Distribution of protected corals in relation to fishing effort and assessment of accuracy of observer identification

Prepared for
Marine Conservation Services (MCS) Department of Conservation | Te Papa Atawhai

June 2011

Authors/Contributors:

Di Tracey
Susan Jane Baird
Brian Sanders
Murray H. Smith

For any information regarding this report please contact:

Di Tracey
Scientist
Deepwater Fisheries
+64-4-386 0866
d.tracey@niwa.co.nz

National Institute of Water & Atmospheric Research Ltd
301 Evans Bay Parade, Greta Point
Wellington 6021
Private Bag 14901, Kilbirnie
Wellington 6241
New Zealand

Phone +64-4-386 0300
Fax +64-4-386 0574

NIWA Client Report No:	WLG2011-33
Report date:	30 June 2011
NIWA Project:	MCSINT201003 / DOC11302

Contents

Reviewed by

Approved for release by

Ashley Rowden

Barbara Hayden

Executive summary

Deepsea corals in the New Zealand region are abundant and diverse and, because of their vulnerability, are at risk from effects of anthropogenic activities such as bottom trawling where their distributions overlap. Protected coral species in the orders Antipatharia, Gorgonacea, Scleractinia, and family Stylasteridae are known to be caught incidentally during commercial fisheries in New Zealand, particularly by deepwater trawls targeting orange roughy (*Hoplostethus atlanticus*) or oreo species (Family Oreosomatidae). To understand the risk to protected corals, and ensure commercial fishing impacts on protected corals are minimised, it is important to quantify the spatial extent of these impacts.

Observed data from commercial trawlers were used to identify the fisheries and areas fished where there have been incidental catches of coral in trawl nets. Three years of observed trawl data (2007–08 to 2009–10) indicated that about 10% of the 21 259 observed tows had catch records of corals. The corals reported and verified were combined into nine groups. The most frequently recorded were black corals (Antipatharia), stony branching corals and stony cup corals (Scleractinia), bamboo corals and bubblegum corals (Gorgonacea). Least recorded were precious corals (Gorgonacea) and hydrocorals (Stylasteridae).

Most coral records were from fishing effort in 800–1200 m depths, with over 80% from tows that targeted orange roughy, black oreo (*Allocyttus niger*), smooth oreo (*Pseudocyttus maculatus*), and black cardinalfish (*Epigonus telescopus*). Overall, 19% of observed deepwater tows for these target species had coral catch records. Outside the New Zealand 200 n. mile Exclusive Economic Zone, protected corals were recorded from almost 50% of the observed effort. Within New Zealand waters, most corals were reported from eastern waters, generally south of 42°S. Specific fishing grounds for orange roughy and oreo species could be identified from the location of the observed coral catches. In shallower middle depths areas the target species with coral catches included hoki (*Macruronus novaezelandiae*) and scampi (*Metanephrops challengeri*) on the Chatham Rise, west of 180°.

The corals were widespread in their geographic distribution though there were some between-group regional distribution differences. Large catches (estimated at 15 t and 10.6 t) were reported from smooth oreo tows in depths of about 1400 m east of Pukaki Rise and from orange roughy tows on seamount features on the Chatham Rise.

Samples returned for verification of identification provided an opportunity to map the coral distribution to a finer taxonomic level. A total of 852 samples were returned from 501 observed tows and 733 of these samples were identified as protected corals. These data were used to assess the accuracy of the identifications made by observers. Of the 545 verified records that could be compared, analyses showed that 293 (54%) were incorrectly identified by the observers. The percentage error was particularly high (about 90%) for the stony branching corals, which are difficult to distinguish. Although identification to the lowest possible taxonomic level was poor, accuracy was much improved at the higher taxonomic identification level with only certain gorgonian corals seen as problematic.

The coral distribution data for the region could be expanded by combining the observed data from this project with historical observer data and records from research trawl and biodiversity surveys. While a higher grouping of coral codes provides an understanding of the protected coral groups, the value of identifying the corals to the lowest taxonomic level is paramount to understanding impacts on the regions biodiversity.

1 Introduction

1.1 Background

Government observers on commercial fishing vessels have instructions and procedures for retaining benthic invertebrates caught during fishing activities. Standardised methods are followed to assess each trawl tow or longline set for the presence of invertebrates, including corals (Class Anthozoa, Phylum Cnidaria). Observers record presence and weight data on the Benthic Materials Form (previously these data were recorded on the Catch Form).

Since 2007, as part of the requirements of the Department of Conservation (DOC) Marine Conservation Services (MCS) Conservation Services Programme (CSP), observers have recorded and collected samples of any coral taxa that (1) are protected, (2) that strongly resemble protected coral fauna, or (3) that have been proposed for protection. This instruction was to ensure legal obligations of the Wildlife Act (1953) could be met. Observers photograph coral specimens at sea and all samples, or a sub-sample of the colony, are returned to NIWA (frozen) for identification and curation. Corals are identified to the lowest possible taxonomic level and resulting data are entered into the Ministry of Fisheries (MFish) Centralised Observer Database (*cod*) that is maintained by NIWA. This activity has been carried out under previous CSP Projects (INT200703/DOC08309, INT200802/DOC09305, INT200903/DOC10304; Tracey 2008; 2009; 2010a and 2010b; Tracey & Sanders, 2010, 2011). The focus of the 2007–2010 projects was on fishing vessels targeting the deepwater fisheries for orange roughy (*Hoplostethus atlanticus*), black oreo (*Allocyttus niger*), smooth oreo (*Pseudocyttus maculatus*), and black cardinalfish *(Epigonus telescopus*)*.* Any coral samples retained from these projects are held under stewardship at NIWA and species identification information is also loaded into the NIWA Invertebrate Collection (NIC) *Specify* database.

At the commencement of the CSP 'Identification of Protected Corals' 2007-08 project, the protected coral species listed in the Wildlife Act (1953) included all black corals (Order Antipatharia) and the red hydrocoral *Errina* spp. (which belongs to the Family Stylasteridae) During 2010, an amendment of Schedule 7A of the Wildlife Act (1953) widened the range of corals afforded protection to include "all deepwater hard corals (all species in the Orders Antipatharia, Gorgonacea, Scleractinia, and Family Stylasteridae)". [Nomenclature follows the taxonomic scheme of Cairns et al. (2009).]

The protected deepwater corals are highly variable in size, shape, and form (Tracey et al. 2007) as shown by some examples of the groups in Figure 1. They can be large branching structures, pinnate (feather-like), bushy, fan shaped, or whip-like. Black coral colonies (Figure 1A) can grow up to 3m, but their chitin stem and branches means the large colonies are light in weight relative to other species. In contrast the arborescent or tree-like gorgonian corals can form large (up to 5 m) colonies that have a definite stem characterised by a solid axis that in cross section is shown to be composed of concentric layers of calcium carbonate and gorgonin. Thus, some gorgonian corals such as the bubblegum (*Paragorgia* spp.) (Figure 1B), bamboo (e.g., *Keratoisis* spp.), and seafan corals (e.g., *Primnoa* spp. and *Narella* spp., Figure 1C) can be heavy and dense. The primnoid bottlebrush corals *Thouarella* spp. have feathery-like, small (up to 50 cm), branched colonies (Figure 1D).

Scleractinian corals produce large 3-dimensional matrix colonies that can form ‘reef’, ‘mound’, or ‘thicket’ structures (Figure 1C and E) and often provide biogenic habitat on slope margins, ridges, and seamounts (Rogers et al. 2007, Reveillaud et al. 2008, Roberts et al. 2008). In contrast, stylasterid hydrocorals or lace corals form very small and delicate colonies (Figure 1F).

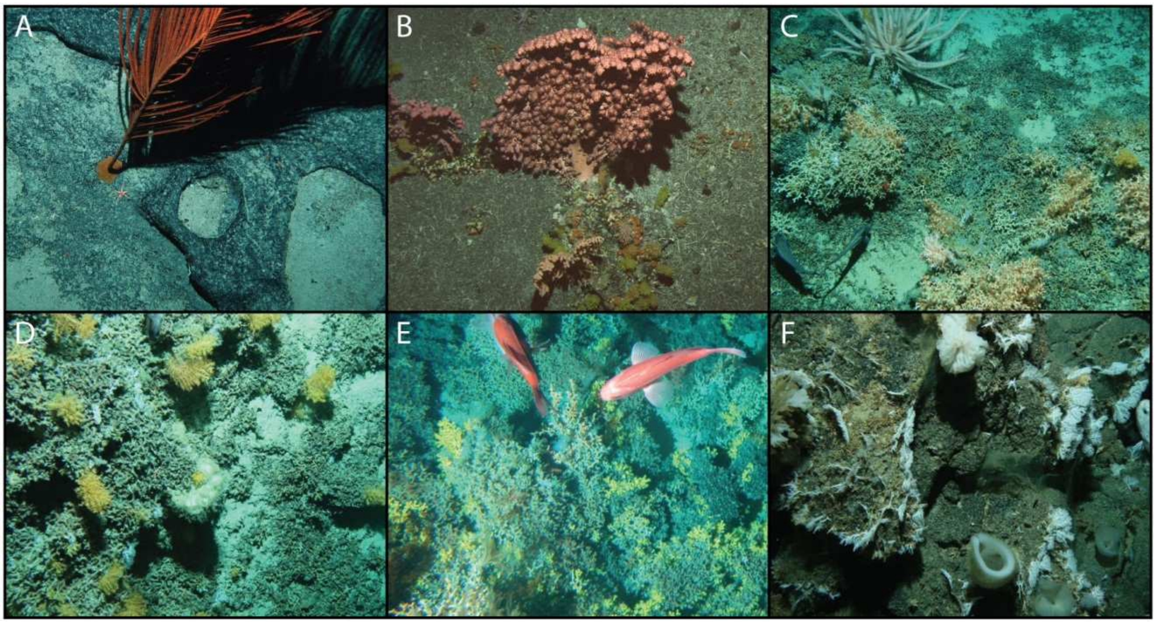

Figure 1: Protected deepsea corals in the New Zealand region.Top A: black coral *Bathypathes* spp., B: gorgonian bubblegum coral *Paragorgia arborea*, C: gorgonian primnoid coral *Narella* spp. top left of image and stony branching coral *S. variabilis*, D: gorgonian primnoid coral *Thouarella* spp., E: stony branching coral *Solenosmilia variabilis*, orange roughy in the foreground, and F: stylasterid hydrocorals (likely *Calyptopora reticulata*). All images were taken in the New Zealand region using NIWA’s Deep towed imaging system.

Currently deep-sea corals are listed as Vulnerable Marine Ecosystem (VME) taxa because they meet several of the ecological criteria used to define fauna included in the VME taxa list. That is, deep-sea corals are fragile relative to trawl gear, can be rare or endemic, and have slow growth rates (Parker et al. 2009a). Certain species in the gorgonian group are classified by DOC as threatened species (Townsend et al. 2008).

Bottom trawls are not efficient tools for quantitatively sampling organisms such as corals, and certain corals will not be retained in the trawl mesh (Parker et al. 2009b). In addition, distribution data of corals from fishing vessels do not adequately reflect the true distribution for the region and are an artefact of sampling effort (Rowe & Tracey 2008). However, the coral collection programme from fishing vessels has provided a diverse and extensive collection of corals and an expanding valuable data source. The records increase our knowledge of the region’s biodiversity, provide additional spatial data to help identify areas of highest risk, and meet the legal requirements for monitoring protected corals.

1.2 Identification of coral samples

Corals samples have previously been identified (verified) to the lowest taxon possible and resulting data presented to the MCS group in summary lists as part of the Progress and Final Client Reports for each of the three one-year duration projects (Tracey 2008, 2009, 2010a & b; Tracey & Sanders 2010, 2011).

In collaboration with coral taxonomists visiting NIWA, as well as a result of a DOC-funded visit of coral expert Juan Sanchez (Universidad de los Andes, Colombia) (Tracey 2010c), NIWA has subsequently been able to identify many of the coral fauna collected by observers to a lower taxonomic level. In December 2008 the black coral (Antipatharia) samples were identified by Dennis Opresko (Oak Ridge National Laboratory, USA) and Tina Molodtsova (Shirshov Institute of Oceanology); Steve Cairns (Smithsonian Institution) identified Scleractinia and Stylasteridae; and Les Watling (University of Hawaii), Scott France (University of Louisiana at Lafayette), Nestor Ardila and Luisa Duenas (Universidad de los Andes, Colombia), and Asako Matsumoto (University of Tokyo) identified some gorgonian corals. Primnoid (Gorgonacea) coral expert Susanna S. de Matos-Pita (Universidad de Vigo and Instituto Español de Oceanografía, Spain) visited NIWA in June 2009 and was able to confirm the identifications of a high proportion of the 2008–09 gorgonian samples collected by observers. In January 2010 Steve Cairns visited again and was able to carry out additional identifications of some scientific observer samples.

1.3 Database storage

Since the CSP project began in October 2007, observer collected coral samples have been sorted, identified to the lowest possible taxonomic level, and catalogued using three letter MFish codes (e.g., *Narella* spp. = NAR). Some samples could only be identified to order or phylum due to their condition. More recent and accurate use of coral codes and the allocation of new coral codes to genus and family have added to and improved the overall dataset on coral fauna for the region. New coral codes have been given for Families Primnoidae (PRI) and Plexauridae (PLE), and for several black coral genera. We note however that coral codes have not been allocated for all coral taxa recognised by experts.

Originally data were stored in an excel spreadsheet and more recently a web interfaced NIWA database — Observer Samples Database (OSD). The interface was designed to facilitate both data entry and record searches as well as updates with new information (e.g., by visiting taxonomists updating species names). Data entered into the system are immediately available for viewing or updating by other users of the system. OSD has linkages with existing databases — MFish *Species Master* for coral codes and MFish database *cod* for ease of uploading data (using the links for trip and station information). For coral samples retained at NIWA, the same information was loaded into the NIWA Invertebrate Collection's *Specify* database.

Linkages between OSD and *cod* allow the verified sample identification information to be joined to the observed catch and effort data; thus, updating the observed coral code with a verified coral code for records where samples exist. These data are available to describe the distribution of the observed coral catch and the identification of commercial fisheries and areas where corals are incidentally caught during fishing operations.

1.4 Assessment of coral identification by observers

The amount of coral samples returned for processing by NIWA to date has been large with 43 trips in 2007–08 producing over 539 samples (Tracey 2008), 36 trips in 2008–09 producing 302 samples (Tracey 2009), and 23 trips in 2009–10 producing 213 samples (341 specimens) (Tracey 2010a). [Note historical coral samples previously received by Te Papa, formed part of the database summaries in the 2007–08 report but these records are not included in the dataset for this report].

Until now, no formal comparison has been made between observer and expert identifications. The use of DOC-funded educational material to aid coral identification — *Deepsea Coral Identification Guide* (Tracey et al. 2008)[1] that complements *A Guide to Common Deepsea Invertebrates in New Zealand Waters* (Tracey et al. 2007) — has resulted in more corals being identified to a lower taxonomic level by observers. However some corals continue to be easily confused (Tracey & Sanders 2011): among different species of stony branching corals (e.g., *Madrepora oculata, Enallopsammia rostrata, Goniocorella dumosa,* and *Solenosmilia variabilis*), between some of the hydrocorals and gorgonian corals (e.g., the gorgonian *Corallium* spp. confused with hydrocorals), and between gorgonian coral families (e.g., such as species of bamboo corals (Isididae) confused with sea fan species (Primnoidae)).

With the increase in the number of corals now afforded protection, it is important to investigate the accuracy with which observers identify coral to the available coral codes. To assess the accuracy of the observers' records for the coral samples returned for identification and verification by NIWA, the observer allocated coral codes can be compared with the NIWA expert allocated coral code.

1.5 Objectives

This report presents the results of analyses undertaken to address the two specific objectives of the CSP protected coral project:

1. To identify areas where deep sea corals are at highest risk of interactions with fishing gear;

2. To assess the value of identifying sub-samples of corals returned by observers and, specifically, whether there is an ongoing need to monitor and quantify the level of interaction between fisheries and protected corals.

The emphasis in this report is on the observed trawl data. Samples were returned for verification from observed trawl trips only. Observer data collected from trawlers during 2007–08 to 2009–10 are analysed to identify target fisheries and areas with coral bycatch and to describe the spatial distribution of coral catches by coral group in relation to fishing effort. A measure of accuracy of the observer coral identification is assessed by comparing the at-sea coral identifications of returned samples with expert identifications made later in the laboratory.

[1] http://www.doc.govt.nz/publications/conservation/marine-and-coastal/marine-conservation-services/other-publications/coral-identification-guide/)

2 Methods and Results

2.1 Objective 1

The aim of this objective is to describe the spatial distribution of the coral bycatch from observed fishing operations during 2007–08 to 2009–10, and thus identify areas where protected corals may be at risk from fishing activities.

2.2 Observed data and grooming

All verified coral data that had been recorded in OSD were uploaded into the *cod* load table and reconciled with the observed coral data. These data included the final identification data (coral code to lowest taxonomic coral identification possible, sample weight, trip number, and tow number). Appendix 1 gives the taxonomic name (family, genus, species) for each group and definitions of the coral codes for the individual corals. At the lowest identification level the corals represent around 30 different genera or species.

A brief description of the methodology used to update *cod* and allocate verified coral codes and redistribute catch weights by verified coral code is given below.

Upgrading of the research dataset in *cod* follows instructions provided by Research Data Manager (RDM), MFish. These are as follows: *Species_true is populated with the "best" identification possible given the Ministry of Fisheries code constraints. If a sample_id (benthic form species = INV, gwt = 100kg) returns more than one species_true (true_species for above = COB, ONG, and BRZ 2kg, 3kg and 1 kg respectively (6kg retained and sampled)), then the species should be proportioned between all relevant rows (species = INV 33 kg, INV 50kg, INV 17 kg). Benthic catch however should be in x_fishing_event_catch (although much of the information Di Tracey provides should reside in either Load or Stage) – if it is decided that an X_benthic_catch table is required then historic and current benthic species records should all be in x_benthic_catch.* (Craig Loveridge, RDM MFish, pers. comm.)

The above instructions were followed when the ground-truthed sample identification data were loaded, then a list of maximum expected weights per coral type was generated to check for outliers such as unusual recorded or proportioned weights. For example, it was noted in the data extract that two recorded catches of cup corals had a much greater than expected total weight: a 4000 kg catch for the cup coral *Caryophyllia* (code CAY) and a 2500 kg catch for the cup coral *Desmophyllum* (DDI). Text in the comments field and ground-truthing of returned samples indicated the DDI weight for the particular tow to be correct and so this record remained grouped with all stony cup coral (CUP) weights. For the CAY record, however, the comments included the word "rubble" and the identification had not been ground-truthed. Hence this CAY coral record and weight was removed from the cup coral grouping and combined with the scleractinian stony coral group (SIA generic stony coral code), CBD (dead coral rubble, a code infrequently used), and CBB (coral rubble usually comprising dead and live samples).

Observers estimate and record catch weights (kg per tow) of corals against the observed coral code. For this work, these data for protected corals were combined into nine broad groups (Table 1) and appended to the relevant observed tow and set data. These nine groups represent groupings based on taxonomy and ease of identification. For example, the Scleractinia were placed into three groups (stony branching corals, cup corals, and unspecified scleractinians including dead and live coral rubble). Thus, the catch records for the stony branching coral species *Madrepora oculata* (MOC), *Enallopsammia rostrata* (ERO), *Goniocorella dumosa* (GOC), and *Solenosmilia variabilis* (SVA) were combined into the stony branching corals group (CBR) (see Table 1). Where there was no sample for verification of the CUP and CBR coral identification, the groups were combined into SIA. The Gorgonacea were assigned to four groups, with the precious corals, bamboo corals, and bubblegum corals separated from the remaining gorgonian corals (primarily primnoid and plexaurid sea fan families). This separation was used because precious, bamboo, and bubblegum corals are easy to identify to family level. Verified coral code data were used where available (see Tracey & Sanders 2011); otherwise the coral codes reported by the observer were used to summarise the coral catch data at the higher group level.

An extract of data relating to observed trawl and bottom longline fishing events was requested from the MFish observer database *cod* for the fishing years (1 October–30 September) 2007–08, 2008–09, and 2009–10. This extract provided a dataset of observed catch and effort data, including the total coral weights estimated for each positive catch in a tow or set.

The observed data included attributes recorded on catch-effort logbooks on a tow-by-tow or set-by-set basis. The primary effort attributes used described the start and finish tow/set time, date, location, and depth; target species; and fishing method and gear type. Each tow/set has an identifier for the vessel and observer(s). The catch data included the greenweights of the total catch, the target species, and the coral taxon or taxon groups. Other information requested included all data fields from the Benthic Material Forms, the *comments* fields for tow, catch, and benthic data records, and the observer trip reports to aid in the interpretation of some data.

Table 1: The coral groups used to represent the distribution of corals caught during observed fishing events, 2007–08 to 2009–10. Appendix 1 gives the taxonomic name for each group and definitions of the coral codes for the individual corals included in the data extract request for each group. *For the stony branching coral catch records where there was no sample for verification of the identification, the groups were combined (SIA). Coral codes given below represent the corals included in the three-year final dataset.

Name	Combined coral code	Coral codes
Black corals	COB	COB, TPT, CIR, LSE, LEI, BTP, DEN, PTP
Stony corals*	SIA	SIA, CBB, CBD
Stony corals – branching	CBR	CBR, ERO, GDU, MOC, SVA
Stony corals - cup	CUP	DDI, CAY, STP, COF, CUP
Gorgonian corals	GOC	GOC, MTL, IRI, CHR, PLE, THO, PMN, NAR, PRI, CLG, CTP, PLL,
Precious coral	CLL	CLL
Bamboo corals	ISI	ACN, ISI, LLE, BOO
Bubblegum coral	PAB	PAB
Hydrocorals	COR	COR, LPT, ERR, CRE

The observed trawl effort data were checked for outliers, and obvious errors were amended, where possible. The main errors were in fine-scale position data, especially where the observed tows of a trip were located east of 180°, but the recorded start and finish longitudes were either 'east' or 'west' of 180°. Other positio n errors were typographical errors. Related fields for amended position data, such as the Fishery Management Areas (FMAs) both inside and outside the New Zealand Exclusive Economic Zone (EEZ) shown in Figure 2, were checked and adjusted where necessary. Tows recorded as 'BPT' (bottom paired trawl) were identified as twin trawl tows and amended to 'BT', and the one 'MPT' (midwater paired trawl) was assigned 'BT', after checking through observer trip reports. Obvious typographic mistakes in the target fishery codes were amended after reference to the observer trip reports. In the final trawl dataset, trawls longer than 100 km were ignored to give a total dataset of 21 259 tows for the three fishing years. This represents 99.9% of the observed trawl data for 2007–08 to 2009–10.

The bottom longline dataset contained 863 observed longline records, for the fishing years 2007–08 to 2009–10. The grooming procedure was similar to that for the trawl data. The position and date data were checked and the position data for a few sets across 180° were amended. One target fishery code was considered unlikely and changed to match the target reported for the rest of the effort for that trip.

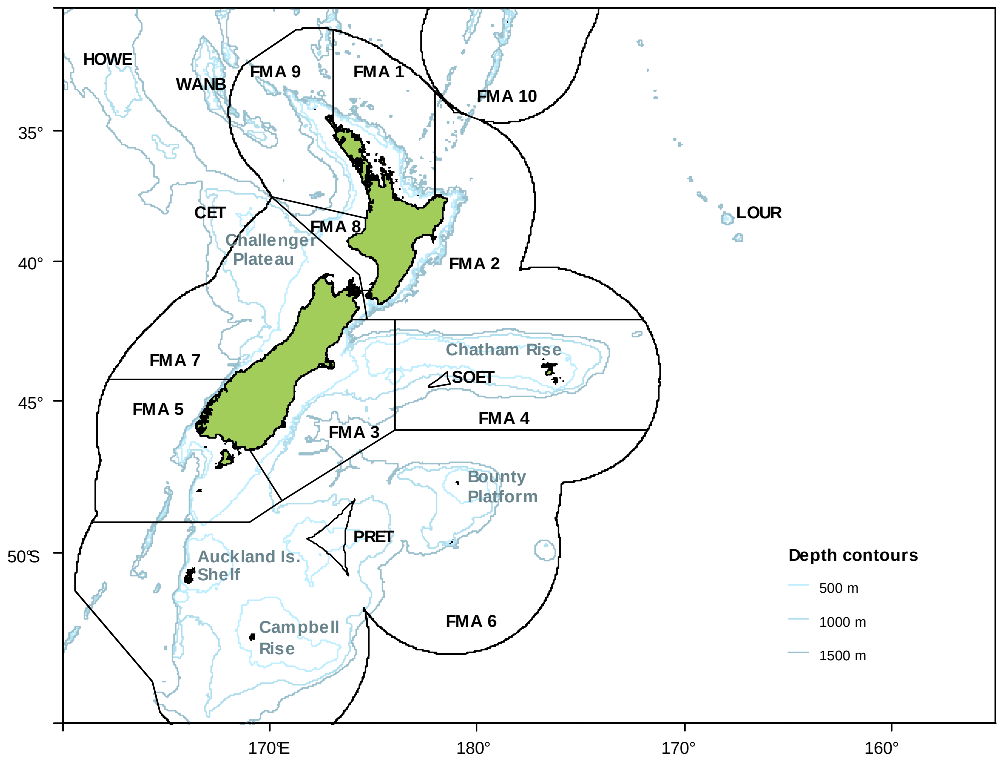

Figure 2: Fishery management areas (FMAs) and areas outside the 200 n mile EEZ used to describe the location of fishing effort. CET is outside the EEZ on the Challenger Plateau, HOWE is the Lord Howe Rise, LOUR is the Louisville Ridge, PRET is the occluded area of the EEZ near Pukaki Rise, SOET is the occluded area in FMA 4, WANB is the Wanganella Bank.

The verified coral code data were merged with the observed effort data and used to map the distribution of verified species, taxa, or taxonomic groups based on samples returned from sea. [These datasets are available to MCS as supplementary electronic files.]

2.3 Description of observed trawl effort

The final trawl dataset of 21 259 observed tows represented 233 observed trips made during the three fishing years from 2007–08 to 2009–10. The species targeted, areas fished, and the numbers of tows by gear type reported for each target are listed in Tables 2.1 and 2.2 in Appendix 2. Over 80% of observed tows used bottom trawl gear. The deepwater species such as orange roughy, oreo species, and black cardinalfish accounted for about 42.5% of all observed tows. Middle depths species such as hake (*Merluccius australis*), hoki, ling (*Genypterus blacodes)*, and white warehou (*Seriolella caerulea*) accounted for almost 25% of the observed effort; arrow squid (*Nototodarus sloani*, *N. gouldi*) for another 14%; scampi for 6%; and jack mackerels (*Trachurus* spp.) for almost 6%.

About 33% of observed tows were reported from the Chatham Rise where hoki was the main observed middle-depths target in FMA 3 and oreos the main deepwater targets (Table 2, see Figure 2.1 in Appendix 2), and orange roughy and smooth oreos were the main deepwater targets in FMA 4 in discrete areas that include known underwater features (see Dunn et al. 2008). Scampi was an important target in the shallower depths at the western edge of FMA 4 near Mernoo Bank. The southern FMAs 5 and 6 accounted for 37% of the observed trawl effort. These areas were characterised by squid effort in waters shallower than 500 m off the Stewart-Snares shelf and the Auckland Islands Shelf and, in FMA 6, the remainder of the observed effort mainly targeted oreos and orange roughy in deepwater fishery areas near the Bounty Platform and east of Pukaki Rise.

Table 2: The number of observed tows by Fishery Management Area and the percentage with coral bycatch, 2007–08 to 2009–10. Areas are shown in Figure 1. The two occluded areas are assigned to the surrounding FMAs: PRET in FMA 6 and SOET in FMA 4.

Area	No. observed tows	% observed tows with coral
FMA 1	867	12.9
FMA 2	519	4.2
FMA 3	2 344	7.3
FMA 4	4 712	10.7
FMA 5	2 860	2.8
FMA 6	4 917	7.4
FMA 7	1 787	1.5
FMA 8	716	0.3
FMA 9	610	32.5
CET	614	18.7
HOWE	600	28.5
LOUR	293	46.4
WANB	420	49.5
All areas	21 259	9.9

Observed effort in the northern waters of FMAs 1, 2, 8, and 9 accounted for another 12% of tows, with orange roughy and black cardinalfish the main deepwater targets and scampi and alfonsino (*Beryx* spp.) also important bottom trawl fisheries. Effort in FMA 7 off the west coast was mainly targeted at middle depths species (see Table 2.1 in Appendix 2), though some orange roughy effort was reported from the Challenger Plateau. This fishery was closed during this sampling period and the observer's trip report confirms that this effort (see Figure 2.1 in Appendix 2) represents the presence of an observer on an industry-vessel research survey.

The observed tows from areas outside the EEZ (see Table 2), mainly targeted orange roughy (Table 2.1 in Appendix 2). The priority for observers on these vessels was the collection of data on VME taxa which include coral (Parker et al. 2009a). The vessels were operating in areas where discrete underwater features are fished and MFish has obligations to report catches to the South Pacific Regional Fishery Management Organisation (SPRFMO) (Ministry of Fisheries 2008).

The distribution of all observed tows is shown in Figure 3, and the three peaks in the depth density plot represent:

- the shallower water target species at about 100–300 m, such as arrow squid, barracouta (*Thyrsites atun*), and jack mackerels, and the inshore targets of snapper (*Pagrus auratus*), tarakihi (*Nematodactylus macropterus*), and trevally (*Pseudocaranx dentex*)
- the main middle depths targets in about 300–650 m of hake, hoki, ling, and white warehou, as well as alfonsino, scampi, silver warehou (*Seriolella brama*), and southern blue whiting (*Micromesistius australis*)
- the deepwater targets, mainly in over 700 m, of orange roughy, oreo species, and black cardinalfish.

2.4 Presence of coral catch in observed trawl nets

Over the three years, 2112 observed tows had catch records for at least one of the coral groups listed in Table 1. The distribution of observed tows with coral catch records is shown in Figure 4, and the distribution of coral catch weights per tow is shown in Figure 5. To aid in the definition of the effort for certain target species, plots of the observed effort for the main target species (in relation to coral catch) are given in Figure 2.1, Appendix 2.

The highest density of observed tows with coral catch was in deeper waters, between 800 and 1000 m. Some of these areas represent target fishery areas based around underwater topographical features such as hills, seamounts, ridges, and drop-offs (see Dunn et al. 2008, Mormede 2010).

Although over the entire dataset 10% of observed tows had records of coral catch, the deepwater targets are the most pertinent to this study because observers on vessels targeting orange roughy, oreos, and black cardinalfish were specifically instructed to collect coral data, as were those fishing in the SPRFMO areas. About 61% of tows with coral records targeted orange roughy and another 21% targeted oreo species or cardinalfish. (Table 3) Corals were reported from orange roughy tows in all areas except FMA 5 (where only two orange roughy tows were observed). For these deepwater targets, about 81% of the tows had no coral catch records, 14% had records for one group listed in Table 1, 3.5% for two groups, and the remainder had records for three to six coral groups (Table 4).

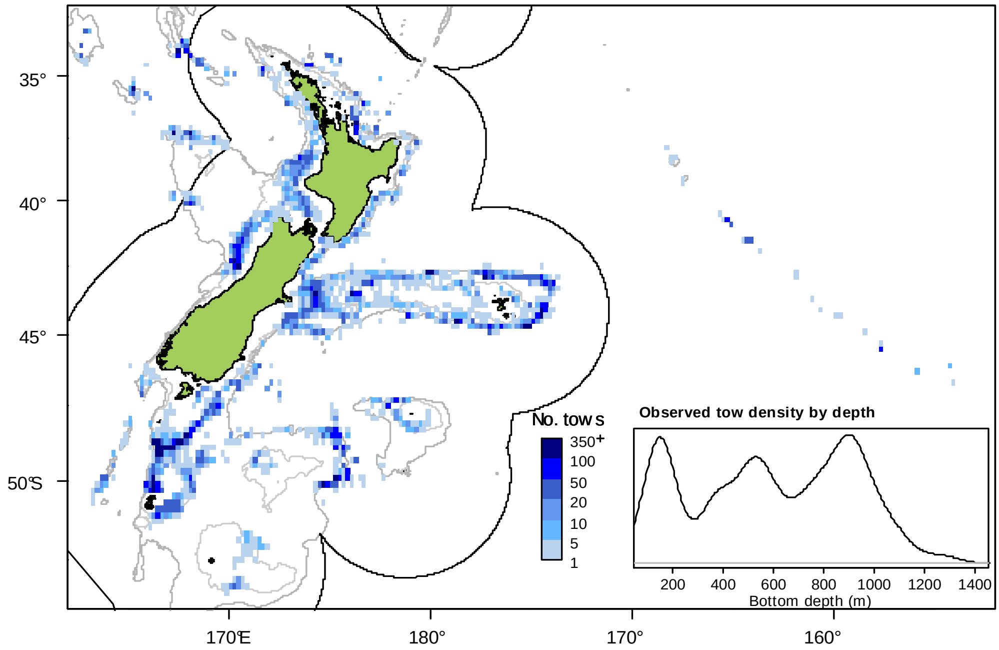

Figure 3: Distribution of observed tow effort (by 0.2° latitude x 0.2° longitude cells), based on the reported start locations, for 2007–08 to 2009–10. The inset shows the depth distribution of the 21 259 observed tows.

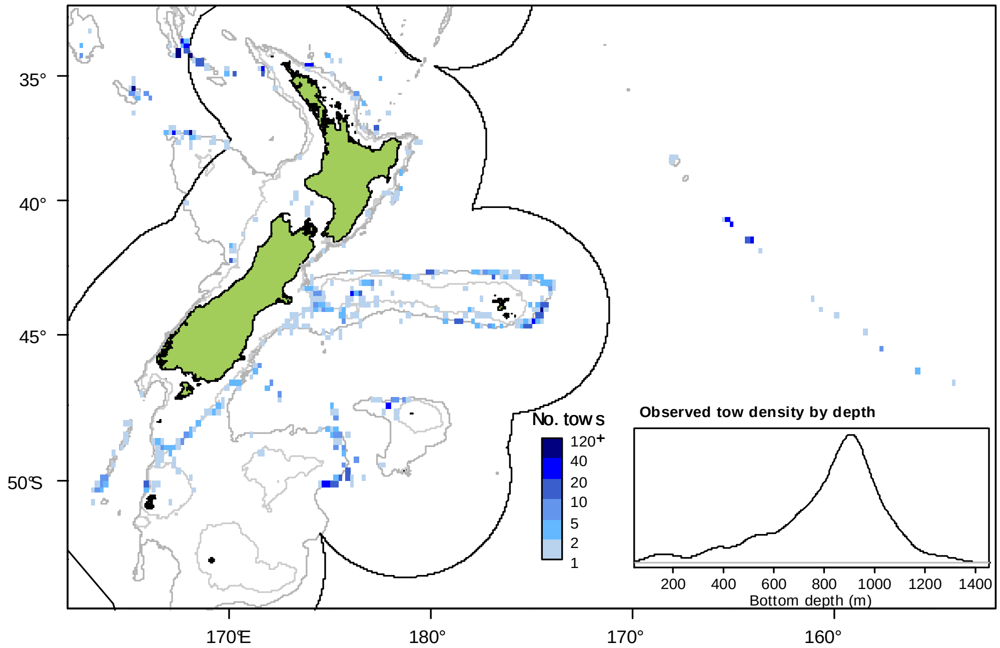

Figure 4: Distribution of observed tow effort (by 0.2° latitude x 0.2° longitude cells) for those tows with coral catch records, based on the reported start locations, for 2007–08 to 2009–10. These data represent a subset of the data in Figure 2. The inset shows the depth distribution of the 2112 observed tows with coral catch.

Table 3: The number of observed tows with coral catch, by area and target species, for 2007–08 to 2009–10. Areas are shown in Figure 1 and target species codes are defined in Appendix 2.

Species	Fishery Management Area									Outside EZZ				
codes	1	2	3	4	5	6	7	8	9	CET	HOWE	LOUR	WANB	All
BAR			2	1										3
BAS				1										1
BOE			5	4	1	146								156
BYX	7	4		5					3	3	12			34
CDL	19	11								2				32
HAK			2			1	20							23
HOK		1	114	21	19	13	1							169
JMA							5	2						7
LIN				2		4								6
MDO									1					1
OEO			1	3		57								61
ORH	86	3	1	367		23	1		193	110	158	136	208	1 286
SBW						2								2
SCI		3	1	60										64
SOR											1			1
SQU				1	49	7								57
SSO			39	36	3	113								191
SWA			6	3	3									12
UNI									1					1
WWA					5									5
All	112	22	171	504	80	366	27	2	198	115	171	136	208	2 112

Table 4: Number of observed tows targeting deepwater species (orange roughy, oreos, and black cardinalfish) by the number of coral groups represented in the tow catch, by fishery area (see Table 1).

	Number of coral groups							Total
Area	0	1	2	3	4	5	6	tows
FMA 1	331	66	29	9	0	0	0	435
FMA 2	151	12	1	0	0	0	0	164
FMA 3	397	34	7	1	1	0	0	440
FMA 4	3 176	321	54	16	2	0	1	3570
FMA 5	26	4	0	0	0	0	0	30
FMA 6	1774	227	77	16	8	0	0	2102
FMA 7	150	1	0	0	0	0	0	151
FMA 9	184	137	34	11	1	1	0	368
CET	462	94	12	5	1	0	0	574
HOWE	328	111	36	9	3	0	0	487
LOUR	157	125	9	1	1	0	0	293
WANB	212	133	53	15	5	2	0	420
	7 348	1 265	312	83	22	3	1	9 034

Within the EEZ, about 33% of observed tows in FMA 9 (where the main target was orange roughy) had coral records, and the 13% of tows in FMA 1 with coral catch were mainly orange roughy and black cardinalfish tows. This observed effort reflects the distribution of distinct feature-based orange roughy fisheries in these northern waters (Mormede 2010).

In southern waters, examples of the feature-based fisheries that are reflected in the observed effort include “Priceless” northeast of Pukaki Rise and “Bounty” off the Bounty Platform in the sub-Antarctic part of the Fishstock area ORH3B, and the “Graveyard Hills”, the “Spawning Box” with “Mount Muck”, “Northeast Hills”, and the “Andes complex” on the eastern Chatham Rise (see figures 16 & 19, Dunn et al. 2008). Black oreo tows contribute to most of the effort east of Pukaki Rise, along with smooth oreo tows, where tows reached depths of about 1400 m. The largest catches (by weight) were from these fishery areas (see Figure 5), with larger catches also reported from the Macquarie Ridge to the south and the West Norfolk fishery area that extends southeast from the Wanganella Bank (see Mormede 2010) in the northwestern waters of the EEZ.

The SPRFMO areas, where orange roughy was the main target, had relatively high percentages of tows with coral catch records. Almost 50% of observed tows in both the Wanganella Bank and Louisville Ridge areas had coral catch records, 29% at Lord Howe Rise, and 19% of CET observed tows caught corals (Table 2).

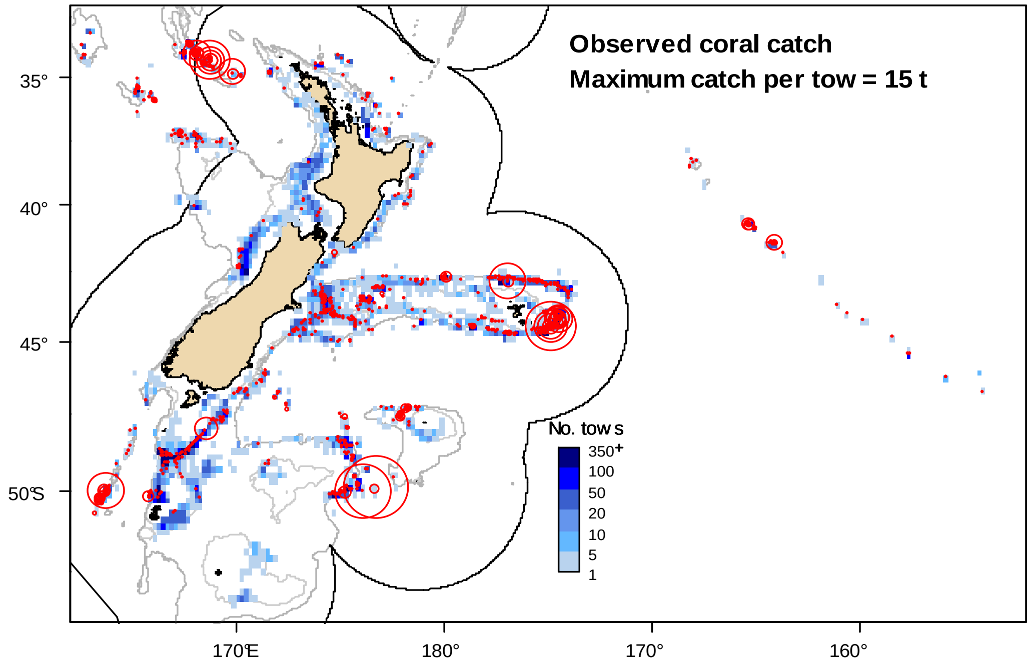

Figure 5: Distribution of observed tows in 0.2° latitude x 0.2° longitude cells and the recorded catch weights (t) of coral per tow (red circles: size is proportional to the maximum recorded catch of 15 t).

2.5 Distribution of observed catches of protected coral groups

The distributions of the main coral groups listed in Table 1, based on the observed trawl data for 2007–08 to 2009–10, are broadly discussed below. Appendix 3 gives tabulated data summaries relevant to this section, by target species (Tables 3.1 & 3.2) and fishery area, (Tables 3.3 & 3.4). For most coral groups, 1.6–2.7% of all observed tows had reported coral catches. NB: The catch weight distribution figures for each group are plotted at different scales for each group. The plots for gorgonian corals exclude the bamboo, bubblegum, and precious coral families as these are presented separately.

Observers returned samples of the coral catch from 24% of the observed tows with coral catch. Experts identified the sample material to the lowest taxonomic level possible. These verified identification data are a subset of the coral catch data presented here and are summarised in Appendix 4.

2.5.1 Black coral

Over all the observed trawl data, 369 tows (under 2%) had records of black coral catches (Table 3.1 in Appendix 3). These corals were reported from observed tows that targeted 11 species/species groups, and the highest catch weight by target was from orange roughy tows. Black corals were reported from all areas except FMA 3 (Table 3.3 in Appendix 3). The distribution of the reported catch weights per tow for positive catches is shown in Figure 6. Catches were light relative to other coral groups, showed little variation in reported weight, and the maximum catch was 10 kg (Table 5). Catches were predominantly from 800–1000 m depths.

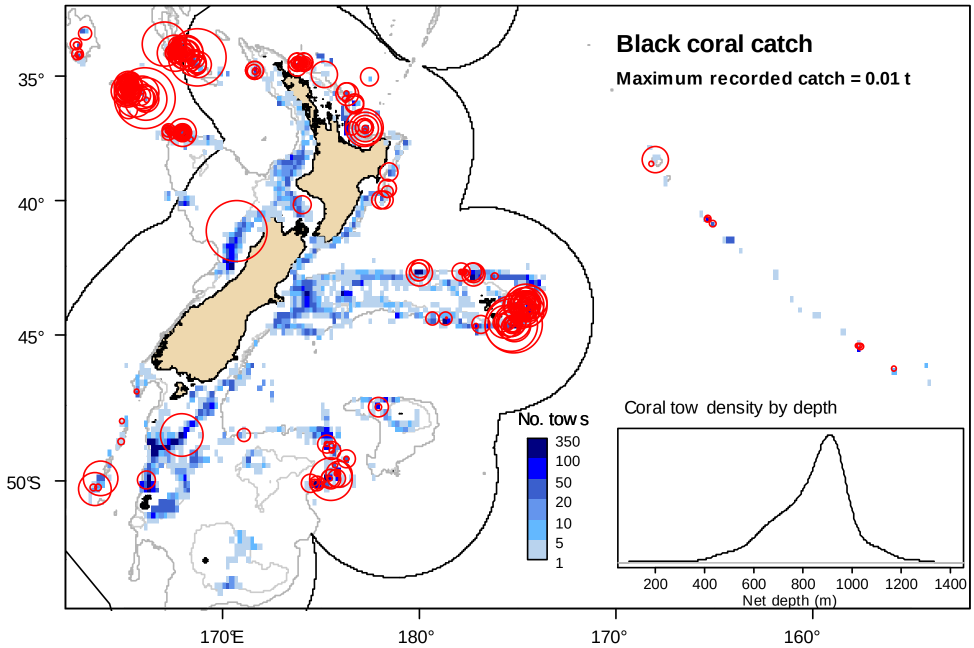

Figure 6: Distribution of observed tow effort (by 0.2° latitude x 0.2° longitude cells) and black coral tow catch weights (t) (red circles: size is proportional to the maximum recorded catch), based on the reported start locations, for 2007–08 to 2009–10. The inset shows the depth distribution of observed tows with black coral catch.

Table 5: Number of observed tows with catch weight records and summary catch weight (kg/tow) data (minimum, mean, maximum, and quantiles) for coral groups. Common names for the coral group codes are listed in Table 1.

	No. tows	Minimum	1st quantile	Median	Mean	3rd quantile	Maximum
COB	359	0.006	0.20	0.5	0.95	1.0	10.0
SIA	440	0.100	1.00	2.0	89.12	7.6	8005.0
CBR	576	0.040	0.60	2.0	100.80	8.0	15000.0
CUP	355	0.001	0.21	1.0	13.56	2.0	2500.0
GOC	377	0.001	0.10	0.3	3.64	1.0	400.0
ISI	333	0.002	0.20	1.0	3.21	1.2	200.0
PAB	117	0.100	0.50	2.0	18.09	10.0	376.1
COR	35	0.048	0.20	1.0	0.97	1.0	8.0
CLL	13	0.100	0.30	1.0	1.05	1.0	3.8

2.5.2 Unspecified stony coral

This coral group includes coral records for coral rubble (dead or alive), and stony corals that could not be assigned to branching (CBR) or cup (CUP) coral groups, and catches were reported from 440 observed tows. Over 90% of the total catch weight of this group came from observed orange roughy tows and 80% was reported from FMA 4 and FMA 9 (Tables 3.1 & 3.3). The maximum catch per tow was 8005 kg and the largest catches were reported from southeast of the Chatham Islands in FMA 4 (Andes complex) and northwest of the North Island in FMA 9 (West Norfolk fishery area) (Figure 7). No catches of this group were reported from tows in FMA 2 or FMA 7. Although a few catches of this group were reported from tows in shallower than 500 m, most were from depths of 700–1000 m.

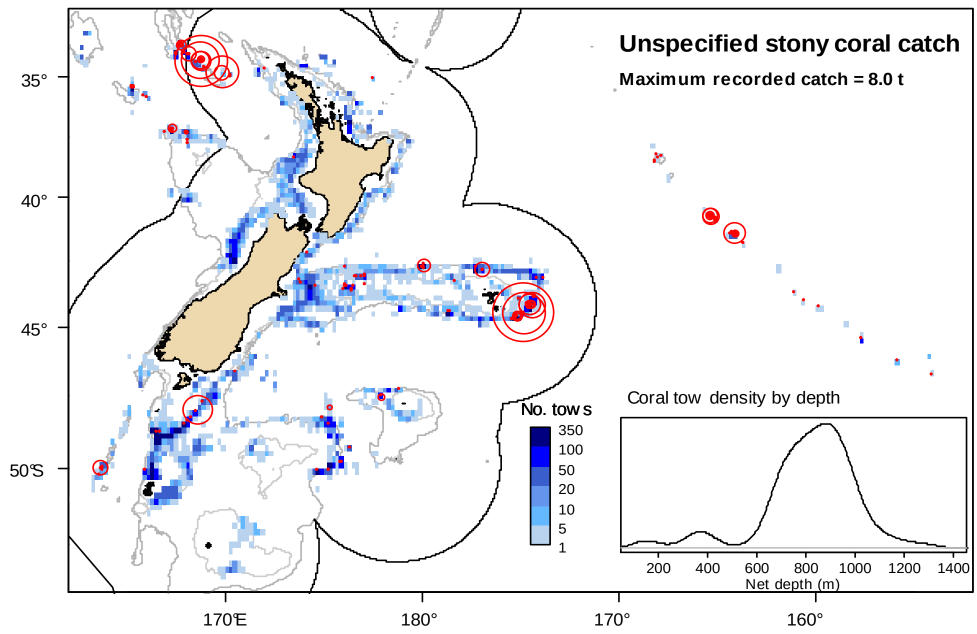

Figure 7: Distribution of observed tow effort (by 0.2° latitude x 0.2° longitude cells) and the SIA stony coral tow catch weights (t) (red circles: size is proportional to the maximum recorded catch), based on the reported start locations, for 2007–08 to 2009–10. The inset shows the depth distribution of observed tows with SIA coral catch.

2.5.3 Stony branching coral

Stony branching corals were reported from 576 tows that represented 10 target species, particularly orange roughy and smooth oreo (Table 3.1 in Appendix 3). The highest total catches were from FMA 6, FMA 4, and FMA 9 (Table 3.3), and no catches were reported from FMA 7 or FMA 8. The largest catch weights per tow were from southern waters (maximum of 15 000 kg, Table 5), east of Pukaki Rise in depths of over 1400 m (Figure 8). Most other catches were reported from 800–1000 m.

2.5.4 Stony cup coral

Stony cup corals were reported from 355 observed tows. Although 12 species were recorded as targets for these tows, the greatest total weight of stony cup corals was the total from orange roughy tows, particularly in FMA 4 (Tables 3.1 and 3.3). None were reported from FMA 8 or from the Louisville Ridge. The depth distribution of stony cup corals had two peaks, one in 400–600 m (with most from hoki tows on the western Chatham Rise) and a smaller one in 900–1100 m (Figure 9). Catch weights were generally small for this group (Table 5), apart from a couple of large catches southeast of the Chatham Islands at the Andes complex.

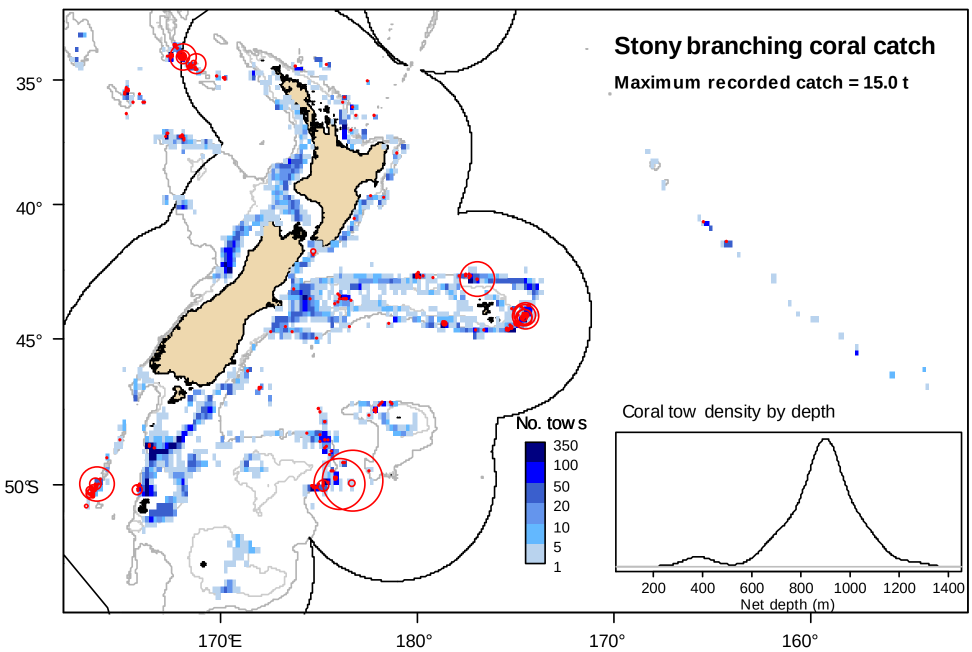

Figure 8: Distribution of observed tow effort (by 0.2° latitude x 0.2° longitude cells) and the stony branching coral tow catch weights (t) (red circles: size is proportional to the maximum recorded catch), based on the reported start locations, for 2007–08 to 2009–10. The inset shows the depth distribution of observed tows with stony branching coral catch.

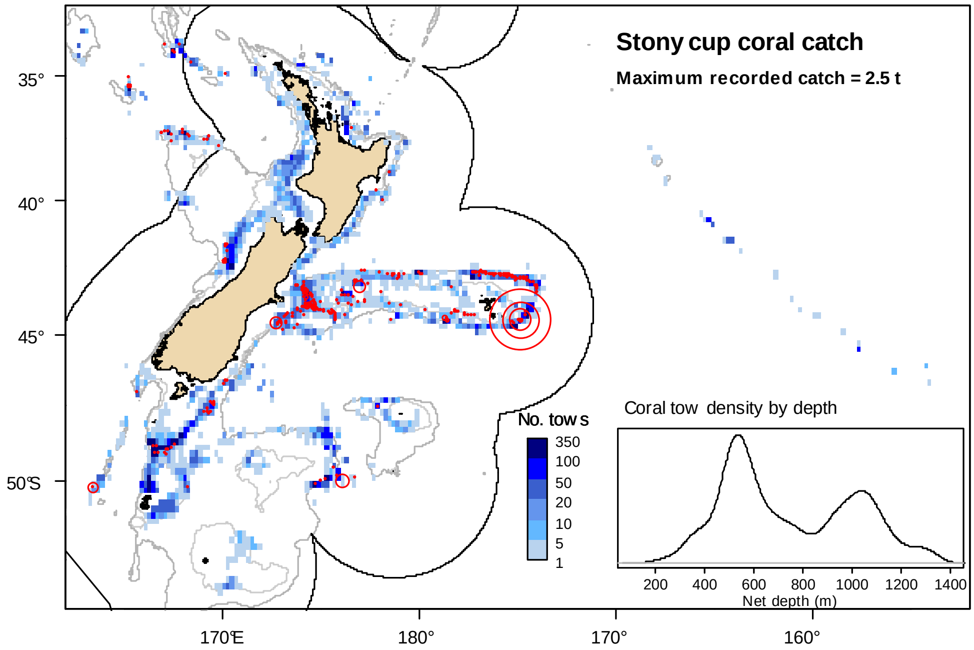

Figure 9: Distribution of observed tow effort (by 0.2° latitude x 0.2° longitude cells) and the stony cup coral tow catch weights (t) (red circles: size is proportional to the maximum recorded catch), based on the reported start locations, for 2007–08 to 2009–10. The inset shows the depth distribution of observed tows with stony cup coral catch.

2.5.5 Gorgonian coral

The families for bubblegum, bamboo, and precious corals are excluded from the Gorgonian group in this report and are treated separately, as shown in Table 1. At least 14 species were targeted on observed tows with gorgonian coral catch records (377 tows), particularly oreo species, orange roughy, and alfonsino (Table 3.2). Catches of gorgonians were reported from all areas except FMA 8, and FMA 6 and FMA 3 contributed over 80% of the total weight for the three fishing years (Table 3.4). Catch weights per tow were small, and the largest catches per tow, including the maximum catch of 400 kg, were from tows east of southern New Zealand (Figure 10). Apart from one shallow catch in a squid tow, most tows with gorgonian records were at depths of 800–1000 m.

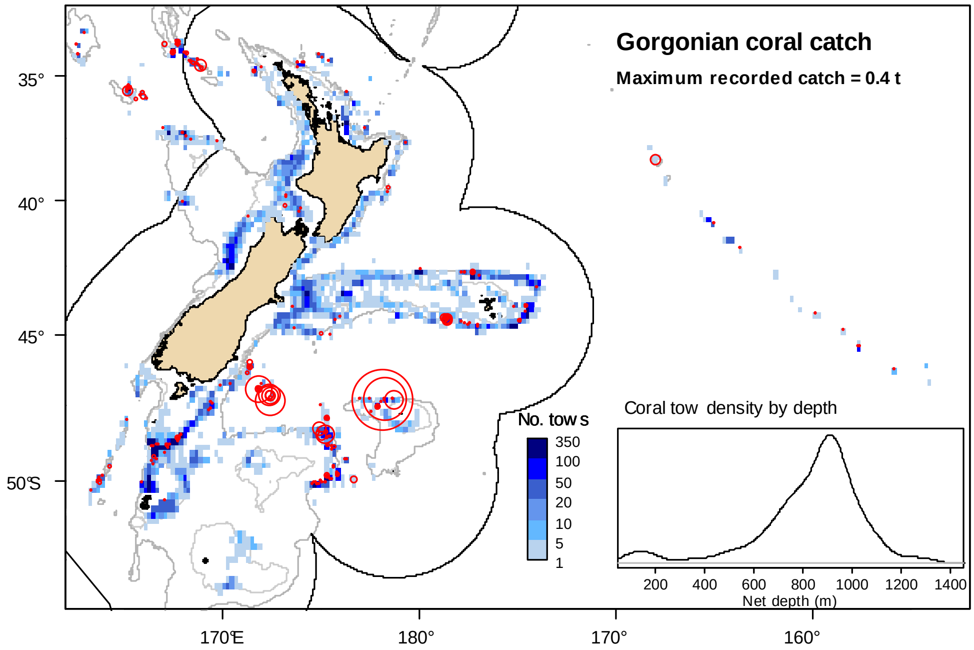

Figure 10: Distribution of observed tow effort (by 0.2° latitude x 0.2° longitude cells) and the gorgonian coral tow catch weights (t) (red circles: size is proportional to the maximum recorded catch), based on the reported start locations, for 2007–08 to 2009–10. The inset shows the depth distribution of observed tows with gorgonian coral catch. [Note the bamboo, bubblegum and precious gorgonian coral families are presented in separate plots.]

2.5.6 Bamboo coral

Bamboo corals were reported from tows targeting 11 species, including the deepwater species and squid (Table 3.2). These corals were reported from 333 observed tows. Total catch weights (all years combined) were highest on the Lord Howe Rise and in FMA 5 and FMA 6 (Table 3.4). Catch weights per tow were small compared with most other coral groups, with a maximum of 200 kg (Table 5, Figure 11). Peak density of observed tows with bamboo coral catch was at depths of around 900 m.

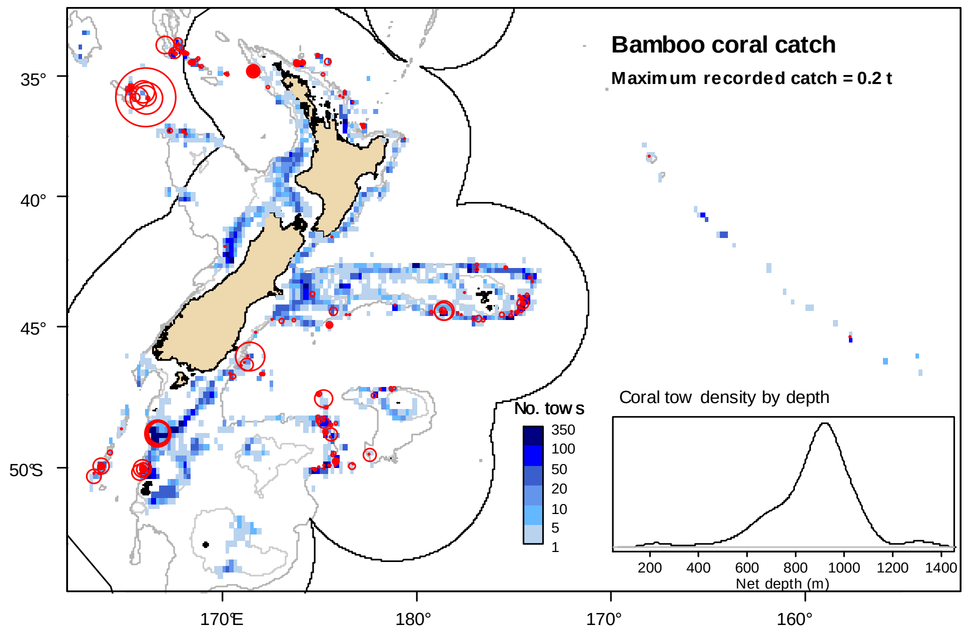

Figure 11: Distribution of observed tow effort (by 0.2° latitude x 0.2° longitude cells) and the bamboo coral tow catch weights (t) (red circles: size is proportional to the maximum recorded catch), based on the reported start locations, for 2007–08 to 2009–10. The inset shows the depth distribution of observed tows with bamboo coral catch.

2.5.7 Bubblegum coral

Relatively few observed tows (117 tows) caught bubblegum corals. Apart from hoki and alfonsino, the main target fisheries that reported catches of bubblegum corals over the three years were the deepwater target species (orange roughy, oreos, and black cardinalfish) (Table 3.2). No catches were reported from FMAs 1, 5, 7, or 8; nor from the Louisville Ridge. Most tows with these catches were in 700–900 m, and catch weights were relatively small, with a maximum of 376 kg (Table 5, Figure 12). The largest catches per tow were in waters south of the Chatham Islands, to the east of the Bounty Platform, and on the Wanganella Bank in the north.

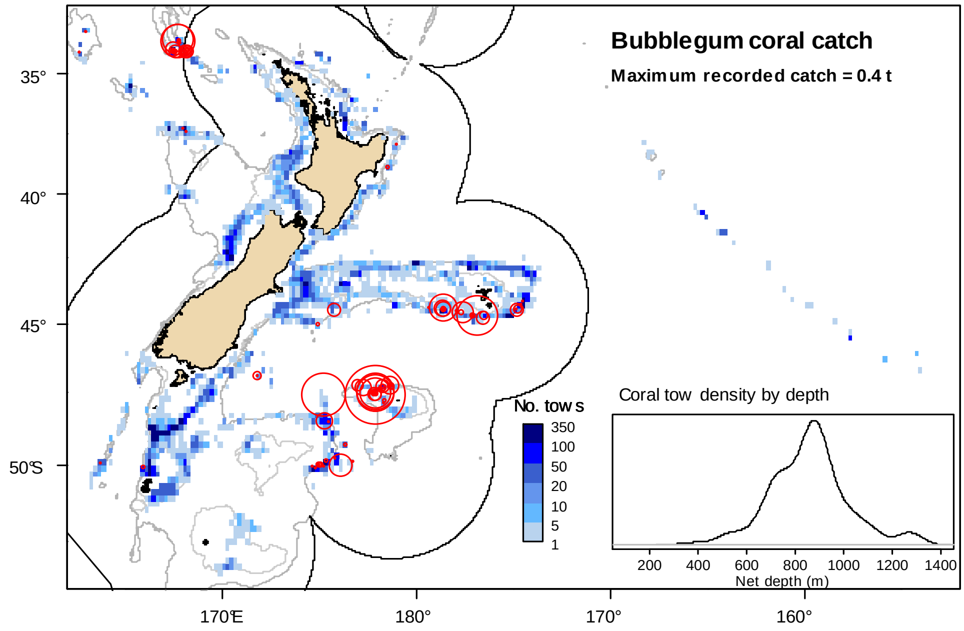

Figure 12: Distribution of observed tow effort (by 0.2° latitude x 0.2° longitude cells) and the bubblegum coral tow catch weights (t) (red circles: size is proportional to the maximum recorded catch), based on the reported start locations, for 2007–08 to 2009–10. The inset shows the depth distribution of observed tows with bubblegum coral catch.

2.5.8 Precious coral

Thirteen observed tows in about 800–1200 m had precious coral records, with estimated catch weights of between 0.1 and 3.8 kg (Table 5, Figure 13). All catches were from deepwater targets in FMAs 3, 4, and 6, as well as outside the EEZ (CET and WANB) (Tables 3.2 and 3.4 in Appendix 3).

2.5.9 Hydrocoral

Hydrocorals were not often recorded by observers. The total over the 3 years was 35 kg from 35 observed tows, with targets of orange roughy, oreo, or squid (Table 3.2). Most records were from FMAs 4 & 6 and the Wanganella Bank (Table 3.4), from where the largest catch per tow was reported (Figure 14). Catch weights were mostly under 1.0 kg per tow (Table 5).

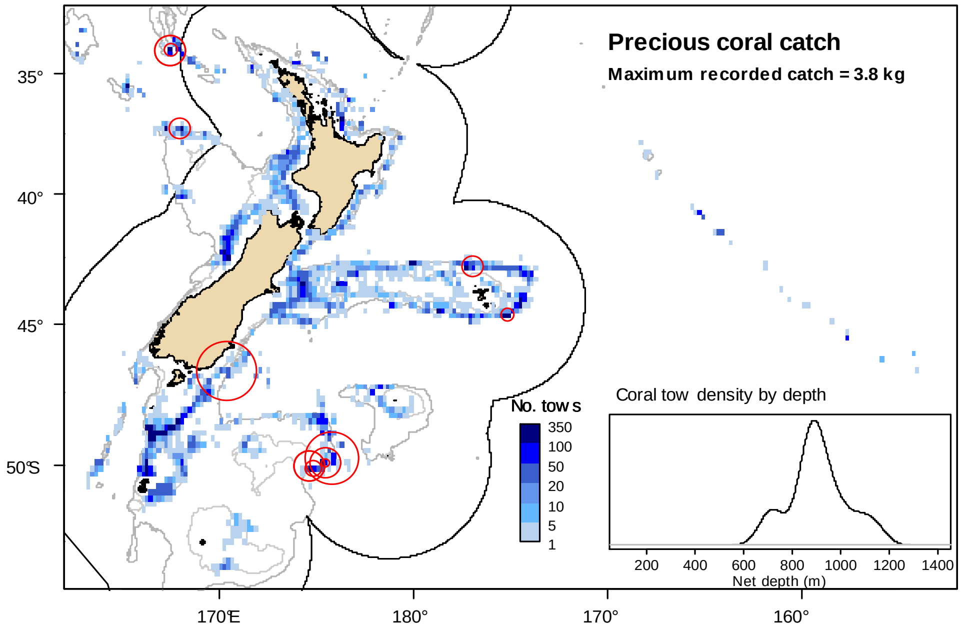

Figure 13: Distribution of observed tow effort (by 0.2° latitude x 0.2° longitude cells) and the precious coral tow catch weights (t) (red circles: size is proportional to the maximum recorded catch), based on the reported start locations, for 2007–08 to 2009–10. The inset shows the depth distribution of observed tows with precious coral catch.

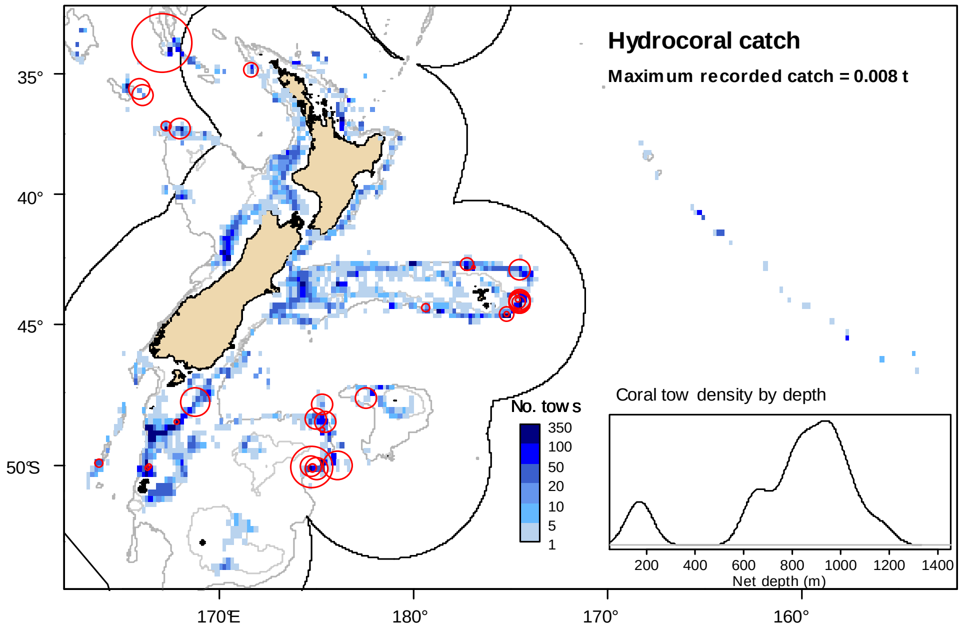

Figure 14: Distribution of observed tow effort (by 0.2° latitude x 0.2° longitude cells) and the hydrocoral tow catch weights (t) (red circles: size is proportional to the maximum recorded catch), based on the reported start locations, for 2007–08 to 2009–10. The inset shows the depth distribution of observed tows with hydrocoral catch.

2.5.10 Brief description of observed bottom longline effort and coral catch

The bottom longline observed effort of 863 longline sets and hauls represented the effort of 8 trips on four vessels, with 80% of the observed sets from one vessel that fished in FMA 6 and FMA 4. Almost 95% of observed longlines targeted ling in FMAs 4, 6, and 3. The other 5% targeted bluenose (*Hyperoglyphe antarctica*) in FMAs 2 and 3, hapuku/bass (*Polyprion* spp.) in FMA 4, ribaldo (*Mora moro*) in FMA 3, and school shark (*Galeorhinus galeus*) in FMA 4. Longlines targeting ling were generally in 280–525 m (range 140–727 m, median 422 m), whereas the other species were generally targeted in slightly shallower depths of 100–380 m (range 40–727 m, median 140 m).

Observers reported coral catches from nine observed bottom longlines set by the two vessels that accounted for the most effort. Of these sets, seven targeted ling, one targeted bluenose, and one targeted hapuku/bass. There were no records of catches of black or precious corals. The bluenose and hapuku longlines had catch records for hydrocorals only (estimated weights of 1.0 kg), from FMA 3 in 200–400 m (bluenose set) and FMA 4 in about 130 m east of the Chatham Islands (hapuku/bass).

Five of the coral records from ling longlines were from effort in the mid-Chatham Rise, east of 180°. These catch records included: unspecified sto ny coral catches of 0.7, 1.2, and 5.0 kg on separate lines in depths of 400–450 m; 1.0 kg of stony cup coral from 400 m; and a 0.5 kg of stony branching coral and 0.2 kg of bubblegum coral from one longline. The remaining coral records were for a stony branching coral from a ling longline in FMA 3 in under 400 m (1.0 kg) and the most southern catch was from the northern slope of the Auckland Islands Shelf in FMA 6 (catch weight of 0.08 kg of gorgonian coral).

3 Objective 2

The aim of this objective was to verify and evaluate the accuracy of the taxonomic classification by scientific observers, identify potential causes for taxonomic confusion, and make recommendations for improvements in the coral and invertebrate guides, observer training, and data collection protocols. The results from this objective will aid in deciding which fauna should continue to be retained for later expert identification ashore.

3.1 Data sources and grooming

The coral codes provided by the observer (recorded on specimen labels or extracted from *cod* from the Catch or Benthic form tables) were compared with NIWA allocated coral codes after expert identification.

To carry out this comparison a data request was made to the MFish Data Manager to provide an extract of observer and expert coral codes. The data extract (*n*= 852 records) is available to MCS as a supplementary electronic file and includes *cod* data fields:

trip_number	(observer trip number)
station_number	(vessel, observer station number)
sample_id	(NIWA database *OSD* sample number)
species_obs	(when provided MFish coral code given by observer)
species	(NIWA expert code - MFish coral code)
species obs_common	(common name obtained by linking the MFish coral code to *Species* db)
common_name	(common name obtained by linking the MFish coral code to *Species* db)

The extracted data went through a detailed data grooming process to ascertain which records could be compared. Each record was allocated a category code of 1, 2, or 3. The allocation of the three codes category criteria were as follows:

3.1.1 Code 1

Code 1 indicates that the record was unable to be used in the comparison analysis because the coral code was clearly wrong, or the coral record is from an expert's identification of an attached sample on the "host" specimen.

For example, the observer used the code KWH (Knobbed Whelk) while the expert used the coral code HDR (Hydroid). The taxon code represents a different group, was an obvious error, and is unable to be resolved. The observer used the code MUD for *M. oculata* instead of MOC. If we were unsure the coral code should have been MOC, was a misuse of a code, or a possible typographical error (MUD or MOC), we were unable to use the record. The expert identified a specimen attached to another coral but the observer provided no corresponding code.

A code of code category 1 was allocated to 80 records (9%).

3.1.2 Code 2

A category code 2 represents a correct coral identification and coral code provided by the observer, but at a higher taxonomic level than the expert coral code. The observer identification is correct and acceptable, but unable to be compared with the expert's lower level identification. For example, observer coral code COB (black coral at order level) expert coral code LEI (*Leiopathes spp.,* black coral at genus level); observer coral code SIA (unspecified scleractinian stony coral at order level), expert coral code SVA (stony branching coral *Solenosmilia variabilis* at species level).

A code of category 2 was allocated to 227 records (27%).

3.1.3 Code 3

Category code 3 represents the samples in the dataset able to be compared. The observer coral code and the expert coral codes match exactly, the observer has used a very obvious incorrect coral code (e.g. a fish code when it was a coral specimen), or the observer has identified the specimen to the lower taxonomic level for the coral, but the expert has identified the coral to a higher level.

For some observed records the code is clearly a typographical error, e.g., PBA *Pasiphaea* prawn instead of PAB bubblegum coral, or GBR grey brotula (a fish) instead of CBR stony branching coral. These are obvious errors and these data have been edited and coded as a 3 as opposed to unresolvable errors that were given a code 1.

A code of category 3 was allocated to 545 records (64%). Thus the number of records we could compare for accuracy was reduced from 852 to 545, primarily due to the identifications being made by the observer to the higher taxonomic level.

3.2 Accuracy analysis

Once each record had been allocated a 1, 2, or 3 code, the expert 'species' column and 'species obs_common' column coded '3' (545 records) were compared. Methods employed to compare the codes were similar to those established and detailed by Parker et al. (2009a) and Tracey et al. (2010), who evaluated the monitoring of VME taxa by observers from New Zealand vessels in the Ross Sea Antarctic toothfish longline fishery during the 2008–09 and 2009–10 seasons (respectively).

The observer coral codes and the expert coral codes were compared in a contingency table to determine the proportions of percentage of 'wrong' identifications'. Accuracy was investigated at two-levels: Level A, accuracy by coral codes, and Level B, accuracy to a higher taxonomic level by the grouping of coral codes into the grouping presented in Table 1. Also included in the Level B analysis are those non-protected Cnidaria groups (hydroids, soft corals, sea pens, anemones, and zoanthids) that observers misidentified as protected corals.

3.2.1 Level A: Analysis by accuracy by 3-letter MFish codes

Results of the analysis by individual codes are shown as a table that plots agreement between observer and NIWA expert identifications (Appendix 5). Each specimen coded and retained by an observer is represented by a row (A2 to A61) and the correct or verified NIWA expert identification code is listed in column headers. Codes are listed alphabetically. The numbers in each row represent a count of the number of times the observer used a particular code. Summaries at the bottom of the table show how often the observer's identiification was incorrect: the percentage wrong (% Wrg), the total number of samples (Total), and the proportion of the total samples that were wrong (Tot wrg). Of the 545 records, 293 were incorrect. The diagonal shows where there is agreement between the observer and the expert (also see row 67).

Some examples are provided to interpret the table (see columns highlighted in orange, Appendix 5). The bamboo coral *Acanella* species (ACN) is identified correctly twice and incorrectly 12 times. The incorrect identifications are instances where the corals are bamboo corals but were incorrectly called other genera in the same family (*Keratoisis* BOO and *Lepidisis* LLE).

A high number of stony branching coral species (*Madrepora oculata*, *Enallopsammia rostrata*, *Goniocoralla dumosa*, and *Solenosmilia variabilis*, had been mis-identified by the observers. For SVA (*S. variabilis*), the percentage wrong was high (89.8%) with 88 of the 98 samples labelled incorrectly. Summarised below are the instances that SVA was mis-identified and what it was identified as:

SVA coded as GDU *G. dumosa* (66 instances)
SVA coded as ERO *E. rostrata* (8 instances)
SVA coded as GOC Gorgonian coral (6 instances)
SVA coded as MOC *M. oculata*, (4 instances)
SVA coded as DDI *Desmophyllum dianthus* (1 instance)
SVA coded as COB black coral, (1 instance)
SVA coded as ROK rock (1 instance)
SVA coded as CBB coral rubble (1 instance)

For the stony branching coral *G. dumosa* (GDU), 6 observer identifications were correct and 2 incorrect: mis-identified as either the stony branching coral SVA (*S. variabilis* (SVA) or a Gorgonian coral (GOC). Two corals were coded as glass sponges (GLS) by observers.

3.2.2 Level B: Analysis of accuracy to a higher taxonomic level by the grouping of coral codes into main groups of protected coral

Results of the analysis by combined codes are shown as a table that plots agreement between observer and NIWA expert identification (Table 6). The diagonal indicates where there is agreement between the observer and the expert's verified code. The diagonal numbers showing agreement are also listed at the bottom of the Table 6.

There was good agreement (<15% error) between the expert and observers for the black corals, branching stony corals, bamboo and bubblegum corals. Whereas there was not good agreement between the gorgonian and hydrocoral identifications. However, the observers identified the gorgonian bamboo and bubblegum corals to a high level of accuracy (*see* Column 6, Table 6, and Appendix 5). While the sample sizes are small, certain taxa are being confused: hydroids with black corals, gorgonian corals, and soft corals; and some gorgonian corals are being confused with stony branching corals. There is good identification for the non-protected anemones and sea pens.

Table 6: Plot to compare grouped coral codes. Grouped verified coral codes are listed in the columns and grouped observer coral codes in the rows. The numbers in each row represent a count of the number of times the observer used a particular code. The diagonal indicates where there is agreement between the observer and the expert. Diagonal numbers are also listed at the bottom of the table. Summaries at the bottom of the table show how often the observer's classification was incorrect: the percentage wrong (% wrong), the total number of samples (Total), and the proportion of the total samples that were wrong (Tot wrong).

Expert

Observer	Corals	Black corals	Stony corals	Stony branching corals	Stony cup corals	Gorgonian corals	Corallium precious coral	Bamboo corals	Bubblegum coral	Hydrocorals	Hydroids	Soft corals	Sea pens	Anemones	Epizoanthid	Crustacean	Sponge	Seaweed	Rock
Corals																	3		
Black corals		36		2		5		1			2								
Stony corals			2	1		2		1		2									
Stony branching corals				133	1	2		3		1									
Stony cup corals				3	54							1			1				
Gorgonian corals		1		10		45			1		3								
Corallium precious coral				1						2									
Bamboo corals		2				20		58					1						
Bubblegum coral						10		4	37										
Hydrocorals				3		2				5	3								
Hydroids				1				1			6								
Soft corals						12						3							
Sea pens		1											9						
Anemones			1									1	1	19					
Epizoanthid															6				
Crustacean															1				
Sponge	1					1						3							
Seaweed						3					6		1						
Rock	1			1		1													
Barnacle														1					
Percent wrong	**100.0**	**10.0**	**33.3**	**14.2**	**1.8**	**56.3**		**14.7**	**2.6**	**50.0**	**70.0**	**62.5**	**25.0**	**5.0**	**25.0**		**100.0**		
Total	2	40	3	155	55	103		68	38	10	20	8	12	20	8		3		
Tot wrong	2	4	1	22	1	58		10	1	5	14	5	3	1	2		3		
Diagonal		36	2	133	54	45		58	37	5	6	3	9	19	6				

4 Discussion

New Zealand's major deep-sea fisheries target orange roughy, black oreo, smooth oreo, and black cardinalfish, and these species are trawled on topographic features such as hills and seamounts as well as 'drop-offs' and 'flat' slope (Clark 1999; Dunn et al. 2008, Mormede 2010). Deepwater corals, including scleractinian (stony corals), also occur on these features of the New Zealand seafloor (Tittensor et al. 2009, Tracey et al. 2011). This overlap between the distribution of fishing activity and deepwater corals means that corals, which are vulnerable to damage or removal by fishing gear, are at risk to disturbance from bottom trawling (Koslow et al. 2001). An analysis of orange roughy bycatch records from the Tasman Sea showed that a considerable amount of corals was caught; an estimated catch that was reduced from 1750 t to 100 t yr^{-1} over the three years that the fishery was observed (Anderson & Clark 2003). Clearly, deepwater coral populations in the New Zealand region, including protected corals, are at risk of being affected by interactions with fishing activity.

The extent of this interaction, and whether some protected coral groups are at greater risk than others, can be assessed by comparing the distribution and catch of the observed corals to the distribution of the fishing effort. However, observer data can present some data reliability issues, so another aim of the research presented here was to assess the accuracy of the identifications provided by observers, and to evaluate what measures can be taken to improve identification accuracy and thereby coral bycatch data reliability.

4.1 Distribution of corals relative to observed trawl fishing effort

Collecting data on the presence of protected corals in the catch of commercial fishing vessels was a priority for observers on vessels targeting deepwater species (orange roughy, oreo species, and black cardinalfish) during 2007–08 to 2009–10. Observers in other fisheries were also tasked with the collection of benthic invertebrate data, including coral taxa, as part of their normal duties. Thus, the observed trawl effort and coral catch data described here indicate a wider range of targets (and trawl gear), depths, and areas for which protected corals are at risk from commercial trawling. The spatial extent of the observed effort provides a defined range in which any coral distribution can be described using these data.

Coral catches were reported from a wide range of depths, but the majority of coral catches were from depths of 800–1000 m. The fishery areas of highest risk to protected corals, as shown by this 3-year dataset, were the underwater topographic feature (UTF) focused, deepwater fisheries for: (1) orange roughy on the northern and southern slopes of the Chatham Rise, and southeast of the Wanganella Bank in northeast waters of the EEZ; and (2) oreo species east of the Pukaki Rise and on the Macquarie Ridge. The bottom trawl gear and fishing strategies used by deepwater vessels in these areas are likely to be similar. Coral catches in these areas were the highest recorded by observers, with up to 15 t of stony branching coral reported in a tow east of Pukaki Rise, and more than one coral group per tow often reported from these areas. The coral catch from the orange roughy fishery on the Chatham Rise included mainly black corals, stony branching and cup corals, and coral rubble, with relatively smaller catches of bubblegum coral, precious coral, other gorgonians such as primniods or plexaurids, and hydrocoral. The same main groups were also recorded from the oreo fishery effort east of Pukaki Rise; but with more bubblegum coral catches and fewer and smaller catches of stony cup corals, and relatively larger catches of precious corals and hydrocorals reported from this fishery area compared to the orange roughy effort on the Chatham Rise. All of the nine coral groups except hydrocorals were recorded from the oreo fishing effort on the Macquarie Ridge fishing. The protected coral catch from the orange roughy fishery southeast of the Wanganella Bank (within the EEZ) included black coral, stony branching coral, stony cup coral, gorgonian coral, and bamboo coral. Relatively high catches of protected coral, and the catching of the majority of the main coral groups, most likely reflects the optimum environmental conditions that occur for deepwater corals at these fishery depths (e.g. scleractinians, Tittensor et al. 2009) and the targeting of habitat particularly suitable for corals (i.e. UTFs) (Clark et al 2006, Clark & Tittensor 2010).

For some fishery areas, such as off the west coast of the New Zealand mainland, few protected coral were recorded, despite large numbers of observed tows. The fisheries here, for hoki and jack mackerel, occur largely in waters shallower than about 500 m. For hoki targeted off the South Island west coast, bottom trawl nets and midwater trawl nets are used; the latter fished very close to the seafloor. Coral catch records from this fishery were only reported from the western edge of the fishing effort close to the 500 m contour. For jack mackerel, vessels will fish with the net in the water column, and generally in relatively shallow water. Low catches in these depths may be due to the lack of protected corals in the area, a very low catchability if they are present, poor retention in the net, or a low detection rate by the observer. A relative lack of corals could reflect the true distribution of protected corals e.g., lack of suitable bottom type for species to attach, or physico-chemical parameters such as temperature limit distribution (Tracey et al. 2011), or that coral on the seafloor may have been removed through fishing activity (Koslow et al 2001, O'Driscoll & Clark 2003, Clark & Rowden 2009).

The distributions of some coral groups (as indicated by these observer data), whilst they are limited in their geographic extent by their preferred depth range, indicate that fisheries may have a more limited effect on one coral group than on others. For example, black corals were not recorded for any fishing effort on the western Chatham Rise, and on just a few tows in other areas where middle depths fisheries are conducted. Along the northern Chatham Rise, there were no records of bubblegum corals, and gorgonian and bamboo corals were restricted to the known seamount areas.

In deeper waters, orange roughy targeted tows caught all coral groups except precious corals; black and smooth oreo tows caught all coral groups; and black cardinalfish tows caught all coral groups except precious corals and hydrocorals. For the middle depth fisheries, hoki tows off the east coast South Island and the Stewart-Snares shelf caught mostly stony cup corals. There were few catches of bubblegum and bamboo corals and no records of black corals, precious corals, or hydrocorals from middle depth tows. Alfonsino targeted tows in 250–730 m north of 44° S caught al l coral groups except stony cup corals, precious corals, and hydrocorals. Scampi tows in 300–500 m on the western edge of northern Chatham Rise and East Coast North Island recorded corals belonging to the three stony coral groups. Tows in other scampi fishery areas (the Bay of Plenty and the south eastern edge of the Auckland Islands Shelf) had no records of coral catch. Trawls targeting squid in 100–400 m from the edge of the Stewart-Snares shelf and Auckland Island Shelf (north and southeast) produced the occasional catch that had representatives of all coral groups except bubblegum, precious corals, and hydrocorals. Jack mackerel tows in the shallower depths (80–140 m) both south and north of the Taranaki Bight, caught black corals, gorgonian corals, and scleractinian coral rubble.

Thus, certain target fishery areas showed a more diverse coral catch and higher estimated catch weights. These areas are generally fished by few vessels compared with the effort in middle depths fisheries (see Baird et al. 2011). It could be argued that all fishery areas with coral catch records indicate areas where protected corals are at risk from mobile fishing gear, and the importance of these areas, in terms of fishing being a risk to coral populations, will depend on the whatever coral taxon is present and the perceived or confirmed understanding of the vulnerability of the local and the wider coral population.

4.1.1 Verified coral distribution data

The larger dataset used to plot the grouped coral codes for verified and non-verified records adds to our understanding of the coral groups found in the region and their locality in relation to fishing effort. The verified dataset provides accurate spatial distribution information to lowest taxonomic level, often down to genus or species (there are around 30 different genera or species represented in the dataset, Appendix 1).

Although many corals caught during fishing are not able to be identified to a genus, the existence of verified identifications from returned samples provides some knowledge of the diversity and the extent of different coral families or genera within the main coral groups. For the black coral for example, *Bathypathes* was reported for tows in 600 -1200 m, particularly on seamounts such as the Andes complex southeast of the Chatham Islands, as well as in drop-offs east of the Pukaki Rise. Whilst it is very difficult for an observer to identify these black corals to a specific genus, this verified information provides a fuller description of the distribution of black corals that are obviously vulnerable to capture.

Unlike most of the other protected corals, stony cup corals were recorded from all depths. The largest catches (by weight) of cup corals were from the seamounts southeast of the Chatham Islands; these corals were verified as *Desmophyllum dianthus*, which had a wide depth and geographic distribution. In comparison, another cup coral, *Flabellum*, was returned only from tows in 400-600 m on the slope of the Chatham Rise, Stewart-Snares shelf, and Auckland Islands Shelf.

Catch records for gorgonians suggest a wide range, both in latitude and depth, including from the waters west of the New Zealand mainland. Unfortunately, no samples were required for verification of identification from these tows because they were in middle depths fisheries.

Some areas with coral catch records, particularly in northern waters within the EEZ, had few or no samples returned, perhaps because of the instructions to observers. This limited a fuller description of the distribution by lower coral taxonomic level for those caught during alfonsino, black cardinalfish, and orange roughy tows in northern waters.

4.2 Accuracy assessment

Observer data provide a very valuable source of information when investigating protected coral by-catch in the New Zealand region, but it is important to assess the reliability of these data-specifically the level of accuracy of the observer identifications.

The proportion of data able to be used directly to measure accuracy of the observer identifications was good (545 records categorised as code 3). While noting that there were limitations in the remaining dataset that restricted its use to measure accuracy, important information was also provided from the records categorised as code1 or 2. The 80 samples categorised as code 1 highlighted a mis-use of codes and labelling issues and shows a need for an improvement in data recording. Samples categorised as code 1 also showed the need for a method to accommodate recording corals associated with another coral, e.g., a stony cup coral attached to a stony branching coral. The high proportion of data categorised as code 2 (227 records) highlights the importance of having experts able to identify samples to a lower taxonomic level and so enhance the dataset available to provide distribution maps of deep-sea protected corals for the region.

Once it was ascertained what records could be directly compared (code 3), accuracy was assessed at two levels, by coral codes (Level A) and at a higher taxonomic level of grouped codes (Level B). Accurate identification by the observers of the corals to the three letter code was low. Overall, 54% of identifications at this level were wrong. Identification to species level by observers had a low level of accuracy, particularly for the identifications for the four stony branching coral species (e.g. *Solenosmilia variablis*, where 90% were wrong). This latter result is perhaps not surprising, as identifying branching stony corals to species level is difficult. Identification of hydrocorals (and hydroids) by the observers was also poor, although the small sample sizes indicate this is probably a lesser problem overall. It is also clear from the results that it would have been more appropriate if the observers had used a higher taxonomic level for bamboo corals (ISI), rather than species codes such ACN (*Acanella* spp.).

The results of the level B accuracy analysis show that observer identifications across all coral groups was, overall, reasonably accurate (78% correct). However, the level of accuracy achievable depended on the taxonomic group. For black corals and stony cup and branching corals identification accuracy was high (>85% correct). Certain gorgonian corals (those excluding the accurate identifications of the bamboo and bubblegum corals) were often identified incorrectly (70% wrong). High numbers of gorgonian corals were confused with either soft corals or black corals. Only a few hydrocorals records were compared (n=10), with an identification error of 50%. In a similar study of observer identifications for VME taxa in the Ross Sea fishery (Tracey et al. 2010), observer identifications were reasonably accurate (overall, 88% correct), however, here there was also a problem in distinguishing hydrocorals.

There has been considerable effort over the years to improve at-sea identifications of protected coral species, with the production of the Coral Identification Guide (Tracey et al. 2008). More recently, in collaboration with DOC and MFish, NIWA has provided tools such as coral specimens, improved label design, and additional text to help improve identifications (K. Ramm, D. Bilton, D. Tracey, D. Stotter July 2010). An update to ‘A guide to common deepsea invertebrates in New Zealand waters (Tracey et al. 2007) is also underway (MFish Project ZBD201039). This publication will provide additional sheets for deep-sea coral families to help improve at-sea identification.

Despite the best efforts to improve at-sea identification by observers, the results of the accuracy analysis show there was low level of accuracy for some coral groups and species. While the observers are encouraged to identify corals to species level if they are confident in their identification (see Invertebrate Guide Instructions to Observers (Tracey et al. 2007)), it is now clear that their confidence at this level can be misplaced.

This finding highlights the caution required when interpreting observer data. Clearly continued sample collection is important to verify identifications, both as a means to ground truth the observer data but to also help identify measures to improve future identifications and improve overall accuracy.

There are certain limitations with the use of observer data to describe coral distribution. Fishing gear is not an efficient tool for quantitatively sampling fragile organisms such as corals. Observer data come from an uneven sampling effort and are not specifically designed to measure coral distribution in relation to fishing effort. Identification and taxonomic consistency are often a major problem with deepsea data sets and some inconsistencies in the way data are recorded at sea are noted in the report. However the data do provide good information on spatial distribution for protected coral groups for the region, particularly for grouped species, and to a high level of accuracy when using returned ground-truthed coral samples.

5 Recommendations

The results of the present research can be used to identify a number of actions that can serve to achieve a better understanding of where protected deepwater corals are most at risk from interactions with the fishery, and what can be done to improve the reliability of observer bycatch data that is used to monitor these interactions. Below these actions are listed as a series of recommendations.

5.1 Assessing the interaction between the fishery and protected deepwater corals

(a) Observer coral bycatch data from this project should be combined with earlier observer data (particularly the samples verified by Sanchez (Tracey 2010c)), and scientific research data from biodiversity and research trawl surveys, to obtain a better understanding of the distribution of protected corals. The observer-based distributions contribute to the wider knowledge base of coral distribution in New Zealand waters.

These can be used with published accounts of coral occurrence to more fully describe the true distribution of a coral. For example, Sanchez (2005), Consalvey et al. (2006), Sanchez et al. (2008) and Tracey et al. (2011) show additional regions where these groups are found. Tracey et al. (2011) combined historical research data, trawl, observer, and biodiversity survey records, to determine the distribution of habitat forming stony corals in the New Zealand region. Their data show a wider geographic distribution and depth range for the four stony branching corals species than presented in this report. The species geographic extent includes the Kermadec Ridge, south Macquarie Ridge, Challenger Plateau, and north and south Chatham Rise. Depths ranged from 90 m to a maximum of 2850 m. The report by Consalvey et al. (2006) shows wider geographic distributions for black corals where records are also shown to occur in abundance in Fiordland, in the northern region of the Kermadec Ridge, and on the western edges of the Chatham Rise, and for bubblegum corals distribution plots that samples also occur on the North Chatham Rise, the observer records were only from the south Chatham Rise in this report.

(b) Future investigations could include statistical analyses to quantify the interaction between fishing and the incidental catch of corals. Such an analysis may provide a measure of the interaction, and allow an assessment of how this interaction may change over time (assuming data continue to be collected).

5.2 Improving identification accuracy by observers

(a) Some descriptions of corals in the Coral Identification Guide (Tracey et al. 2008) need to be updated (as well new coral codes included) to assist observers improve the accuracy of their identifications.

(b) More expert participation in the identification and recording briefings given to observers needs to take place. This could include: - identification of all invertebrates, not just the protected corals; providing clearer and targeted instructions on specimen identification, what samples to retain, and what to record on the benthic forms and labels. An emphasis during the briefing on the appropriate taxonomic level to record for difficult to identify species will reduce the proportion of misidentifications.

(c) - Clearer instructions to observers on sub-sampling to enable the use of more records in any future analysis. For example, at the data grooming level, there were some issues with apportioning realistic weights when reloading weight data from *cod* with the ground-truthed expert identifications. If the observer has not provided proportions of the various corals in the catch for the estimated catch weight, the instructions provided by RDM MFish (detailed in the Methods and results section) are followed to apportion the weights and load the data. When a large amount of coral by-catch is taken, the apportioning weight method can at times produce unrealistically high proportions for some species.

(d) Samples need to be collected and returned for expert identification (and ideally molecular verification). These samples are important to monitor the reliability of the observer data (improvements or declines).

Additional recommendation

Incidences of fauna associated with protected coral, such as ophiuroids and polychaetes, have been recorded in the NIWA OSD database comments field. There are insufficient data to investigate these associations because species association information has not been routinely recorded. It would be useful to have an "association" species code that could be used by observers on the MFish Benthic Materials Form.

There are certain limitations with the use of observer data to describe coral distribution. Fishing gear is not an efficient tool for quantitatively sampling fragile organisms such as corals. Observer data come from an uneven sampling effort and are not specifically designed to measure coral distribution in relation to fishing effort. Therefore future research should be specifically designed to address the issue of the interaction between fishing and corals.

6 Acknowledgements

Thanks are extended to the CSP observers for sample collection, NIWA staff who helped produce the datasets by processing returned samples from the earlier projects including Dean Stotter and Mark Fenwick, Kareen Schnabel NIWA Collections Manager, Lynda Griggs for helping resolve data issues. We thank expert international taxonomists particularly Juan Sanchez and Stephen Cairns, and MFish Research Data Manager Craig Loveridge for approving the data extracts from *cod* and for providing Trawl Trip Reports. We also thank Ashley Rowden (NIWA) for providing a detailed and constructive review of this report. Finally we acknowledge the Marine Conservation Services for funding under Project: MCSINT 2010/03 (NIWA DOC11302) and for their ongoing support of this project.

7 References

Althaus, F., Williams, A., Schlacher, T.A., Kloser, R.J.; Green, M. A.; Barker, B. A.; Bax, N. J.; Brodie, P.; Schlacher-Hoenlinger, M. A. (2009). Impacts of bottom trawling on deep-coral ecosystems of seamounts are long-lasting. *Marine Ecology Progress Series 397*: 279–294.

Anderson, O.F., Clark, M.R. (2003). Analysis of bycatch in the fishery for orange roughy *Hoplostethus atlanticus*, on the South Tasman Rise. *Marine & Freshwater Research 54*: 643–652.

Baird, S.J., Wood, B.A., Bagley, N.W. (2011). Nature and extent of commercial fishing effort on or near the seafloor within the New Zealand 200 n. mile Exclusive Economic Zone, 1989–90 to 2004–05. *New Zealand Aquatic Environment and Biodiversity Report No. 73*. 144 p.

Cairns, S.D., Gershwin, L.-A., Brook, F.J., Pugh, P, Dawson, E.W., Ocaña, O., Vervoort, W., Williams, G., Watson, J.E., Opresko, D.M., Schuchert, P., Hine, P.M., Gordon, D.P., Campbell, H.J., Wright, A.J., Sánchez, J.A., Fautin, D.G. (2009). Phylum Cnidaria - corals, medusae, hydroids, myxozoans. Pp. 59-101 in: Gordon, D.P. (ed.), New Zealand Inventory of Biodiversity. Volume 1. Kingdom Animalia: Radiata, Lophotrochozoa, Deuterostomia. Canterbury University Press, Christchurch. 568 + [16] p.

Clark, M. R. (1999) Fisheries for orange roughy (*Hoplostethus atlanticus*) on seamounts in New Zealand*. Oceanologica Acta 22*, 593–602.

Clark, M.R., Rowden, A.A. (2009). Effect of deepwater trawling on the macro-invertebrate assemblages of seamounts on the Chatham Rise, New Zealand. *Deep-Sea Research I 56*:1540–1544.

Clark, M.R., Tittensor, D.P. (2010). An index to assess the risk to stony corals from bottom trawling on seamounts. *Mar Ecol 31(Suppl 1):*200–211.

Consalvey, M., MacKay, K., Tracey, D. (2006). Information review for protected deep-sea coral species in the New Zealand region. NIWA Client Report prepared for Department of Conservation. WLG2006-85. 60 p.

Dunn, M.R., Anderson, O.F., McKenzie, A. (2008). Descriptive analysis of catch and effort data from New Zealand orange roughy fisheries in ORH 1, 2A, 2B, 3A, 3B, and 7B to the end of the 2005-06 fishing year. *New Zealand Fisheries Assessment Report 2008/22*. 76 p.

Koslow,J.A., Gowlett-Holmes, K., Lowry, J.K., O'Hara, T., Poore, G.C.B., Williams, A. (2001). Seamount benthic macrofauna off southern Tasmania: community structure and impacts of trawling. *Marine Ecology Progress Series 213*:111–125

Ministry of Fisheries (2008). Bottom Fishery Impact Assessment. Bottom Fishing Activities by New Zealand Vessels Fishing in the High Seas in the SPRFMO Area during 2008 and 2009. Ministry of Fisheries. 102 p. [Available at http://www.fish.govt.nz.]

Mormede, S. (2010). Feature by feature catch and effort analysis of the ORH 1 fishery to the end of the 2007–08 fishing year. *New Zealand Fisheries Assessment Report 2010/28.*13 p. plus appendices.

Parker, S.J., Mormede, S. Tracey D., Carter, M. (2009a). Evaluation of VME taxa monitoring by scientific observers from New Zealand in the Ross Sea Antarctic toothfish longline fishery during the 2008-09 season. Document WG-TASO 09/08. CCAMLR, Hobart, Australia. 13p.

Parker, S. J., Penney, A.J., Clark, M.R. (2009b). Detection criteria for managing trawl impacts to Vulnerable Marine Ecosystems in high seas fisheries of the South Pacific Ocean. *Marine Ecology Progress Series 397*: 309–317.

Roberts, J.M., Wheeler, A.J., Freiwald, A., Cairns, S. (2009). Coldwater corals. The biology and geology of deep-sea coral habitats. Cambridge University Press, Cambridge.

Rogers, A.D., Baco, A., Griffiths, H., Hall-Spencer, J.M. (2007). Corals on seamounts, pp 141–169*. In*: Pitcher TJ, Hart PJB, Morato T, Santos R, Clark M (eds) Seamounts: ecology, fisheries and conservation. Blackwell Publishing Fisheries and Aquatic Resources Series. Blackwell Scientific, Oxford.

Reveillaud, J., Freiwald, A., Van Rooij, D., Le Guilloux, E.; Altuna, A.; Foubert, A.; Vanreusel, A.; Karine, O.; Henriet, J. (2008). The distribution of scleractinian corals in the Bay of Biscay, NE Atlantic*. Facies 54(3):*317–331.

Rowe, S., Tracey, D. (2008). Assessing the Incidental Catch of Corals in New Zealand Fisheries. Presentation to the Deepsea Coral Symposium 2008. Theme: Management Decisions and Policy for Corals, Conservation and Human Impacts. 1 p.

Sánchez, J.A. (2005). Systematics of the bubblegum corals (Cnidaria: Octocorallia: Paragorgiidae) with description of new species from New Zealand and the Eastern Pacific. *Zootaxa 1014*: 1–72.

Sánchez, J., Dueñas, L., Tracey, D. (2008). Systematics and Distribution of Deep-Sea Bamboo Corals (Octocorallia: Isididae) in New Zealand Waters. Presentation to the Deepsea Coral Symposium 2008. Theme: Systematics and Biogeography. 1 p.

Tittensor, D.P., Baco, A.R., Brewin, P.E., Clark, M.R., Consalvey, M., Spencer, J.H., Rowden, A.A., Schlacher, T., Stocks, K.I., Rogers, A.D. (2009) Predicting global habitat suitability for stony corals on seamounts *Journal of Biogeography (J. Biogeogr.)* 18 p.

Townsend, A., de Lange, P., Duffy, C., Miskelly, C., Molloy, J., Norton, D. (2008). New Zealand Threat Classification System Manual. Department of Conservation. DOCDM-508603: Natural heritage Immediate Outcomes and Objectives – Final version 2011.

Tracey, D. (2008). Progress report to the Department of Conservation Te Papa Atawhai. Identification of protected corals. 22 p.

Tracey, D. (2009). Final Research Report to the Department of Conservation Te Papa Atawhai. Identification of protected corals. 11 p.

Tracey, D. (2010a). Progress Report for Marine Conservation Services (CSP), Department of Conservation | Te Papa Atawhai. 2 p.

Tracey, D. (2010b). Identification of Protected Corals. NIWA Client Report: WLG2010-07. Prepared for Marine Conservation Services, Department of Conservation. 11 p.

Tracey, D. (2010c). Identification of Protected corals: Visiting coral taxonomist and processing scientific observer deepsea coral bycatch samples – DOC10301. . NIWA Client Report: WLG2010-43. Prepared for Marine Conservation Services, Department of Conservation. 5 p.

Tracey, D.M.; Anderson, O.F.; Naylor, J. R. (Comps.) (2007). A guide to common deepsea invertebrates in New Zealand waters. *New Zealand Aquatic Environment and Biodiversity Report No*. 10. 282 p.

Tracey, D., Carter, M., Parker, S. (2010). Evaluation of VME taxa monitoring by scientific observers. Final Research Report for Ministry of Fisheries Research Project ANT2009/01 Objective 8. 17 p.

Tracey, D., Consalvey, M., Mackay, K. (2008). New Zealand's protected corals: what do we know? Presentation to the Deepsea Coral Symposium 2008. Theme: Management Decisions and Policy for Corals, Conservation and Human Impacts. 1 p.

Tracey, D., Mackay, E., Gordon, D. Sanchez, J., Opresko, D. (2008). A Guide to Deepsea Coral. Report prepared for CSP Unit, Department of Conservation, DOC08309 Project (Objective 3). 15 p.

Tracey, D.; Mackay, E.; Gordon D.; Sanchez, J.; Opresko, D.; Rowe, S. (2008). Coral Identification Guide. Report prepared for CSP Unit, Department of Conservation, DOC08309 Project (Objective 3). 16 p.

Tracey, D., Rowden, A., Mackay, K., Compton, T. (2011). Habitat-forming coldwater corals show affinity for seamounts in the New Zealand region. *Marine Ecology Progress Series 430*: 1–22.

Tracey, D., Sanders, B. (2010). Updated coral identifications and subsequent loading into COD, – supplement report to (Tracey, 2010) prepared for Marine Conservation Services, Department of Conservation. 4 p.

Tracey, D., Sanders, B. (2011). Identification of Protected Corals. NIWA Client Report WLG2011-2 prepared for Marine Conservation Services, Department of Conservation | Te Papa Atawhai. 26 p.

8 Appendices

Appendices 1 to 5 below; Appendix 6 attached.

Appendix 1 Codes listed by group or species

Code	Common name	Scientific name	Family
Black corals			
ATP	Black coral	*Antipathes spp.*	Antipathidae
BTP	Black coral	***Bathypathes spp.***	Schizopathidae
CIR	Whip corals	***Cirrhipathes spp.***	Antipathidae
COB	Black coral	**Antipatharia (Order)**	
DEN	Black coral	***Dendrobathypathes spp.***	Schizopathidae
LEI	Leiopathes black coral	***Leiopathes spp.***	Leiopathidae
LIL	Black coral	*Lillipathes spp.*	Schizopathidae
LSE	Leiopathes black coral	***Leiopathes secunda***	Leiopathidae
PTP	Black coral	***Parantipathes spp.***	Schizopathidae
STI	Black coral	*Stichopathes spp.*	Antipathidae
TPT	Black coral	***Trissopathes spp.***	Cladopathidae
Stony corals - branching			
CBB	Coral rubble	**Scleractinia**	
CBD	Coral rubble - dead	**Scleractinia**	
CBR	Stony branching corals	**Scleractinia**	
ERO	Deepwater branching coral	***Enallopsammia rostrata***	Endrophylliidae
GDU	Bushy hard coral	***Goniocorella dumosa***	Caryophylliidae
MOC	Madrepora coral	***Madrepora oculata***	Oculinidae
OVI	Deepwater branching coral	*Oculina virgosa*	Oculinidae
SIA	Stony corals	**Scleractinia**	
SVA	Deepwater branching coral	***Solenosmilia variabilis***	Caryophylliidae
Stony cup corals			
CAY	Carnation cup coral	***Caryophyllia spp.***	Caryophylliidae
COF	Flabellum cup coral	*Flabellum spp.*	Flabellidae
CUP	Stony cup corals	Scleractinia	
DDI	Crested cup coral	***Desmophyllum dianthus***	Caryophylliidae
FUG	Fungiacyathus cup coral	*Fungiacyathus spp.*	Fungiacyathidae
JAA	Javania cup coral	*Javania spp.*	Flabellidae
STP	Solitary bowl coral	***Stephanocyathus platypus***	Caryophylliidae
STS	Solitary bowl coral	*Stephanocyathus spiniger*	Caryophylliidae
Gorgonian corals			
GOC	Gorgonian coral	**Gorgonacea (Order)**	
CHR	Golden coral	***Chrysogorgia spp.***	Chrysogorgiidae
CLG	Gorgonian coral	***Callogorgia spp.***	Primnoidae
CTP	Sea fan	***Calyptrophora spp.***	Primnoidae
IRI	Iridescent coral	***Iridogorgia spp.***	Chrysogorgiidae
MTL	Metallic coral	***Metallogorgia spp.***	Chrysogorgiidae
NAR	Rasta coral	***Narella spp.***	Primnoidae
PLE	Sea fan	**Plexauridae (Family)**	Plexauridae
PLL	Sea fan	***Plumarella spp.***	Primnoidae
PML	Sea fan	*Primnoella spp.*	Primnoidae
PMN	Sea fan	***Primnoa spp.***	Primnoidae
PRI	Sea fans	**Primnoidae**	Primnoidae
THO	Bottlebrush coral	***Thouarella spp.***	Primnoidae
TRH	Plexaurid coral	*Trachymuricea spp.*	Plexauridae
Precious coral			
CLL	Precious coral	***Corallium spp.***	Corallidae
Bamboo corals			
ACN	Bushy bamboo coral	***Acanella spp.***	Isididae
BOO	Bamboo coral	***Keratoisis spp.***	Isididae
ISI	Bamboo corals	**Isididae**	Isididae
LLE	Bamboo coral	***Lepidisis spp.***	Isididae
MIN	Worm-commensal bamboo coral	*Minuisis spp.*	Isididae
PAN	Bamboo bottlebrush coral	*Primnoisis antarctica*	Isididae
Bubblegum coral			
PAB	Bubblegum coral	***Paragorgia arborea***	Paragorgiidae
Hydrocorals			
COO	Conopora hydrocoral	*Conopora spp.*	Stylasteridae
COR	Hydrocorals	Stylasteridae (Family)	Stylasteridae
CRE	White hydrocoral	***Calyptopora reticulata***	Stylasteridae
CRY	Starry white hydro coral	*Cryptelia spp.*	Stylasteridae
ERR	Red hydrocoral	***Errina spp.***	Stylasteridae
LPP	Bushy lace coral	*Lepidopora spp.*	Stylasteridae
LPT	Spiny lace coral	***Lepidotheca spp.***	Stylasteridae
STL	Rose lace corals	*Stylaster spp.*	Stylasteridae
COU	Coral (unspecified)	**Alcyonacea**	

Bold text indicates the corals represented in the dataset.

Appendix 2 Summary of observed tow effort in 2007–08 to 2009–10

Table 2.1: Number of observed tows during 2007–08 to 2009–10, by target species and Fishery Management Area (FMA). Target species codes are given in Table B.2.

	FMA1	FMA2	FMA3	FMA4	FMA5	FMA6	FMA7	FMA8	FMA9	CET	HOWE	LOUR	WANB	Total
BAR	0	0	204	64	143	0	91	0	0	0	0	0	0	502
BAS	0	0	0	1	0	0	0	0	0	0	0	0	0	1
BNS	0	2	0	0	0	0	0	0	0	3	0	0	0	5
BOE	0	0	119	19	16	1 033	0	0	0	0	0	0	0	1 187
BYX	45	105	0	105	0	0	0	0	6	36	113	0	0	410
CDL	126	77	0	0	0	0	0	0	1	6	2	0	0	212
EMA	0	0	0	0	0	0	2	19	1	0	0	0	0	22
FRO	0	0	0	0	0	0	2	0	0	0	0	0	0	2
GUR	0	0	0	0	0	0	1	0	0	0	0	0	0	1
HAK	0	0	66	24	38	203	548	0	0	0	0	0	0	879
HOK	3	71	1 427	361	385	604	646	0	2	0	0	0	0	3 499
JMA	0	0	14	9	30	0	282	697	160	0	0	0	0	1 192
LIN	0	0	31	32	127	209	3	0	0	1	0	0	0	403
MDO	0	0	0	0	0	0	0	0	1	0	0	0	0	1
OEO	0	0	29	34	4	351	0	0	0	0	0	0	0	418
ORH	309	86	17	2977	2	253	151	0	367	567	484	293	420	5 926
RBT	0	0	0	0	13	0	0	0	0	0	0	0	0	13
RBY	18	10	0	0	0	0	0	0	0	0	0	0	0	28
SBO	0	0	0	0	0	0	0	0	1	0	0	0	0	1
SBW	0	0	0	0	0	320	0	0	0	0	0	0	0	320
SCH	0	0	0	0	0	0	0	0	2	0	0	0	0	2
SCI	361	167	3	489	0	246	0	0	0	0	0	0	0	1 266
SNA	0	0	0	0	0	0	0	0	51	0	0	0	0	51
SOR	0	0	0	0	0	0	0	0	0	1	1	0	0	2
SPD	0	0	19	0	0	0	0	0	0	0	0	0	0	19
SPE	0	0	0	1	0	0	0	0	0	0	0	0	0	1
SQU	0	0	23	1	1 778	1 208	0	0	0	0	0	0	0	3 010
SSO	0	1	275	540	8	465	0	0	0	0	0	0	0	1 289
STA	0	0	0	0	1	0	0	0	0	0	0	0	0	1
SWA	0	0	116	55	122	0	33	0	0	0	0	0	0	326
TAR	5	0	0	0	0	0	28	0	1	0	0	0	0	34
TRE	0	0	0	0	0	0	0	0	14	0	0	0	0	14
UNI	0	0	0	0	0	0	0	0	3	0	0	0	0	3
WAR	0	0	1	0	17	0	0	0	0	0	0	0	0	18
WWA	0	0	0	0	176	25	0	0	0	0	0	0	0	201
All	867	519	2 344	4 712	2 860	4 917	1 787	716	610	614	600	293	420	21 259

Table 2.2: Number of observed tows (excluding those with no catch records) by gear type, 2007–08 to 2009–10. BT is bottom trawl, MW is midwater trawl. The percentage of observed twos with coral bycatch is based on the species or family codes used by observers.

Target species			BT	MW	Total	% with coral
BAR	Barracouta	*Thysites atun*	90	412	502	0.6
BAS	Bass	*Polyprion americanus*	1	0	1	100.0
BNS	Bluenose	*Hyperoglyphe antarctica*	5	0	5	0.0
BOE	Black oreo	*Allocytus niger*	1 187	0	1 187	13.1
BYX	Alfonsino	*Beryx splendens*, *B. decadactylus*	300	110	410	8.3
CDL	Cardinal fish	*Epigonus telescopus*	212	0	212	15.1
EMA	English mackerel	*Scomber australasicus*	0	22	22	0.0
FRO	Frostfish	*Lepidopus caudatus*	0	2	2	0.0
GUR	Red gurnard	*Chelidonichthys kumu*	1	0	1	0.0
HAK	Hake	*Merluccius australis*	787	92	879	2.6
HOK	Hoki	*Macruronus novaezelandiae*	2 975	524	3 499	4.8
JMA	Jack mackerels	*Trachurus declivis*, *T. murphyi*, *T. novaezelandiae*	2	1 190	1 192	0.6
LIN	Ling	*Genypterus blacodes*	403	0	403	1.5
MDO	Mirror dory	*Zenopsis nebulosus*	1	0	1	100.0
OEO	Oreo species	See BOE, SOR, SSO	418	0	418	14.6
ORH	Orange roughy	*Hoplostethus atlanticus*	5 926	0	5 926	21.7
RBT	Redbait	*Emmelichthys nitidus*	0	13	13	0.0
RBY	Ruby fish	*Plagiogeneion rubiginosum*	1	27	28	0.0
SBO	Southern boarfish	*Pseudopentaceros richardsoni*	1	0	1	0.0
SBW	Southern blue whiting	*Micromesistius australis*	8	312	320	0.6
SCH	School shark	*Galeorhinus galeus*	2	0	2	0.0
SCI	Scampi	*Metanephrops challengeri*	1 266	0	1 266	5.1
SNA	Snapper	*Pagrus auratus*	51	0	51	0.0
SOR	Spiky oreo	*Neocyttus rhomboidalis*	2	0	2	50.0
SPD	Spiny dogfish	*Squalus acanthias*	19	0	19	0.0
SPE	Sea perch	*Helicolenus* spp.	1	0	1	0.0
SQU	Arrow squid	*Nototodarus sloanii*, *N. gouldi*	1 908	1 102	3 010	1.9
SSO	Smooth oreo	*Pseudocyttus maculatus*	1 289	0	1 289	14.8
STA	Giant stargazer	*Kathetostoma giganteum*	1	0	1	0.0
SWA	Silver warehou	*Seriolella punctata*	323	3	326	3.7
TAR	Tarakihi	*Nemadactylus macropterus*	34	0	34	0.0
TRE	Trevally	*Pseudocaranx dentex*	14	0	14	0.0
UNI	Unknown		3	0	3	33.3
WAR	Blue warehou	*Seriolella brama*	7	11	18	0.0
WWA	White warehou	*Seriolella caerulea*	198	3	201	2.5
All			17 435	3 824	21 259	9.9

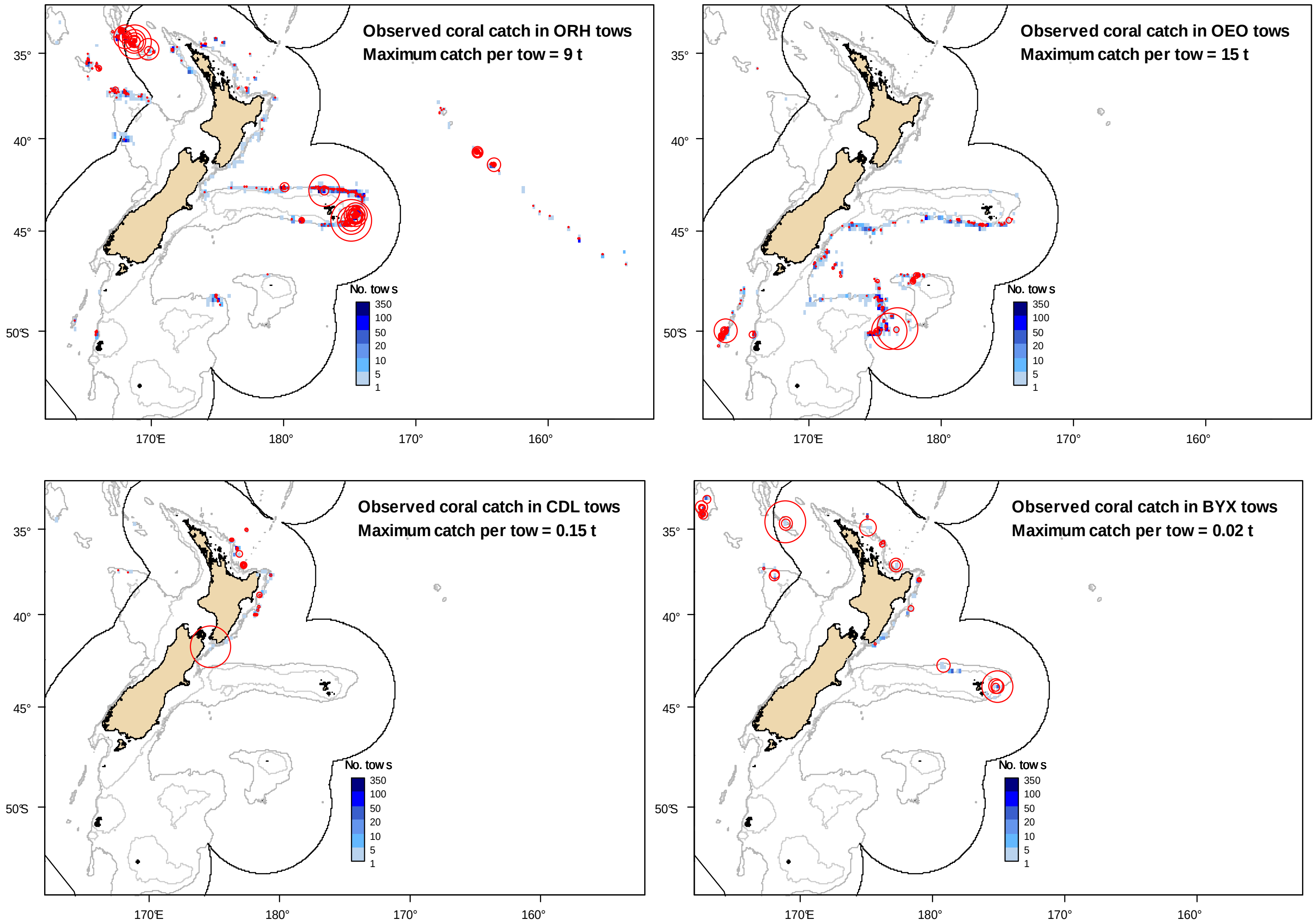

Figure 2.1: Distribution of observed tows in 0.2° latitude x 0.2° longitude cells, where orange roughy ORH, oreo species OEO, black cardinalfish CDL, and alfonsino BYX were targeted, for 2007–08 to 2009–10.

Appendix 2: — *continued*

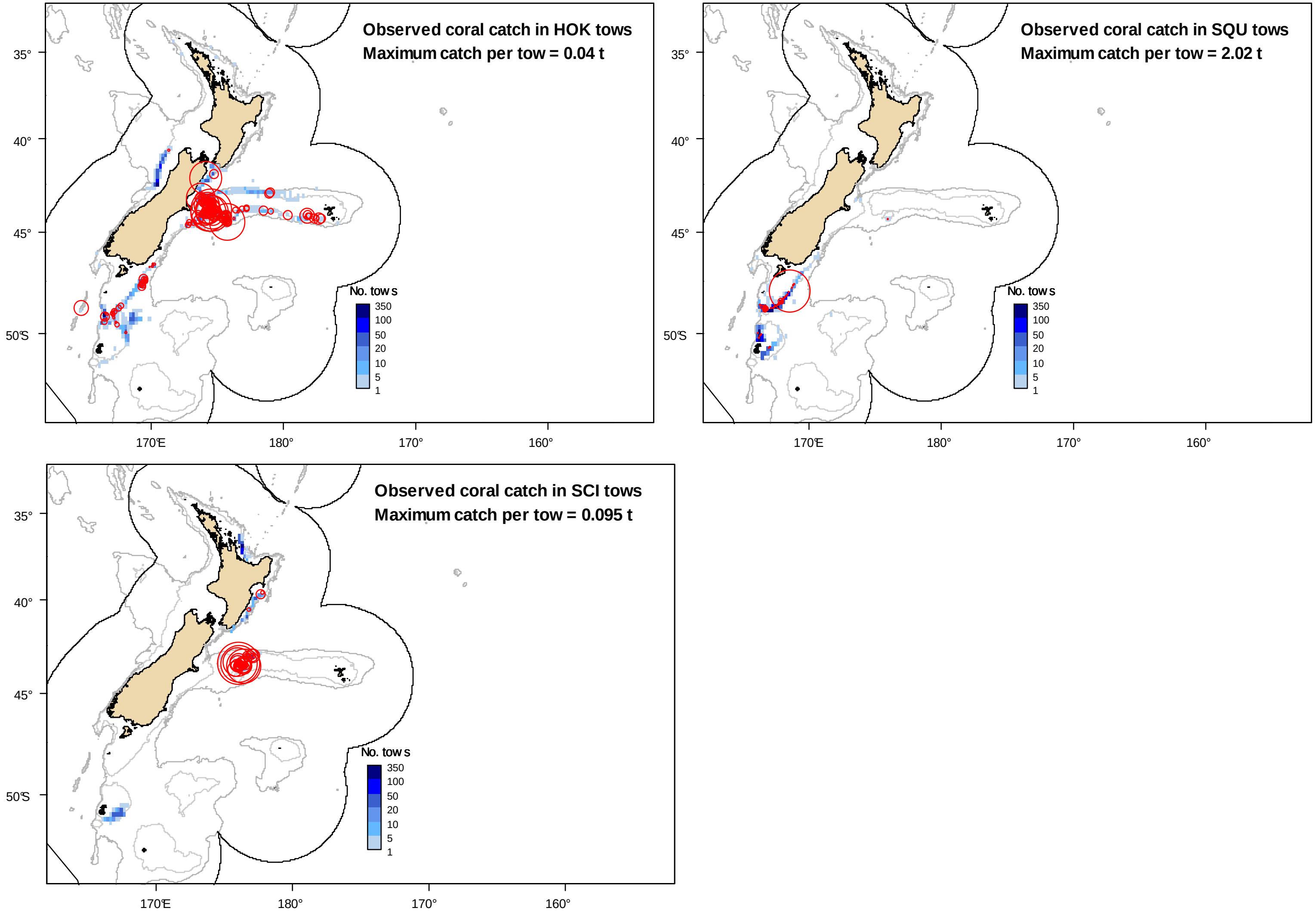

Figure 2.1 — continued: Distribution of observed tows in 0.2° latitude x 0.2° longitude cells, where h oki HOK, squid SQU, and scampi SCI were targeted, for 2007–08 to 2009–10.

Appendix 3 Observed coral catch weights by target fishery

Table 3.1: Number of observed tows, percentage of observed tows with catch of the main coral groups, and recorded weights for each group (where COB is black coral, SIA is unspecified stony coral, CBR is stony branching coral, and CUP is cup stony coral, as listed in Table 1), by target species code.

Code*	No. tows	% with COB	COB (kg)	% with SIA	SIA (kg)	% with CBR	CBR (kg)	% with CUP	CUP (kg)
BAR	502	0.0	0	0.0	0	0.0	0	0.2	100.0
BAS	1	0.0	0	0.0	0	0.0	0	0.0	0
BNS	5	0.0	0	0.0	0	0.0	0	0.0	0
BOE	1 187	1.9	14.4	0.3	14.0	5.2	1 042.9	0.6	45.4
BYX	410	7.3	9.3	1.0	13.2	2.5	4.3	0.0	0
CDL	212	10.4	26.2	0.0	0	2.4	159.0	0.9	2.0
EMA	22	0.0	0	0.0	0	0.0	0	0.0	0
FRO	2	0.0	0	0.0	0	0.0	0	0.0	0
GUR	1	0.0	0	0.0	0	0.0	0	0.0	0
HAK	879	0.1	10.0	0.0	0	0.0	0	2.2	17.4
HOK	3 499	0.0	0	0.1	46.0	0.1	5.0	4.1	336.8
JMA	1 192	0.1	1.0	0.1	5.0	0.0	0	0.0	0
LIN	403	0.0	0	0.0	0	0.0	0	0.5	0.6
MDO	1	0.0	0	0.0	0	0.0	0	0.0	0
OEO	418	0.5	2.0	3.1	669.4	5.0	70.5	0.7	1.0
ORH	5 926	4.7	260.0	6.4	36 179.6	6.5	22 389.2	2.3	3 592.8
RBT	13	0.0	0	0.0	0	0.0	0	0.0	0
RBY	28	0.0	0	0.0	0	0.0	0	0.0	0
SBO	1	0.0	0	0.0	0	0.0	0	0.0	0
SBW	320	0.0	0	0.0	0	0.0	0	0.0	0
SCH	3	0.0	0	0.0	0	0.0	0	0.0	0
SCI	1 265	0.0	0	1.4	26.9	1.3	94.4	1.5	42.0
SNA	51	0.0	0	0.0	0	0.0	0	0.0	0
SOR	2	50.0	1.0	0.0	0	50.0	1.0	0.0	0
SPD	19	0.0	0	0.0	0	0.0	0	0.0	0
SPE	1	0.0	0	0.0	0	0.0	0	0.0	0
SQU	3 010	0.1	6.0	0.3	2 073.3	0.1	1.2	0.0	0.3
SSO	1 289	1.0	10.7	0.2	181.0	5.7	34 269.8	0.9	563.2
STA	1	0.0	0	0.0	0	0.0	0	0.0	0
SWA	326	0.0	0	0.9	4.3	0.3	2.6	2.5	109.1
TAR	34	0.0	0	0.0	0	0.0	0	0.0	0
TRE	14	0.0	0	0.0	0	0.0	0	0.0	0
UNI	3	0.0	0	0.0	0	0.0	0	0.0	0
WAR	18	0.0	0	0.0	0	0.0	0	0.0	0
WWA	201	0.5	0.1	0.0	0	0.0	0	1.0	1.8
All	21 259	1.7	340.8	2.1	39 212.7	2.7	58 039.8	1.7	4 810.7

Target codes are given in Appendix 2.

Appendix 3: — *continued*

Table 3.2: Number of observed tows, percentage of observed tows with catch of the main coral groups, and recorded weights for each group (where GOC is gorgonian coral, ISI is bamboo coral, PAB is bubblegum coral, and COR is hydrocoral, as listed in Table 1), by target species code. The occurrence and catch of precious corals (CLL) is given below†.

Code*	No. tows	% with GOC	GOC (kg)	% with ISI	ISI (kg)	% with PAB	PAB (kg)	% with COR	COR (kg)
BAR	502	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
BAS	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BNS	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BOE	1 187	4.5	31.9	2.4	40.5	1.0	49.0	0.3	1.7
BYX	410	3.4	23.8	2.0	3.7	0.7	0.8	0.0	0.0
CDL	212	1.9	2.2	2.8	3.6	0.5	3.0	0.0	0.0
EMA	22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FRO	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GUR	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HAK	879	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0
HOK	3 499	0.4	9.7	0.1	7.0	0.0	23.0	0.0	0.0
JMA	1 192	0.4	4.7	0.0	0.0	0.0	0.0	0.0	0.0
LIN	403	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0
MDO	1	100.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
OEO	418	4.3	60.5	4.8	56.5	0.5	32.0	1.4	9.0
ORH	5 926	3.1	201.1	3.6	683.8	0.8	506.5	0.3	18.7
RBT	13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RBY	28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SBO	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SBW	320	0.0	0.0	0.0	0.0	0.6	3.0	0.0	0.0
SCH	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SCI	1 265	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SNA	51	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOR	2	50.0	1.0	50.0	1.0	0.0	0.0	0.0	0.0
SPD	19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SPE	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SQU	3 010	0.4	17.0	0.1	140.0	0.0	0.0	0.1	2.3
SSO	1 289	5.2	1021.3	3.5	132.8	3.6	1 498.9	0.2	2.2
STA	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SWA	326	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0
TAR	34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TRE	14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNI	3	33.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0
WAR	18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WWA	201	0.5	0.1	0.5	0.3	0.0	0.0	0.0	0.0
All	21 259	1.8	1373.8	1.6	1 069.7	0.6	2 116.2	0.2	33.9

* Target codes are given in Appendix 2.

† Under 0.1% of observed tows had records of precious coral (total of 13.6 kg), with 0.5% BOE tows (6.4 kg CLL), 0.1% of ORH tows (3.4 kg), and about 0.1% of SSO tows (3.8 kg).

Appendix 3: — *continued*

Table 3.3: Number of observed tows, percentage of observed tows with catch of the main coral groups, and recorded weights for each group (where COB is black coral, SIA is unspecified stony coral, CBR is stony branching coral, and CUP is cup stony coral, as listed in Table 1), by Fishery Management Areas (FMA) and areas outside the EEZ.

Area*	Total tows	% with COB	COB (kg)	% with SIA	SIA (kg)	% with CBR	CBR (kg)	% with CUP	CUP (kg)
FMA 1	867	5.7	39.3	0.1	5.0	1.4	46.5	0.1	0.2
FMA 2	519	1.3	6.4	0.0	0.0	1.2	159.1	0.6	3.0
FMA 3	2 344	0.0	0	0.2	56.2	0.5	55.8	5.0	408.3
FMA 4	4 712	1.5	98.5	2.0	16 677.0	2.9	14 384.8	3.2	4 093.3
FMA 5	2 860	0.1	5.4	0.3	2 073.3	0.1	18.8	0.6	11.0
FMA 6	4 917	0.7	26.0	0.4	877.9	2.9	35 183.6	0.3	243.4
FMA 7	1 787	0.1	10.0	0.0	0.0	0.0	0.0	0.9	15.1
FMA 8	716	0.1	1.0	0.1	5.0	0.0	0.0	0.0	0.0
FMA 9	610	6.1	44.4	6.2	14 641.6	14.1	7 795.8	0.3	0.3
CET	614	5.7	13.9	5.0	347.8	6.0	90.0	2.6	28.9
HOWE	600	14.2	75.6	3.2	81.7	9.3	129.8	1.7	5.2
LOUR	293	3.1	3.1	42.7	3 662.5	1.0	11.0	0.0	0.0
WANB	420	6.9	17.2	23.3	784.6	18.8	164.6	1.2	3.7
All	21 259	1.7	340.7	2.1	39 212.7	2.7	58 039.8	1.7	4 812.5

* Areas are shown in Figure 1.

Appendix 3: — *continued*

Table 3.4: Number of observed tows, percentage of observed tows with catch of the main coral groups, and recorded weights for each group ((where GOC is gorgonian coral, ISI is bamboo coral, PAB is bubblegum coral, and COR is hydrocoral, as listed in Table 1), by Fishery Management Areas (FMA) and areas outside the EEZ. The occurrence and catch of precious corals (CLL) is given below†.

Area*	Total tows	% with GOC	GOC (kg)	% with ISI	ISI (kg)	% with PAB	PAB (kg)	% with COR	COR (kg)
FMA1	867	3.0	9.7	8.4	58.3		0.0	0.0	0.0
FMA2	519	0.6	3.1	0.4	0.2	0.4	3.3	0.0	0.0
FMA3	2 344	1.1	332.9	0.8	80.3	0.2	36.0	0.0	0.0
FMA4	4 712	0.8	79.3	1.0	88.5	0.4	442.4	0.3	6.9
FMA5	2 860	0.7	20.4	0.2	140.3	0.0	0.0	0.1	2.1
FMA6	4 917	2.3	786.5	1.6	201.9	1.0	1 267.3	0.3	13.1
FMA7	1 787	0.4	5.9	0.1	0.2	0.0	0.0	0.0	0.0
FMA8	716	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FMA9	610	3.8	32.0	8.5	95.4	1.1	68.3	0.2	0.5
CET	614	1.6	3.7	1.0	3.4	0.3	0.4	0.3	1.3
HOWE	600	8.0	52.3	2.9	357.7	0.3	0.5	0.3	2.0
LOUR	293	3.8	16.3	0.3	0.3	0.0	0.0	0.0	0.0
WANB	420	11.9	31.6	6.5	43.1	7.1	298.0	0.2	8.0
All	21 259	1.8	1 373.8	1.6	1 069.7	0.6	2 116.2	0.2	33.9

* Areas are shown in Figure 1.

† Under 0.1% of observed tows had records of precious coral (total of 13.6 kg), with 0.05% of FMA 3 tows (3.8 kg CLL), 0.05% of FMA 4 tows (0.7 kg), 0.1% of FMA 6 tows (6.4 kg), 0.2% of CET tows (0.5 kg), and 0.7% of WANB tows (2.2 kg).

Appendix 4 Distribution of samples of protected corals whose identifications were verified

Sample identifications

Samples of “coral” bycatch were returned from 501 observed tows, 455 of which targeted deepwater species. A total of 852 sample identifications of benthic taxa resulted from this data collection and the 733 samples that represented the main coral groups were returned from 439 observed tows (Table 4.1). No samples of precious coral were returned. Table 4.2 gives the target fishery-area data that describe the broad collection locations for these samples. Sampled tows with catch of a specific coral group generally had samples just of that coral group or of the group and one other (Figure 4.1). At least one sampled tow per coral group returned a combination with other coral groups, apart from bubblegum and hydrocorals, which were not sampled together (Figure 4.2).

The distribution of the tow start locations associated with these verified samples is described below under the coral group headings given in Table 1.Most samples were from FMAs 4 & 6 (see Table 4.2). Few samples were returned from the observed effort off the east coast of the North Island in FMAs 1 & 2, from where observers recorded coral catches.

Table 4.1: Number of sample identifications for the main protected coral groups listed in Table 1 from data collected and returned from observed trawl trips, by target species, for 2007–08 to 2009–10. The target species are shown in Appendix 2.

	Coral groups							
Target code	Black	Stony branching	Stony cup	Bamboo	Bubblegum	Gorgonian	Hydrocoral	All
BOE	11	20	6	13	5	37	0	92
BYX	1	1	0	0	1	2	0	5
HOK	0	0	6	0	1	3	0	10
LIN	0	0	1	0	0	0	0	1
OEO	2	31	3	10	1	28	6	81
ORH	54	135	58	34	4	53	8	346
SBW	0	0	0	0	1	0	0	1
SCI	0	0	1	0	0	0	0	1
SOR	0	0	0	0	0	1	0	1
SQU	0	0	0	0	0	0	3	3
SSO	11	66	10	36	25	41	2	191
WWA	0	0	0	1	0	0	0	1
All	79	253	85	94	38	165	19	733

Table 4.2: The number of sampled tows for each coral group by target and fishery area. [Species codes are given in Table 2.2 in Appendix 2. SOI is within FMA 6.]

	FMA 1	FMA 9	FMA2	FMA 7	FMA 3	FMA 4	SOI	FMA 5	FMA 6	CET	HOWE	LOUR	WANB	Total
Bamboo corals														
BOE	0	0	0	0	2	0	0	0	10	0	0	0	0	12
OEO	0	0	0	0	0	1	0	0	8	0	0	0	0	9
ORH	1	1	0	0	0	18	2	0	2	1	2	1	1	29
SSO	0	0	0	0	8	5	2	0	14	0	0	0	0	29
WWA	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Total	1	1	0	0	10	24	4	1	34	1	2	1	1	80
Black corals														
BOE	0	0	0	0	0	0	0	0	10	0	0	0	0	10
BYS	0	0	1	0	0	0	0	0	0	0	0	0	0	1
OEO	0	0	0	0	0	0	0	0	2	0	0	0	0	2
ORH	2	0	0	0	0	28	0	0	0	0	7	1	1	39
SSO	0	0	0	0	0	3	0	0	7	0	0	0	0	10
Total	2	0	1	0	0	31	0	0	19	0	7	1	1	62
Branching corals														
BOE	0	0	0	0	2	1	0	0	15	0	0	0	0	18
BYX	0	0	0	0	0	1	0	0	0	0	0	0	0	1
OEO	0	0	0	0	1	0	1	0	18	0	0	0	0	20
ORH	0	0	0	0	0	82	2	0	1	5	6	2	2	100
SSO	0	0	0	0	4	8	3	1	34	0	0	0	0	50
Total	0	0	0	0	7	92	6	1	68	5	6	2	2	189
Bubblegum corals														
BOE	0	0	0	0	0	2	0	0	3	0	0	0	0	5
BYX	0	0	0	0	0	0	0	0	0	0	1	0	0	0
HOK	0	0	0	0	1	0	0	0	0	0	0	0	0	1
OEO	0	0	0	0	0	0	0	0	1	0	0	0	0	1
ORH	0	0	0	0	0	4	0	0	0	0	0	0	0	4
SBW	0	0	0	0	0	0	0	0	1	0	0	0	0	1
SSO	0	0	0	0	0	6	0	0	17	0	0	0	0	23
Total	0	0	0	0	1	12	0	0	22	0	1	0	0	35
Cup corals														
BOE	0	0	0	0	2	2	0	0	2	0	0	0	0	6
HOK	0	0	0	0	4	1	0	1	0	0	0	0	0	6
LIN	0	0	0	0	0	0	0	0	1	0	0	0	0	1
OEO	0	0	0	0	0	0	0	0	3	0	0	0	0	3
ORH	1	0	0	0	0	45	0	0	0	2	1	0	1	50
SCI	0	0	0	0	0	1	0	0	0	0	0	0	0	1
SSO	0	0	0	0	1	2	0	0	6	0	0	0	0	9
Total	1	0	0	0	7	51	0	1	12	2	1	0	1	76
Gorgonian corals														
BOE	0	0	0	0	0	2	0	0	32	0	0	0	0	34
BYS	0	0	1	0	0	0	0	0	0	0	0	0	0	1
BYX	0	0	0	0	0	1	0	0	0	0	0	0	0	1
HOK	0	0	0	0	1	0	0	0	1	0	0	0	0	2
OEO	0	0	0	0	0	1	0	0	16	0	0	0	0	17
ORH	1	1	1	1	0	22	0	0	1	1	9	1	5	43
SOR	0	0	0	0	0	0	0	0	0	0	1	0	0	1
SSO	0	0	0	0	6	6	1	0	24	0	0	0	0	37
Total	1	1	2	1	7	32	1	0	74	1	10	1	5	136
Hydrocorals														
OEO	0	0	0	0	0	0	0	0	6	0	0	0	0	6
ORH	0	0	0	0	0	7	0	0	0	0	0	0	1	8
SQU	0	0	0	0	0	0	2	1	0	0	0	0	0	3
SSO	0	0	0	0	0	0	0	0	2	0	0	0	0	2
Total	0	0	0	0	0	7	2	1	8	0	0	0	1	19

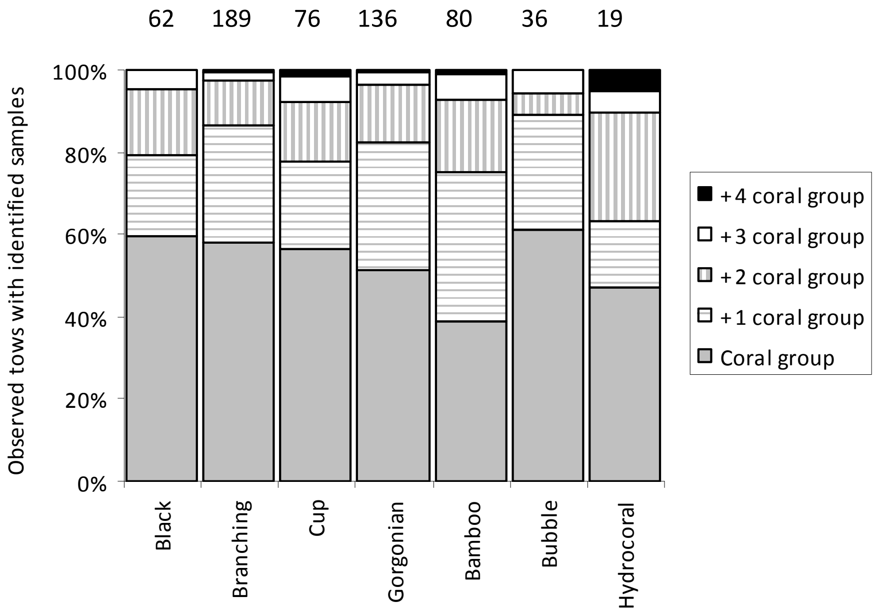

Figure 4.1: Percentage of the observed tows with verified samples by each main coral group. The number of tows with verified samples of the main coral groups is given above each main group.

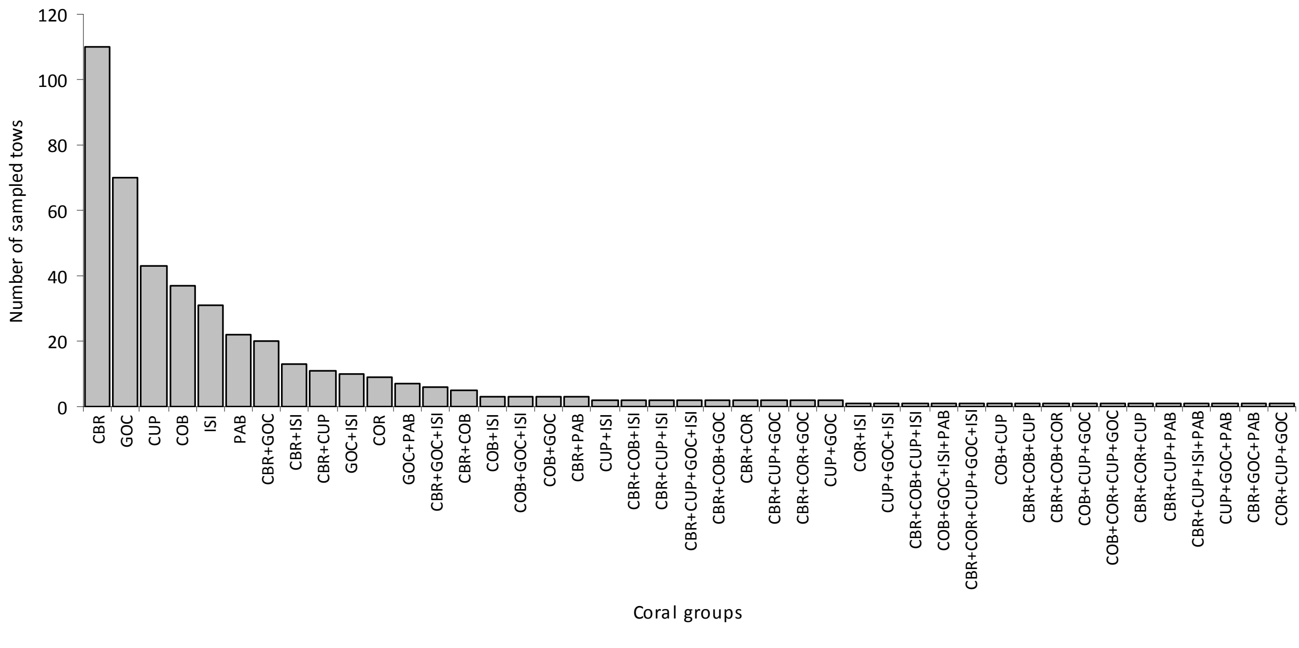

Figure 4.2: Presence of coral groups (individually and / or in combination with other groups) from sampled tows (n=439). Table 1 describes the coral group codes.

Black coral

Samples of black corals were returned from 62 observed tows that targeted oreo species, orange roughy, and alfonsino mainly from FMAs 3 and 4 on Chatham Rise and FMA 6 (Table 4.2) in known pinnacle or seamount fishery areas (Figure 4.3). Few tows in areas outside the EEZ returned black coral samples. The geographic extent of this distribution is bounded by latitudes 33.67° S and 50.3° S and longi tudes 163.5° E and 168° W (Figures 4.3–4.5). Most samples were from 800–1000 m depths (based on bottom depth at tow start locations), and the full range was from about 424 m (alfonsino tow in FMA 2) to 1429 m (smooth oreo tow in FMA 6).

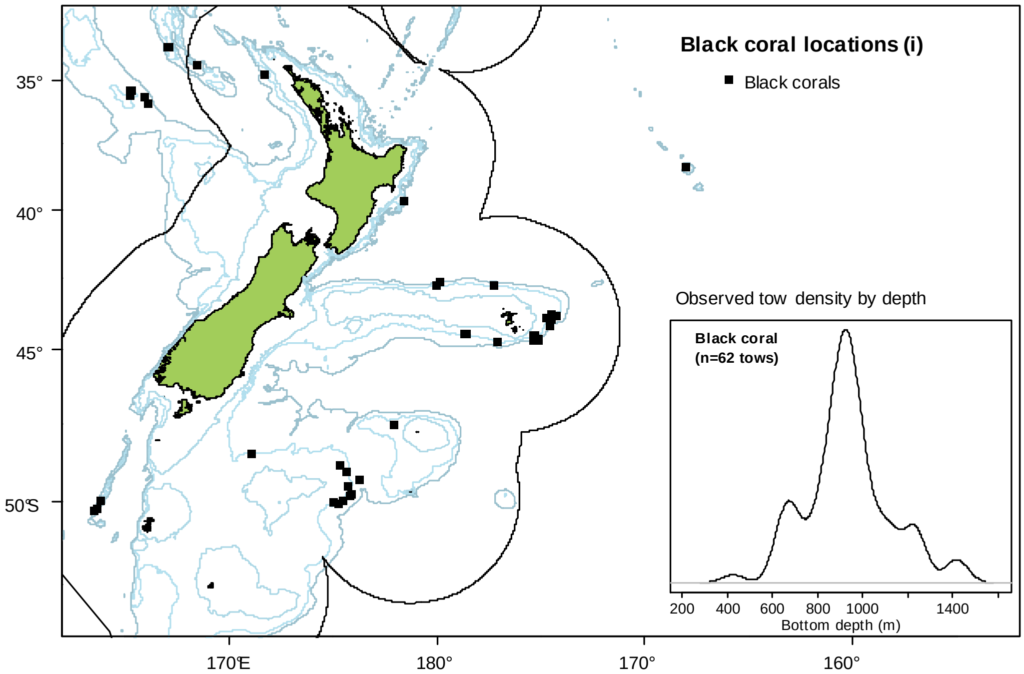

Figure 4.3: Locations and depth distribution of observed tows from which samples of black corals were returned, 2007–08 to 2009–10. The contours are at 500 m, 1000 m, and 1500 m.

Six genera and one species of black coral were identified in the samples (Table 4.2, Figures 4.4 & 4.5). Five identified genera were present in catches from FMA 4, three in FMA 6, and three on Lord Howe Rise, and of these *Bathypathes* was the genus for which there were the greatest number of samples. *Trissopathes* was returned only from Lord Howe Rise, as two samples. *Parantipathes* and *Cirrhipathes* were returned only from waters south of 42° S.

Table 4.3: Number of observed tows with returned samples of black corals (to the lowest taxonomic level possible), by reported target species and fishery area.

	Fishery Management Area								Outside the EEZ				
	1	2	3	4	5	6	7	9	CET	HOWE	LOUR	WANB	Total
Antipatharia													
Oreos						2							2
Black oreo						4							4
Smooth oreo				1		6							7
Orange roughy				13						5		1	19
***Bathypathes* spp.**													
Black oreo						2							2
Smooth oreo				1		1							2
Orange roughy				13							2		15
***Cirrhipathes* spp.**													
Orange roughy				1									1
***Dendrobathypathes* spp.**													
Orange roughy								1					1
Smooth oreo						1							1
***Leiopathes* spp.**													
Alfonsino		1											1
Orange roughy				5						2	1		8
Leiopathes secunda													
Orange roughy				4				1					5
***Parantipathes* spp.**													
Black oreo						5							5
Smooth oreo				1									1
Orange roughy				3									3
***Trissopathes* spp.**													
Orange roughy										2			2
Total	0	1	0	42	0	21	0	2	0	9	3	1	79

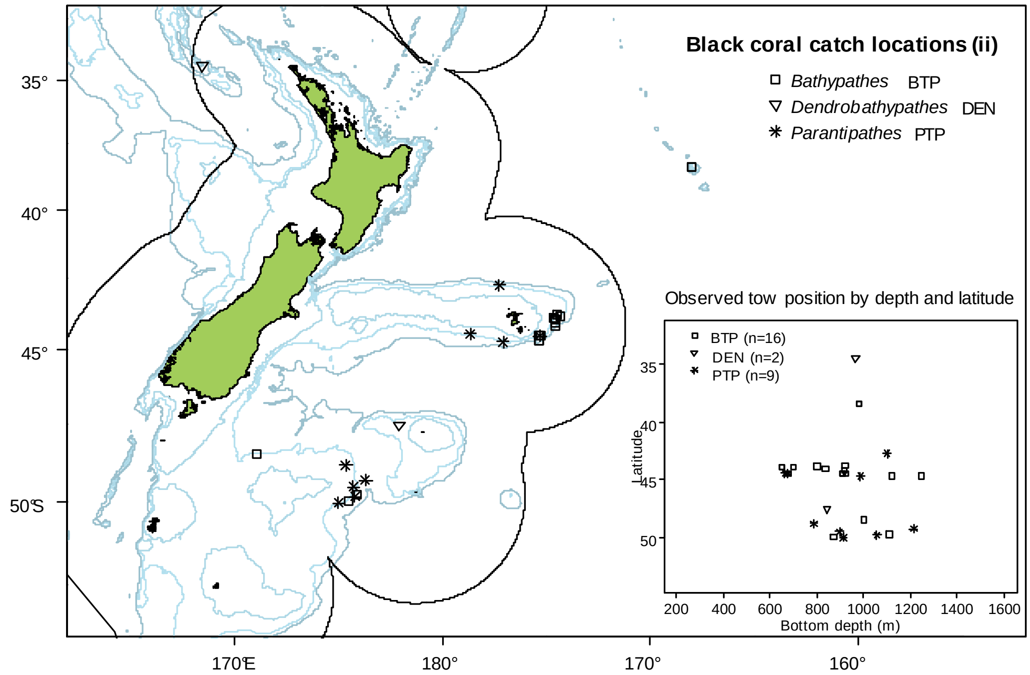

Figure 4.4: Locations and depth distribution of observed tows from which samples of three genera of black corals were returned, 2007–08 to 2009–10. The inset shows the depth distribution by latitude for each genus.

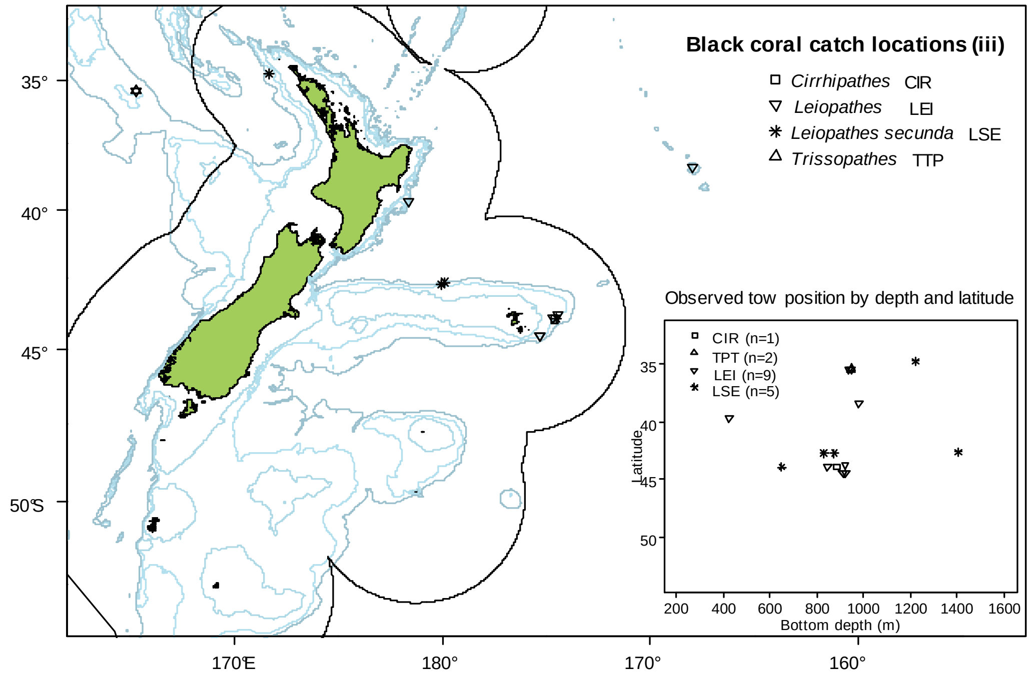

Figure 4.5: Locations and depth distribution of observed tows from which samples of another four genera of black corals were returned, 2007–08 to 2009–10. The inset shows the depth distribution by latitude for each genus or species.

Stony branching coral

Stony branching corals were returned from 189 observed tows, and most of these tows were in depths of 800–1400 m in waters east of New Zealand and south of about 42°S, in known deepwater fishery areas based on seafloor features. The remainder of samples were from outside the EEZ on the Louisville Ridge and to the northwest on the Lord Howe Rise, northwestern slope of the Challenger Plateau, and Wanganella Bank (Figure 4.6). None were returned from observed tows in northern New Zealand waters.

The extent of the distribution of the four identified species varied, with the most prevalent species (*Solenosmilia variabilis*) and *Enallopsammia rostrata* identified from most areas with stony branching coral samples, *Goniocorella dumosa* and *Madrepora oculata* from eastern waters (Figures 4.7 & 4.8). The only stony branching coral identified from the Louisville Ridge was *S. variabilis*. The shallowest sample was of *G. dumosa* from an alfonsino tow in about 300 m.

Table 4.4: Number of observed tows with returned samples of stony branching corals (to the lowest taxonomic level possible), by reported target species and fishery area.

	Fishery Management Area								Outside the EEZ				
	1	2	3	4	5	6	7	9	CET	HOWE	LOUR	WANB	Total
Scleractinia													
Oreos						1							1
Orange roughy				5									5
Enallopsammia rostrata													
Oreos						1							1
Black oreo						4							4
Smooth oreo			3	1		3							7
Orange roughy				28					3	6			37
Goniocorella dumosa													
Oreos						1							1
Black oreo						1							1
Alfonsino				1									1
Smooth oreo				1		1							2
Orange roughy				7									7
Madrepora oculata													
Oreos			0	0		2							2
Black oreo			2	1		1							4
Smooth oreo			2	3		4							9
Orange roughy			0	15		0							15
Solemnosmilia variabilis													
Oreos			1			25							26
Black oreo						11							11
Smooth oreo			2	6	1	39							48
Orange roughy				62		3			2		2	2	71
Total	0	0	10	130	1	97	0	0	5	6	2	2	253

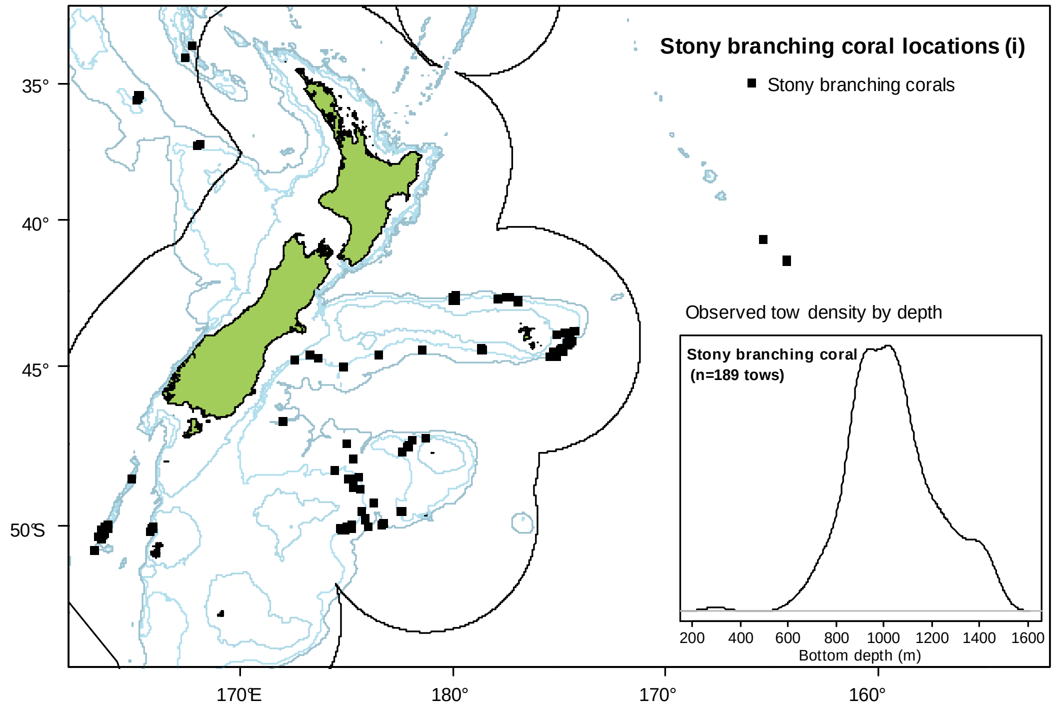

Figure 4.6: Locations and depth distribution of observed tows from which samples of stony branching corals were returned, 2007–08 to 2009–10. The contours are at 500 m, 1000 m, and 1500 m.

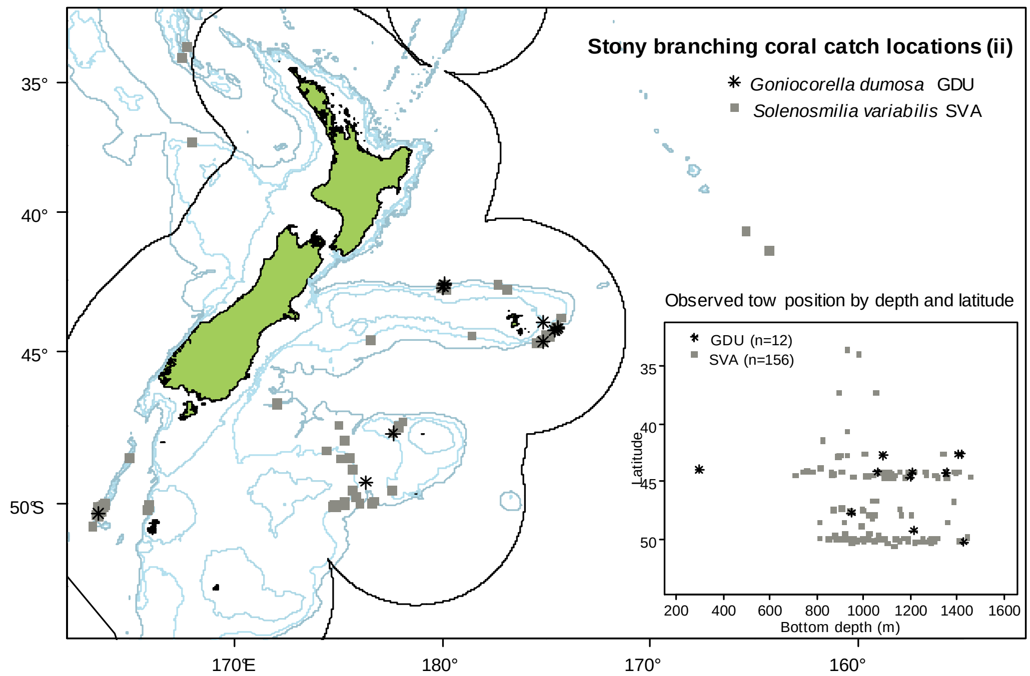

Figure 4.7: Locations and depth distribution of observed tows from which samples of *Goniocorella dumosa* and *Solenosmilia variabilis* were returned, 2007–08 to 2009–10.

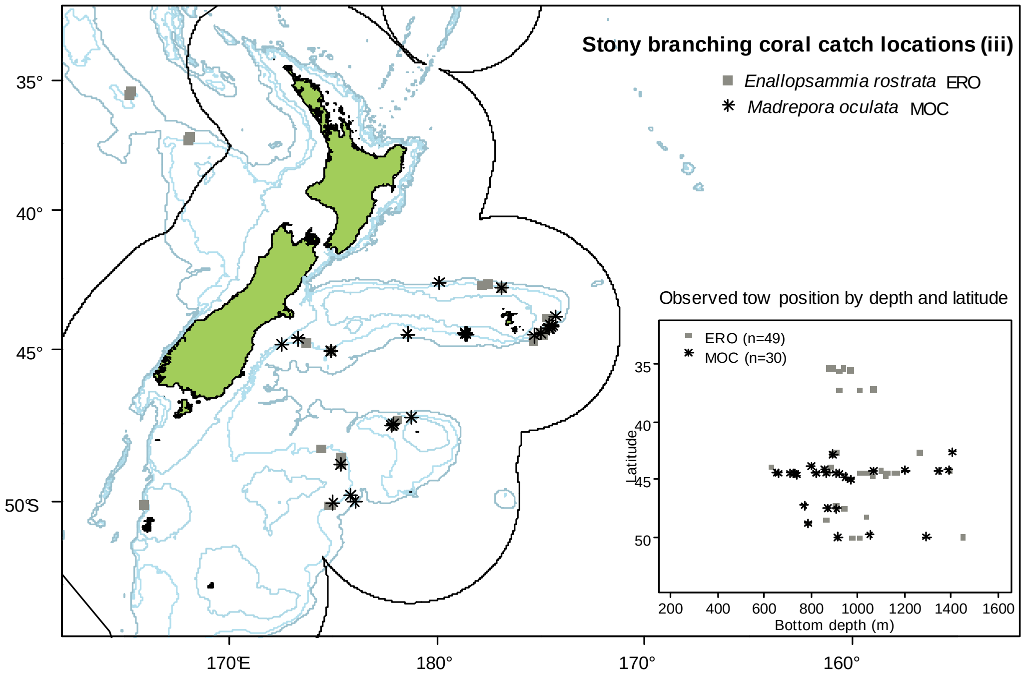

Figure 4.8: Locations and depth distribution of observed tows from which samples of *Enallopsammia rostrata* and *Madrepora oculata* were returned, 2007–08 to 2009–10.

Stony cup coral

Stony cup corals were returned from areas similar to those for stony branching corals (Table 4.4, Figure 4.9). The distribution of *Desmophyllum dianthus* was widespread and the only cup coral from outside the EEZ, whereas *Stephanocyathus platypus* was mainly returned from the northern Chatham Rise. The depth profile for tows with stony cup corals shows that some were from shallower depths than the stony branching corals. *Desmophyllum dianthus* was returned from a scampi tow in about 400 m and *Flabellum* samples came from mainly hoki tows in depths of under 650 m (Figure 4.10).

Table 4.5: Number of observed tows with returned samples of stony cup corals (to the lowest taxonomic level possible), by reported target species and fishery area.

	Fishery Management Area								Outside the EEZ				
	1	2	3	4	5	6	7	9	CET	HOWE	LOUR	WANB	Total
Scleractinian													
Oreos						1							1
Orange roughy				1									1
***Caryophyllia* spp.**													
Smooth oreo			1										1
Orange roughy				8									8
***Flabellum* spp.**													
Black oreo			1										1
Hoki			4	1	1								6
Ling						1							1
Desmophyllum dianthus													
Oreos						2							2
Black oreo			1	2		1							4
Smooth oreo			1	2		6							9
Orange roughy				18				1	2	1		1	23
Scampi				1									1
Stephanocyathus platypus													
Black oreo						1							1
Orange roughy				25					1				26
Total	0	0	8	57	1	11	0	1	3	1	0	1	83

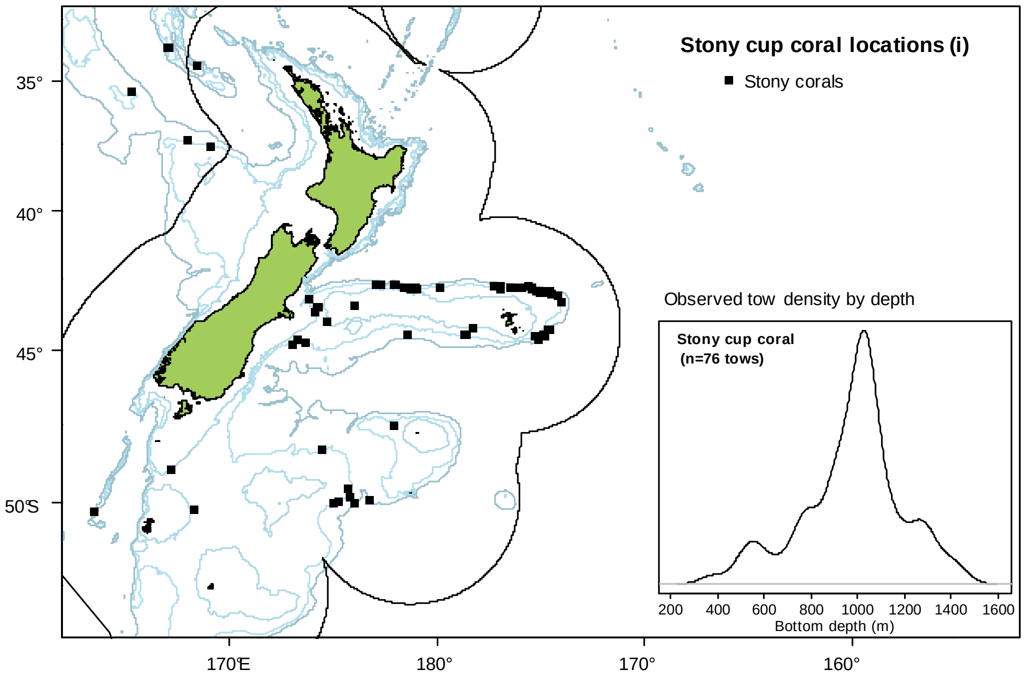

Figure 4.9: Locations and depth distribution of observed tows from which samples of stony cup corals were returned, 2007–08 to 2009–10. The contours are at 500 m, 1000 m, and 1500 m.

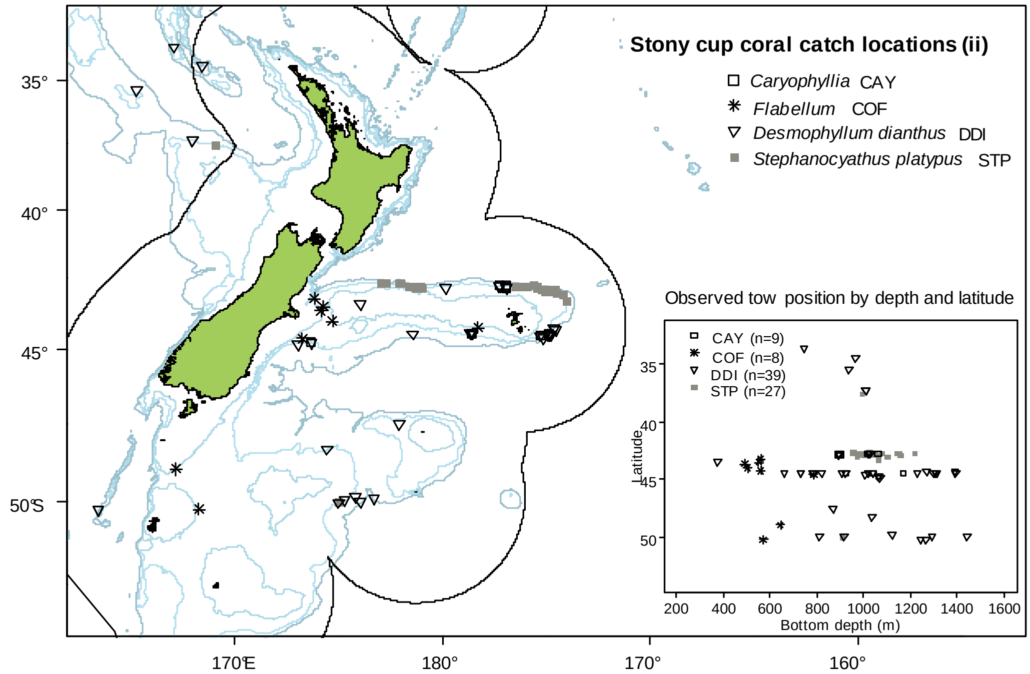

Figure 4.10: Locations and depth distribution of observed tows from which samples of stony cup corals were returned, 2007–08 to 2009–10. The contours are at 500 m, 1000 m, and 1500 m.

Gorgonian coral

Gorgonians were returned from 136 deepwater tows in all areas outside the EEZ and all FMAs except FMA 8 (Figure 4.11, Table 4.5), with most from tows in 800–1000 m depths. Gorgonians were the only group, other than black coral, that were returned from deepwater tows off the shelf off the North Island east coast. These gorgonians were identified to nine genera and two families, but 69 samples could not be identified to a lower taxonomic level than to Order Gorgonacea.

Of those identified to a lower level, the most commonly returned genera were *Thourella* and *Primnoa*. Genera that appeared to be more limited in their distribution represented few samples: for example, from northern locations only (*Callogorgia*, *Iridogorgia*, and *Narella*), and *Calyptrophora* and *Plumarella* from southern locations.

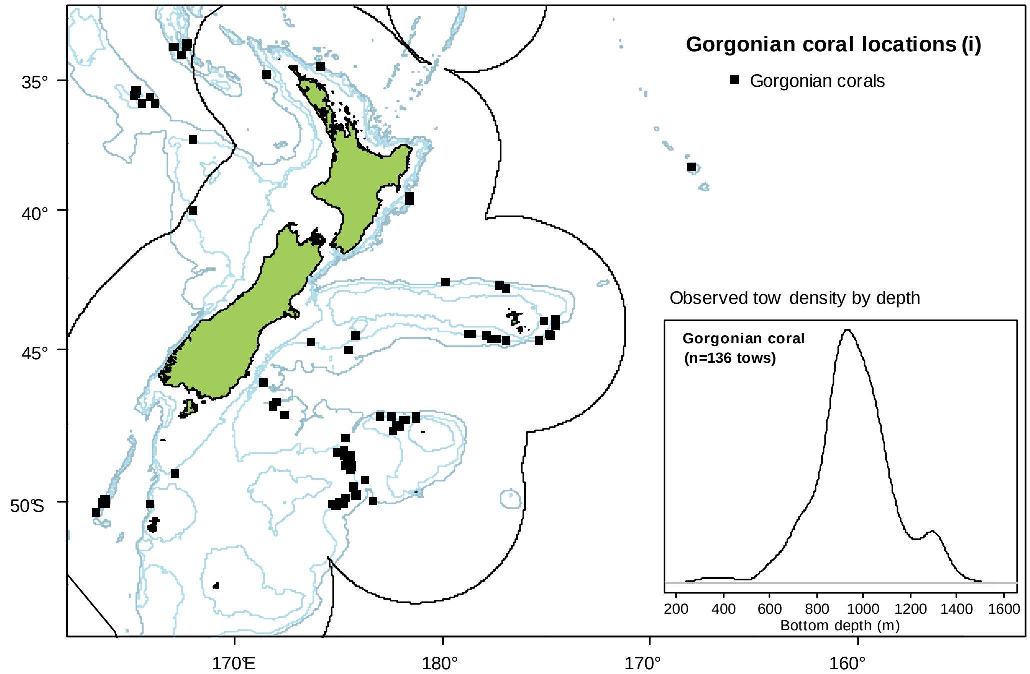

Figure 4.11: Locations and depth distribution of observed tows from which samples of gorgonian corals were returned, 2007–08 to 2009–10. The contours are at 500 m, 1000 m, and 1500 m.

Table 4.6: Number of observed tows with returned samples of gorgonian corals (to the lowest taxonomic level possible), by reported target species and fishery area.

	Fishery Management Area								Outside the EEZ				
	1	2	3	4	5	6	7	9	CET	HOWE	LOUR	WANB	Total
Gorgonacea													
Black oreo						17							17
Alfonsino		1		1									2
Hoki			2										2
Oreos						20							20
Smooth oreo			3	1		10							14
Spiky oreo										1			1
Orange roughy		1		7					1	2	1	1	13
***Chrysogorgia* spp.**													
Oreos						1							1
Black oreo						3							3
Smooth oreo						2							2
Orange roughy	1							1				1	3
***Callogorgia* spp.**													
Orange roughy										1		1	2
***Calyptrophora* spp.**													
Orange roughy				3									3
***Iridogorgia* spp.**													
Orange roughy										1			1
***Metallogorgia* spp.**													
Orange roughy	1											1	2
***Narella* spp.**													
Orange roughy												1	1
Plexauridae													
Black oreo						4							4
Orange roughy						1				1			2
***Plumarella* spp.**													
Oreos						1							1
***Primnoa* spp.**													
Oreos						2							2
Black oreo				2		2							4
Smooth oreo			3	3		6							12
Orange roughy				8			1			2			11
Primnoidae													
Black oreo						4							4
Smooth oreo						5							5
Orange roughy				6									6
***Thouarella* spp.**													
Oreos				1		3							4
Black oreo						5							5
Smooth oreo				3		5							8
Hoki						1							1
Orange roughy				4						3		2	9
All	2	2	8	39	0	92	1	1	1	11	1	7	165

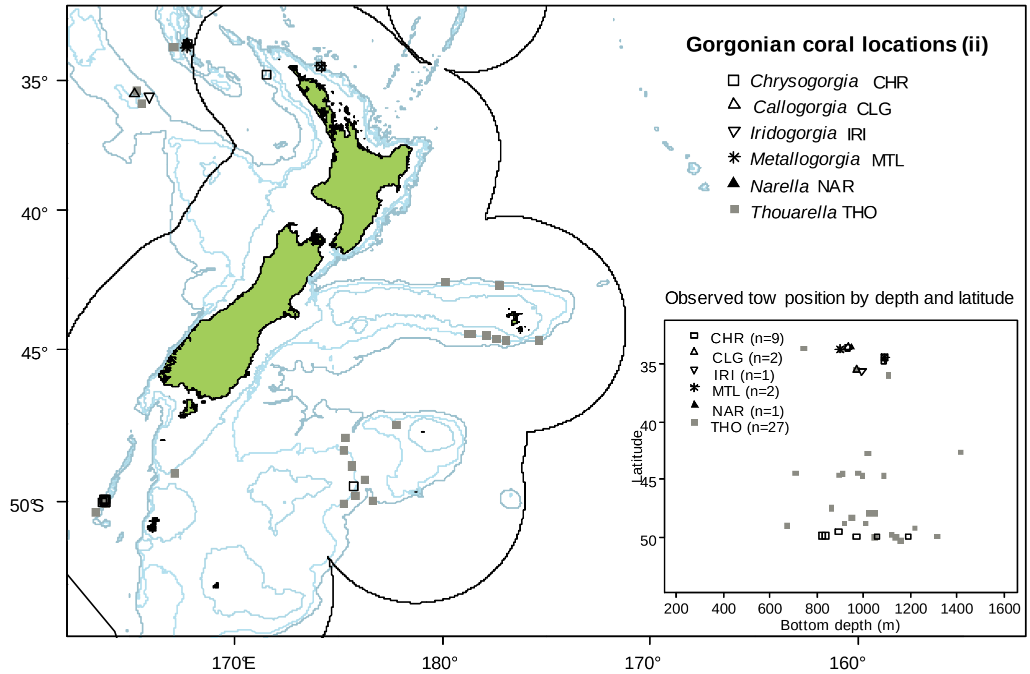

Figure 4.12: Locations and depth distribution of observed tows from which samples of gorgonian corals were returned, 2007–08 to 2009–10. The contours are at 500 m, 1000 m, and 1500 m.

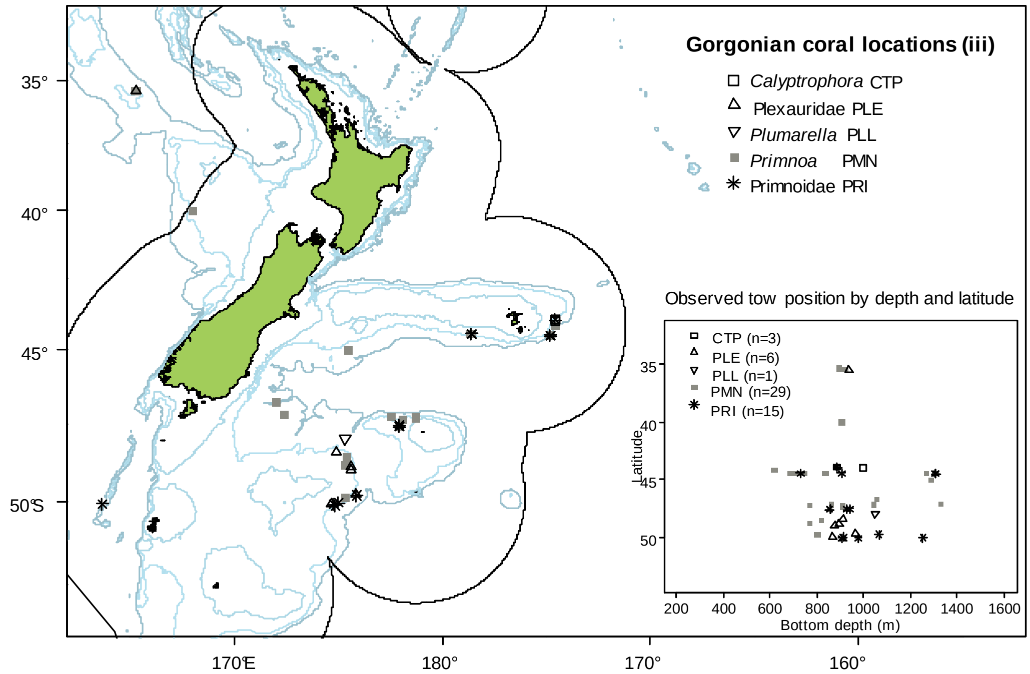

Figure 4.13: Locations and depth distribution of observed tows from which samples of gorgonian corals were returned, 2007–08 to 2009–10. The contours are at 500 m, 1000 m, and 1500 m.

Bamboo coral

Samples identified as belonging to the bamboo group of corals were returned from 80 observed tows that targeted orange roughy, oreo species, and white warehou. Most samples of bamboo corals were from 800–1200 m depths and south of 42°S (Figure 4.14), especially off the southern slope of the Chatham Rise and the north-northeastern slope of the Pukaki Rise. Other southern catches were reported from tows east of the Auckland Islands. Bamboo corals in northern waters were returned from tows between 34°and 38°S, in FMAs 1 & 9 and outside the EEZ, in fishing areas northwest of the Challenger Plateau, Lord Howe Rise, and Wanganella Bank, as well as Louisville Ridge to the east.

Three bamboo coral genera were identified from the 94 samples: *Acanella* and *Keratoisis* from northern and southern tows and *Lepidisis* from southern waters (Figure 4.15). *Keratoisis* was the most commonly returned genus, the most widespread (and the only bamboo coral sample returned from the Louisville Ridge), and represented the shallowest catch (from a white warehou tow in about 460 m). A small number (13 samples could not be identified to genus).

Table 4.7: Number of observed tows with returned samples of bamboo corals (to the lowest taxonomic level possible), by reported target species and fishery area.

	Fishery Management Area								Outside the EEZ				
	1	2	3	4	5	6	7	9	CET	HOWE	LOUR	WANB	Total
Isididae													
Oreos						1							1
Black oreo						1							1
Smooth oreo			1			3							4
Orange roughy				5					1			1	7
***Acanella* spp.**													
Oreos				1		4							5
Black oreo						3							3
Smooth oreo			2	2		1							5
Orange roughy						2				1			3
***Keratoisis* spp.**													
Oreos						4							4
Black oreo			3			6							9
Smooth oreo			5	4		16							25
Orange roughy	1			16		4		1		1	1		24
White warehou					1								1
***Lepidisis* spp.**													
Smooth oreo			1	1									2
Total	1	0	12	29	1	45	0	1	1	2	1	1	94

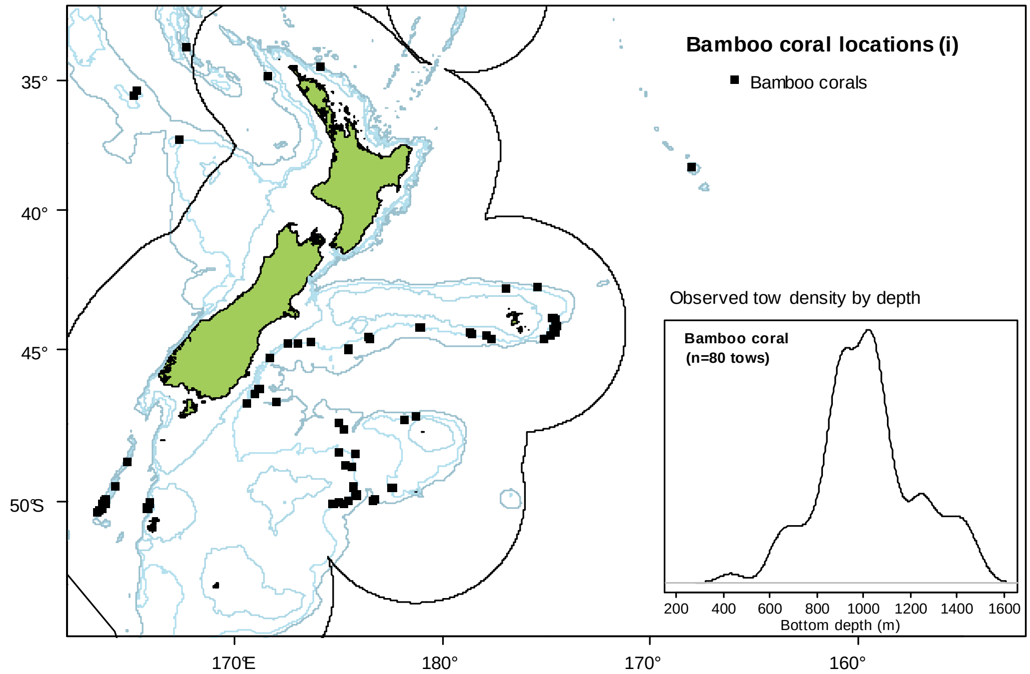

Figure 4.14: Locations and depth distribution of observed tows from which samples of bamboo corals were returned, 2007–08 to 2009–10. The contours are at 500 m, 1000 m, and 1500 m.

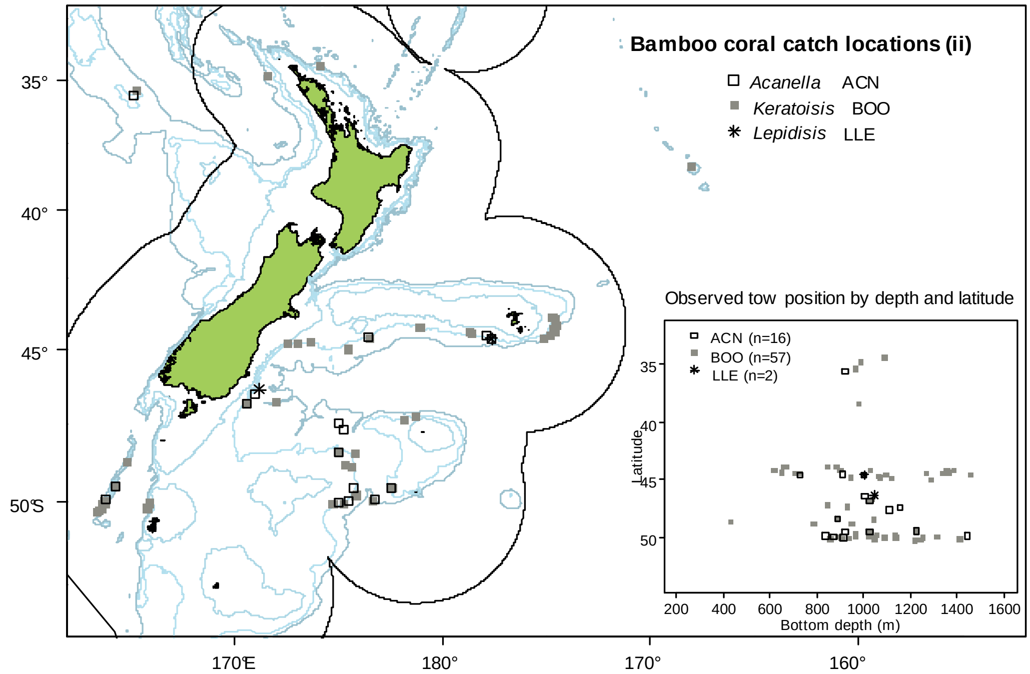

Figure 4.15: Locations and depth distribution of observed tows from which samples of bamboo corals were returned, 2007–08 to 2009–10. The contours are at 500 m, 1000 m, and 1500 m.

Bubblegum coral

All but one of the bubblegum coral samples were returned from tows off the southern slope of the Chatham Rise in FMAs 3 and 4, and in FMA 6 on the western slope of the Bounty Platform and to the east of Pukaki Rise (Table 4.7, Figure 4.16). Samples were collected from 36 tows, mainly from those that targeted smooth oreo. Most were from tows in depths of around 800 m, with several from about 1400 m waters in FMA 6.

Table 4.8 Number of observed tows with returned samples of bubblegum corals, by reported target species and fishery area.

	Fishery Management Area								Outside the EEZ				
	1	2	3	4	5	6	7	9	CET	HOWE	LOUR	WANB	Total
Paragorgia arborea													
Alfonsino										1			1
Hoki			1										1
Oreos						1							1
Black oreo				2		3							5
Smooth oreo				8		17							25
Orange roughy				4									4
Southern blue whiting						1							1
All	0	0	1	14	0	22	0	0	0	1	0	0	38

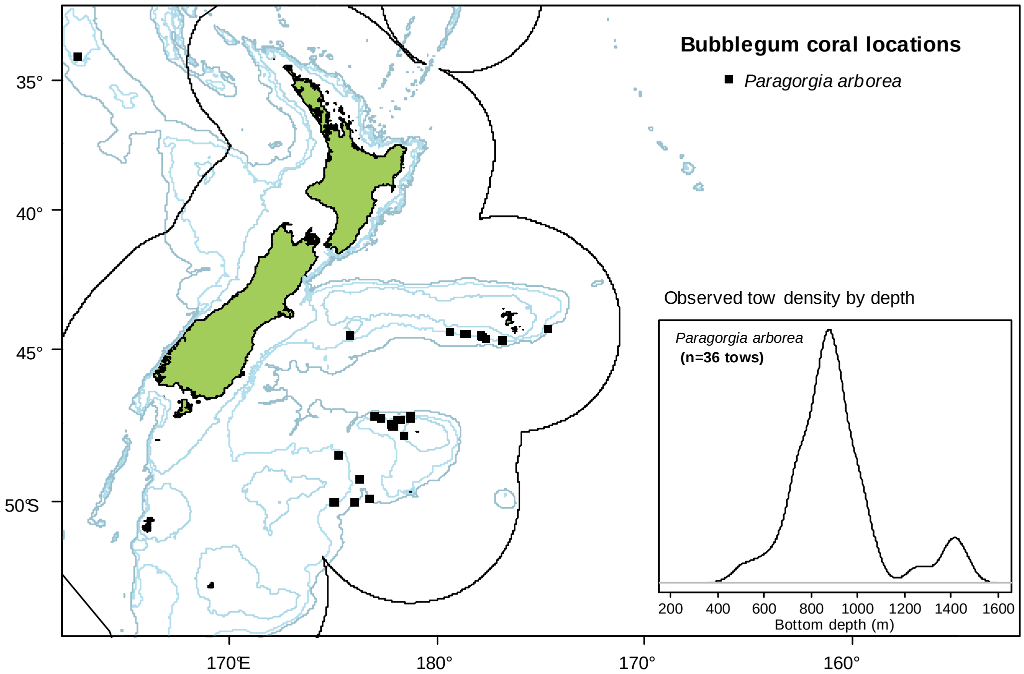

Figure 4.16: Locations and depth distribution of observed tows from which samples of bamboo corals were returned, 2007–08 to 2009–10. The contours are at 500 m, 1000 m, and 1500 m.

Hydrocoral

Of the 19 samples identified as hydrocorals, 10 could not be identified to a genus (Table 13). Most hydrocoral samples were returned from orange roughy and oreo tows in 800–1000 m at the Andes complex and fisheries east of Pukaki Rise, and three came from squid tows off the Stewart-Snares shelf and Auckland Islands Shelf (Figures 4.17 & 4.18).

Table 4.9: Number of observed tows with returned samples of bubblegum corals (to the lowest taxonomic level possible), by reported target species and fishery area.

	Fishery Management Area								Outside the EEZ				
	1	2	3	4	5	6	7	9	CET	HOWE	LOUR	WANB	Total
Stylasteridae													
Oreos						3							3
Smooth oreo						1							1
Orange roughy				4		0							4
Squid						2							2
Calyptopora reticulata													
Orange roughy				3									3
***Errina* spp.**													
Oreos						3							3
Smooth oreo						1							1
Orange roughy												1	1
***Lepidotheca* spp.**													
Squid					1								1
All				7	1	10	0	0	0	0	0	1	19

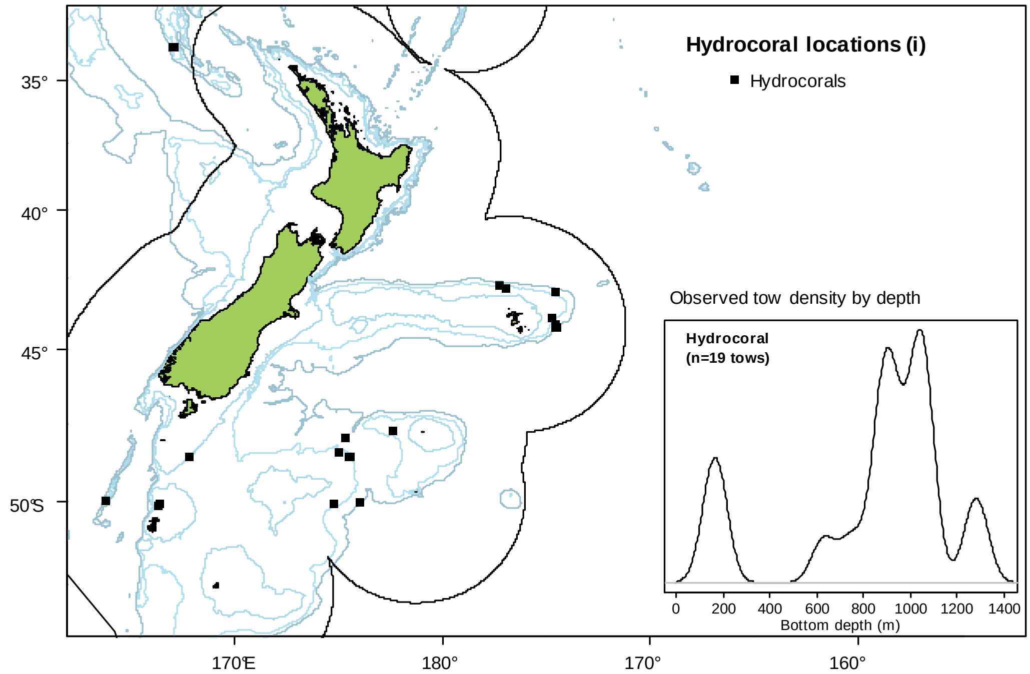

Figure 4.17: Locations and depth distribution of observed tows from which samples of hydrocorals were returned, 2007–08 to 2009–10. The contours are at 500 m, 1000 m, and 1500 m.

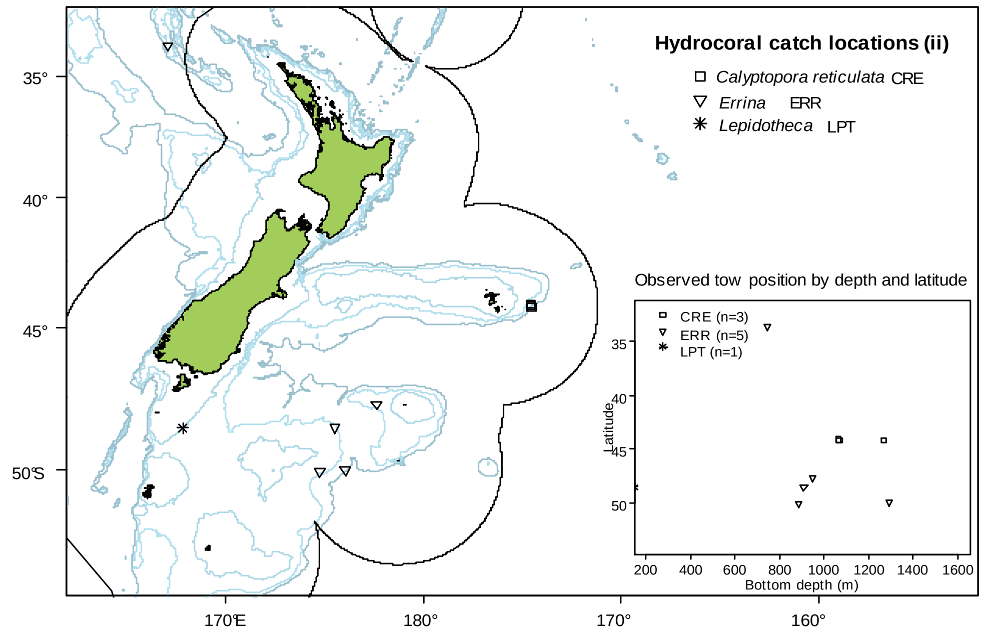

Figure 4.18: Locations and depth distribution of observed tows from which samples of hydrocorals were returned, 2007–08 to 2009–10. The contours are at 500 m, 1000 m, and 1500 m.

Appendix 5 Plot of the compared observer and expert species codes (attached).

Verified NIWA expert identification codes are listed in the columns and observer codes in the rows (A2 to A61). The numbers in each row represent a count of the number of times the observer used a particular code. The diagonal indicates where there is agreement between the observer and the expert. Diagonal numbers are also listed at the bottom of the table. Summaries at the bottom of the table show how often the observer's classification was incorrect: the percentage wrong (% Wrg), the total number of samples (Total), and the proportion of the total samples that were wrong (Tot wrg).