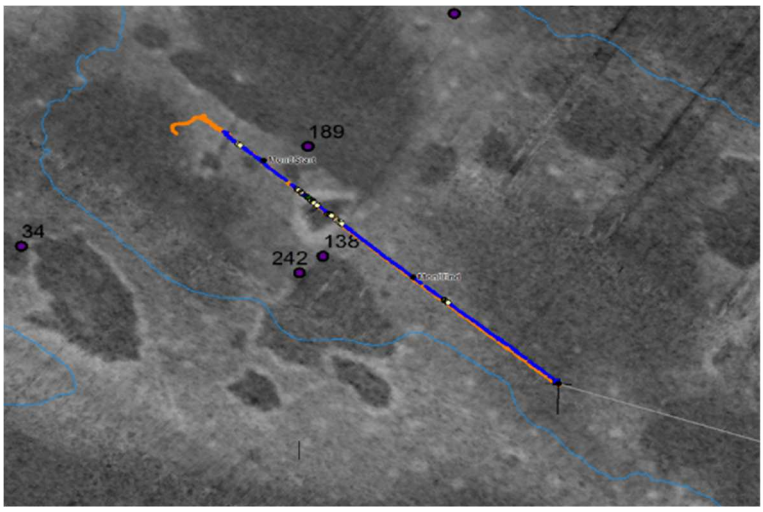


Station 43, MON5



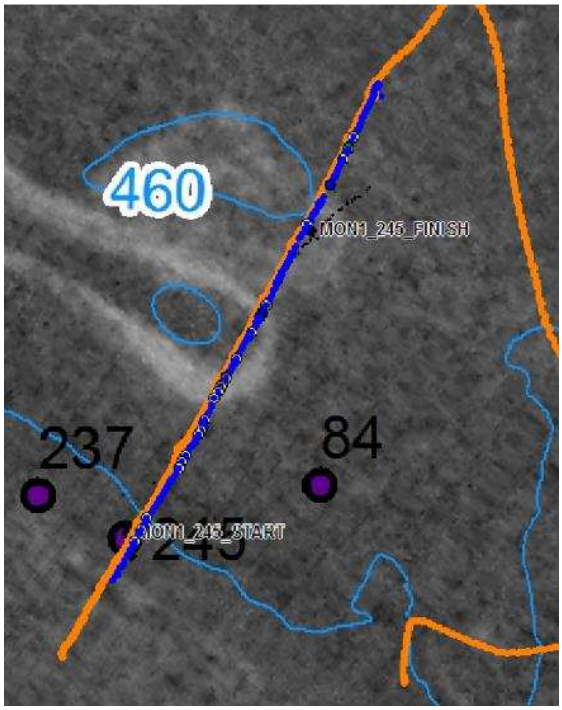
Repeat of tan1805 96, site MON5. Tow started in 437m with muddy sediment. Pebble-cobble patches in places with some demosponges. Muddy sediment dominated until a small outcrop of cobbles and pebbles with GDU and sponge on the eastern end of a small depression. The tow continued to shallow, with muddy sediment with mounds and burrows, occasional *Flabellum* cup coral, seapens, rattails.

Station 44, MON8

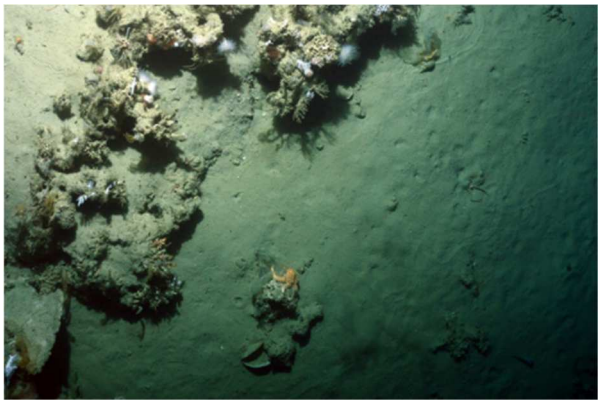


Transect SE through a small depression with high reflectivity edges sampled on stations 138, 189 and 242 during TAN1805. Pebbles and small cobbles at the start of the transect, a lip of cobbles and a crust of hard material on the NW lip including GDU, sponges and stylasterids, possibly also stalked cup corals, moundy soft sediment in the drepression and for most of the remaining transect apart from a small patch of pebbles and a boulder over a patch of high reflectivity, common fauna over soft sediment included heart urchins, anemones and the occassional flabellum, asteroid and holothurian. Fishes included eels, javelinfish, sea perch and lanternish.

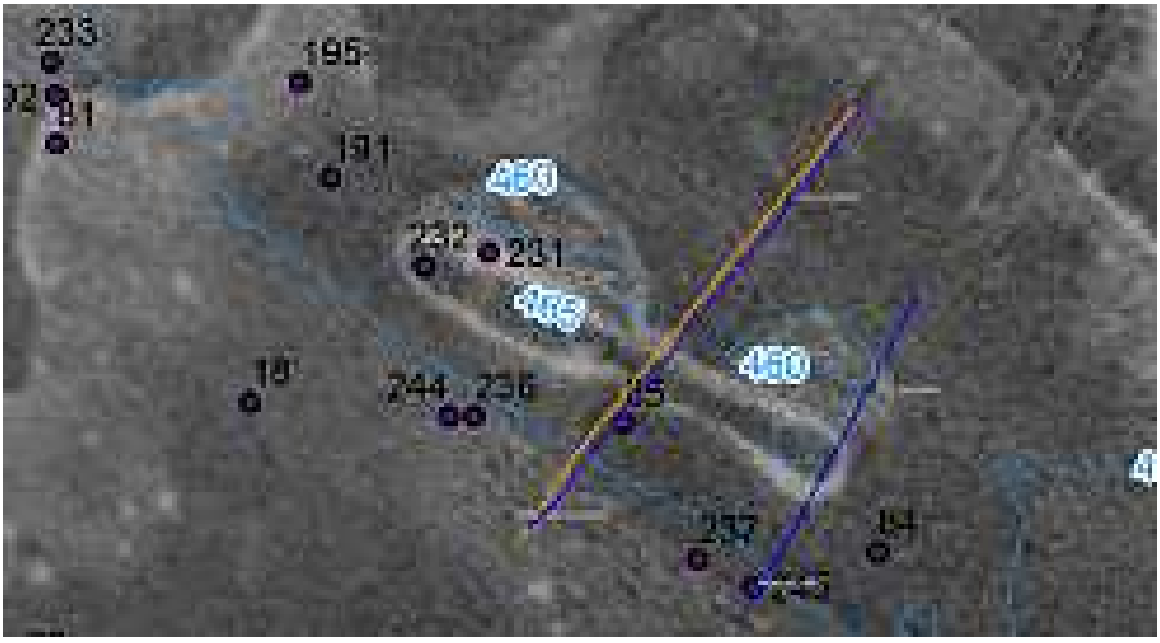
Station 48, MON2



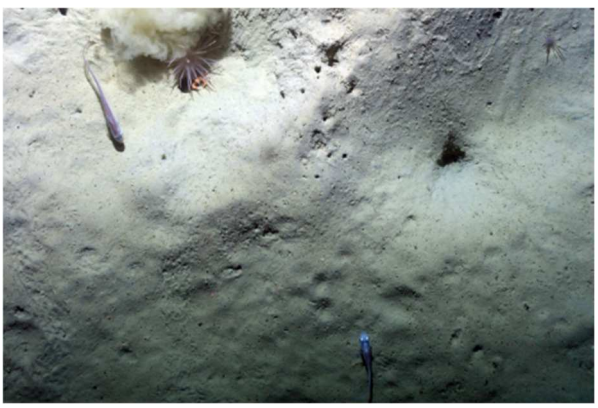
Transect across the south eastern end of the butterknife, revisiting the TAN1805/245 transect. Mud, burrows, mounds throughout bar for pebbles, cobbles at 460 m as we crossed the butterknife rim. GDU, sponges, anemones, pagurid, cidarid urchins, hydrocorals, Rattails and eels.



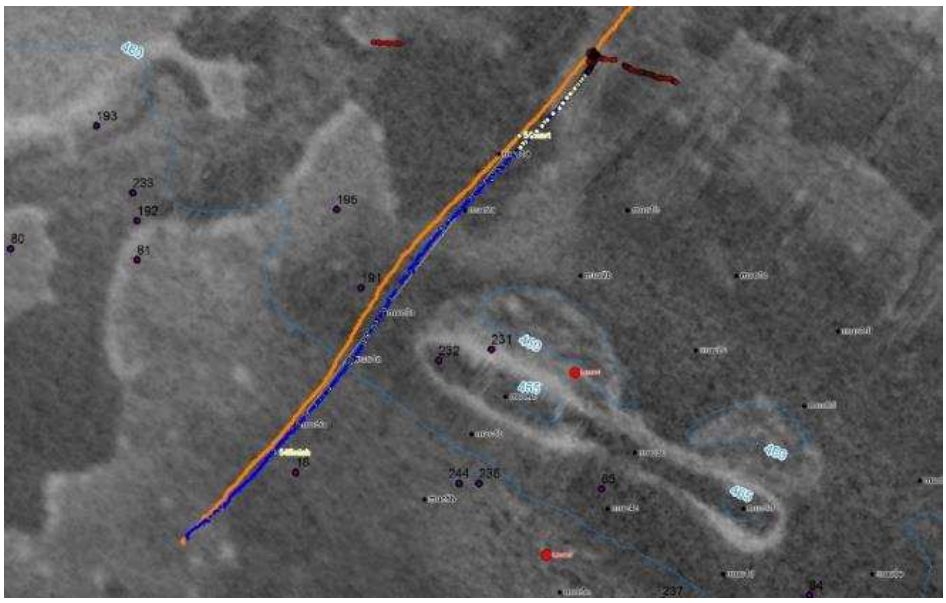
Station 49, MON1 (new)



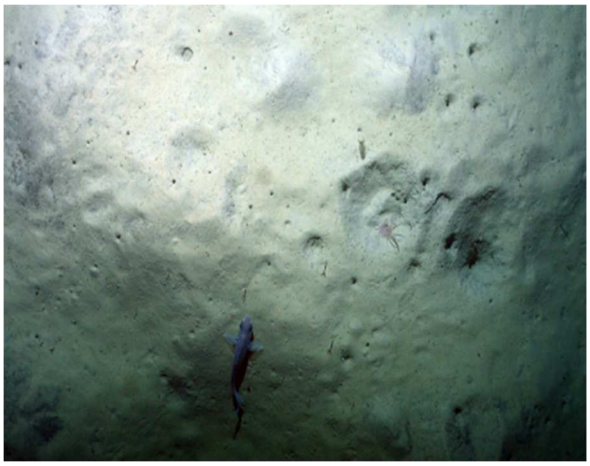
Mud, burrows, mounds. Very little life. One small patch of GDU pebbles @ 455m. Asteroids, rattails. Hauled just before the end of the line to avoid Lander 2.



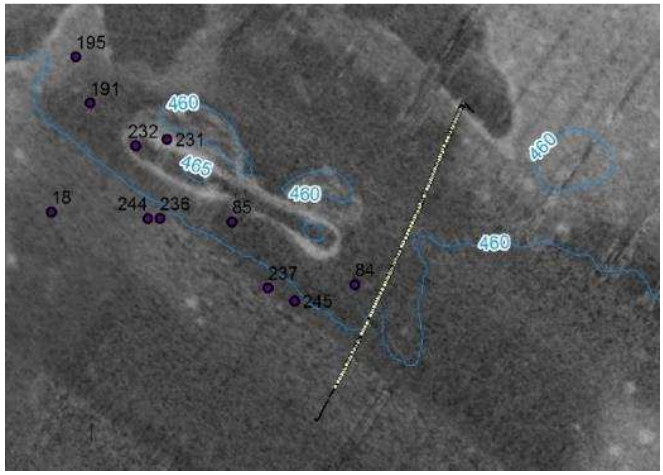
Station 054, Butterknife, westend.



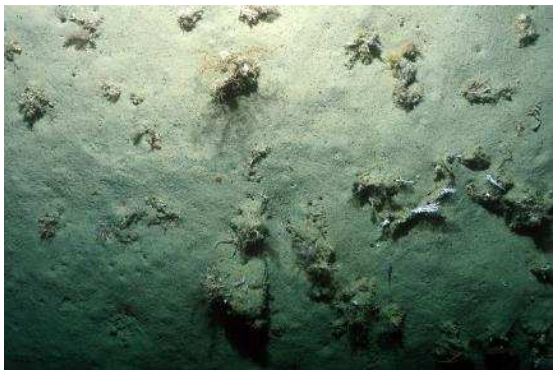
This transect was down the western line of the multicore grid. Seabed was muddy sediment with mounds and pits in patches, burrows throughout. Occasional asteroids, heart urchins, tube anemones, cidarid urchins. Rattails occurred frequently. Flat bottom, 456-460m.

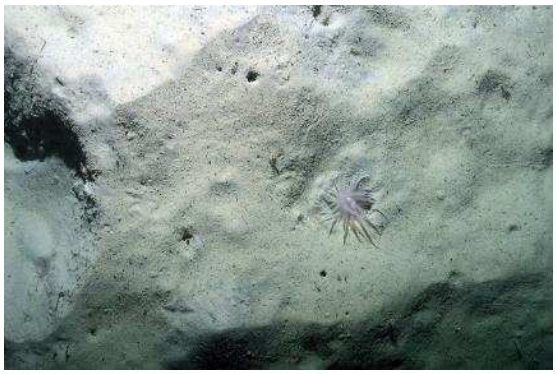


Station 065, Butterknife (new eastend)

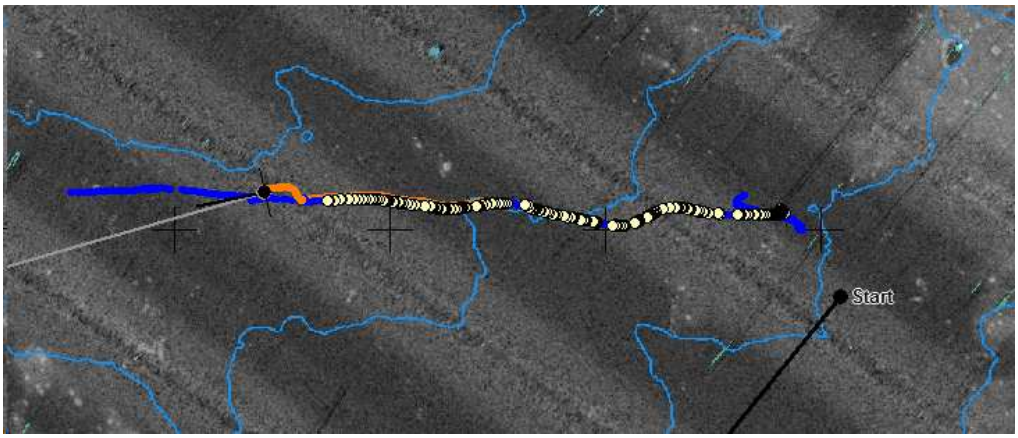


The tow was along the eastern MUC grid line around the Butterknife.At the start was a small patch of GDU and sponges associated with a small band of high reflectivity. Substrate comprised muddy sediments with mounds, pits and burrows for the rest of the transect, with occasional anemones, heart urchins, asteroids and rattails.



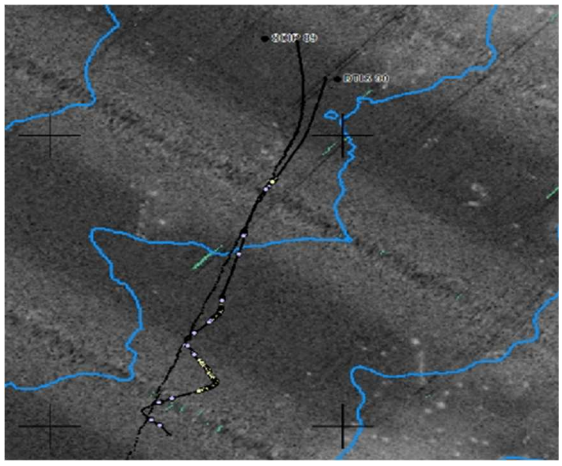


Station 86 SCIP Test 4 line



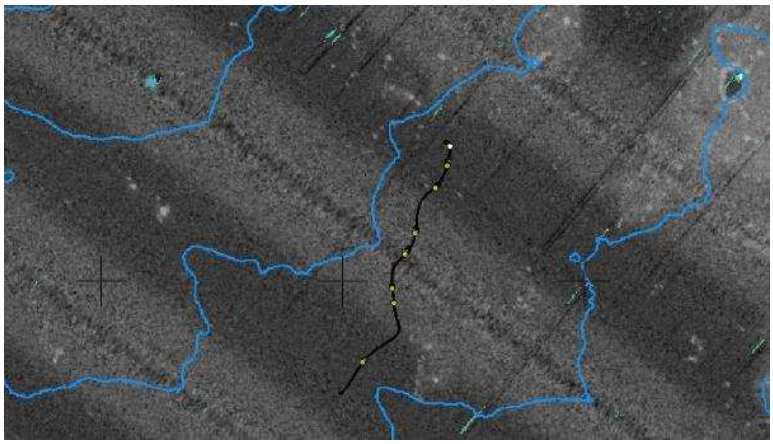
Tracks only encountered twice, an hour and a half in. Slight change of course to north then south to search out tracks. Mud, burrows, mounds. Spatangidae, some anemones, rattails and quite a high number of eels. sea perch.

Station 90: DTIS run over SCIP lines

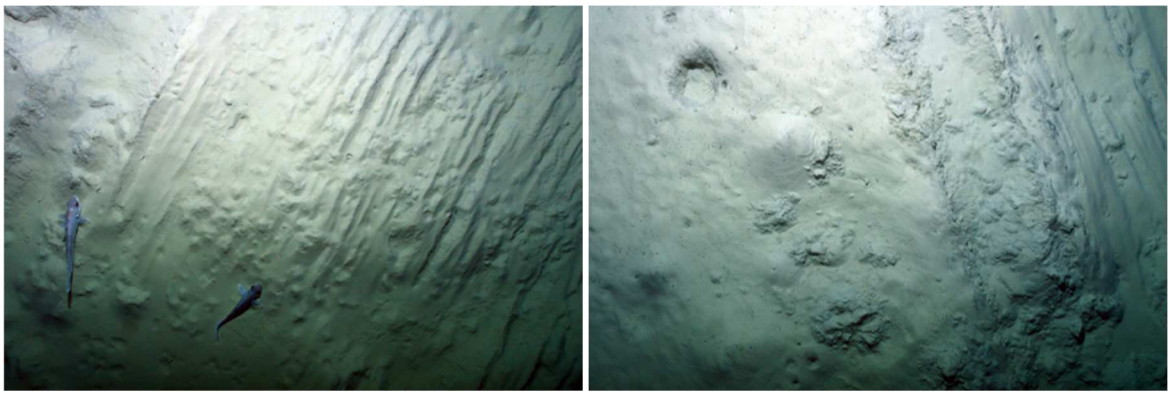


SCIP trial lines (stations 88 and 89) were run parallel, with the DTIS line partly following them and partly zig-zagging across to evaluate the Impact of the plough. Good images showing the tyne and harrow mat marks, also DTIS crosses a plume of sediment that obscures the sea floor in several places along the line. The sediment plume has small euphasids within the denser patches in some still images. Benthic fauna includes numerous crabs, bellowsfish and rattails, and some holothurians, scampi , hydroids and small carnivous sponges.

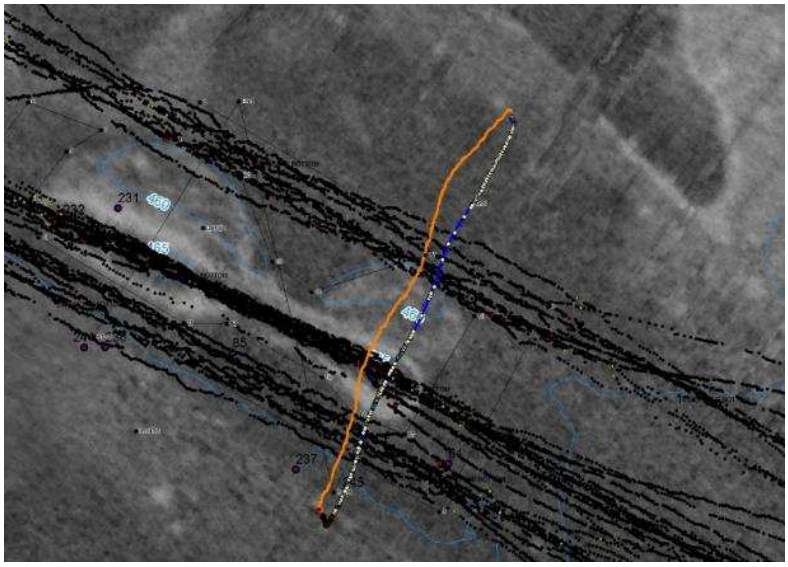
Station 92, DTIS run over SCIP trial line



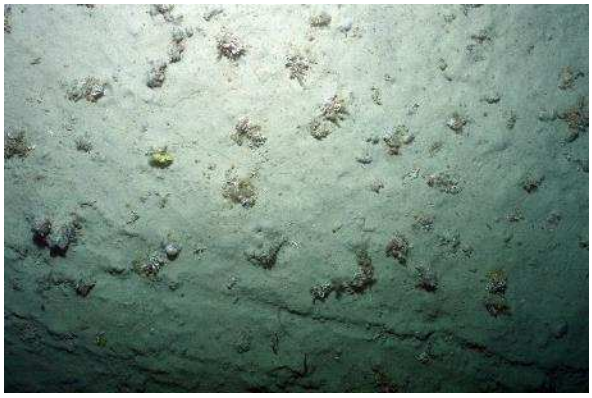
DTIS run over trial SCIP 91 line, crossed track marks 8 times. Zig zag DTIS run along the SCIP line. Attempt to locate the plume seen on previous DTIS were not pursued as the indicated current was calculated to have dispersed it well to the east.



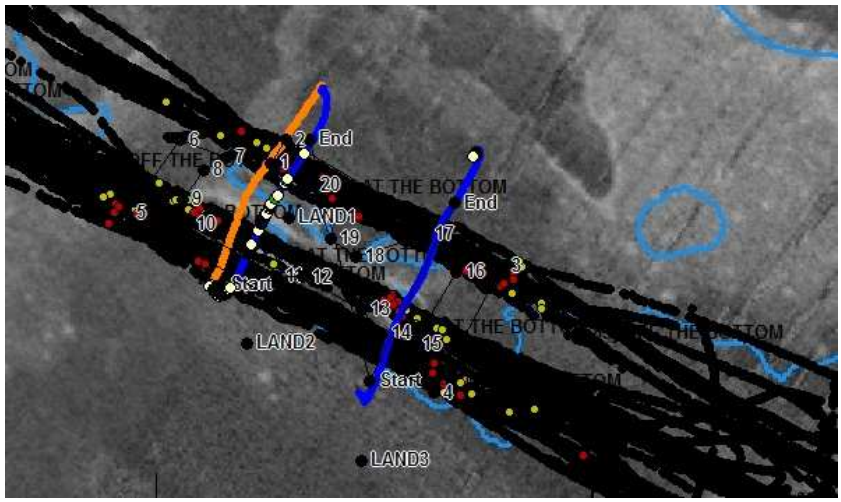
Station 102, Butterknife, eastern end



This tow was similar to baseline #048. SCIP marks were frequent on the southern side of the feature. GDU was common on both the southern and northern rims, with litle sign of any sedimentation.

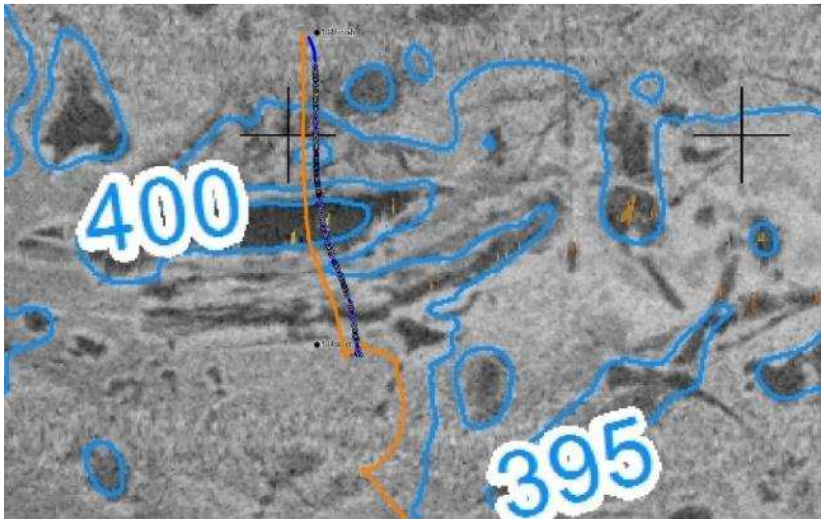


Station 103, Butterknife, western end

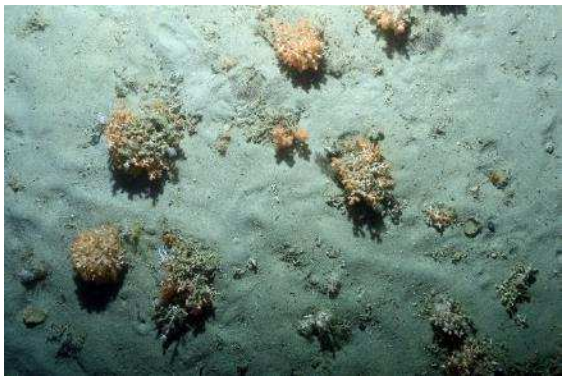


This tow was similar to the baseline #021 tow, running south to north across both rims of the Butterknife. The toe started with muddy sediments and then crossed multiple SCIP marks within the Disturbance polygon. GDU communities were clear on the south and north rims, with little sign of any sedimentation. SCIP tracks were frequent “inside” the feature, as well as to the north.

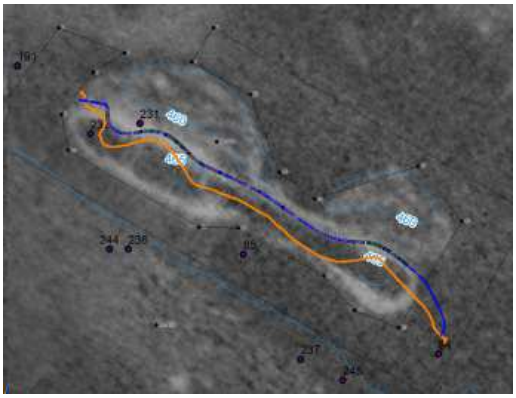
Station 104, “Harts Hillock”



This ran over a feature identified in TAN1805/024, as a potential target for live GDU capture. The tow ran over patches of muddy sediment,mounds-pits-burrows and heart urchins; and areas of pebbles and cobbles with GDU, stylasterids, and cup corals. Most live GDU was around the peak and targetted by subsequent sled shots.

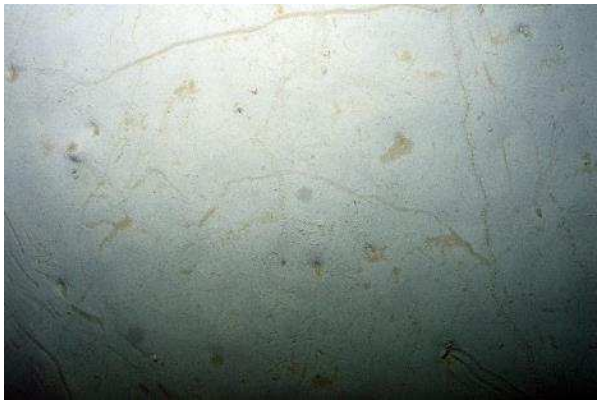


Station 118

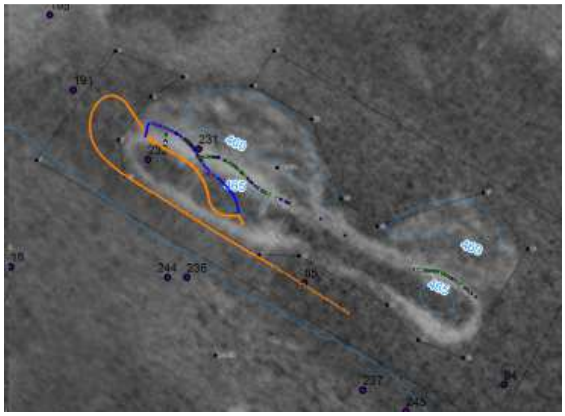


Post-disturbance DTIS transect along northern rim of butterknife. Beginning of line missed white high reflectivity region on landing. Current affect. Mud sediment burrows and mounds initially, then cobbles, pebbles, bedrock and GDU prevalent after around 20 minutes. Tracks from SCIP visible for

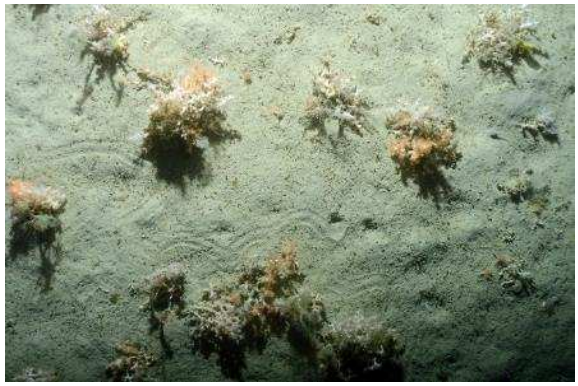
half way along the track for about 5 minutes. Observed some GDU seemed covered in sediment! Fresh fine powdery sediment, fresh invertebrate tracks. Invertebrates included: asteroids, anemones, demosponges, echinoids. Rattails, bony fish, shark.



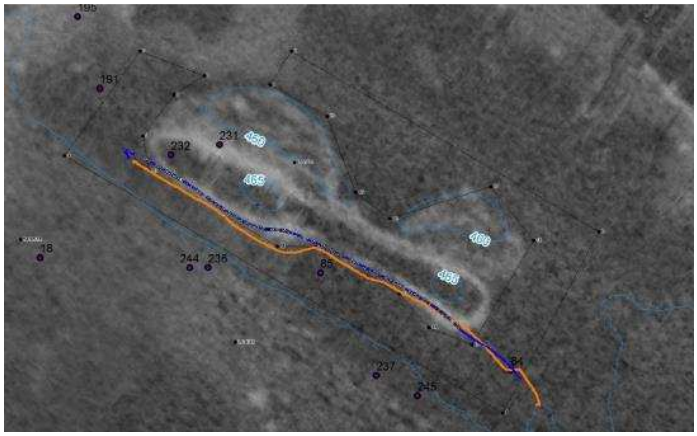

Station 119



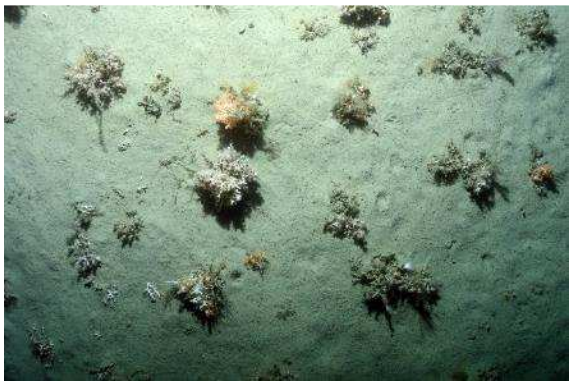
Additional DTIS station to cover the missed region, north west sector of butterknife. Repeat of intial part of station 118. Brief region of mud and burrows followed by extensive GDU, cobbles, pebbles, some bedrock. 10 min transect.

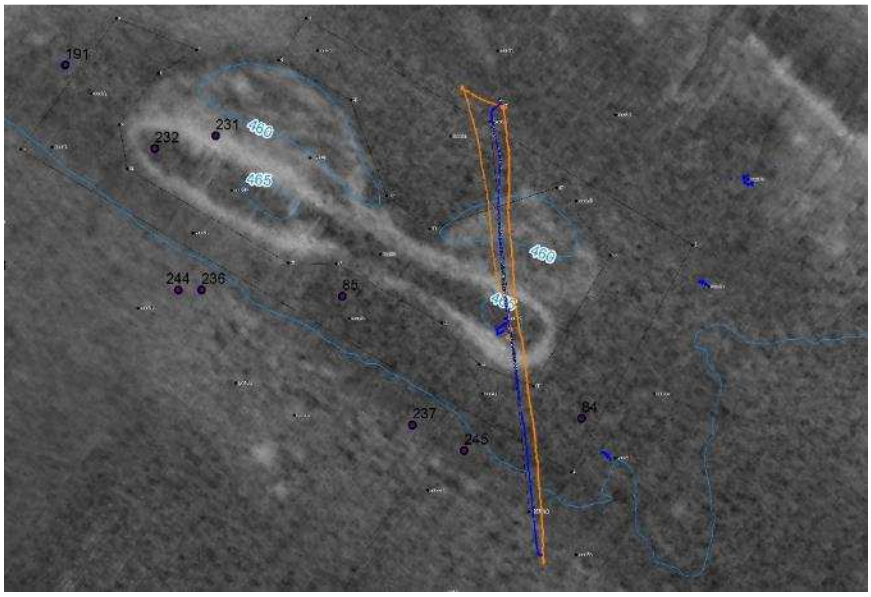
Station 120, Butterknife, South rim



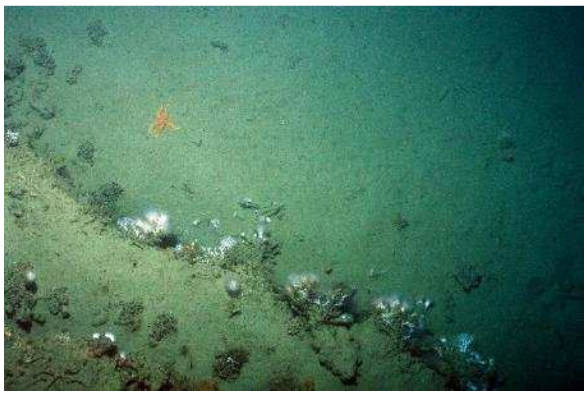
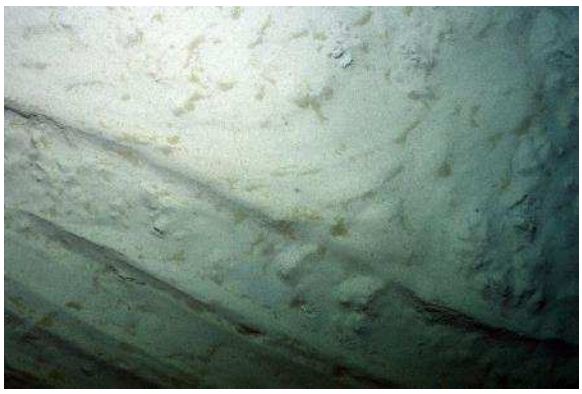
Post-disturbance transect along southern rim of butterknife. From northwest to southeast. Mud, burrows, mounds. SCIP tracks mid transect. GDU clumps toward the end with pebbles, cobbles, mud. Some anemones but overall invertebrates sparse. Fish, rattails increased by track marks. Ling, morid cod, bellowsfish.



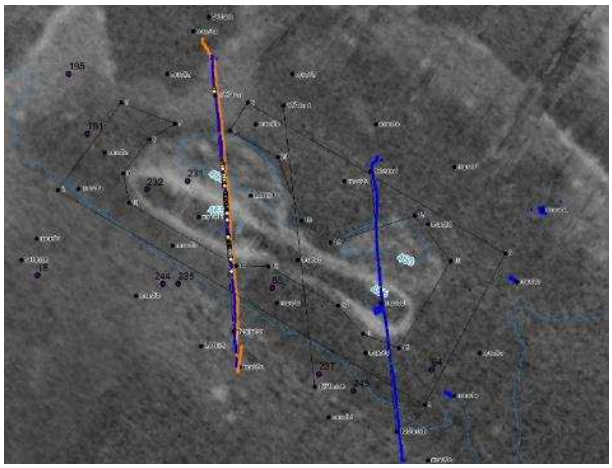
Station 125: Butterknife, eastern end



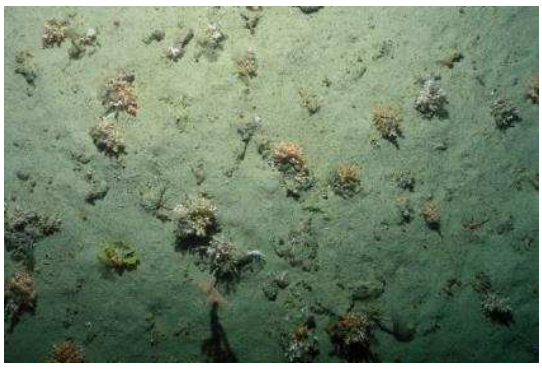
Towed south across the southestern end (~#048). Conscipuous SCIP marks to north, centre, and south. Sparse fauna on muddy sediment included asteroids, heart urchins, and anemones, with fish (rattails, sea perch, deep-sea flathead). GDU communities (stylasterids, sponges, bryozoans) on southern rim in particular, little sign of sedimentation, but noticeable brownish "fluff".

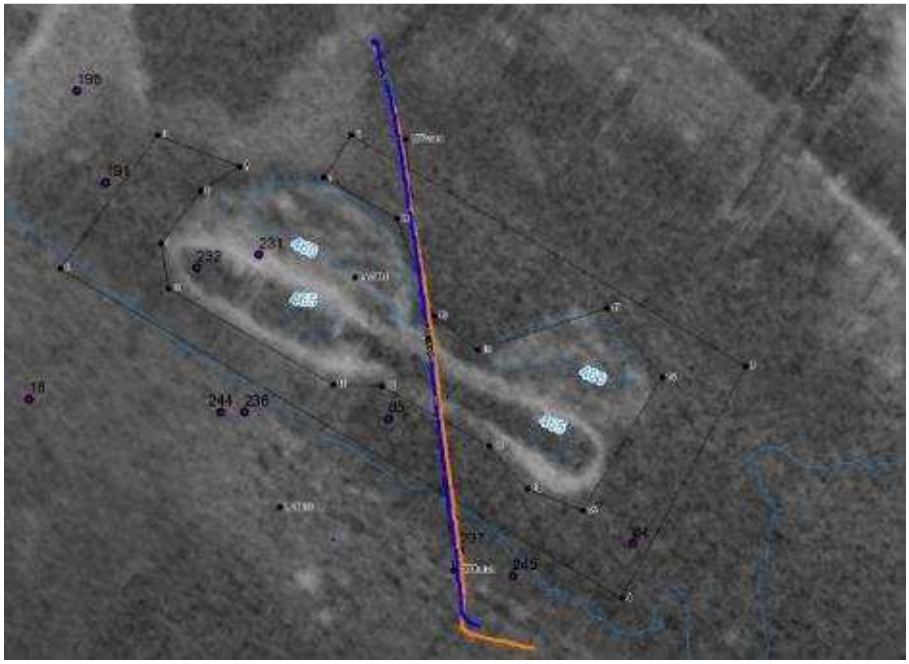
Station 126: Butterknife, western section.



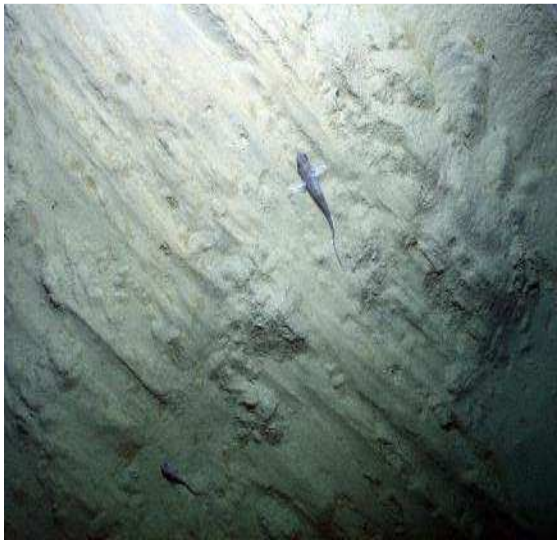
This tow aligned with the pre-disturbance #021. It spanned muddy sediments to the north of the butterknife, the harder rims with cobbles and pebbles, and muddy sediments again to the south. Muddy sediments in the disturbance polygon were heavily scarred by SCIP marks. Non disturbed areas were the usual mud with mounds, pits and burrows with anemones, heart urchins, asteroids and rattails. Cobble-pebble substrate on the rims hosted the usual GDU communities with stylasterids, bryozoans and demosponges. The GDU was relatively dense on the northern rim, sparser on the south. Some areas appeared to have fresh sediment, but nothing blanketing the corals.

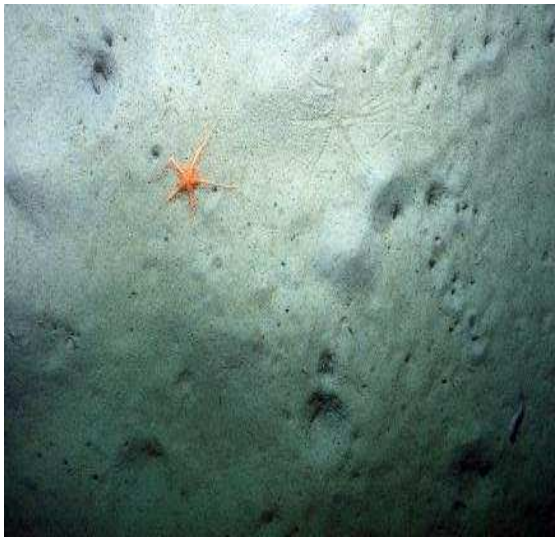



Station 127: Butterknife, central section.

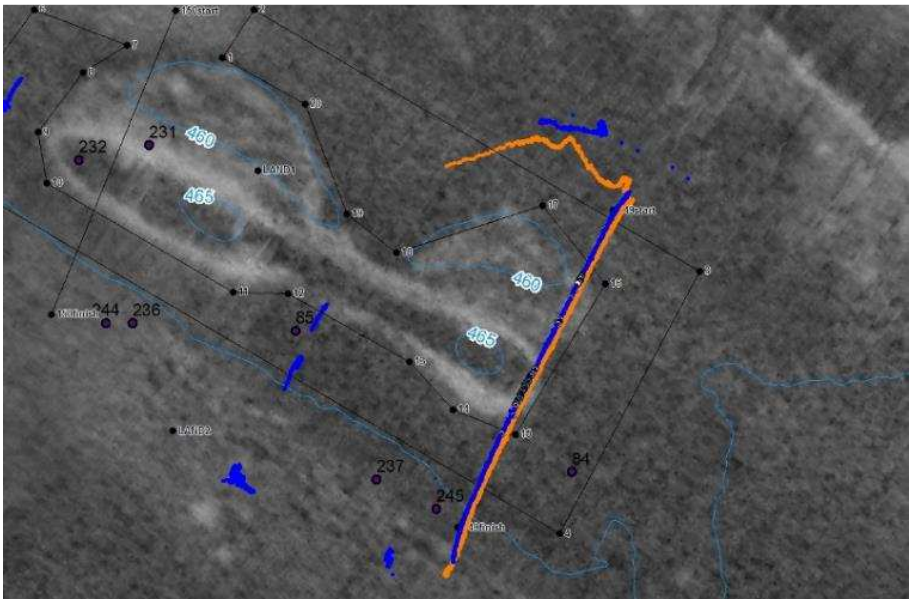


This tow targetted the general location of pre-disturbance #049. It ran over muddy sediments with SCIP marks to the north, in the centre and south of the butterknife. The cobbles and pebbles on the rims had the usual fauna with GDU, stylasterids, sponges etc-although not extensive as either end of the feature. Small rattails were very common over SCIP locations, and several ghost sharks, eels and a ling were observed.

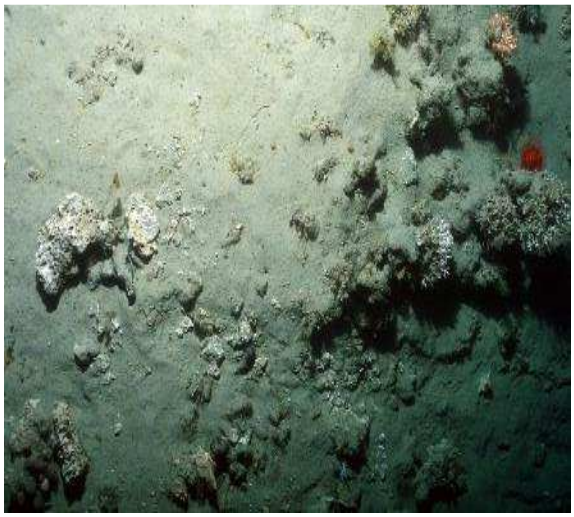




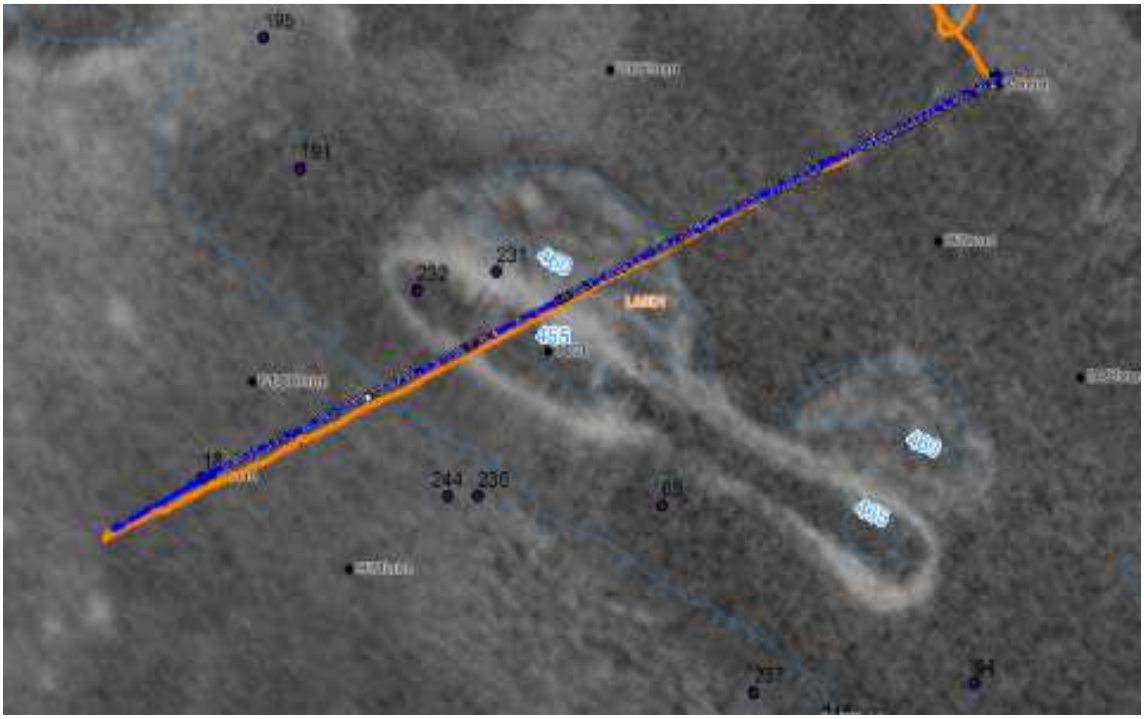
Station 149: Butterknife, very eastern end.



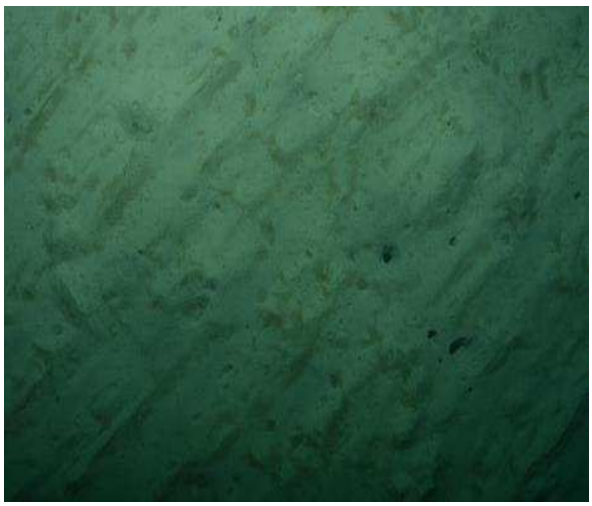
This DTIS tow was along the eastern end of Butterknife, clipping the end to check close SCIP proximity. It ran SSW across the northern area of disturbance, through the speckly backscatter extension of the Butterknife, across the eastern rim and out onto the southern disturbed zone. 6-7m swell mid transect made control difficult, switched to manual still shot mode when DTIS was nearest to bottom (swells caused it to range 1m to 9m off). There was evidence of SCIP tracks in the central region of the eastern rim, which also had the usual GDU, stylasterids, sponges fauna on cobbles. The muddy sediment had anemones, cidarids, and some asteroids, although in general seabed fauna were mostly obscured due to DTIS movement.



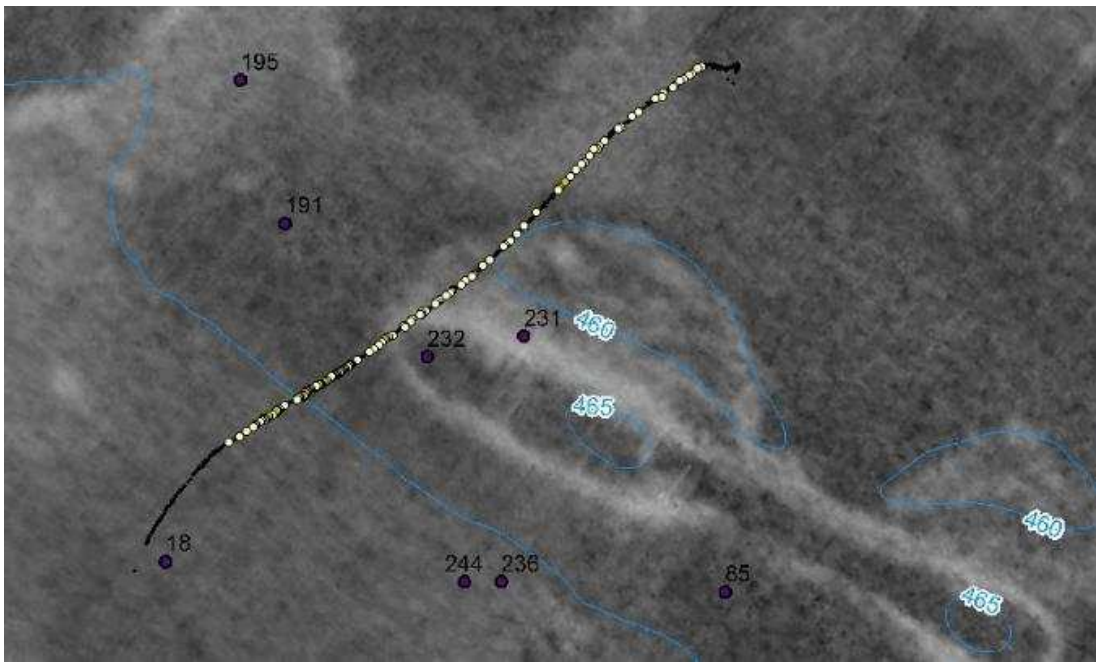
Station 161: Butterknife



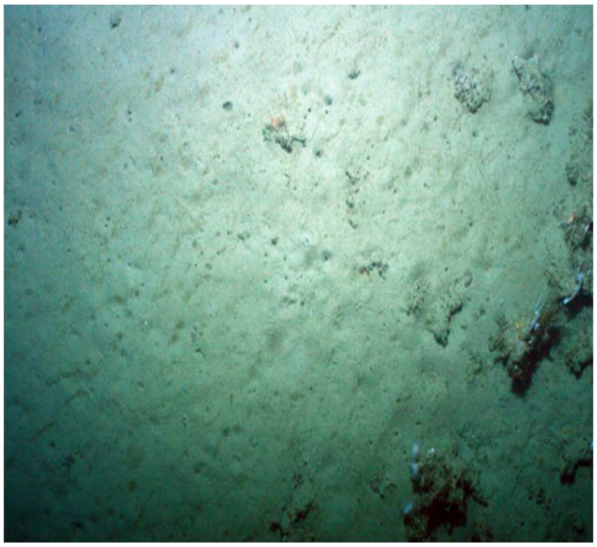
DTIS transect across butteknife - repeat of station 21. Muddy sediment, burrows, mounds, occasional pits. SCIP tracks visible north side of butterknife, centre, and southern areas. GDU, stylasterid and sponge area. Otherwise asteroids, sea pen, echinoids, holothurian. Rattails, javelinfish, banded bellows,ling.



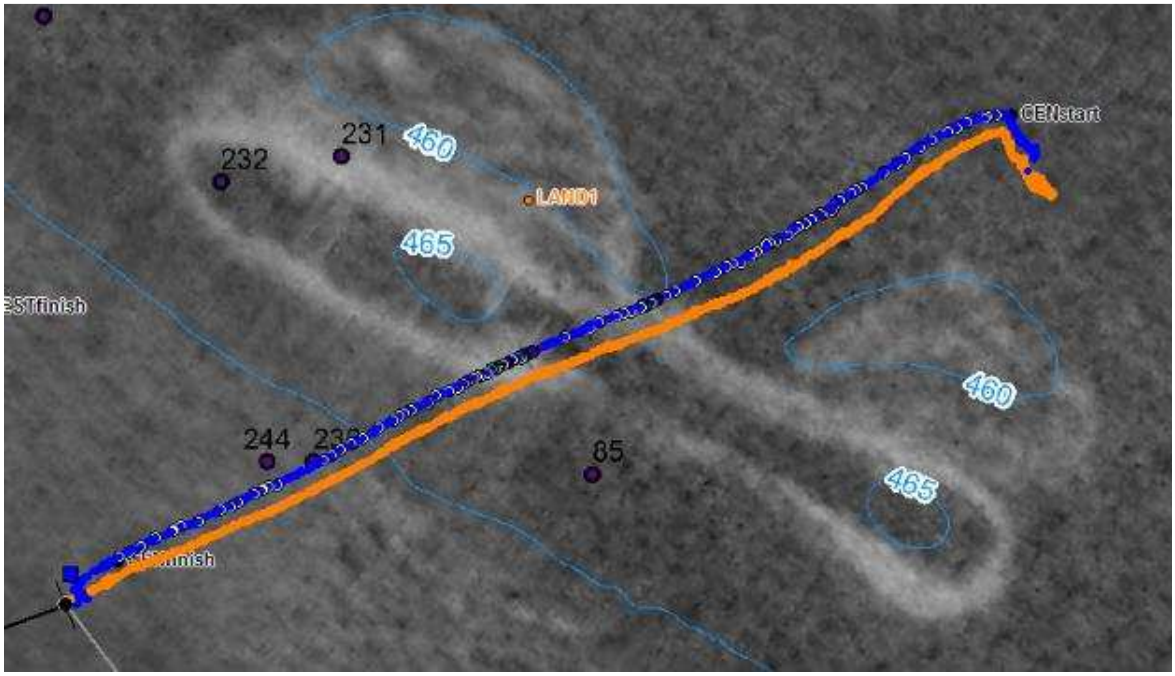
Station 162: Western edge of butterknife



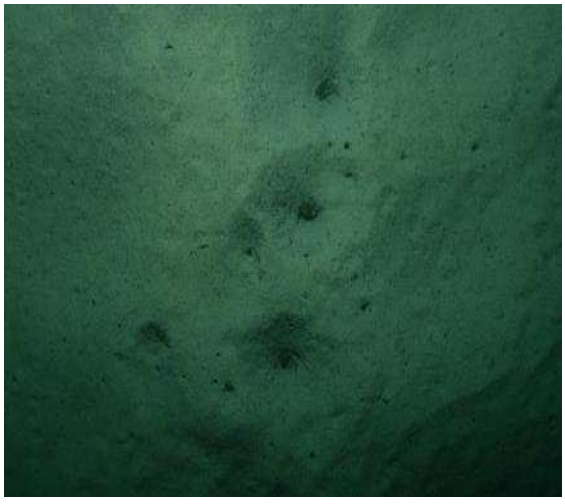
Muddy sediment burrows and mounds. Tracks visible for short period NW corner of Butterknife and in southern area out to the end of the transect line. Only a few animals - sponges, asteroids, anemone. Rattails, ghostshark, deepsea flathead.



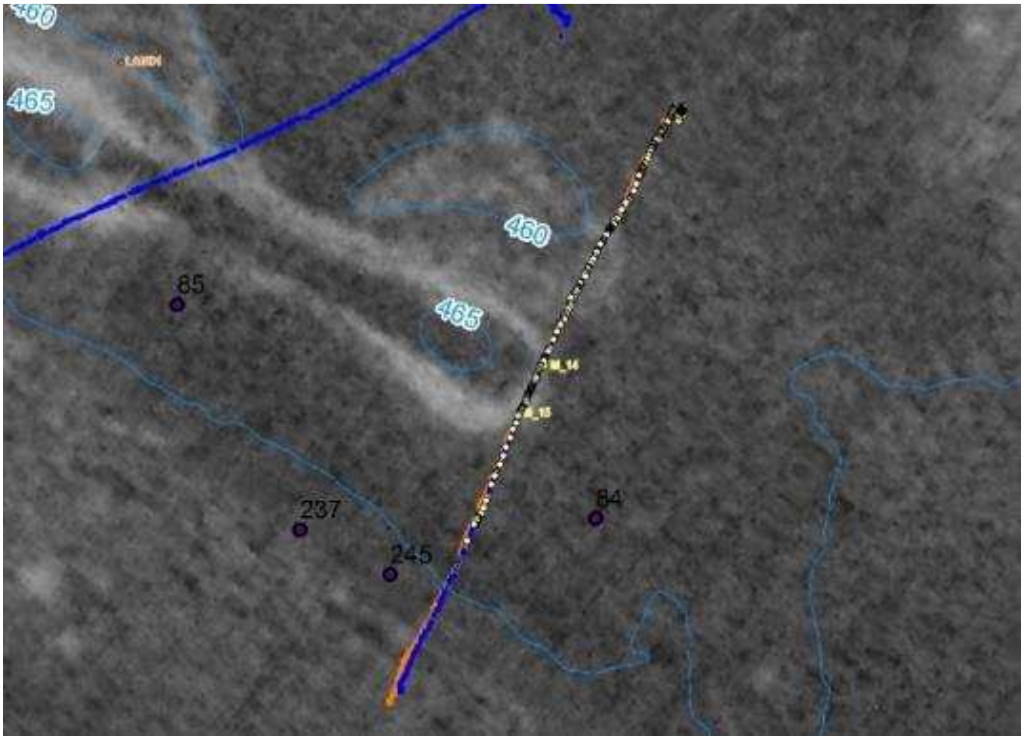
Station 163: Middle of butterknife



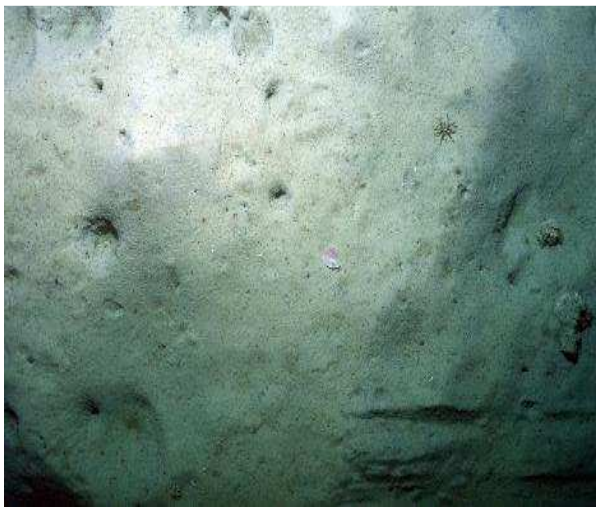
Muddy sediment, burrows, mud. Tracks in north and south regions, less defined tracks in the north. Not a lot of fauna, asteroids, echinoids. Rattails and eels.



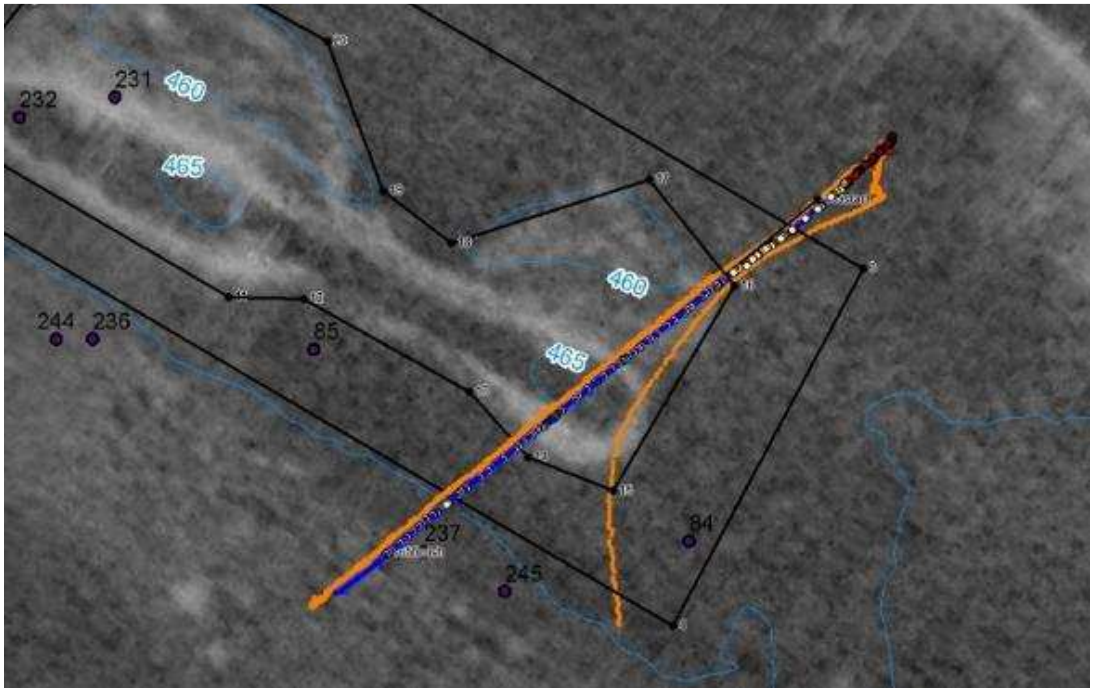
Station 164: Butterknife, eastern rim



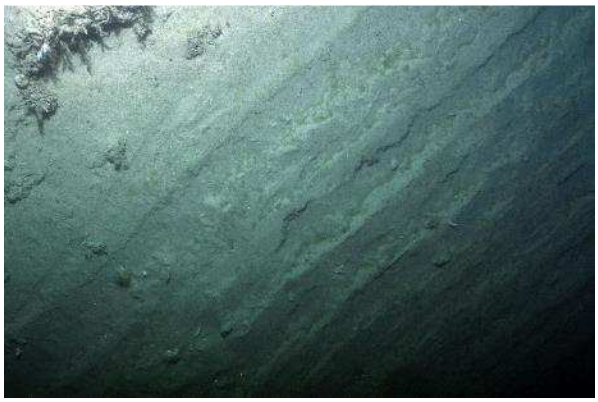
DTIS new transect eastern side of butterknife.Repeat of stn 149 undertaken in heavy swell. Muddy sediments to the north with SCIP marks. Running onto speckled backscatter substrate included patches of cobbles and pebbles with stylasterids, sponges and some GDU. The mix of muddy sediments with cobbles and pebbles continued across the eastern rim, with usual GDU in patches, and several SCIP marks. Further south was muddy sediment, with extensive SCIP marks.

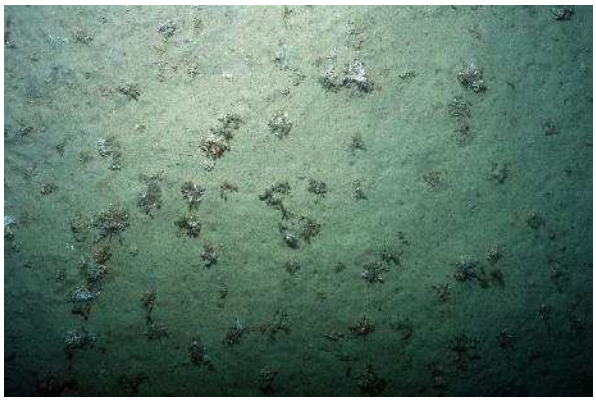


DTIS station 165: Butterknife

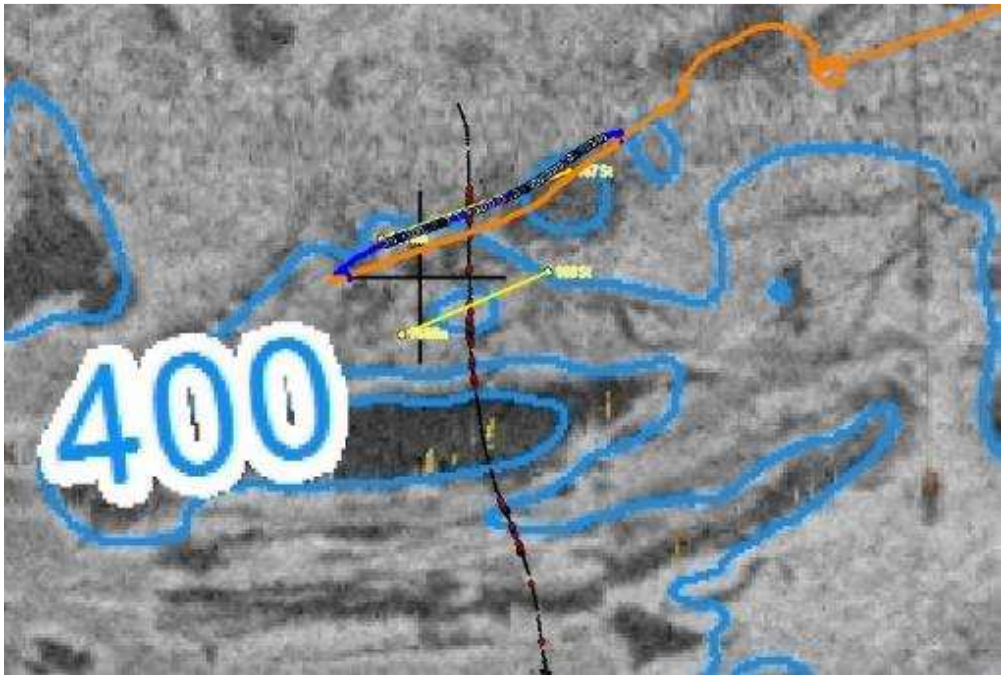


East-Central line, aligned with TAN1805/237.Muddy sediment (pits, mounds, burrows) at start to north of disturbance zone, then SCIP marks frequent until running south into speckly backscatter with patches of cobbles, pebbles, some stylasterids, GDU, sponges, bryozoans. GDU communities on northern rim of Butterknife, then SCIP marks on the muddy sediment in between rims. Good GDU on cobbles and pebbles on southern rim, some SCIP marks. On the mud to the south, SCIP marks common, still fresh. Muddy sediment (pits, mounds, burrows) at end. Rattals were common.



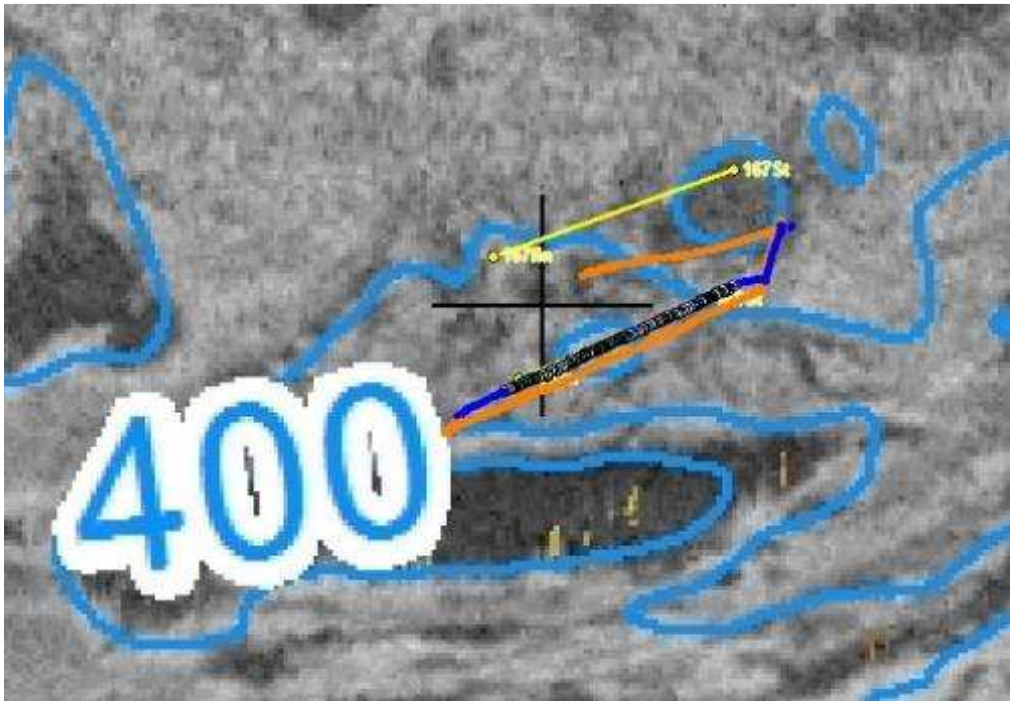


Station 167: Hart's Hillock beam trawl line

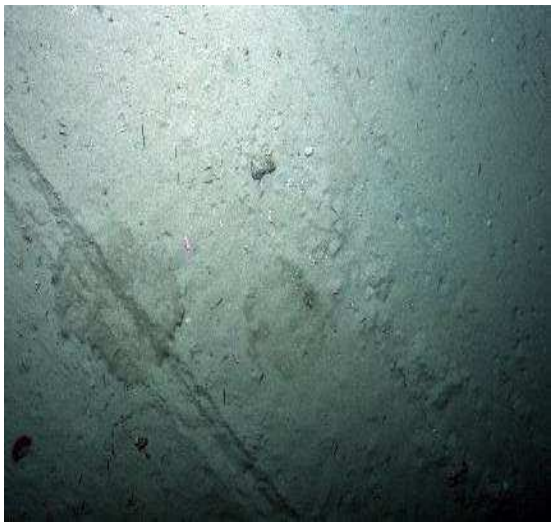


Harts hillock, running DTIS across the line of the beam trawls (Stations 154-156).Very patchy transect, areas of muddy sediment interspersed with cobbles and pebbles. GDU, stylasterids, bryozoan, demosponges on the harder ground. Heart urchins common throughout, abundant in places. Trawl marks from the beam trawls evident in several places.

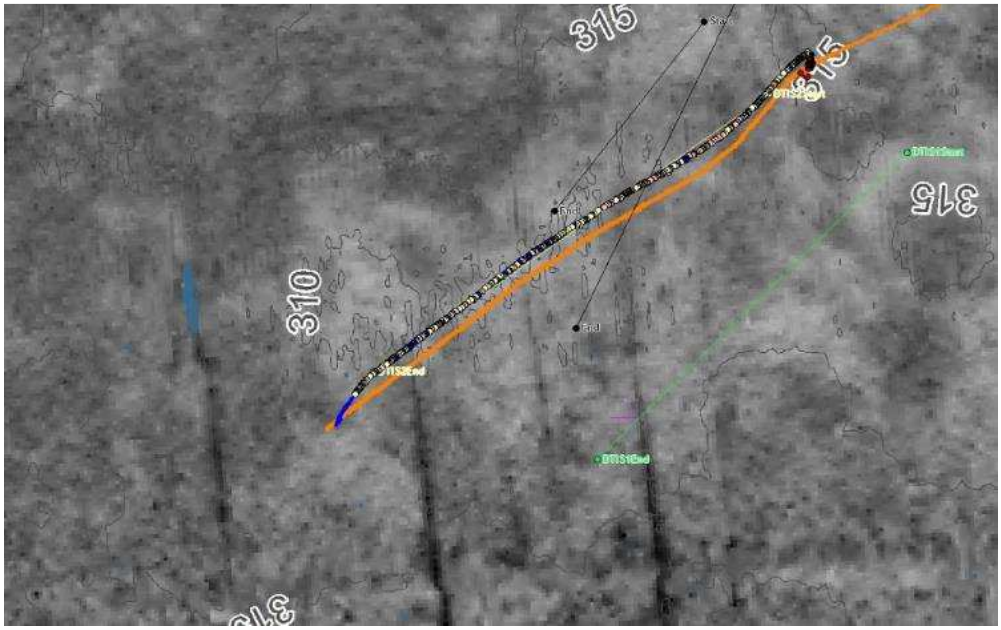
Station 168: Hart's hillock beam trawl line



Run across beam trawl lines, southern end on the crest of the hillock. The tow started on muddy sediment to the east of the beam trawl tracks. There were patches of cobbles and pebbles with good communities of GDU, stylasterids, demosponges and some bryozoans-especially on the top and western side of the hillock. Trawl marks were observed regularly on the muddy sediment approaching the summit.



Station 169: "ANZ" site for sponges



This transect covered an area where *Ecionemia* had previously been caught. Substrate was muddy sediment (mounds, pits, burrows) with gravelly overlay in places. There were patches of pebbles and cobbles, with some sponges, sytylasterids. Galatheids were common, with some scampi.