

# Voyage Programme

## Acoustic Biomass Surveys of Orange Roughy and benthic biodiversity camera trials in ORH 3B North Chatham Rise

**Vessel:** FV *Amaltal Apollo* (ID 62373)

**Survey area:** North Chatham Rise (ORH 3B NWCR and ORH 3B ESCR)

**Survey period:** 28 June to 22 July 2021

**Key Personnel:**

- Project Leader – George Clement (Deepwater Group Ltd)
- Voyage Leader – Tim Ryan (CSIRO)
- Vessel Management – Andy Smith (Talley's Group Ltd)
- Biological sampling and survey management – Rob Tilney (Thalassa)

**Research survey objective:**

To obtain estimates of orange roughy spawning biomass in ORH 3B NWCR and ORH 3B ESCR in terms of the Medium Term Research Plan for Deepwater Fisheries 2020/21 – 2024/25, to inform updated stock assessments.

**Primary objectives:**

- To estimate the abundance of spawning orange roughy using an Acoustic Optical System (AOS) and a hull-mounted acoustic system.
- To undertake targeted trawls on aggregations to collect the biological information required to inform the acoustic data and to collect otolith samples for population age structure determination.

**Ancillary objectives:**

- To undertake towed camera transects of the seabed on key Underwater Terrain Features (UTFs) to map the nature and extent of their benthic biodiversity.
- To trial CSIRO's new modular AOS to test for operation, noise performance, optimise camera settings for image quality and measure fish target strength (TS) using new wide-beam transducers
- Using CSIRO Modular AOS measure TS of aggregated basketwork eels at Smiths along with biological measures of length, gonad stage, sex and swimbladder cavity. Tissue samples preserved in 100% analytical ethanol will be taken from up to 50 eels caught at Smiths.

**Special Permit exemptions**

The following special permit exemptions have been approved.

1. Within the Morgue Seamount Closure, to undertake:
  - Acoustic survey transects above the seabed using a net-mounted AOS
  - Non-seabed-contacting target identification trawl tows (maximum of three tows)
  - Non-seabed-contacting towed camera transects.
2. To deploy a towed camera system using a fibre-optic cable.

### Survey timing and areas:

The planned survey time is aligned with the optimal spawning period in NWCR (during late June) and in ESCR (during the first half of July).

The planned survey areas are shown in Figure 1 below.

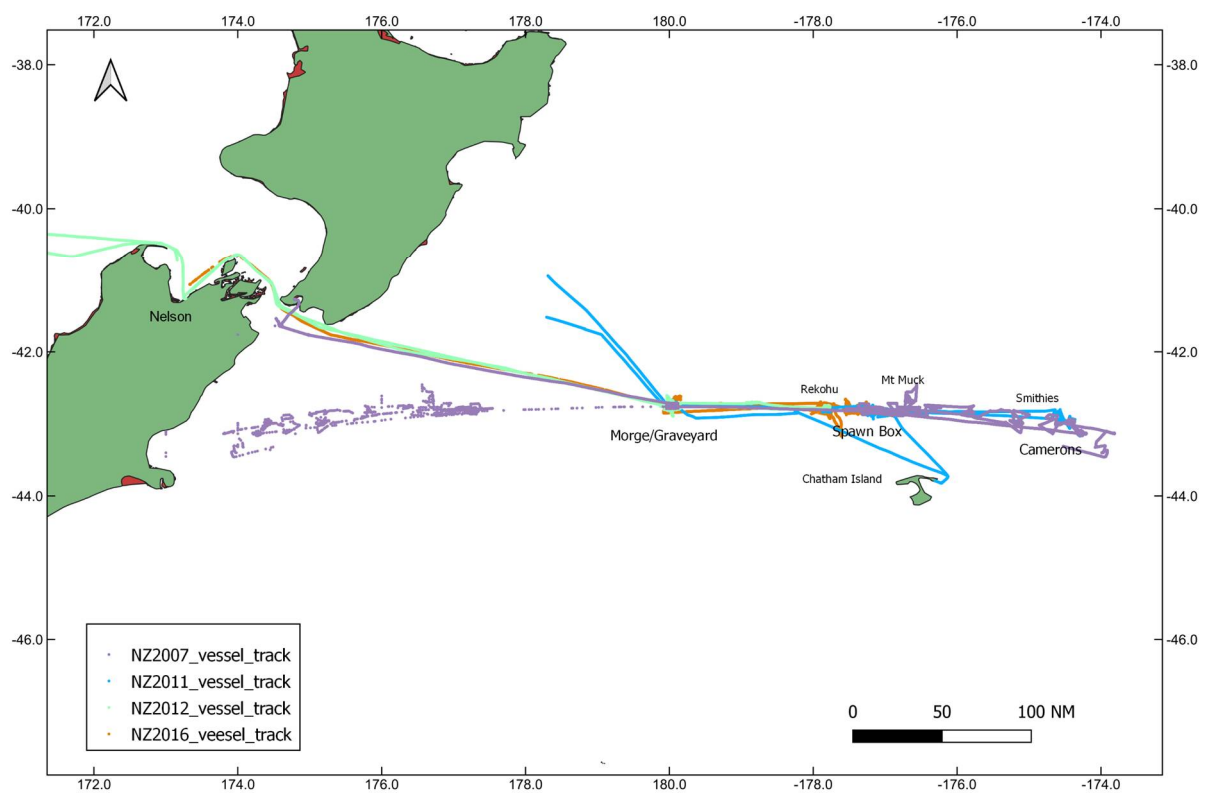


Figure 1. Survey locations for 2021 Amaltal Apollo orange roughy and benthic habitat surveys. Voyage tracks from historic AOS surveys are shown.

Timing of survey activities are provided in Appendix 1, noting that these will be subject to change depending on observations of fish spawning progress and other factors (e.g. weather).

### Eastern Chatham Rise (ESCR)

Surveying of the ESCR involves two main aggregations on the flats, Spawn Plume (also known as 'Old' plume) and Rekohu plume, and a single UTF, Mt Muck/The Crack (Figure 2). A period of 11 days has been allocated for surveying in ESCR commencing around the 3<sup>rd</sup> of July.

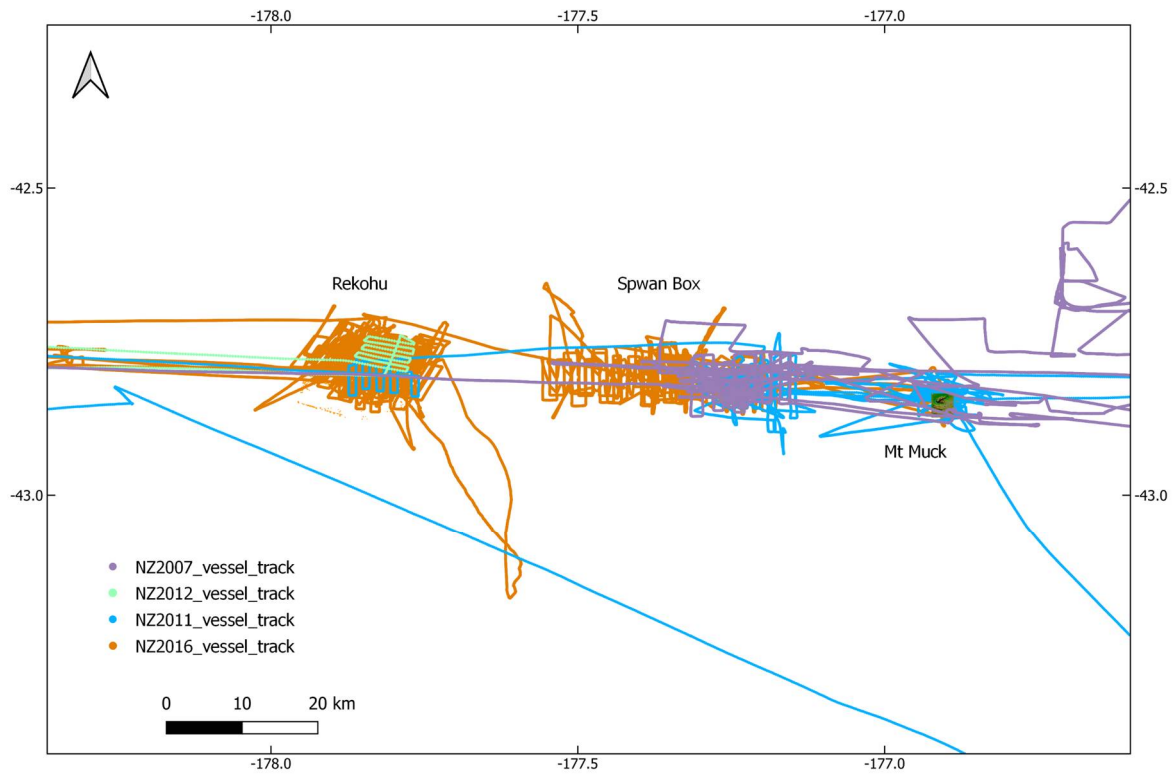
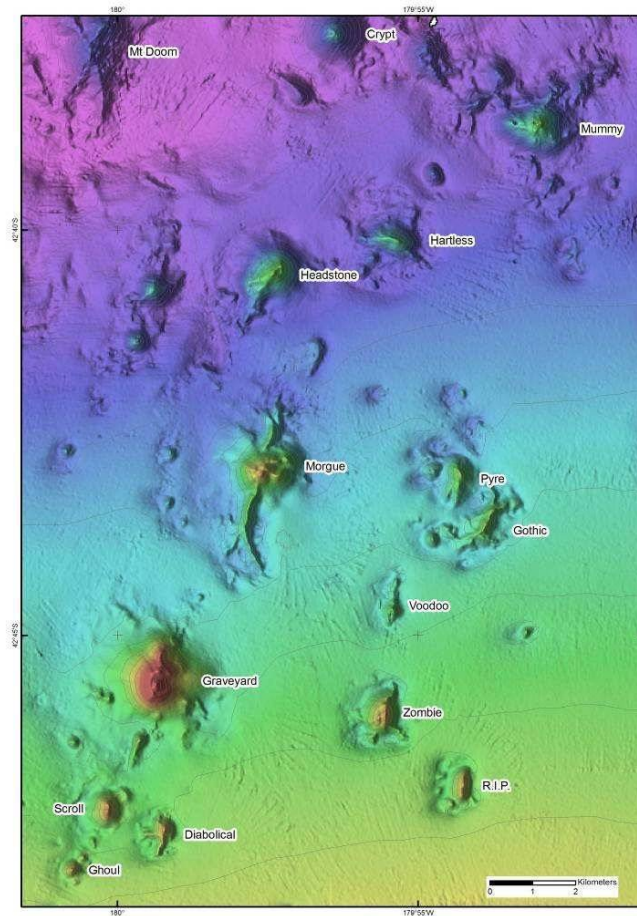


Figure 2. Rekohu, Spawn Plume and Mt Muck spawning locations, Eastern Chatham Rise. Voyage track from historic AOS surveys are shown.

### North West Chatham Rise

A period of three days has been allocated to surveying in NWCR (referred to as the 180 hills) commencing on the 30<sup>th</sup> of June. The main focus will be Morgue and Graveyard with additional hills within the 180 hills complex will be scouted for aggregations and will be surveyed should any be found (e.g. Dead Ringer; Scroll; Zombie; Mummy; Voodoo; Headstone), (Figure 2). Known fishing grounds over the flats will be searched for possible aggregations.



**Figure 2: The NWCR 180° hill features to be scouted for aggregations during the survey. Features that have high potential for orange roughy biomass (e.g. Graveyard; Morgue) will be surveyed repeatedly (after O'Driscoll, 2010).**

### **Vessel:**

Quota Owners have agreed to charter FV *Amaltal Apollo*, a 43 m factory trawler, for use as a survey platform. This will be a dedicated survey voyage under direction of the Voyage Leader.

Talley's and DWG have agreed that the vessel skipper and Voyage Leader will confer towards deploying the vessel in areas and on dates that would provide for the best possible survey result. It has also been agreed that surveys of aggregations will be conducted prior to target identification tows being undertaken and that aggregations will be rested for at least 8 hours between fishing events and subsequent acoustic surveys.

Accommodation is provided for six scientists/technicians and an MPI observer (i.e. a total of seven personnel additional to vessel crew). The vessel has a hold capacity sufficient to support 24-days of survey-related fishing on the grounds.

## Survey Methodology:

### Acoustic surveying:

The survey will use methodologies agreed by the Deep Water Working Group (DWWG) both in terms of survey design and biomass estimation procedures. The survey plan will be presented to the DWWG for consideration in June 2021 and any feedback from the Working Group will be incorporated as may be required.

Because of issues associated with mixed species acoustic marks on UTFs, estimates using single-frequency acoustic systems are considered unreliable. The survey of aggregations on Graveyard and Morgue (NWCR) and on Mt Muck/The Crack (ESCR) will require the use of a dual-frequency (i.e. 38 kHz and 120 kHz) acoustic-optic system (AOS), which will be deployed on the head-rope of the trawl net. Use of the AOS will enable echo-returns from gas-bladdered species to be identified and separated out from the acoustic backscatter, thereby producing defensible estimates of orange roughy biomass.

The AOS operates in two modes:

- For biomass estimation, a 'survey mode' is used where transect lines are conducted with the AOS at no less than 250 m above the top of orange roughy aggregations (to avoid avoidance reactions). For the NWCR UTFs, star pattern surveys will be adopted. A minimum of three AOS biomass surveys are proposed each for Morgue and Graveyard.
- In 'trawl mode' the AOS has acoustics set for close range measurement of target strength (TS) with video and calibrated stereo digital stills operating concurrently. This will allow us to monitor and advance knowledge of TS of orange roughy and co-occurring species (e.g. deepwater sharks that are common at this location). 'Trawl mode' operations also allow for collection of biological samples to monitor the spawning progression, take length measurements and extract otoliths for ageing.

Surveys of the two main spawning aggregations in ESCR (Spawn Plume and Rekohu plume) will be prosecuted using interleaved, parallel transecting that minimizes potential biases due to fish movement. These acoustic snapshots may be undertaken using either the hull-mounted acoustic system, the AOS, or both. These aggregations can be quite mobile within their respective greater areas and will require efficient searching using the vessel's hull mounted echosounder in the first instance. Vessel-based acoustic surveys may be appropriate should aggregations be clearly defined, and weather conditions allow. A key advantage of the vessel-based surveys is that they can be conducted more rapidly than AOS surveys. This can be important if aggregations are particularly mobile. AOS surveys will be important where species are not clearly delineated and/or when weather conditions compromise the vessel-based system. It is expected a combination of both approaches will be needed for optimal outcomes.

DWG has leased Sealord's proven AOS for these surveys and has contracted CSIRO scientists to direct and undertake the surveys.

Biomass estimates will be made by echo-integration of partitioned echograms that were classified as orange roughy using CSIRO's multiple lines of evidence approach. Biomass estimates will apply the TS regression accepted by the MPI Deep Water Working Group. Biomass estimates will be made at 38 kHz. These will add to the time-series at this frequency that is used in the stock assessment process. Biomass estimates at 120 kHz will also be calculated as a separate metric which provides a semi-independent check on the 38 kHz estimates. Geostatistical methods will be used to estimate survey CV. CTD data will be recorded with each deployment to allow estimates of sound speed and acoustic absorption to be made.

Acoustic snapshots will, as far as possible, occur over the periods of the main spawning events to provide biomass estimates representative of the spawning stock at peak occurrences.

### **Acoustic data:**

Vessel mounted 38 kHz acoustic data will be logged to *Amaltal Apollo*'s ES80 computer and will be backed up onto two independent systems after each snapshot. The entire database will be backed up onto a separate drive at the end of each day. A log will be maintained for each snapshot to record ancillary information (e.g. weather details, nature of snapshot execution).

Analysis of acoustic backscatter from the surveys, in conjunction with biological information from catches (i.e. mean lengths and weights of orange roughy), will be undertaken by CSIRO using accepted methods to estimate aggregation biomass.

### **Biological sampling:**

On completion of each survey snapshot on an aggregation, one or more dedicated fishing tows will be undertaken to collect representative biological information required to inform the acoustic data (i.e. lengths, weights, spawning condition, species composition) and to collect otolith samples for age-frequency determination. Tows will be taken into the edges of aggregations to avoid excessively large catches. Catch sensors will be positioned on the codend to trigger at approximately 5 t and catches of around 5 – 10 t are anticipated per tow. All tows will be monitored by an MPI observer aboard the vessel, who will also assist the onboard scientists in undertaking the biological sampling.

Target-identification trawl catches will be sampled as follows:

- The entire bycatch will be sorted by species and weighed
- Quota species and deepwater sharks will be measured for length, sex and gonad development stage
- Where large catches of orange roughy occur, catch weight will be determined from landing figures

Random samples of 100 orange roughy will be measured for:

- Length frequency, using an electronic measuring board (EMB)
- Individual weights, using a motion-compensated electronic scale interfaced with the EMB
- Gonad development state (8-stage scale for females) and sex (male, female, juvenile). Stomach content and stomach fullness will be recorded for the first 20 fish from each random sample.

Should an orange roughy catch exceed 10 t, two random samples will be processed.

A minimum of 500 orange roughy otolith samples will be collected from each spawning aggregation surveyed, preferably from multiple tows. Regardless of the number of otoliths secured from an aggregation, otoliths will continue to be collected from all tows undertaken.

For other abundant species in catches, samples of 50 – 100 individuals will be randomly selected from the catch to determine length distributions.

The catch and biological data will be backed up onto an external hard-drive after each station.

### **Survey management:**

An open dialogue will be maintained between Talley's, DWG and FNZ throughout the survey and the number of survey snapshots, tows and catches will be reported to DWG and FNZ on a weekly basis.

### **Disposal of aquatic life:**

All product emanating from survey catches will be landed into Talley's Group Ltd's Licenced Fish Receiver (LFR No. 8462926) in Port Nelson. The orange roughy product will be distributed to ORH 3B quota owners who contributed funding and ACE for the survey on a *pro rata* basis. ACE to cover QMS bycatch will be provided by Talley's.

### **ETP species mitigation:**

Best practice mitigation measures will be employed as per the Vessel Management Plan (VMP) to minimise the risk to seabirds during the survey, as follows:

- Port and starboard bafflers will be deployed at all times
- The VMP Seabird Trigger Limit reporting standard will result in:
  - An immediate assessment of actions and conditions at the time of capture, an evaluation of the probable causes and action taken to address any identified risk factors
  - Report sent from the vessel and/or Talley's Group Ltd managers to DWG within 12 hrs
  - DWG to contact FNZ deepwater manager within 24 hrs should two or more seabirds be captured, together with a brief on the circumstances of the event and remedial actions taken.

FV *Amaltal Apollo* is a factory freezer vessel and offal will be produced. A strict discharge regimen for offal and non-QMS bycatch will be implemented as per the vessel's VMP (i.e. no discharge during shooting or hauling). This will diminish the vessel's attractiveness to seabirds and serve to reduce the risk that seabirds will come into contact with the trawl gear.

### **Reporting:**

- A Voyage Report will be submitted to DWG and FNZ by 31 August 2021
- Provisional biomass estimates will be reported to DWG during December 2021
- A draft FAR will be submitted to DWG and FNZ by 31 March 2022.
- Acoustic and biological data will be lodged with MPI's research database by 31 March 2022.

### **Benthic habitat mapping:**

As a parallel project, sponsored by ORH 3B quota owners, an ancillary objective of the voyage is to undertake towed camera transects of the seabed on key UTFs to map the nature and extent of their benthic biodiversity. The camera system will be towed using an optic-fibre cable which will enable real-time video transmission to the operator, essential for controlling the deployment depth near the seabed during transecting. A dedicated winch will be mounted on the trawl deck of FV *Amaltal Apollo* for this purpose and the camera system will be deployed over the stern of the vessel.

It is estimated that each UTF will require approximately 24 hours of transecting. The following UTFs have been identified for camera-transecting:

- Graveyard (NWCR) – trial shakedown deployment
- Mt Muck/The Crack (ESCR)

- Cameron's (ESCR)
- Smith's City (ESCR).

A review of existing benthic image data holdings is provided in Appendix 2

### Pre-defined camera survey transects

Camera transects will be conducted according to pre-defined randomly selected bearings to ensure selection of transect lines is not biased. These are given in Table 1 where transects should be conducted sequentially if weather conditions are allowed. Camera tows need to start at the top of the feature and go down the slope. Vessel will need to tow into the weather to allow the slow speed needed to get the camera to the required depths. Camera transects should be of consistent length and run out on to the 'flats'. They should not be cut short just because of a lack of interesting fauna.

*Table 1. Pre-defined bearings for deep-camera tows.*

	seamount_1	seamount_2	seamount_3	seamount_4	seamount_5
transect_1	228	324	324	33	17
transect_2	24	199	199	283	267
transect_3	274	42	43	158	142
transect_4	149	292	293	96	79
transect_5	87	167	168	346	329
transect_6	337	105	105	221	204
transect_7	212	355	355	18	48
transect_8	56	230	230	268	298
transect_9	306	27	27	143	173
transect_10	181	277	277	80	110
transect_11	118	152	152	330	360
transect_12	243	89	90	205	235
transect_13	5	339	340	49	9
transect_14	255	214	215	299	259
transect_15	130	58	58	174	134
transect_16	67	308	308	112	71
transect_17	317	183	183	237	321
transect_18	192	121	121	10	196
transect_19	36	246	246	260	40
transect_20	286	7	8	135	290
transect_21	161	257	258	73	165
transect_22	99	132	133	323	103
transect_23	349	70	70	198	353
transect_24	224	320	320	41	228
transect_25	20	195	195	291	24
transect_26	270	38	39	166	274
transect_27	145	288	289	104	149
transect_28	83	163	164	354	87
transect_29	333	101	101	229	337
transect_30	208	351	351	26	212



### Testing of CSIRO Modular AOS

CSIRO's new modular AOS will be tested during this voyage. It is expected these tests will take place at the latter end of the voyage when orange roughy surveys have largely been completed. These tests could take place at Smith's/Cameron's during periods when the priority deep-camera tows are not being conducted. Tests would include biomass mode (300 m above fish schools) to test performance of the acoustics. Additionally tows for fish target strength (TS), i.e. trawl mode, would be made running the M-AOS system close to the seafloor in the same manner as a normal fishing shot. Catch from these tows would be processed in the usual manner for scientific biological sampling. These TS mode shots will also enable optimization of camera settings.

### Sampling of basketwork eels (opportunistic)

Opportunistically, aggregations of basketwork eels at Smith's, if found, will be targeted with the modular AOS in trawl mode to measure their TS and catch samples. Length, weight, sex and stage would be measured. Additional measures of swimbladder cavities would be made for the purpose of understanding TS. Tissue samples would be taken for up to 50 eels and preserved in 100% analytical grade ethanol.

### References:

FNZ (2020). Fisheries Assessment Plenary May 2020: Stock Assessments and Stock Status, Vol. 2 Hoki to Redbait. <https://www.mpi.govt.nz/dmsdocument/40784-Fisheries-Assessment-Plenary-May-2020-Volume-2-Hoki-to-Redbait>.

## Appendix 1. Survey timetable

This survey timetable gives estimated dates and location of activities. It may change depending on spawning progression and other factors – e.g. weather.

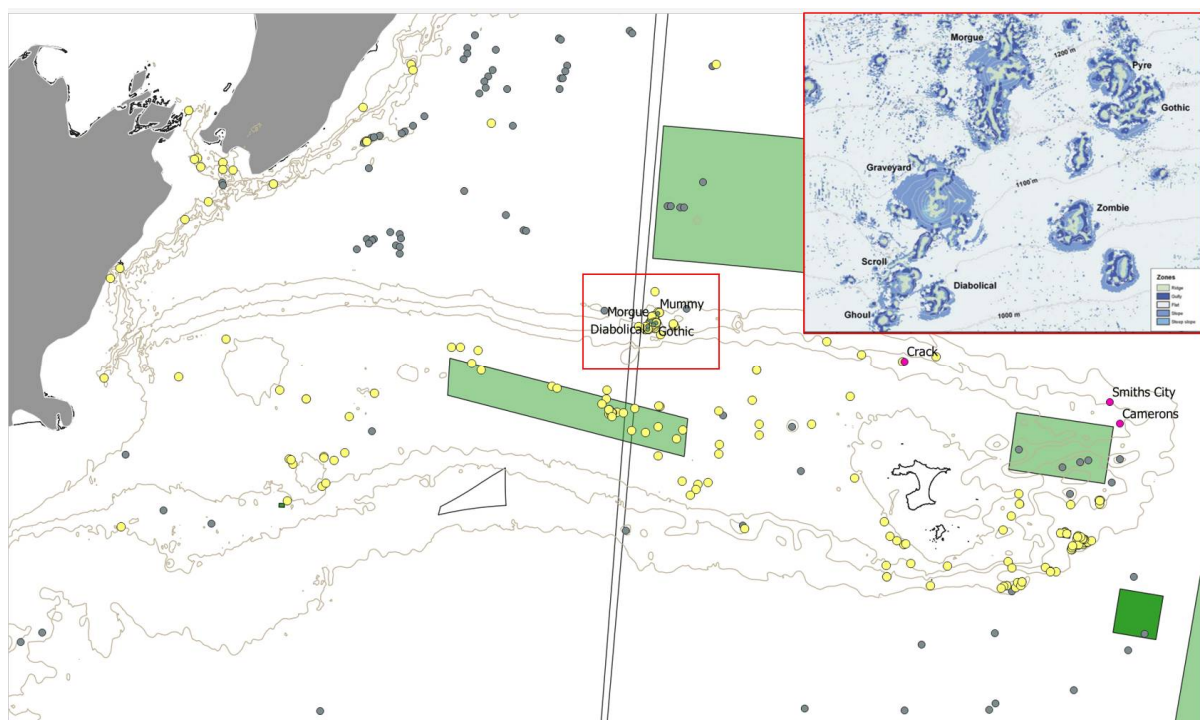
28/06/21	Depart Nelson, transit to NWCR
29/06/21	Transit to NWCR
30/06/21	Morgue/Graveyard
1/07/21	Morgue/Graveyard
2/07/21	Morgue/Graveyard
3/07/21	Rekohu
4/07/21	Rekohu
5/07/21	Rekohu
6/07/21	Rekohu
7/07/21	Rekohu
8/07/21	Spawn Plume
9/07/21	Spawn Plume
10/07/21	Spawn Plume
11/07/21	Mt Muck
12/07/21	Mt Muck
13/07/21	Spawn Plume
14/07/21	Spawn Plume
15/07/21	Transit to Smith's/Cameron's
16/07/21	Smith's/Cameron's
17/07/21	Smith's/Cameron's
18/07/21	Smith's/Cameron's
19/07/21	Weather contingency
20/07/21	Weather contingency
21/07/21	Transit
22/07/21	Transit to Nelson

## Appendix 2 Existing data holdings

Review of existing data holdings follows as background information to help guide benthic sampling.

### *2021 Study Area: Mt. Muck (The Crack), Smith's City, and Cameron's*

- A test run of the towed camera to be deployed at Graveyard hill (Figure 1)
- Three UTFs will be surveyed for benthic biodiversity in the NE region of the Chatham Rise (Figure 1 & 2)
- All 3 UTFs have extensive trawl history, and contain coral rubble
- Refuge areas may include the very top of the UTF (these areas are avoided – Pers. Comms)
- Potential refuge area on Mt. Muck on the SW 'canyon'
- Potential refuge on alternative UTFs around targeted UTFs.



**Figure 1.** The Chatham Rise (insert of Graveyard complex) and NZ\_2021 biodiversity target UTFs, Mt. Muck (The Crack), Smith's City, and Cameron's. Light green indicates benthic protected areas, dark green indicates Seamount Closure areas. Yellow dots are NIWA coral data, grey dots are knolls. Note, some UTF not shown on this map. Insert map: <https://deepwatergroup.org/wp-content/uploads/2013/08/Clark-et-al-2010-Effects-Fishing-Graveyard-Complex-AEBR-46.pdf>

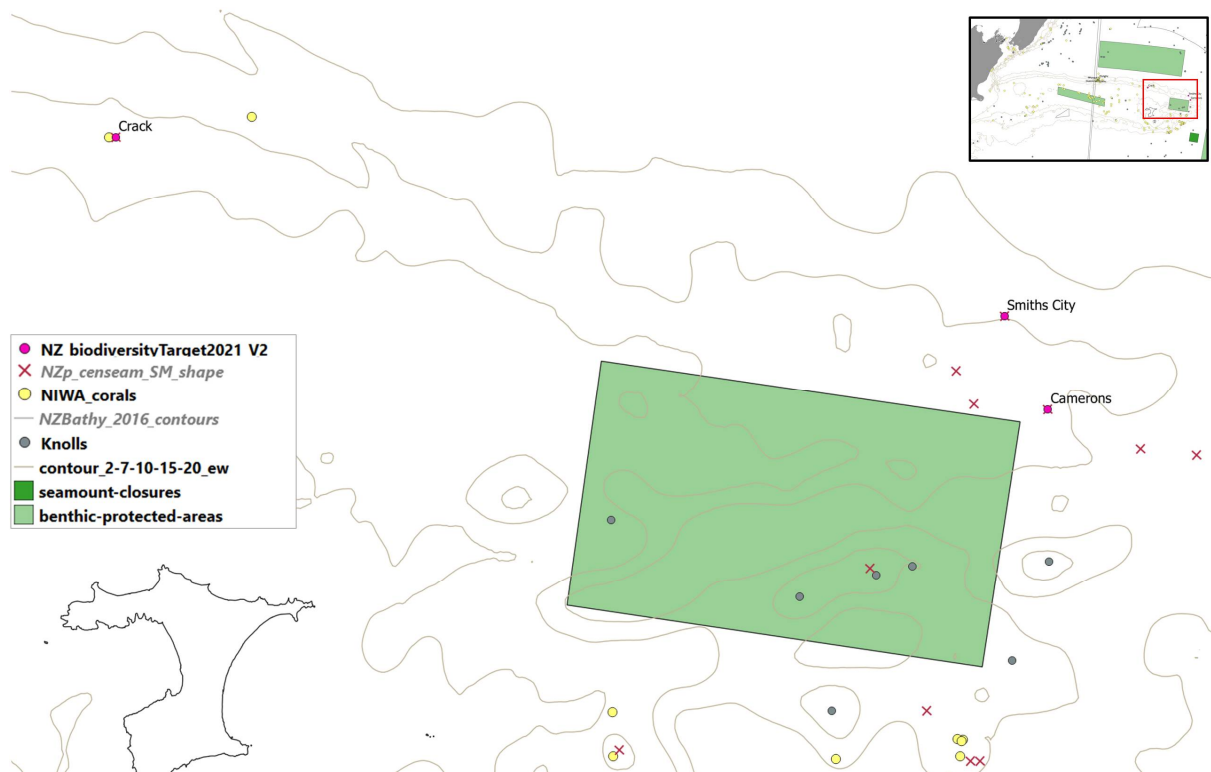


Figure 2. NZ\_2021 benthic biodiversity target seamounts.

## Mt. Muck (The Crack)

Mt. Muck is a highly impacted UTF with no evidence of remaining intact stony corals. Large areas of SVA (assumed species) rubble indicate refuges may be present in areas with rocky relief, or, in areas unsuitable for trawling.

- The Crack on the Chatham Rise had the highest catch during the 20 years leading up to 2000, with 48,442 tonnes of orange roughy. It was trawled 3,970 times during this period.
- *Solenosmilia variabilis* found in 2008 (Tracey et al., 2011)
- Extensive areas of dense rubble observed in AOS historical image summary (Table 1; Figure 3 & 4)
- Low to minimal relief (opportunity for refuge) observed in AOS historical imagery
- SSW of Mt. Muck are 2 smaller UTFs – may be interesting to see what is there?



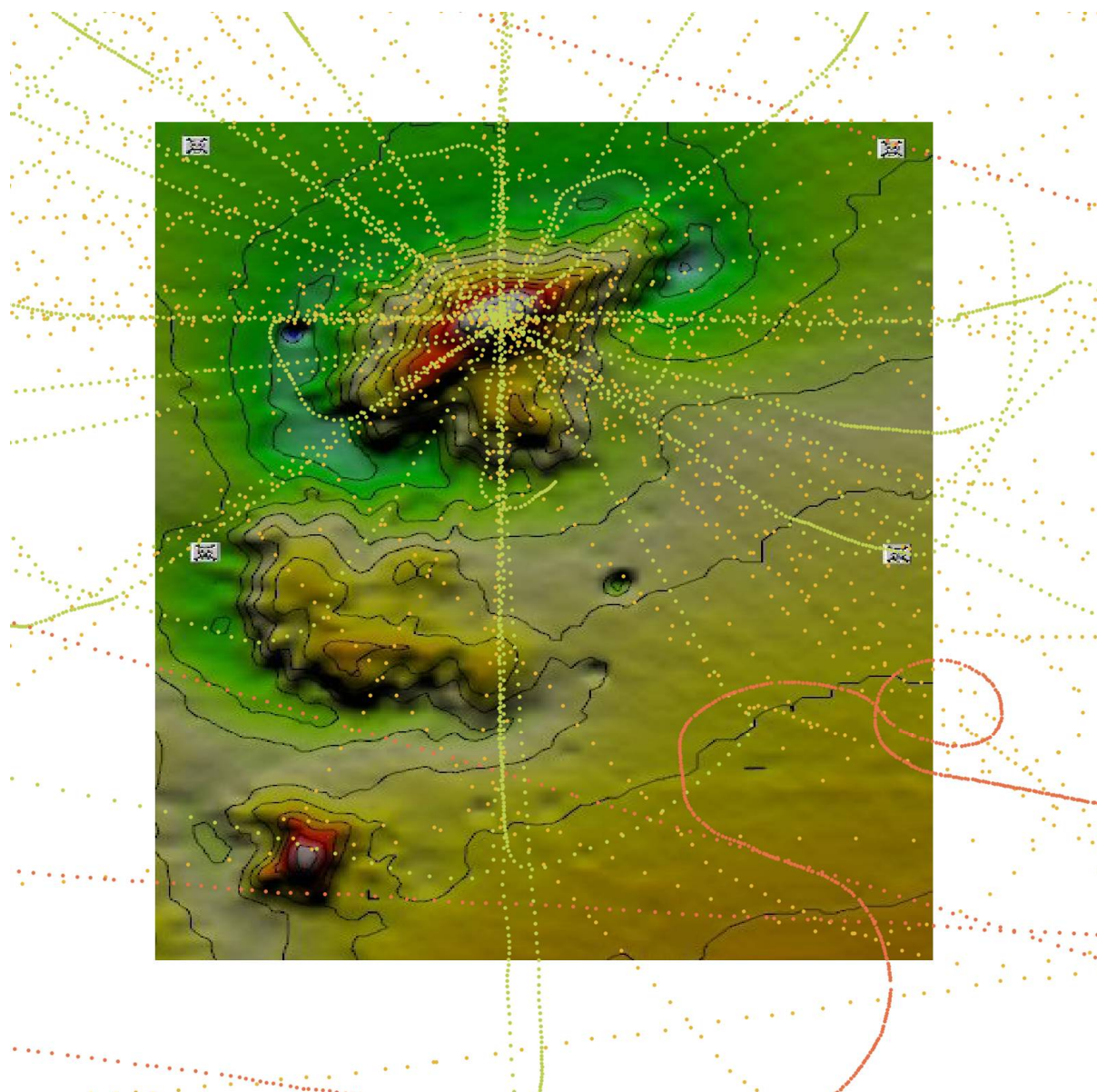
Figure 3. Dense coral rubble on Mt. Muck (AMX201301\_op75\_0.033jpg)



Figure 4. Dense coral rubble and many-armed sea-star on Mt. Muck (AMX201601\_op79\_0.514jpg)

**Table 1.** Summary and notes from CSIRO historical imagery of Mt. Muck

Voyage Acronym (year)	Op_number	Notes
AMX201601	79	Checked. Coral rubble. Gear marks. Dark images.
AMX201601	84	Checked. Dense coral rubble. Sand. Mix of UE and OE
AMX201301	60	Blurred, blue OE images. Coral rubble. Lots of gear images.
AMX201301	74	(Video) shows extensive area of coral rubble at top with gear marks. No relief. Some basalt rock among sand substrate (little relief) further along tow.
AMX201301	75	(Video) Similar to Op_74
2011	7	Sand and Rock. Lots of gear (net) captured and fish.
2011	24	Sand. Could be coral rubble? Images out of focus.
2011	26	Rock and sand. Could be coral rubble? Images generally dark and out of focus.



**Figure 5.** Mt. Muck (The Crack) UTF group with CSIRO survey vessel tracks overlaid (green = NZ2016; yellow = NZ2011; orange = NZ2007)



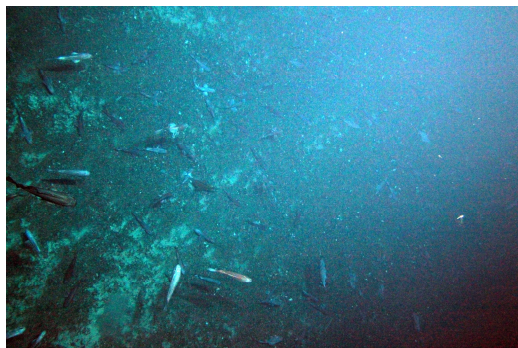
## Smith's (City)

"Heavily trawl-impacted, coral rubble on summit, becoming lava, boulders, and sand on lower flanks"  
– NIWA

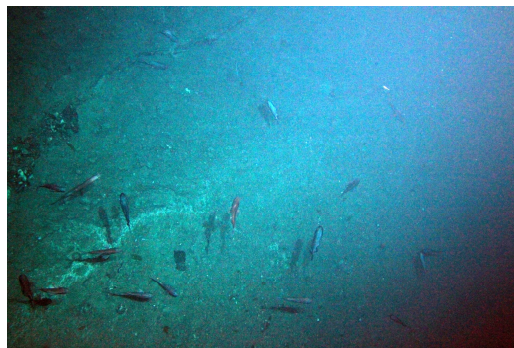
Limited imagery and substrate information. There appears to be more exposed rock substrate here compared to Mt. Muck, and therefore might host a different suite of fauna.

Again, areas outside trawl lines (if any) might be interesting. The smaller knolls around the perimeter of the feature are within SVA depth range. North-east of Smith's is another UTF with extended chains of smaller UTFs – could be interesting.

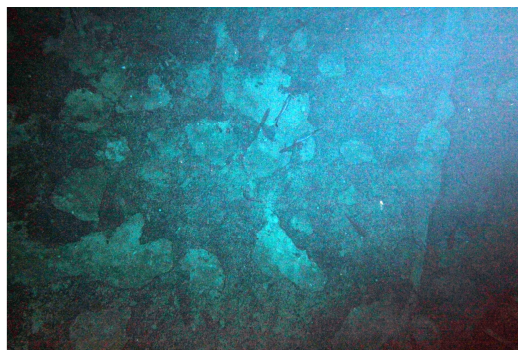
- Between 1991–92 and 2000–01, more than half of the Chatham Rise catch came from four hill complexes: the Andes, Smith's City and neighbours, Graveyard, and Big Chief and neighbours
- Trawl lines uni-directional
- Largest global basketnetwork eel catch (important breeding ground?)
- Coral rubble substrate reported by NIWA (and assumed in historical imagery)



**Figure 6.** Smith's City, may be coral rubble (poor image quality) (2011\_op18\_0391.jpg)



**Figure 7.** Rock substrate, Smith's City (2011\_op18)



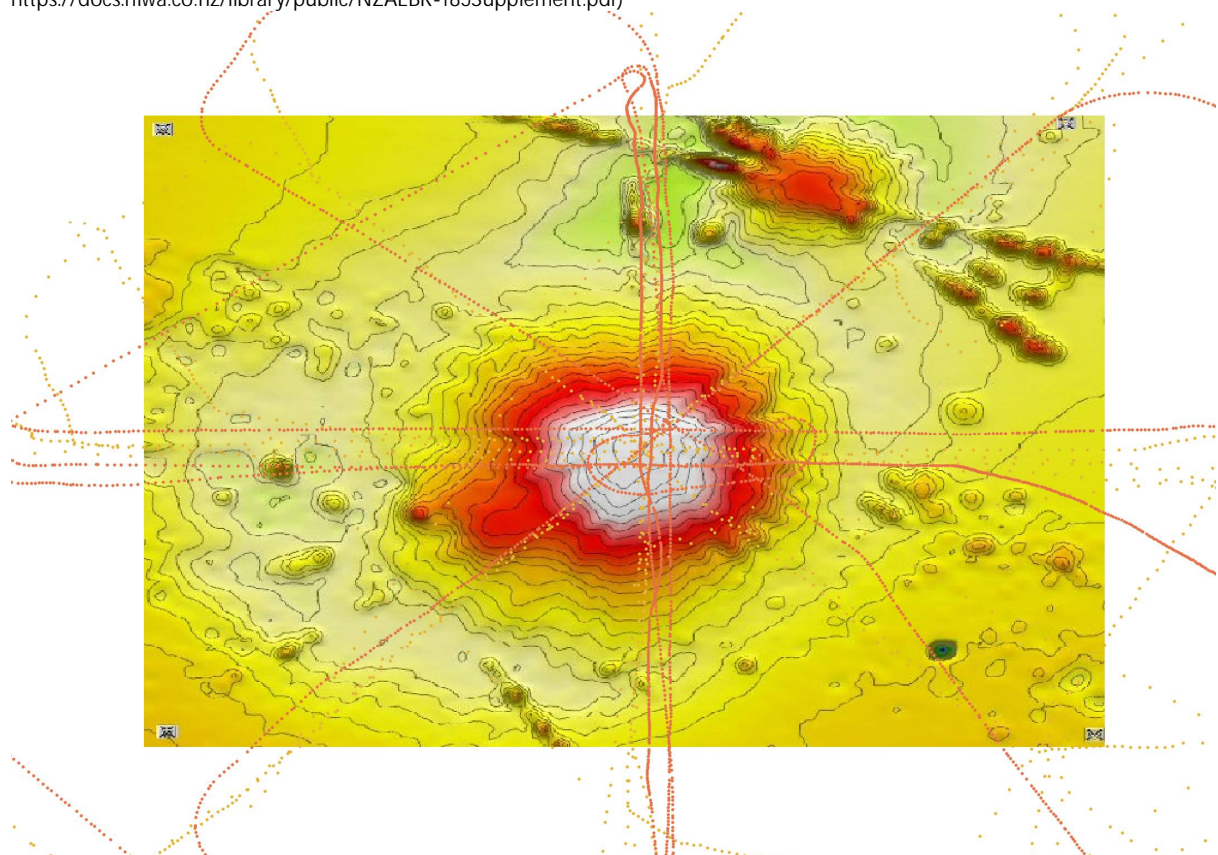
**Figure 8.** Lava plumes, Smith's City (2011\_op23\_0718.jpg)

**Table 2.** Summary and notes from CSIRO historical imagery of Smith's City

Voyage Acronym (year)	Op_number	Notes
2011	18	Sand and rock. Bobbin images. Mix of image quality. Some very bad. Some out of focus but OK. Could be rubble?
2011	23	Sand and Rock. Lots of dark images and images of gear (net). Bad image quality.



**Figure 9.** Figure taken directly from NIWA of Substrates, location and short description (source: <https://docs.niwa.co.nz/library/public/NZAEBR-185Supplement.pdf>)



**Figure 10.** Smith's (City) with CSIRO survey vessel tracks overlaid (green = NZ2016; yellow = NZ2011; orange = NZ2007)



## Cameron's

Mix of sand and basalt plumes at the top of the UTF, with scattered coral rubble (Figure 11, 12, 13). Sand starts to dominate towards base of transect with more rubble. Roughy present throughout transect, and a very large aggregation of cod (*Lepidion* or *Halargyreus* spp.; Figure 14), with many gravid fish on the sand substrate at base of UTF. Some other species also observed (e.g. Figure 15, 16).

- Acoustic survey in 2005 (mentioned in O'Driscoll et al., 2012). Plus roughy surveys
- Literature-poor UTF.

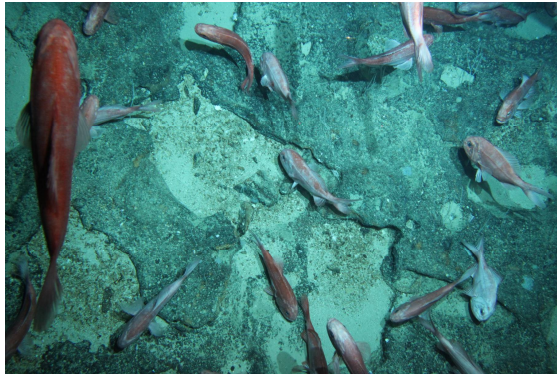


Figure 11. (2011\_Op20\_0661.jpg)



Figure 12. (2011\_Op20\_0445.jpg)

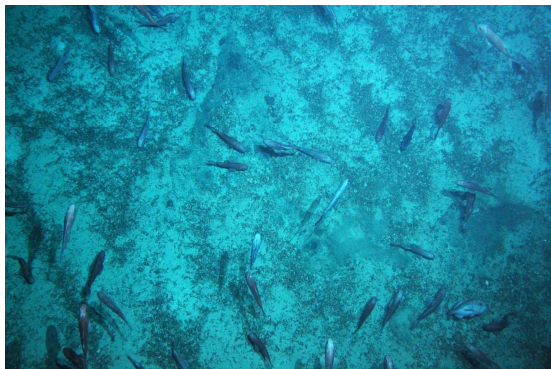


Figure 13. (2011\_Op20\_0384.jpg)

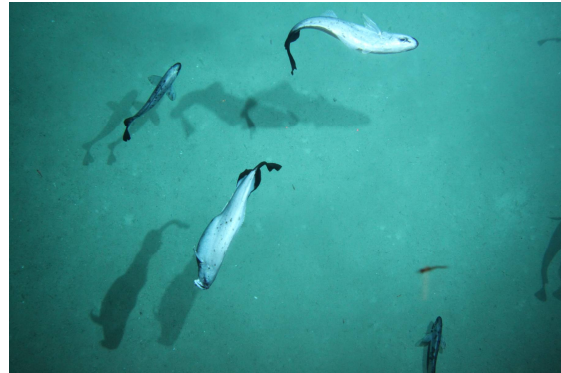


Figure 14. (2011\_Op20\_1138.jpg)



Figure 14. (2011\_Op20\_1259.jpg)

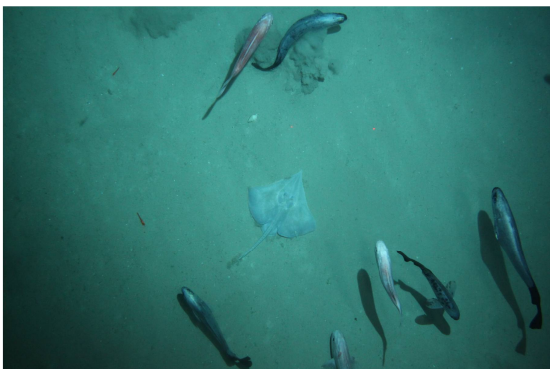
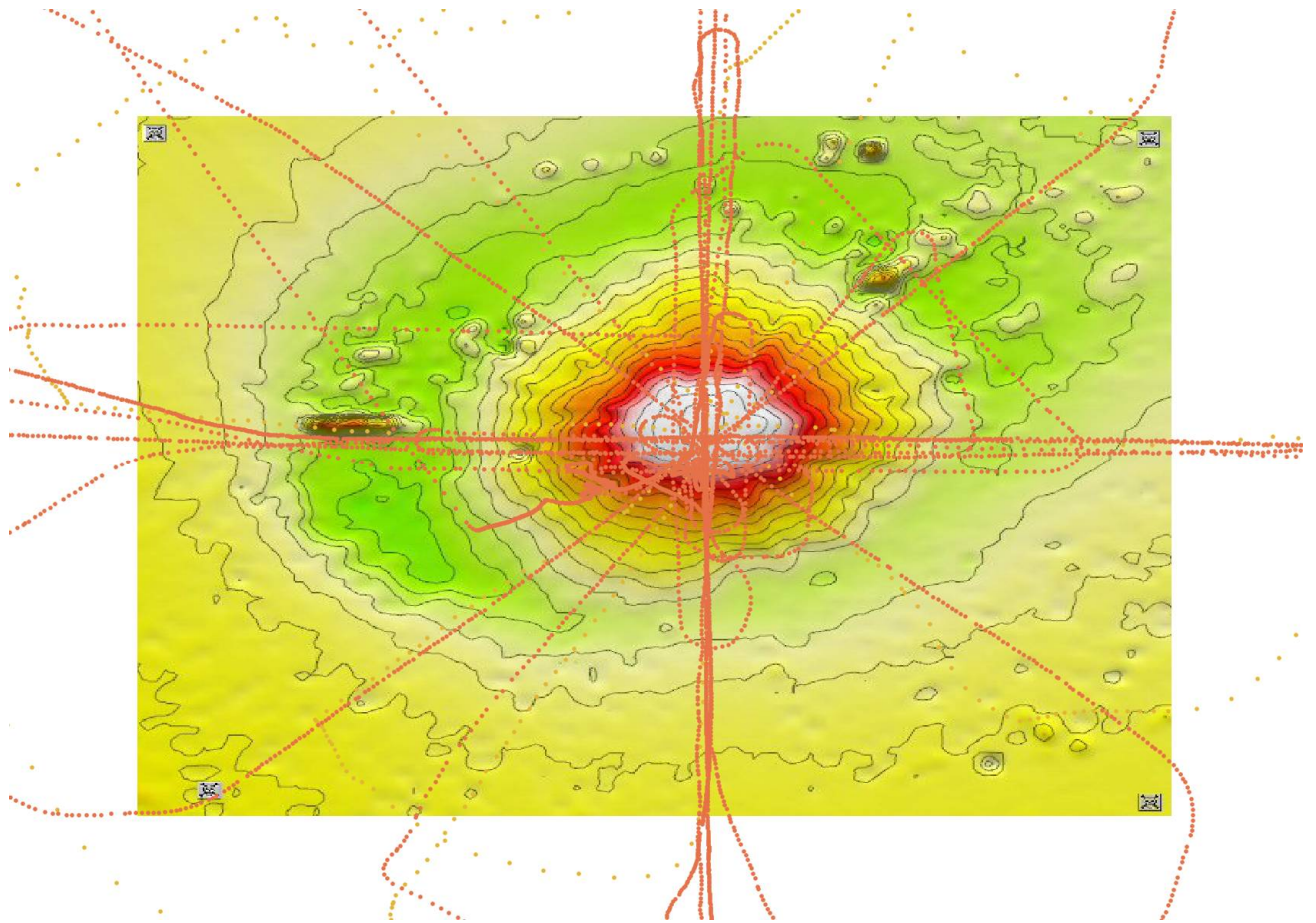


Figure 15. (2011\_Op20\_1331.jpg)

**Table 3.** Summary and notes from CSIRO historical imagery of Cameron's

Voyage Acronym (year)	Op_number	Notes
2011	20	Sand and Rock. Image focus on fish not substrate.





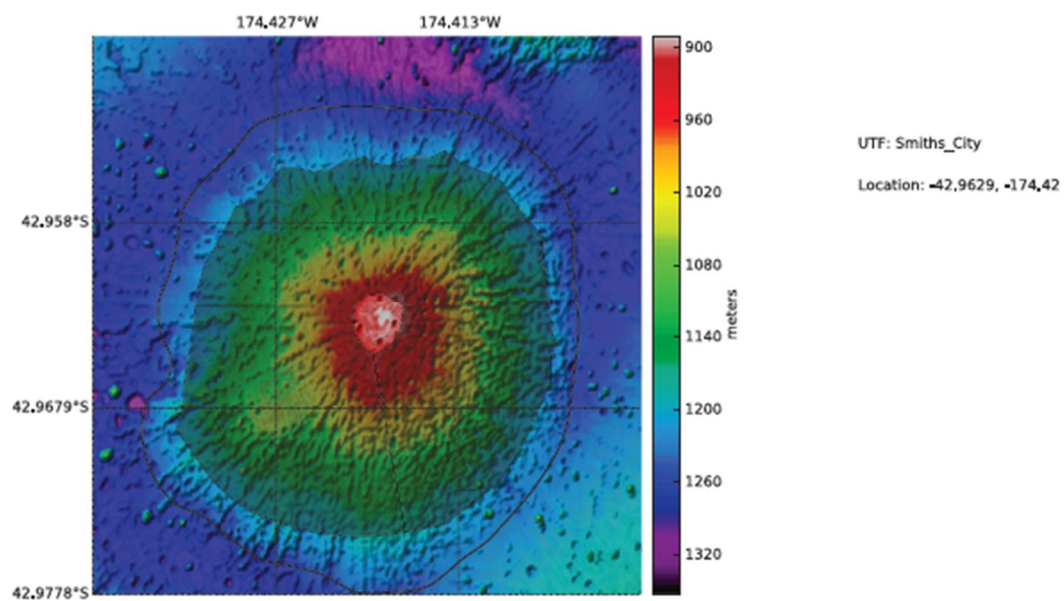
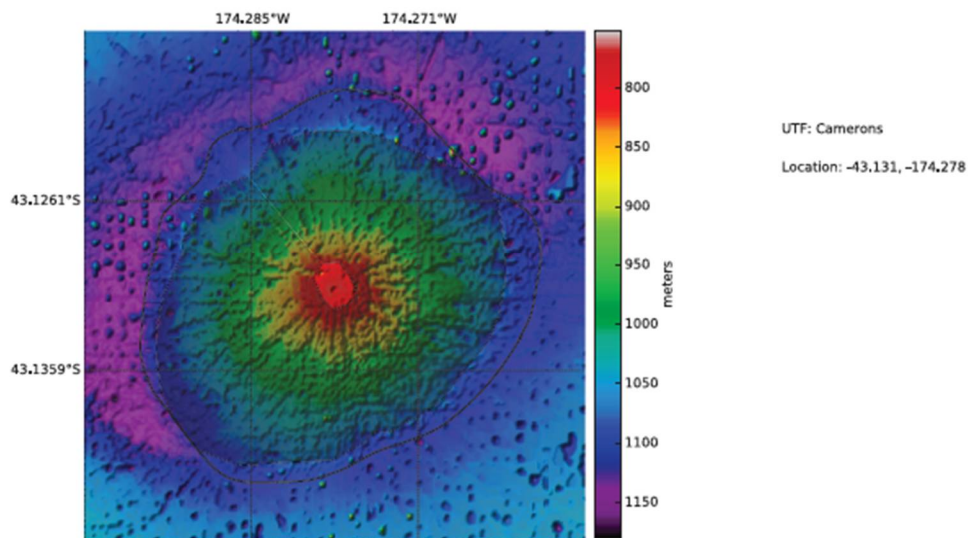
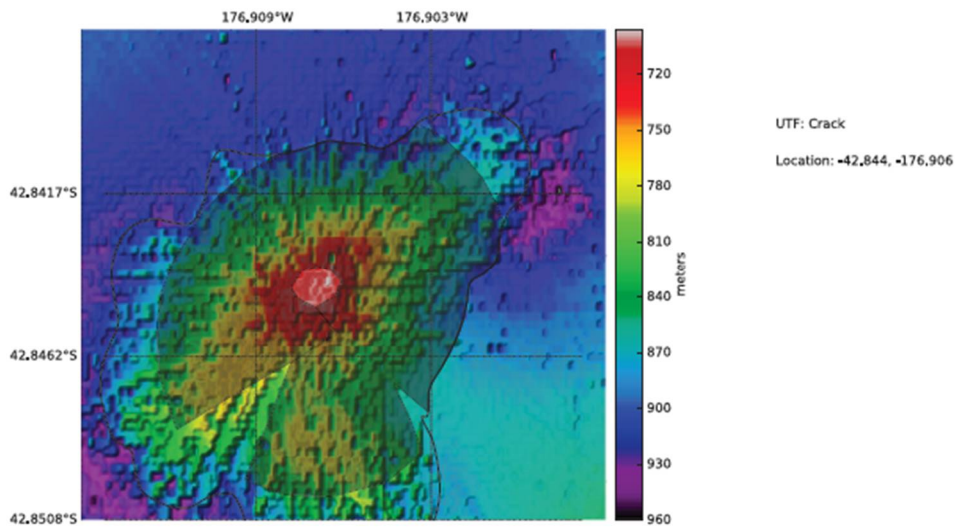
**Figure 16.** Cameron's UTF with CSIRO survey vessel tracks overlaid (green = NZ2016; yellow = NZ2011; orange = NZ2007)

### **Trawl tow lines**

"Some years ago key roughy skippers were interviewed to get their feedback on areas fished on UTFs. Information on the directions of trawl tows down the hills, and a 150 m tow track width based on door-to-door spread, was used to plot the estimated extent of UTF surface areas fished. The attached screenshots illustrate that both Smith's and Cameron's have had trawl tows around pretty much 360°, while for Crack/Mt Muck it is slightly less. Skipper feedback suggested that, for the most part, they avoid landing their nets on the summits of hills"

-Pers. Comms.

Fished areas (shaded) on Mt. Muck (Crack), Cameron's, and Smith's City:



## UTF summary table

LOCATION	Historical imagery observations	UTF surveyed ?	Fishing/ protection status	UTF summit depth (m), elevation (m), and area (km <sup>2</sup> )	Tow direction (%) (O'Driscoll & Clark 2005)*	Notes
Chatham Rise region				~ 1000 km in length		<ul style="list-style-type: none"> <li>Most biologically productive fisheries in the NZ EEZ</li> <li>Intense phytoplankton blooms propagating from West to East</li> <li>Commercial fisheries: scampi, hoki, roughy, oreos</li> </ul>
Mt. Muck	Dense coral rubble, sand and rock, gear marks	Yes SVA at ~ 760m (TRIP2635/172)  **Plus Roughy surveys	Fished - continuous	Summit depth 700m, 200m, Area 1km <sup>2</sup>	Crack (Mt. Muck) N 30; E 39; S 7; W 24	<ul style="list-style-type: none"> <li>Name can also be 'The Crack'</li> <li>"The Crack UTF on the Chatham Rise had the highest catch during the 20 years leading up to 2000, with 48,442 tonnes of orange roughy. It was trawled 3,970 times during this period".</li> <li><i>Solenosmilia variabilis</i> found in 2008 (Tracey et al., 2011)</li> </ul>
Smith's City	Sand and rock. Could be rubble? (bad image quality)	Yes (TAN1701, NIWA)  **Plus Roughy surveys	Fished - continuous	Summit depth 894m, Elevation 306m,	N 33; E 14; S 33; W 21	<ul style="list-style-type: none"> <li>"Heavily trawl-impacted, coral rubble on summit, becoming lava, boulders, and sand on lower flanks" - NIWA</li> </ul>
Cameron's	Sand and rock	Acoustic (O'Driscoll et al., 2012)  **Plus Roughy surveys	Assumed: Fished - continuous	Summit depth 784m, Elevation 276m,		
Morgue	Dense coral rubble. Could be reef? Sand. Brisingiid.	Yes	Trawled then close (2001)	Summit depth 890m  Elevation 310m  Area 3.1 km <sup>2</sup>		<p>SW spur of Morgue is too steep for trawlers (extensive SVA). Benthic communities on Morgue are still like those on its highly and persistently trawled neighbour, Graveyard (R1). The conspicuous SW spur of</p> <p>Morgue is known from official trawl records not to have been fished, whereas the main cone of the</p> <p>seamount was heavily fished up to 2001 (R4)</p>
Graveyard	Impacted reef, coral rubble. Sand and rock, coral rubble, gear marks, cobbles, boulders	Yes	High level of trawling, persistent	Summit depth 748m  Elevation 350m  Area 4.1km <sup>2</sup>		

