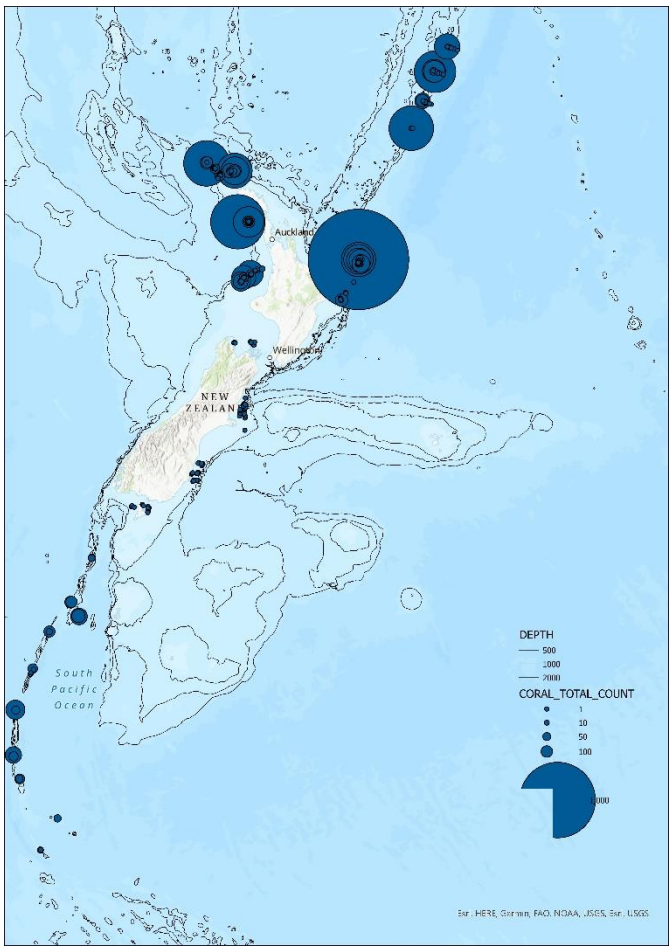
POP2021-02 Identification of protected coral hotspots using species distribution modelling

1 November 2021 – 30 June 2023
Milestone 4. Year 1 Progress Report



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Cover image: Plot of ship-board coral count for selected stations in the New Zealand region.

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Executive summary

Deep-sea corals and sea pens are a structurally and ecologically important component of deep-sea habitats in the New Zealand region and beyond, and many protected coral species occur as bycatch in commercial fisheries. Core Conservation Services Programme (CSP), Department of Conservation (DOC), strategic objectives emphasise the need for data to support evaluation of adverse effects of commercial fishing on protected species, to not only inform their status, but ensure adequate mitigation measures are in place. The objective of this project is to use coral abundance data to identify high conservation value hotspots for protected corals within the New Zealand Exclusive Economic Zone.

This report covers progress to date of a two-year project and presents an initial gap analysis and description of the commencement of data collation and analyses. Using NIWA's Deep-Towed-Image-System (DTIS) shipboard benthic fauna observations database, we interrogated the distribution of DTIS transect stations deployed throughout the region between 2006 and 2020, from NIWA Research Vessels (RV) *Tangaroa* and/or *Kaharoa,* and the level of subsequent detailed faunal analyses conducted. Location data are mapped and tables produced to summarise available data to inform a gap analysis. Selected abundance data will be considered for Species Distribution Models (SDMs) to be produced for a range of protected coral groups and sea pen taxa in year 2 of this project. Sea pens have been added to the analyses opportunistically.

Three surveys, Macquarie Ridge seamounts (TAN0803) and two biogenic habitat surveys (TAN1105 & TAN1108) were selected for detailed DTIS analysis of corals (focussing on protected and non-protected corals and sea pens). The data will provide estimates of abundance compatible with existing datasets, habitat associations, and spatial coverage, to feed into SDM development in Year 2 of the project, and will support other related DOC-funded projects, and support CSP, DOC management priorities.

To date, the analysis of TAN0803 survey has been completed, recording nearly 14,500 taxon data points. The selection of 2011 biogenic habitat survey transects (circumnavigating the New Zealand continental shelf) for analysis within the remit of this project has been completed and detailed analyses of seafloor videos has commenced, to meet project timelines. The analysis of video data from the remaining stations will continue into Year-2 of the project.

Species distribution model development and refinement commencing in Year-2 will incorporate the new data being produced from analyses of videos data from these selected voyages, as well as existing data from a range of other voyages. These models will include both abundance and absence data for a selection of coral taxa to be finalised with project managers and will allow the estimation of abundance distribution, key for managing population status and the level of impacts. Results from this research could support work in identifying high value areas within the region, and/or species that have a greater need for protection.

1 Background

Corals (Phylum Cnidaria) constitute a prominent component of species bycatch in commercial fisheries in New Zealand, and despite most of this group (the hard corals) being afforded legal protection under the Wildlife Act, there is minimal understanding of how fishing can impact their abundance and diversity across the spatial and depth extent of their distribution. This project will use selected deep-sea coral abundance data collected during various biodiversity voyages (for funding agencies please refer to Acknowledgement section). The aim is to identify high conservation value hotspots across the New Zealand region. These data will be used in a novel quantitative modelling approach that builds upon available regional-scale species distribution models (SDM, Anderson et al. 2020) to improve our knowledge of coral abundance and distribution (rather than previous presence-absence based models), and our knowledge of how current and historical commercial fishing effort shapes those patterns. As the first component of the project includes collation and analysis of new seabed imagery data to inform the model, the project will also serve to audit data available for future image-based coral research. As an additional component to this audit, the octocoral sea pens (Order Pennatulacea), are included here as additional opportunistic data as they are a cnidarian group that is considered a vulnerable marine ecosystem (VME) taxon (FAO 2009), biogenic habitat formers (Anderson et al. 2018) and sea pen fields (see distribution models by Stephenson et al 2021a) are considered a Sensitive Environment under Schedule 6 of the Exclusive Economic Zone and Continental Shelf Regulations (2013). Model outputs can inform future model development, risk assessments, and management strategies that consider ecological processes, coral biology, and the current and historical impact of fishing on ecosystem services provided by deep-sea corals and other taxa.

The objectives are:

1. To collate and analyse cold water coral records from existing seabed towed camera transects in the New Zealand region, with a particular focus on areas known to overlap with fishing effort.
2. To identify hotspots for selected protected coral species in the New Zealand region using predictions from abundance-based species distribution models.
3. To better understand the historical effects of fishing on observed patterns of coral distribution and relative abundances.

Milestone 4 of the contract requires provision of a progress report detailing preliminary results, progress and next steps, along with a presentation to the DOC CSP Technical Working Group to agree on the next steps in the project. This report has been prepared to satisfy the first part of this milestone.

2 Objective 1

To collate and analyse cold water coral records from existing seabed towed camera transects in the New Zealand region, with a particular focus on areas known to overlap with fishing effort.

2.1 Compilation of existing analysed camera survey data

Deep Towed Imaging System (DTIS) and Ocean Floor Observation protocol (OFOP)

Seabed photographic and video transects were carried out using NIWA's Deep Towed Imaging System (DTIS) to record data on the type of seabed substrate and on the presence, number (count), and identification of benthic invertebrates, algae, and demersal and benthic fish species. Transect lengths during surveys that deploy DTIS usually range from around 15–90 minutes duration at a target speed of between 0.25 and 0.5 metres / second (m/s). The target altitude of the camera is 2–3 metres (m) above the seabed, and both video and still camera frames include two equidistant laser points (20 cm apart) as a reference, thus allowing for size and area estimates (Hill 2009). During deployments, the real-time, low resolution, video feed was monitored by biologists and all conspicuous organisms and changes in substratum type were recorded as spatially referenced observations using the software Ocean Floor Observation Protocol (OFOP, www.emma-technologies.com/products/software/ofop/). This program automatically logs the time, spatial co-ordinates, depth, and a range of other parameters associated with each observation, every still photograph taken during the transect, and the start and end point of the video transect.

The seafloor observations logged into the OFOP software at-sea and in real time (referred to as ship-board), are conducted at a coarse taxonomic level and are not typically suitable for quantitative analyses but are a useful indicator of a presence of generic taxa such as for the protected corals: gorgonian octocorals, black corals, scleractinian stony corals, or stylasterid hydrocorals.

Video and still images are analysed in detail post-voyage using the high-definition recordings collected by OFOP and include in-detail counts and an improved taxonomic identification – carried out to the best possible level in collaboration with NIWA and International taxonomic experts (referred to as re-run). Detailed methodology is described in Bowden & Hewitt (2012) and Jones et al. (2018).

2.2 Coverage of surveys in the New Zealand region – gap analysis

The DTIS image database, covering all DTIS transects between 2006–2020, indicates that 16 biodiversity surveys have been completed or are near completion of detailed analyses (NIWA unpub. data). A further 13 surveys so far remain incomplete with regards to detailed analyses of the video transects (Table 1, Figure 1).

The data coverage and observations will be considered for inclusion into SDM development (Objectives 2 and 3) in Year-2 of this project.

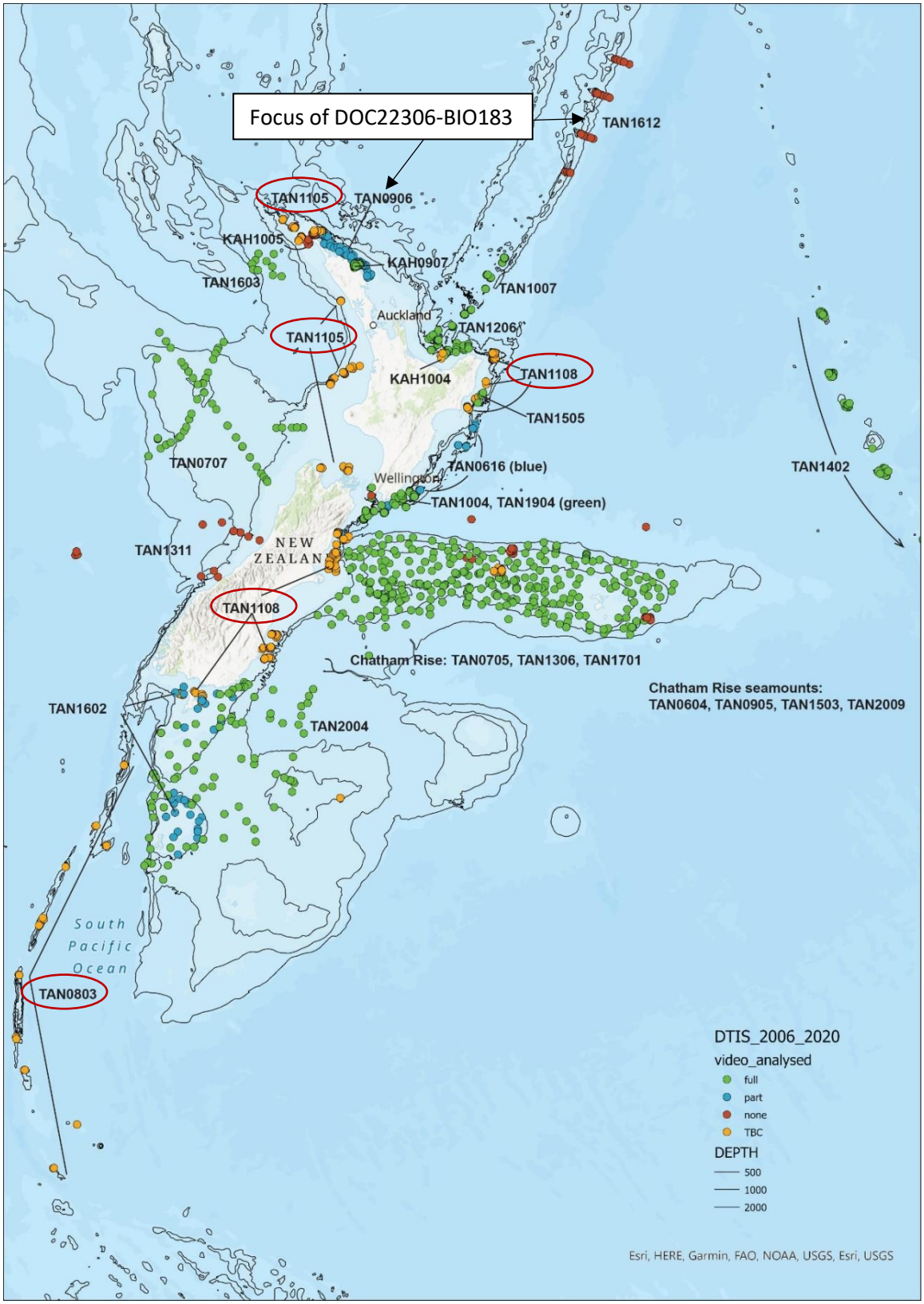

Figure 1: Location of the Deep towed imaging system (DTIS) transects carried out between 2006–2020 and level of analysis (full, part, none, TBC) as shown in the image Key. The focus survey of the separately funded DOC Project in the northern New Zealand region: DOC22306-BIO183 project are highlighted. The three proposed target survey areas for this study (TAN0803, TAN1105 and TAN1108) are circled in red. Location data and the level of analysis of the data also informed the gap analysis.

Table 1: Summary of Deep-Towed-Image-System (DTIS) biodiversity survey voyages (2006–2020) to Inform the gap analysis, with video analyses completed (left column). TAN = RV Tangaroa; KAH = RV Kaharoa.

DTIS video analyses completed:		DTIS video analyses incomplete:	
TAN0705	Chatham Rise 2007	TAN0604	Graveyard seamounts 2006
TAN0707	Challenger Plateau 2007	TAN0616	Hikurangi Margin seeps and Kaikoura Canyon 2006
KAH0907	Bay of Islands 2009	TAN0905	Graveyard and Andes seamounts 2009
TAN0906	***Northland Plateau 2009 (near completion, DOC22306-BIO183)***	KAH1004	Bay of Plenty 2010
TAN1004	Cook Strait and Hikurangi 2010	KAH1005	Spirits Bay 2010
TAN1007	Southern Kermadec Ridge 2010	TAN1105	Cape Reinga, E coast N Island, N coast S Island 2011
TAN1104	Southern Kermadec Ridge 2011	TAN1108	E coast from Stewart Is. to East Cape 2011
TAN1206	Bay of Plenty 2012	TAN1311	W coast S. Island 2013
TAN1306	Chatham Rise 2013	TAN1503	Graveyard and Andes seamounts 2015
TAN1402	Louisville seamounts 2014	TAN1602	Stewart Island and Auckland Island shelves 2016
TAN1505	East Cape 2015	TAN1708	Kaikoura Canyon 2017
TAN1603	Project West, Northland 2016	TAN2005	Chatham Rise 2020
TAN1612	***Kermadec Islands 2016 (to be completed under DOC22306-BIO183)***	TAN2009	Graveyard and Andes seamounts 2020
TAN1701	Chatham Rise 2017		
TAN1904	Cook Strait and Hikurangi 2019		
TAN2004	Challenger Plateau 2020		

2.3 Selection of surveys for further analysis

Considering the gap analysis above, the following surveys are identified as targets for detailed video analysis under the current project (Fig. 1). These voyages provide both the best spatial and bathymetric coverage in the region to supplement the current regional extent for the SDM, Chatham Rise and Challenger Plateau, and from initial ship-board identifications, indicate the presence of localised coral communities.

1. **TAN0803** (Macquarie Ridge 2008): Southern New Zealand diverse coral assemblages west and south of SDM focus area (see Rowden (2008) voyage report).
2. **TAN1105** (Biogenic Habitats I 2011): shallow (19–480 m), New Zealand North Island, localised high abundances of corals (see Morrison & Jones (2011) voyage report).
3. **TAN1108** (Biogenic Habitats II 2011): shallow (20–327 m), East coast North Island and South Island, localised high abundances of corals (see Morrison & Jones (2011) voyage report).

Once combined, these voyages include 214 DTIS transects. We note that a complete analysis of all these station data would exceed the resources available under the current project and a further selection was required.

2.4 Shipboard observations of select coral

The observations logged in real-time into OFOP on the RV *Tangaroa* were queried using entries in the OFOP 'Master list of benthic observations' to identify expected abundances of corals per stations. See Appendix 1 for full list of taxa included in query.

Table 2 lists those taxa of the complete list that were assigned across the three surveys, with a total of 9,395 observations of corals and sea pens. Figure 2 illustrates the spatial distribution of these coral and sea pen counts across the surveys and within the region.

Note that species designations (e.g., for the stony branching coral species *Solenosmillia variabilis* or *Goniocorella dumosa*) are usually assigned to a broader category, e.g., "Scleractinia", during the live recording with the species confirmed in the re-run analyses and often verified in collaboration with experts.

Table 2: Taxonomic categories selected for protected and non-protected coral groups and sea pens from Ocean Floor Observation protocol (OFOP) Master list of benthic observations during live recording.
* Order Gorgonacea is now not in use and "gorgonian octocorals" are now considered an informal subgroup of the Order Alcyonacea.

OFOP coral taxon	Total count
Coral (intact) (substrate classification)	197
Alcyonacea (soft corals and gorgonian octocorals)	127
Pennatulacea (sea pens)	2 113
Gorgonacea (gorgonian octocorals) *	4 650
Scleractinia (branching stony coral)	91
Antipatharia (black corals)	1 766
Stylasteridae (hydrocorals)	435
Primnoidae (gorgonian octocorals)	16
TOTAL	9 395

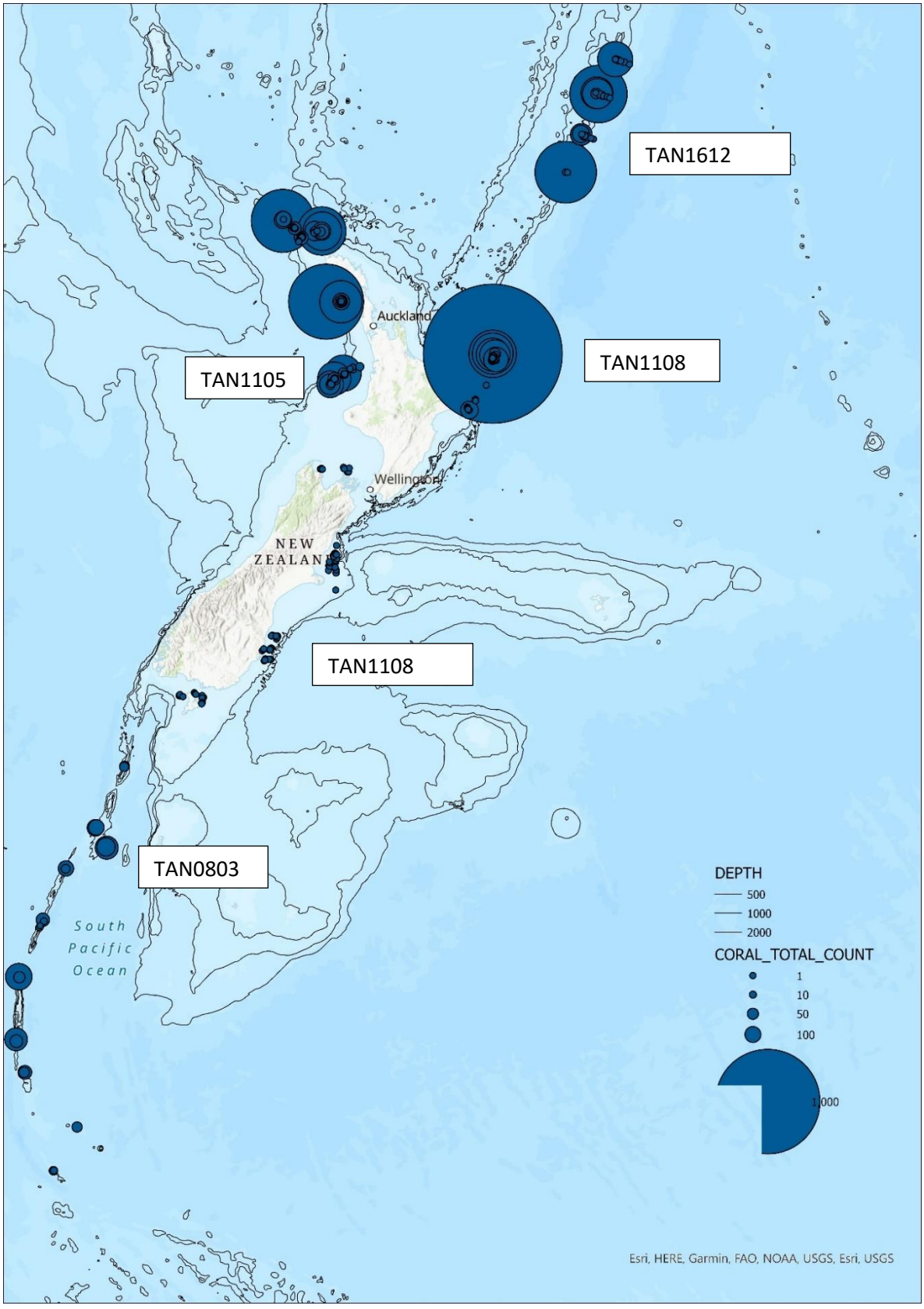

Figure 2: Total coral count per station based on shipboard observation logs into the Ocean Floor Observation Protocol OFOP. General survey labels are included for TAN0803 (Macquarie Ridge), TAN1105 (North Island) and TAN1108 (South Island and eastern North Island). Note: the Kermadec survey TAN1612 is included in this image as it will be covered under Project DOC22306-BIO183.

2.5 Progress up to June 2022 on detailed DTIS analyses of select transects

2.5.1 Macquarie Ridge TAN0803

To date, the Macquarie Ridge survey TAN0803 has been completed with all 21 DTIS video transects collected from this region analysed in detail. The utility of the analysis of the high-resolution video recording is highlighted by the differences of coral and sea pen counts between the ship-board observations and the detailed analyses of the re-runs (Table 3). The high-resolution footage used in the re-run analyses allows for the counting of smaller organisms such as hydrocorals (Stylasteridae) or solitary stony cup corals (Caryophyllidae), which account for the majority of the differences (see Figure 3 for an example of small pink hydrocorals among the coarse sediment along DTIS transect line station TAN0803/66). As a consequence, it is now apparent that DTIS station logs with no record of a coral group should not be considered as true absence locations for subsequent SDM analyses (as we had initially considered) without further assessment of the stills and/or video feed.

Table 3: Macquarie Ridge seamount biodiversity survey (TAN0803) DTIS transect station numbers, along with the total shipboard counts of corals and sea pens during live recording (middle column) and post voyage re-run counts from detailed analysis of abundances (right column).

Station	Coral and sea pen count – shipboard	Coral and sea pen count – rerun
TAN0803_018	38	229
TAN0803_020	32	946
TAN0803_032	105	537
TAN0803_034	95	373
TAN0803_042	123	772
TAN0803_043	171	1021
TAN0803_049	94	1373
TAN0803_051	28	560
TAN0803_064	0	183
TAN0803_066	1	325
TAN0803_068	7	379
TAN0803_070	73	381
TAN0803_078	207	3089
TAN0803_083	53	702
TAN0803_090	170	1891
TAN0803_092	67	483
TAN0803_099	77	260
TAN0803_101	45	246
TAN0803_113	24	193
TAN0803_115	7	79
TAN0803_126	41	460
TOTAL	**1,458**	**14,482**

Figure 3: Macquarie Ridge survey station TAN0803/66 (still image 27) showing coarse sediment substrate with an invertebrate community including small and large anemones, numerous brittle stars, sponges and small pink hydrocorals, a few examples of which are circled in white (scale = 20 cm).

2.5.2 Biogenic Habitat surveys TAN1105 & TAN1108

Several projects funded by DOC complement the research being carried out by this current project (POP2021-02). Data analyses are being shared across these projects.

Two surveys of 'Biogenic Habitats' in Northern New Zealand continental shelf carried out in 2011 (TAN1105 and TAN1108) conducted 193 DTIS transects between depths of 19 – 480 m (Morrison & Jones, 2011). Descriptions of the findings of these surveys can be found in Morrison et al. (2014) and Jones et al. (2018)).

A selection of the DTIS video transects (<300 m depth) from TAN1105 and TAN1108 are to be analysed in detail for two 'deep reefs' DOC funded projects led by Mark Morrison (NIWA) and Mathilde Richer de Forges (DOC) (DOC21101 and DOC22101). Some results from the deep reefs research will inform later stages of this current project (POP2021-02). Additionally, a further ~30 detailed DTIS video transect station analyses, the deepest (300–480 m, n=6), are currently being processed.

A further selection of DTIS transect stations for analysis is to be conducted by the various project managers in July 2022. Notably, this will include transects that had no corals observed during live ship-board recording, primarily around the South Island (Marlborough Sounds, North Canterbury, Otago and Stewart Island, see Fig. 4). This will again help confirm as to whether the live ship-board observations reflect true absence data.

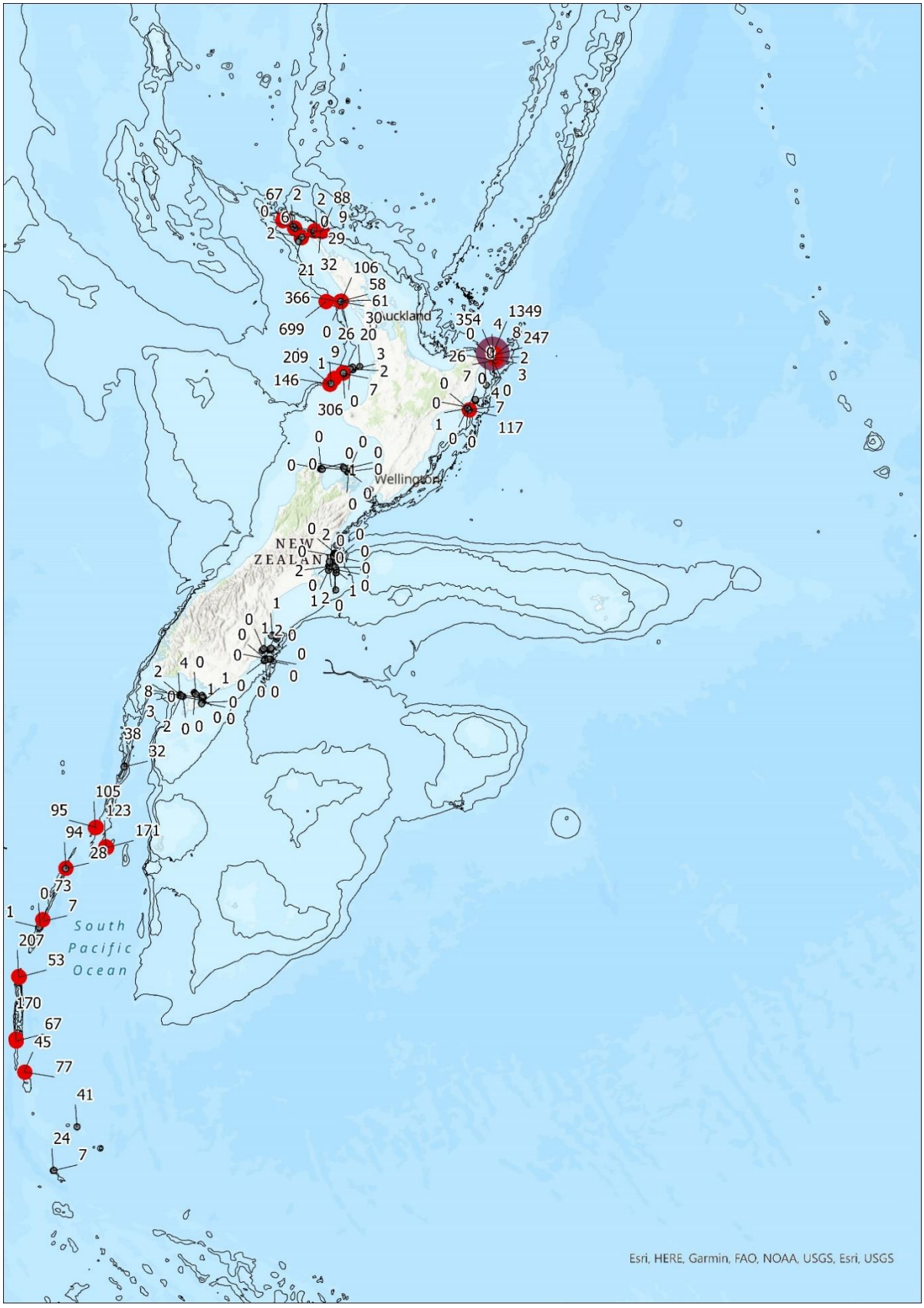

Figure 4: Location of the Deep towed imaging system (DTIS) transect stations (round points), with linked coral counts per station; stations with coral counts greater than 50 are represented by red dots; station TAN1108/251 on Ranfurly Bank, off East Cape (see Figure 2), has the highest coral count (1349).

2.5.3 Campbell Plateau survey (TAN2004)

Taxon count data from video re-runs completed under an earlier contract with FNZ (see Stephenson et al. 2021b) were mapped to the set of protected coral taxa proposed for final abundance modelling. Presences were observed for 14 of the 18 taxa initially being considered for modelling (see Appendix B for the full list), with three taxa (Flabellum, Alcyonacea,) found to be present in over 20 of the 86 stations (Table 4). Stylasterids and gorgonaceans (primnoids in particular) were the most abundant taxa observed on this survey, with about 6000 observations in total for these groups. Only a few antipatharians were observed, however, with low numbers also for some of the corals identified to genus level (Table 4).

Table 4: Campbell Plateau seafloor camera survey (TAN2004). Total counts and number of surveys stations (out of a total of 86) at which each protected coral group was present.

Taxon	Presences	Counts
Antipatharia	5	11
Caryophylliidae	2	23
Stephanocyathus	1	6
Flabellum	22	397
Goniocorella_dumosa	2	55
Alcyonacea	25	501
Taiaroa_tauhou	9	141
Gorgonacea	17	1879
Isididae	11	396
Paragorgiidae	2	2
Primnoidae	10	1415
Pennatulacea	24	384
Kophobelemnon	8	14
Stylasteridae	12	2694

3 Objectives 2 & 3 and next steps

3.1 Objective 2. To identify hotspots for selected protected coral species in the New Zealand region using predictions from abundance-based species distribution models.

This objective will be met in Year 2 of the project. Data inputs for abundance models will be compiled and finalised and model parametrisation, including assembly of predictor variables, will commence. A key predictor variable of interest is one that will be derived from recent EEZ fisheries trawl footprint and high seas South Pacific Regional Fisheries Management Organisation (SPRFMO) bottom trawl analyses under a current FNZ projects. The assembly of year and location-specific fishing effort data will for the first time allow the impact of historical fishing effort on species abundance to be included in SDM models. For this to work adequately, fishing effort at the location of true absences is required – something that is not possible with models based on species captures where pseudo-absences are typically used.

The predicted distributions of each taxon will be analysed separately (to assess taxon-by-taxon abundance estimates), and then combined to highlight the location of hotspots for protected corals as a whole in the New Zealand region, and will be considered in light of current fishing and spatial management efforts.

3.2 Objective 3. To better understand the historical effects of fishing on observed patterns of coral distribution and relative abundances.

Depending on the level of influence that fishing effort has in the models, the effort data may be used to estimate pre-fishing (pre-1990) distributions of protected corals by fitting a model with zero fishing effort, thus providing a spatial representation of the historical effects of fishing on the abundance of these species.

These final two objectives are due to be conducted between September 2022 and March 2023 (Milestones 6. Modelling)

4 Acknowledgements

Our thanks to CSP, DOC staff, principally Lyndsey Holland and Shannon Weaver (ex- CSP) for supporting this project. Thanks to Di Tracey, Malcolm Clark, and Ashley Rowden (NIWA) for support with the development of the project proposal, and Emma Jones and Mark Morrison (also of NIWA), for correspondence relating to the 2011 biogenic habitat surveys. We acknowledge the numerous taxonomic experts who have helped identify the coral fauna captured by DTIS – both at-sea and during the rerun analyses. Finally, for a timely internal review of a draft of this Progress Report we thank Di Tracey.

We acknowledge the following contributing agencies for the research voyages that conducted the DTIS surveys:

1. the interdisciplinary New Zealand-Australian "MacRidge 2" research voyage (TAN0803), the biological component of which was part of NIWA's research project "Seamounts: their importance to fisheries and marine ecosystems" funded by the New Zealand Foundation for Research, Science and Technology, and CSIRO's Division of Marine and Atmospheric Research project "Biodiversity Voyages of Discovery" funded by the CSIRO Wealth from Oceans Flagship.

2. The 'Biogenic Habitats on the Continental Shelf' project (voyages TAN1105 & TAN1108), funded by New Zealand Ministry for Primary Industry (Fisheries) (Biogenic Habitats: ZBD200801), New Zealand Foundation for Research, Science and Technology (CCM: CO1X0907), NIWA Capability Fund (CF111358) and Oceans Survey 20/20 R/V Tangaroa days funded by Land Information New Zealand.

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Appendix A Complete list of coral and sea pen taxa used in 'Master list of benthic observations'

Table A-1: Complete list of coral and sea pen taxa used in 'Master list of benthic observations'.

Taxon	Description
Coral (intact)	Substrate category, significant live hard coral
Alcyonacea	Generic gorgonian and soft coral
Antipatharia	Generic black coral
Gorgonacea	Generic gorgonian octocoral
Pennatulacea	Generic sea pen
Scleractinia	Generic hard stony coral
Stylasteridae	Generic hydrocoral
Alcyoniidae	Soft corals
Chrysogorgiidae	Gold corals
Coralliidae	gorgonian octocorals
Isididae	Bamboo coral
Paragorgiidae	Bubblegum corals
Primnoidae	Primnoid gorgonian corals
Solenosmillia variabilis	Specific hard stony coral, species
Madrepora spp	Specific hard coral, genus
Enallopsammia spp	Specific hard coral, genus
cup corals (*Stephanocyathus* spp)	solitary bowl coral (soft sediments)
Desmophyllum/*Caryophyllia* spp	Specific cup coral (hard substrate)
Goniocorella dumosa	Specific hard stony coral, species
Corallium sp	Gorgonian precious coral genus
Callogorgia spp	Gorgonian primnoid coral genus
Thouarella spp	Bottle brush primnoid gorgonian coral, genus
Paragorgia spp	Bubble gum coral, genus
Metallogorgia melanotrichos	Specific gold coral, species
Radicipes spp	Whip-like gorgonian coral, genus
Errina spp	Specific stylasterid hydrocoral, genus
Bathypathes spp	Black coral genus
Dendrobathypathes spp	Black coral genus
Antipathes spp	Black coral genus

Appendix B Initial proposed set of taxa for abundance modelling (from Chatham Rise/Campbell Plateau DTIS survey-based models (Stephenson et al 2021b)).

Table B-1: Initial proposed set of taxa for abundance modelling (from Chatham Rise/Campbell Plateau DTIS survey-based models (Stephenson et al 2021b)).

Antipatharia	*Taiaroa tauhou*
Caryophylliidae	Gorgonacea
Stephanocyathus sp.	Isididae
Enallopsammia sp.	Paragorgiidae
Flabellum sp.	Primnoidae
Goniocorella dumosa	*Radicipes* sp.
Madrepora sp.	Pennatulacea
Solenosmillia variabilis	*Kophobelemnon* sp.
Alcyonacea	Stylasteridae