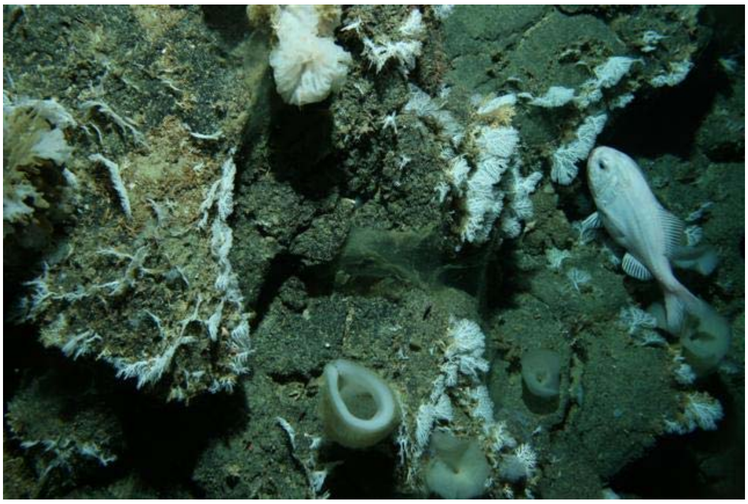
DRAFT
Final Report prepared for
Marine Conservation Services (MCS),
Department of Conservation | Te Papa Atawhai

Identification of Protected Corals: distribution in relation to fishing effort and accuracy of observer identifications



Di Tracey, Susan Jane Baird,
Brian Sanders, Murray H. Smith

Project: MCSINT 2010/03 / DOC11302 (Objective 1, Milestones 3 & 4)

16 June 2011

Draft Final Report prepared for Marine Conservation Services (MCS), Department of Conservation | Te Papa Atawhai

Subject: Identification of Protected Corals
Project: **MCSINT 2010/03 / DOC11302** (Objective 1, Milestones 3 & 4)
Prepared by: Di Tracey, Susan Jane Baird, Brian Sanders, Murray Smith (NIWA)
Date: 13 June, 2011

Attention: Igor Debski (Marine Conservation Services)

Objectives:

- To analyse the spatial distribution of coral sub-samples returned through the CSP observer programme in relation to fishing effort (2007/08 – 2009/10).

Specific Objectives

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.

Executive summary

Deepsea corals in the New Zealand region are abundant and diverse and, because of their vulnerability, are at risk from anthropogenic effects such as bottom trawling. Schedule 7A of the Wildlife Act 1953 affords protection to all deepwater hard corals (all species in the orders Antipatharia, Gorgonacea, Scleractinia, and family Stylasteridae). A number of these taxa are known to be caught incidentally during commercial fisheries in New Zealand, particularly 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 with incidental catches of coral in the trawl nets. Three years of observed trawl and longline data (2007–08 to 2009–10) indicated that about 10% of the 21 259 observed tows had catch records of corals from the following major groups: black corals; stony branching corals; cup corals; gorgonians including the bamboo, bubblegum, and precious corals; and hydrocorals.

Most coral records were from 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. Some specific fishing grounds for orange roughy and oreo species could be identified from the location of the observed coral catches, particularly on the eastern Chatham Rise seamounts and slopes, and waters to the northwest of Bounty Platform and east of Pukaki Rise. In shallower areas the target species with coral catches included hoki (*Macruronus novaezelandiae*) and scampi (*Metanephrops challenger*) on the Chatham Rise west of 180°.

The most commonly-reported corals were stony branching and cup corals and the least-reported were hydrocorals and precious corals. Most of the coral groups were widespread in their geographic distribution, although there were some differences in the observed catch distribution. Only black corals, stony corals, gorgonians, and bamboo corals were reported from the Louisville Ridge. Bubblegum corals were not reported from the northern Chatham Rise. Large catches (by weight) were reported from areas where known underwater features are trawled. The largest observed catches (estimated at 15 t and 10.6 t) were from smooth oreo tows in depths of about 1400 m east of Pukaki 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 (455 of which targeted deepwater species), and 733 of these samples were identified as protected corals. These data also enabled an assessment of the accuracy of the identifications carried out at sea by observers. Identification to the lowest possible taxonomic level was poor. Of the 545 verified records that could be compared, 293 were incorrectly identified by the observers. The percentage error was particularly high (about 90%) for the stony branching coral species, which are difficult to distinguish. However, 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 and can provides a more robust dataset to predict spatial distribution.

Introduction

Background

Government observers on commercial fishing vessels have instructions and procedures for retaining benthic invertebrate bycatch caught by 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) Conservation Services Programme (CSP) [now known as Marine Conservation Services (MCS)], 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 could be followed. Coral specimens have been photographed and all samples, or a sub-sample of the colony, have been returned to NIWA (frozen) for identification and curation. Corals sent to NIWA 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*). For any coral samples retained from these projects and held under stewardship at NIWA, species identification information was 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)'.

The protected deepwater corals are highly variable in size, shape, and form (Figure 1). They can be large branching structures, pinnate (feather-like), bushy, fan shaped, or whip-like. Black coral colonies (Figure 1, top left panel) can achieve large heights (up to 3m), and while obtaining a large size, their chitin stem and branches means the colonies are light in weight. In contrast the arborescent or tree-like gorgonian corals can form massive 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 taxa of the gorgonian corals such as the bubblegum (*Paragorgia* spp.) (Figure 1, middle bottom panel), bamboo (e.g., *Keratoisis* spp.), and seafan corals (e.g., *Primnoa* spp. can be heavy and dense. The primnoid bottlebrush coral *Thouarella* spp are feathery-like branched colonies (Figure 1, top right panel).

Scleractinian corals produce large 3-dimensional matrix colonies that can form 'reef', 'mound', or 'thicket' structures (Figure 1, bottom left panel) and often provide biogenic habitat on slope margins, ridges, and seamounts. Stylasterid hydrocorals or lace corals on the other hand form very small and delicate colonies (Figure 1, bottom right panel).

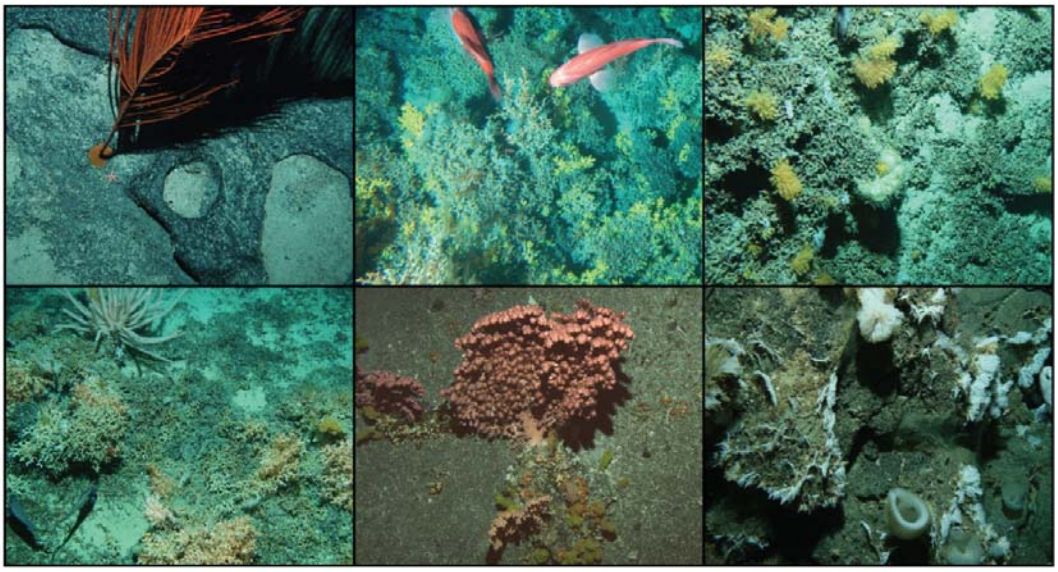


Figure 1: Protected deepsea corals in the New Zealand region. Top L to R: Black coral *Bathypathes* spp., stony branching coral *Solenosmilia variabilis,* and gorgonian primnoid coral *Thouarella* spp. Bottom L to R: Stony branching coral *S. variabilis* and gorgonian primnoid coral *Narella* spp., gorgonian bubblegum coral *Paragorgia arborea,* and stylasterid hydrocorals (likely *Calyptopora reticulata*). All images were taken using NIWA deep towed imaging system.

Currently deepsea corals are listed as Vulnerable Marine Ecosystem (VME) taxa and meet several of the ecological criteria used to define fauna included in the VME taxa list. Examples of these criteria are corals fragility relative to trawl gear, whether they are rare or endemic, and their slow growth rates (Parker et al. 2009)

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. 2009). Nevertheless, 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 and provide additional spatial data to help meet the legal requirements for monitoring protected corals.

Identification of coral samples

Identifications of corals samples have previously been identified (verified) to the lowest taxon possible and 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).

The revised species identifications in the *cod* database have drawn upon NIWA's extensive collection of coral fauna held in the NIWA Invertebrate Collection (NIC), on the coral identification skills of NIWA staff, and on global experts in the field of coral research, particularly expert taxonomists researching black corals, gorgonian corals, stony corals, and hydrocorals.

In collaboration with opportunistic visits from 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 2010d), NIWA has subsequently been able to identify many of the coral fauna collected by observers to a lowertaxonomic 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), 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 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.

Database storage

Since the CSP project began in October 2007, the coral samples have been sorted, identified to the lowest possible taxonomic level, and catalogued in a database. 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, in addition to what is currently in various identification guides, 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.

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 *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 provide for descriptions of the distribution of the observed coral catch and the identification of commercial fisheries and areas where corals are incidentally caught during fishing operations.

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 iodentified to a lower taxonomic level by observers. However, it has been noted in previous reports, e.g., in Tracey & Sanders (2011), that some corals continue to be easily confused: 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* confused with hydrocorals), and between other 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 MFish coral codes. To assess the accuracy of the observers' records for the coral samples returned for identification and verification by NIWA, the observer allocated MFish coral codes can be compared with the NIWA expert allocated coral code.

This Final Report presents the work on the two specific project objectives:

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 in relation to fishing effort. A measure of accuracy of the observer coral identification is assessed by comparing the at-sea coral identifications of samples returned with expert identifications.

Overall the distribution data provided in this report will contribute further to our understanding of the ecological significance of these protected corals, and the likely impact of anthropogenic activities. Given the established relationship between bottom trawling and the impact on corals and associated invertebrates (Koslow et al. 2001, Althaus et al. 2009, Clark & Rowden 2009), and the past distribution of bottom trawling in the New Zealand region (Baird et al. 2011) in areas identified by the present study to be suitable habitat for habitat-forming corals, it is likely that trawling, has had a widespread impact on corals.

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

Methods & Results

Specific Objective 1: Observed coral catch 2007-2008 to 2009-10

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. The work for this objective is presented in four main sections:

- Data sources and grooming
- Summary of observed trawl effort and longline effort
- Distribution of observed coral catch
- Distribution of verified coral samples

Observed data and grooming

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.

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 position 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.

All data in the *cod* load table were reconciled and merged into *cod*. These data included the final identification data (coral code to lowest taxonomic coral identification possible, sample weight, trip number, and tow number). 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.

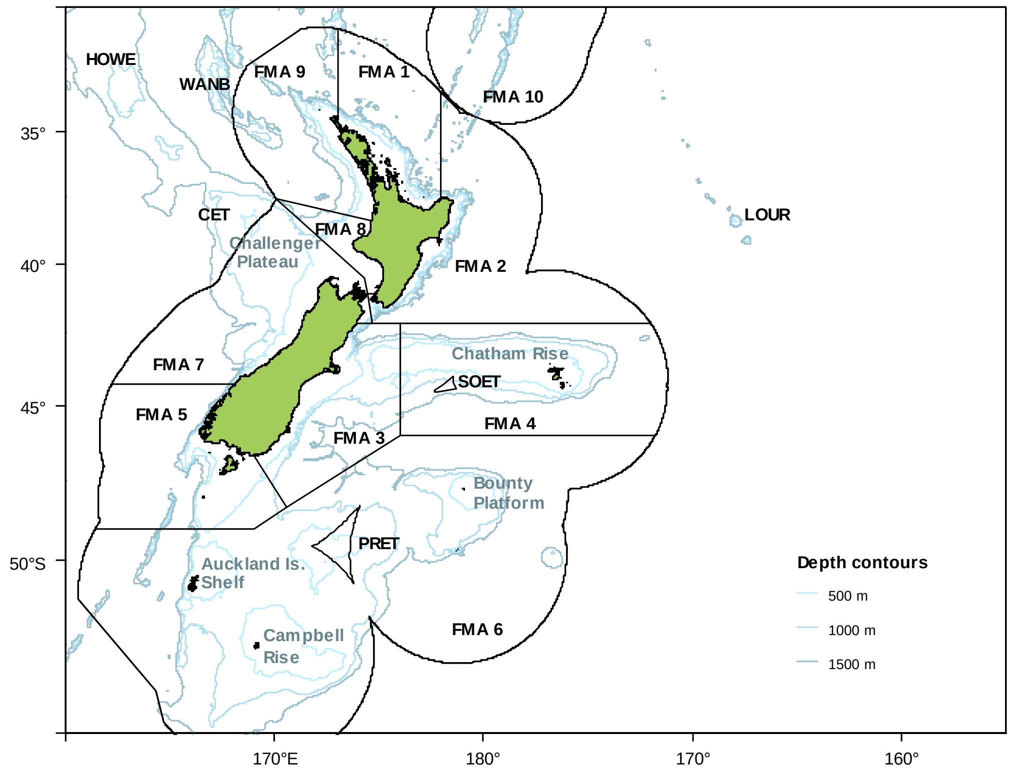


Figure 2: Fishery management Areas (FMAs) and areas outside the New Zealand 200 n. mile EEZ used to describe the location of observed fishing effort. CET is outside the EEZ on the Challenger Plateau, HOWE is Lord Howe Rise, LOUR is Louisville Ridge, PRET is the occluded area of the EEZ near Pukaki Rise,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

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), and CBB (coral rubble)).

Catch weights of corals are estimated by observers and these data for protected corals were combined into nine broad groups (Table 1) and appended to the observed tow and set data. These nine groups represent the groups of protected corals, but where the Scleractinia is divided into three groups (stony branching corals, cup corals, and unspecified scleractinians including coral rubble) and the Gorgonacea into four groups (precious corals, bamboo corals, bubblegum corals, and remaining gorgonian corals). 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. For example, the catch data for the stony branching coral species *Madrepora oculata* (MOC), *Enallopsammia rostrata* (ERO), *Goniocorella Dumosa* (GOC) and *Solenosmilia variabilis* (SVA) are combined into the stony branching corals group (CBR) and for the catch records where there was no sample for verification of the CUP and CBR coral identification, the groups were combined into SIA. The bamboo, bubblegum, and precious corals data have been separated from other gorgonian corals because these groups are easy to identify to family level. The gorgonian coral grouping includes the Primnoid and Plexaurid sea fan families.

A second dataset of the verified coral code data was merged with the observed effort data and used to map the distribution of coral records for which the taxon or taxonomic group had been verified from samples returned from sea. These verified coral code data were also used to meet requirements of Objective 2. [These datasets are available to MCS as a supplementary electronic file.]

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 (Family, Genus, Species) 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

Description of observed trawl effort, 2007–08 to 2009–10

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

Figures 2.1 & 2.2 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 distinctive deepwater fishery areas near the Bounty Platform and east of Pukaki Rise.

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. 2009), 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.

Presence of coral catch in observed trawl nets, 2007–08 to 2009–10

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. 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 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).

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 had coral records, and 19% of CET observed tows caught corals (Table 2).

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).

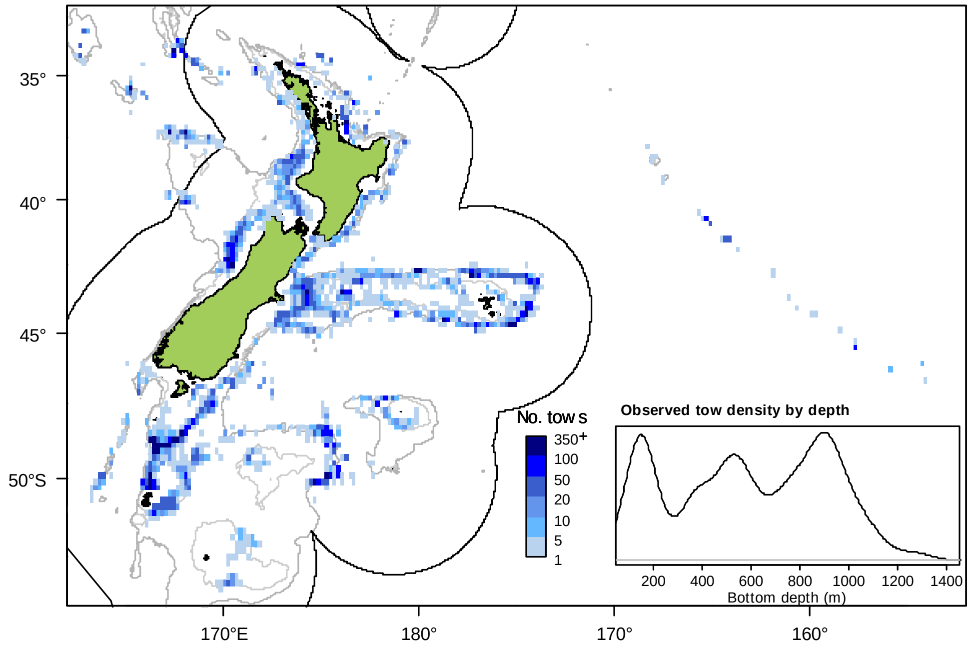


Figure 3: Distribution of observed tow effort (by 0.2° latitude x 0.2° longitude cells), based on the reported start locations, for 2007–08 to 2009–10. The inset shows the depth distribution of the 21 259 observed tows.

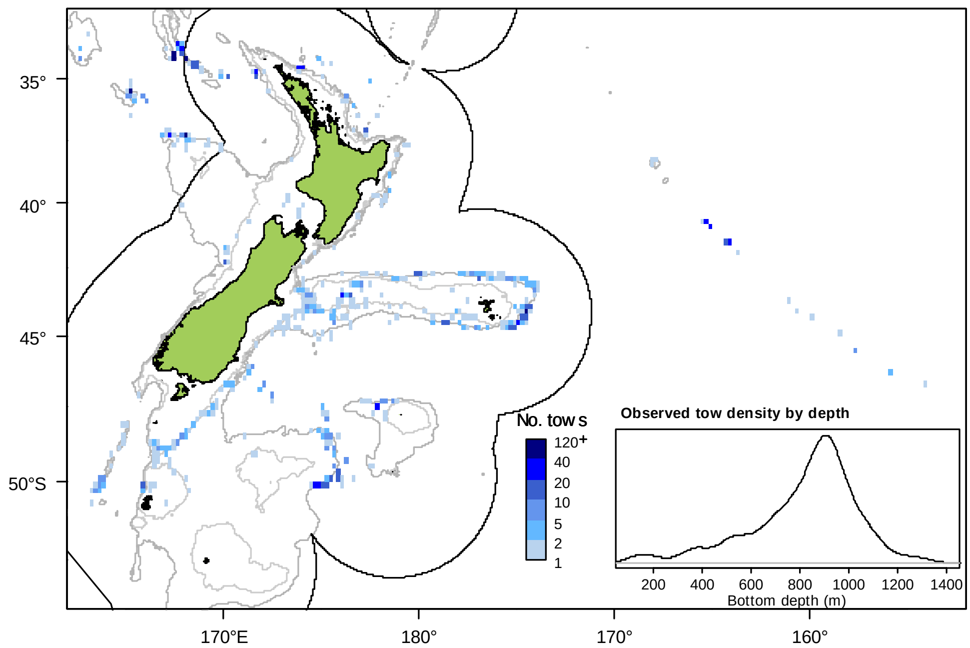


Figure 4: Distribution of observed tow effort (by 0.2° latitude x 0.2° longitude cells) for those tows with coral catch records, based on the reported start locations, for 2007–08 to 2009–10. These data represent a subset of the data in Figure 2. The inset shows the depth distribution of the 2112 observed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

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.

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

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 (OEO, ORH, CDL) by the number of coral groups (see Table 1) represented in the tow catch, by fishery area.

	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

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. 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.

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 5. 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.

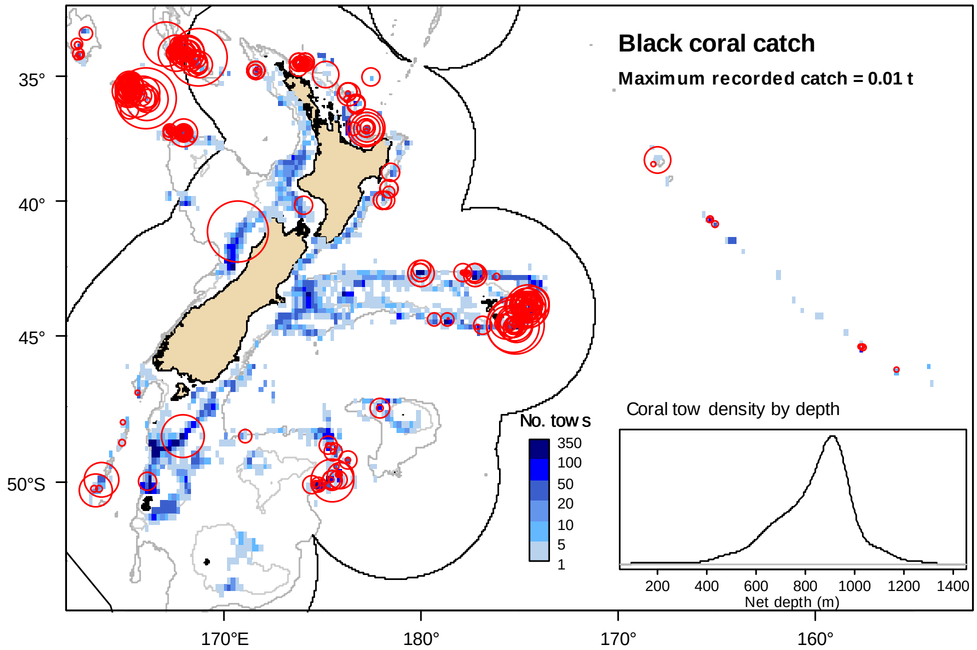


Figure 5: Distribution of observed tow effort (by 0.2° latitude x 0.2° longitude cells) and black coral tow catch weights (t) (red circles), based on the reported start locations, for 2007–08 to 2009–10. The inset shows the depth distribution of observed tows with black coral catch.

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

Unspecified stony coral

This coral group includes corals recorded as coral rubble 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 6). 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.

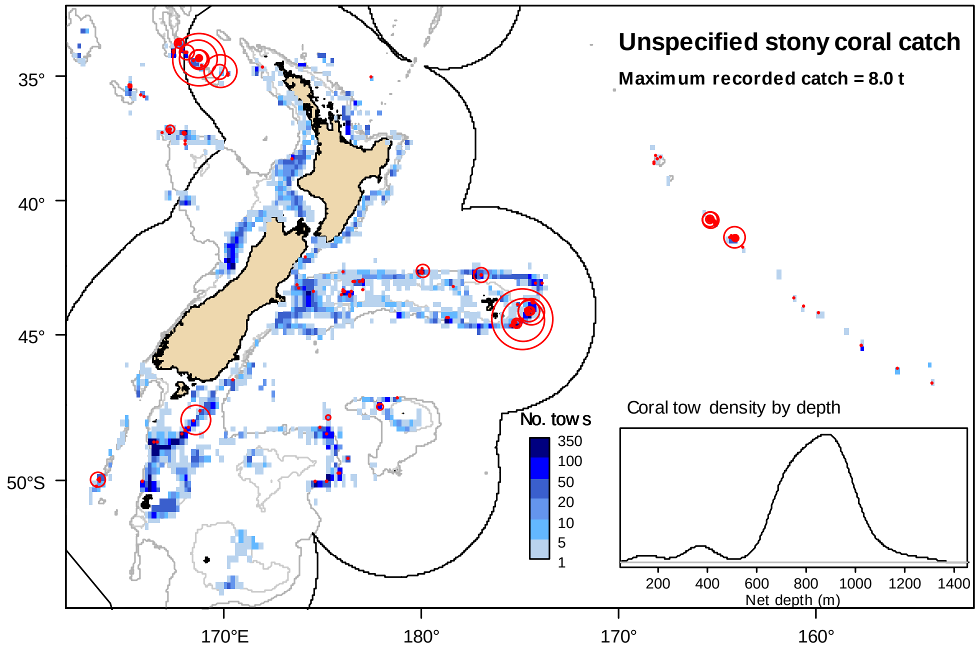


Figure 6: Distribution of observed tow effort (by 0.2° latitude x 0.2° longitude cells) and the SIA unspecified stony coral tow catch weights (t) (red circles), based on the reported start locations, for 2007–08 to 2009–10. The inset shows the depth distribution of observed tows with SIA unspecified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

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 7). Most other catches were reported from 800–1000 m.

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 8). 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.

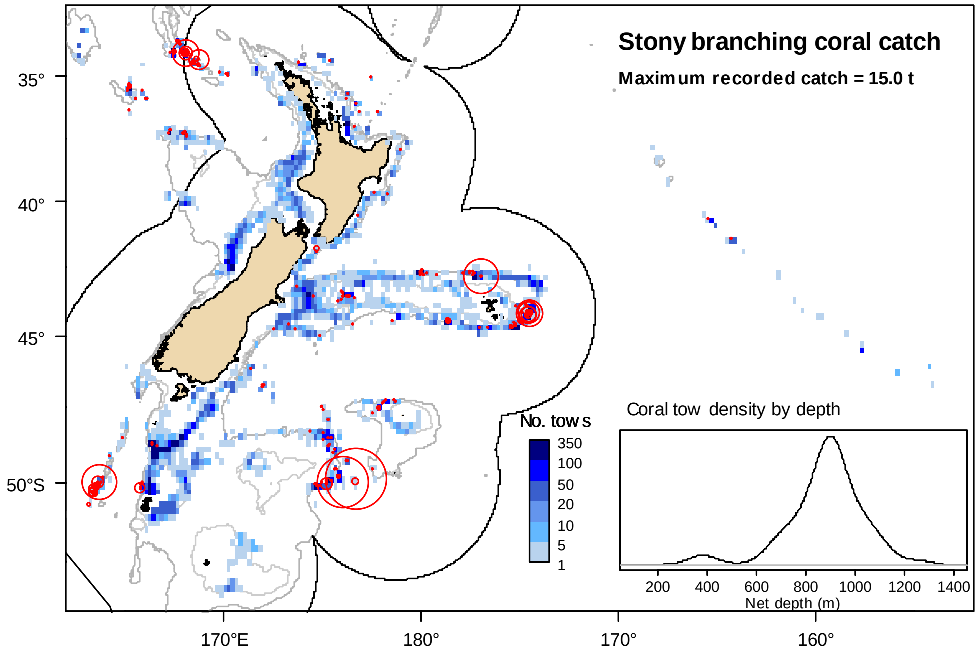


Figure 7: Distribution of observed tow effort (by 0.2° latitude x 0.2° longitude cells) and the stony branching coral tow catch weights (t) (red circles), based on the reported start locations, for 2007–08 to 2009–10. The inset shows the depth distribution of observed tows with stony branching coral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

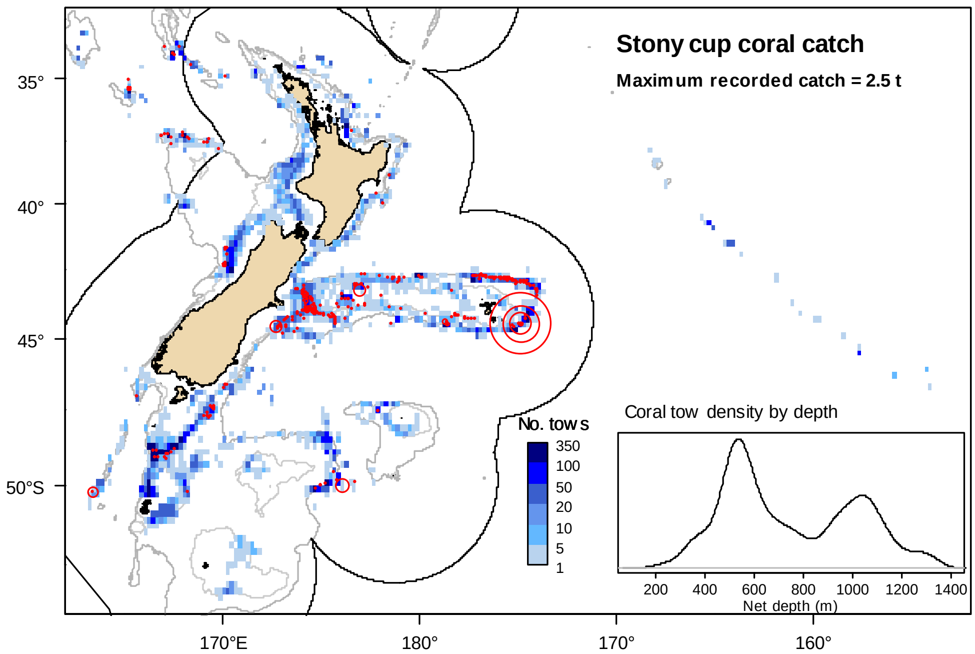


Figure 8: Distribution of observed tow effort (by 0.2° latitude x 0.2° longitude cells) and the stony cup coral tow catch weights (t) (red circles), based on the reported start locations, for 2007–08 to 2009–10. The inset shows the depth distribution of observed tows with stony cup coral catch.

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 9). Apart from one shallow catch in a squid tow, most tows with gorgonian records were at depths of 800–1000 m.

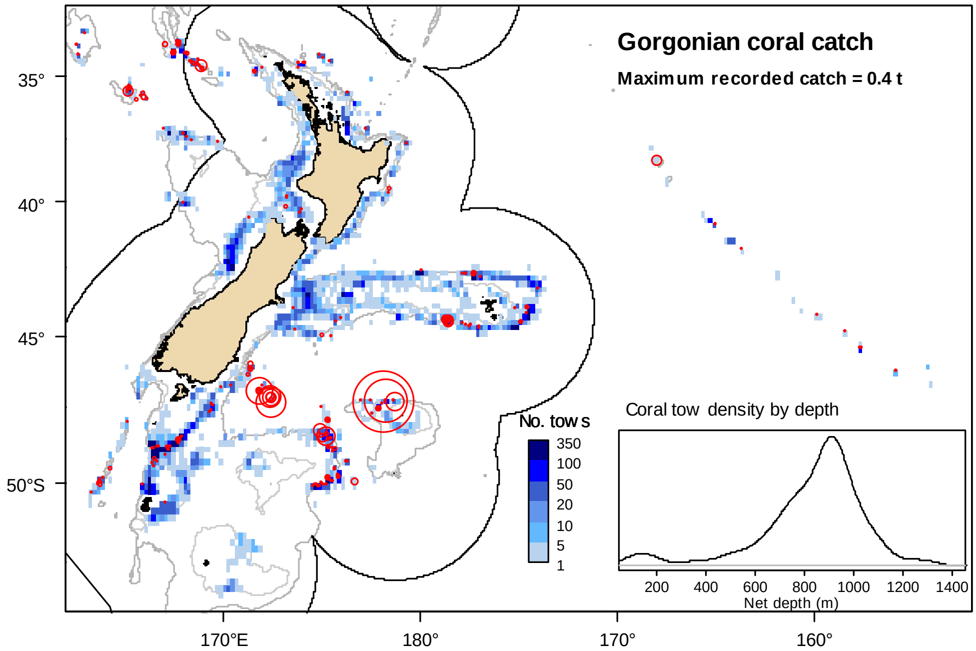


Figure 9: Distribution of observed tow effort (by 0.2° latitude x 0.2° longitude cells) and the gorgonian coral tow catch weights (t) (red circles), based on the reported start locations, for 2007–08 to 2009–10. The inset shows the depth distribution of observed tows with gorgonian coral catch. [Note the bamboo, bubblegum and precious gorgonian coral families are presented in separate plots.]

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 other most coral groups, with a maximum of 200 kg (Table 5, Figure 10). Peak density of observed tows with bamboo coral catch was at around 900 m deep.

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 small, with a maximum of 376 kg (Table 5, Figure 11). 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.

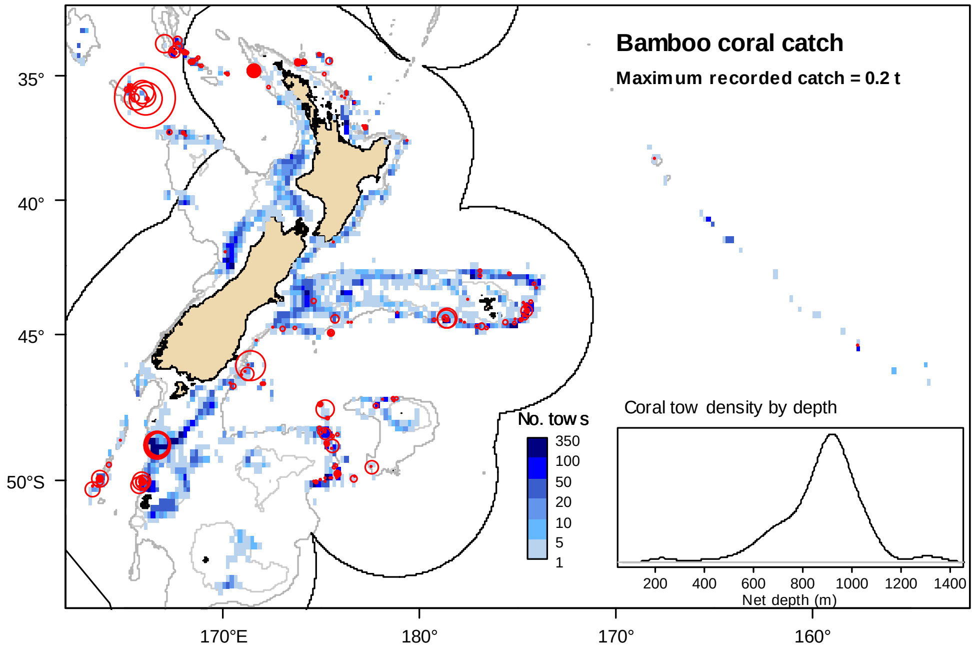


Figure 10: Distribution of observed tow effort (by 0.2° latitude x 0.2° longitude cells) and the bamboo coral tow catch weights (t) (red circles), based on the reported start locations, for 2007–08 to 2009–10. The inset shows the depth distribution of observed tows with bamboo coral catch.

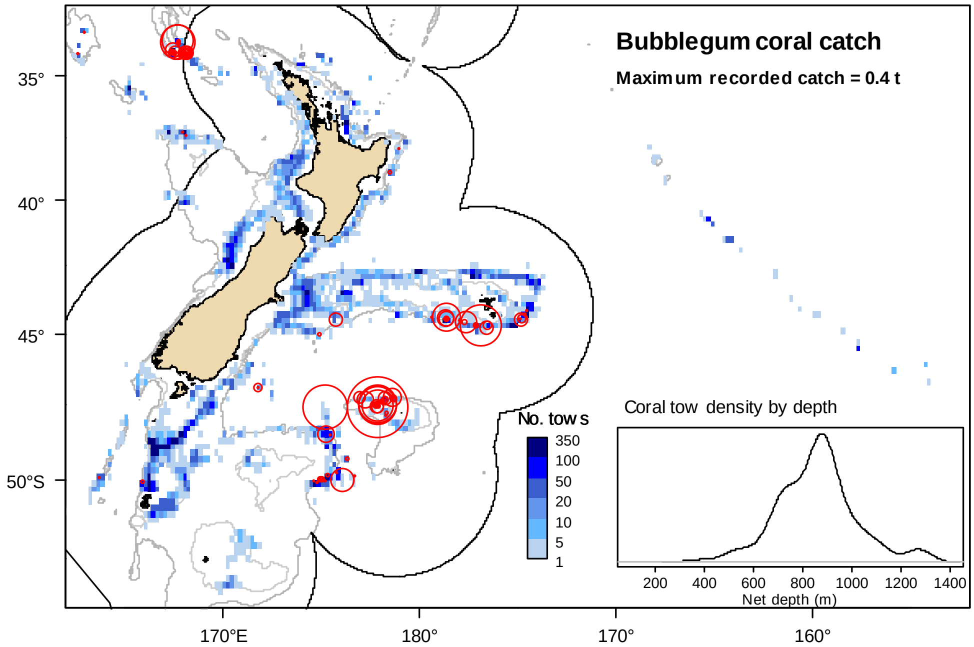


Figure 11 Distribution of observed tow effort (by 0.2° latitude x 0.2° longitude cells) and the bubblegum coral tow catch weights (t) (red circles), based on the reported start locations, for 2007–08 to 2009–10. The inset shows the depth distribution of observed tows with bubblegum coral catch.

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 12). Catch weights were mostly under 1.0 kg per tow (Table 5).

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).

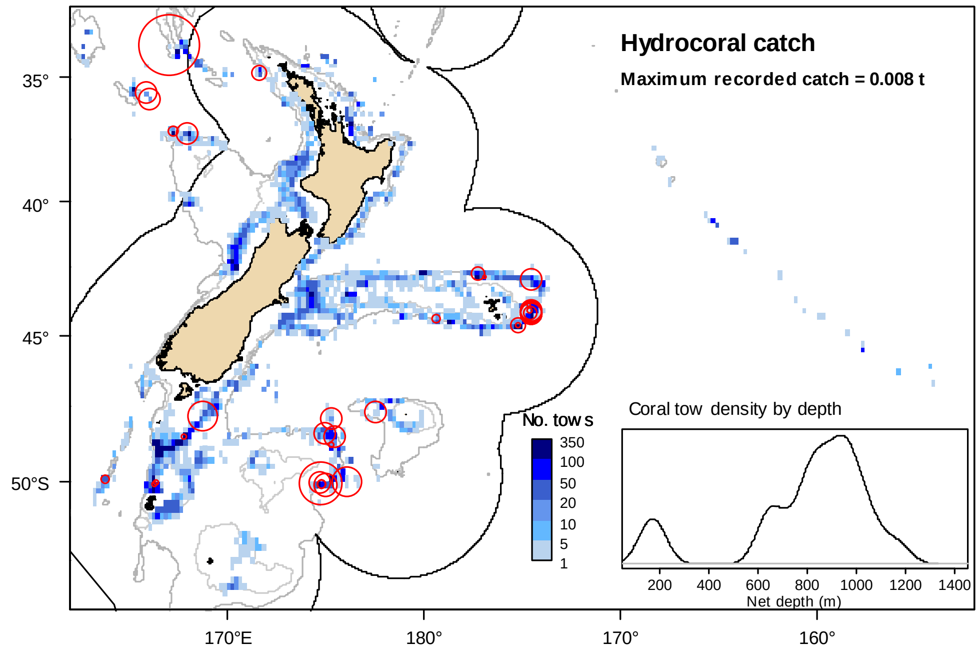


Figure 12: Distribution of observed tow effort (by 0.2° latitude x 0.2° longitude cells) and the hydrocoral tow catch weights (t) (red circles), based on the reported start locations, for 2007–08 to 2009–10. The inset shows the depth distribution of observed tows with hydrocoral catch.

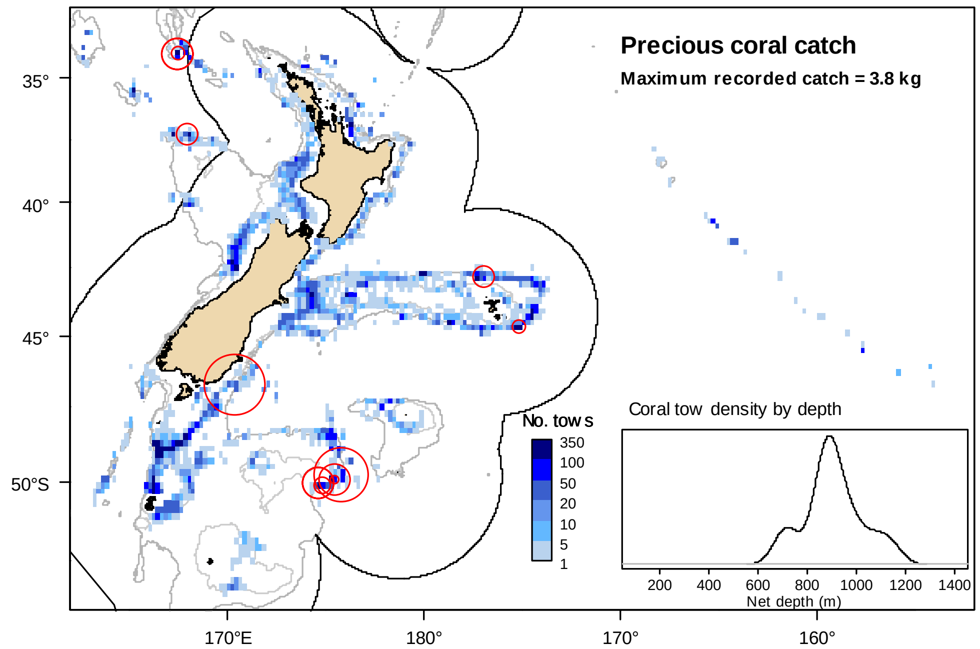


Figure 13: Distribution of observed tow effort (by 0.2° latitude x 0.2° longitude cells) and the precious coral tow catch weights (t) (red circles), based on the reported start locations, for 2007–08 to 2009–10. The inset shows the depth distribution of observed tows with precious coral catch.

Distribution of observed catches of verified protected coral groups.

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 6). No samples of precious coral were returned. Appendix 4 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 14). 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 15).

The distribution of the tow start locations associated with these verified samples is described below under the coral group headings given in Table 1.

Table 6: 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.

	Target species															
Group	BAR	BOE	BYX	HAK	HOK	JMA	LIN	OEO	ORH	SBW	SCI	SOR	SQU	SSO	WWA	Total
Corals																
Bamboo	0	13	0	0	0	0	0	10	34	0	0	0	0	36	1	94
Black	0	11	1	0	0	0	0	2	54	0	0	0	0	11	0	79
Bubblegum	0	5	1	0	1	0	0	1	4	1	0	0	0	25	0	38
Gorgonian	0	37	2	0	3	0	0	28	53	0	0	1	0	41	0	165
Hydrocoral	0	0	0	0	0	0	0	6	8	0	0	0	3	2	0	19
Stony branc	0	20	1	0	0	0	0	31	135	0	0	0	0	66	0	253
Stony cup	0	6	0	0	6	0	1	3	58	0	1	0	0	10	0	85

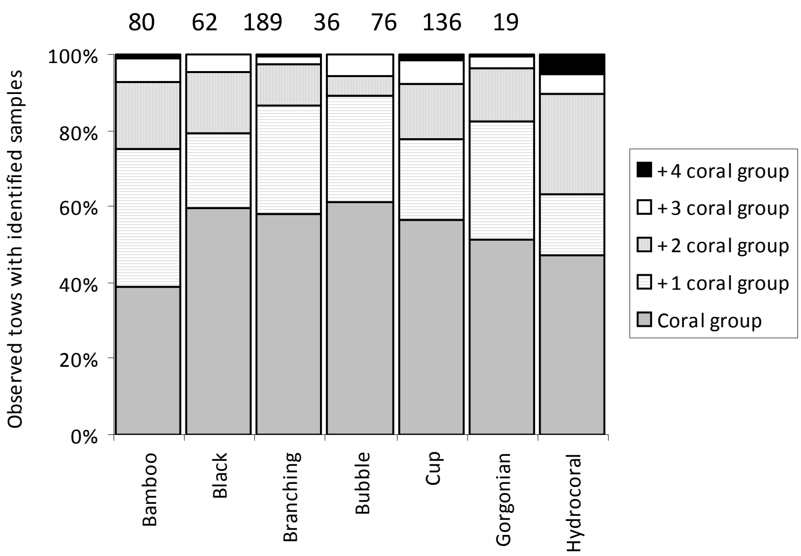


Figure 14: Percentage of the observed tows with verified samples by each main coral group. The number of tows with verified samples of the main coral groups is given above each main group.

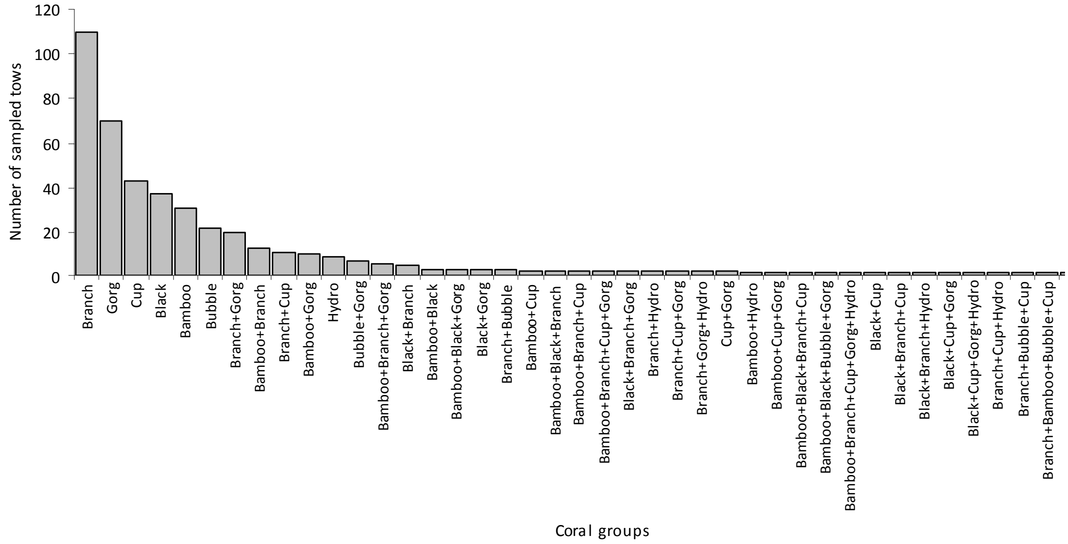


Figure 15: Presence of coral groups from sampled tows (n=439).

Black corals

Samples of black corals were returned from 62 observed tows that targeted oreo species, orange roughy, and alfonsino mainly from FMAs 3 & 4 on Chatham Rise and FMA 6 (Table 7) in known pinnacle or seamount fishery areas (Figure 16). 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 longitudes 163.5° E and 168° W (Figures 16–18). 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).

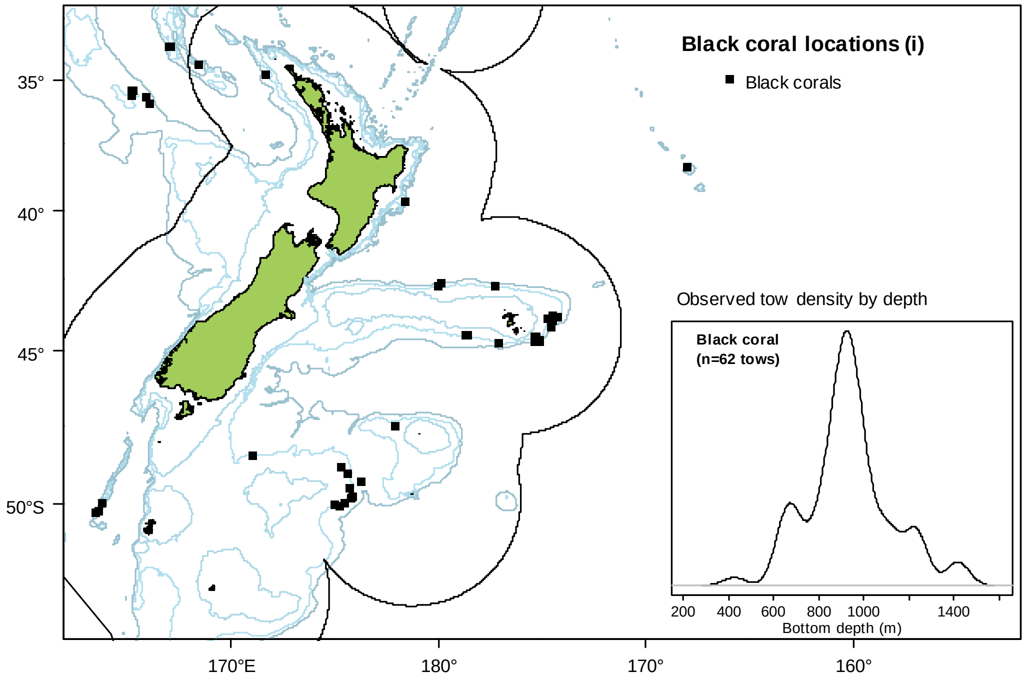


Figure 16: Locations and depth distribution of observed tows from which samples of black corals were returned, 2007–08 to 2009–10. The contours are at 500 m, 1000 m, and 1500 m.

Six genera and one species of black coral were identified in the samples (Table 7, Figure 17–18). 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 7: 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

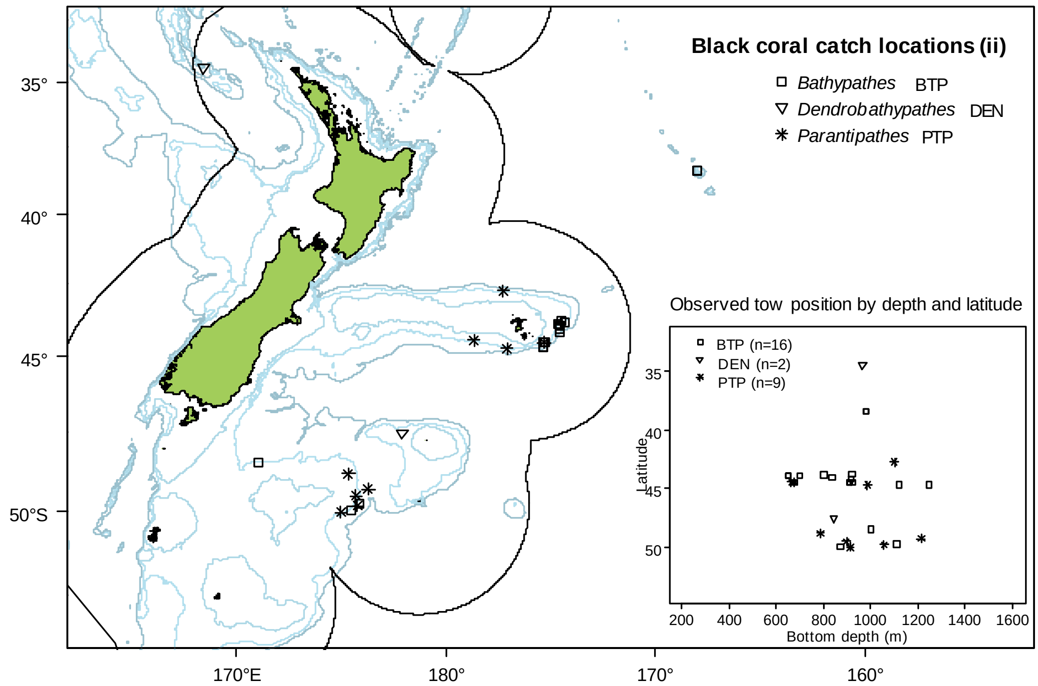


Figure 17: Locations and depth distribution of observed tows from which samples of three genera of black corals were returned, 2007–08 to 2009–10. The inset shows the depth distribution by latitude for each genus.

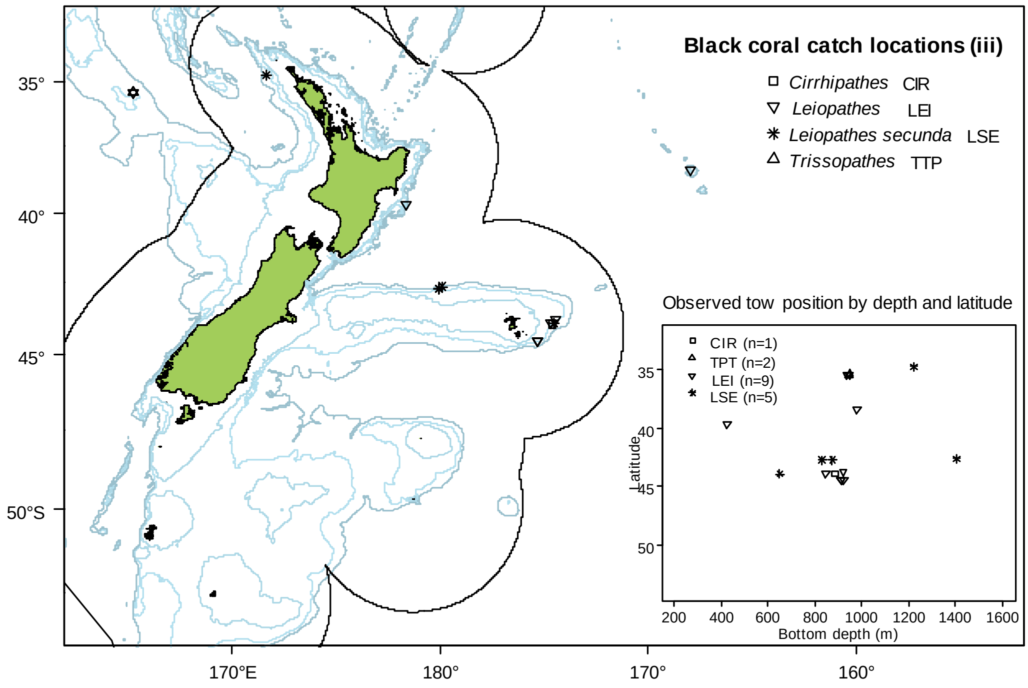


Figure 18: Locations and depth distribution of observed tows from which samples of another four genera of black corals were returned, 2007–08 to 2009–10. The inset shows the depth distribution by latitude for each genus or species.

Stony branching corals

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 19). 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 20 & 21). 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 8: 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

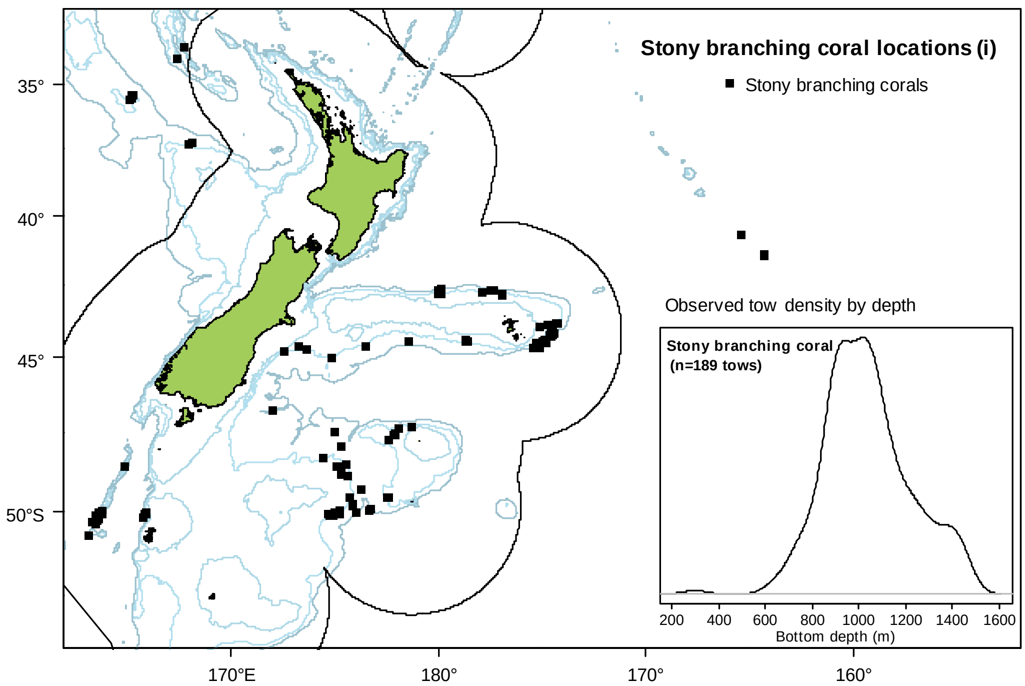


Figure 19: Locations and depth distribution of observed tows from which samples of stony branching corals were returned, 2007–08 to 2009–10. The contours are at 500 m, 1000 m, and 1500 m.

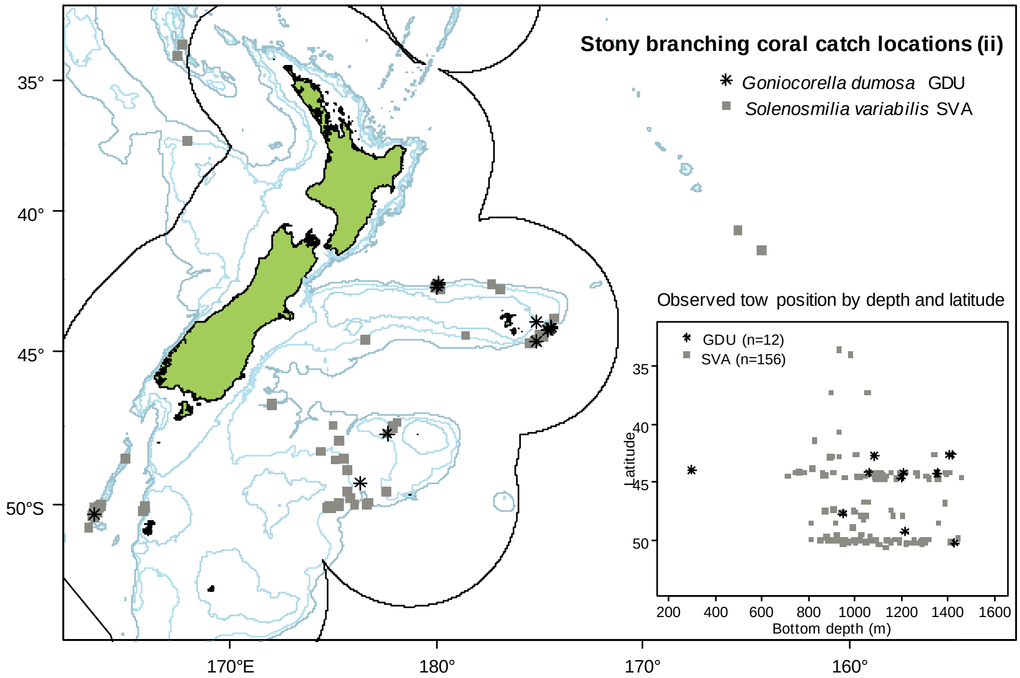


Figure 20: Locations and depth distribution of observed tows from which samples of *Goniocorella dumosa* and *Solenosmilia variabilis* were returned, 2007–08 to 2009–10.

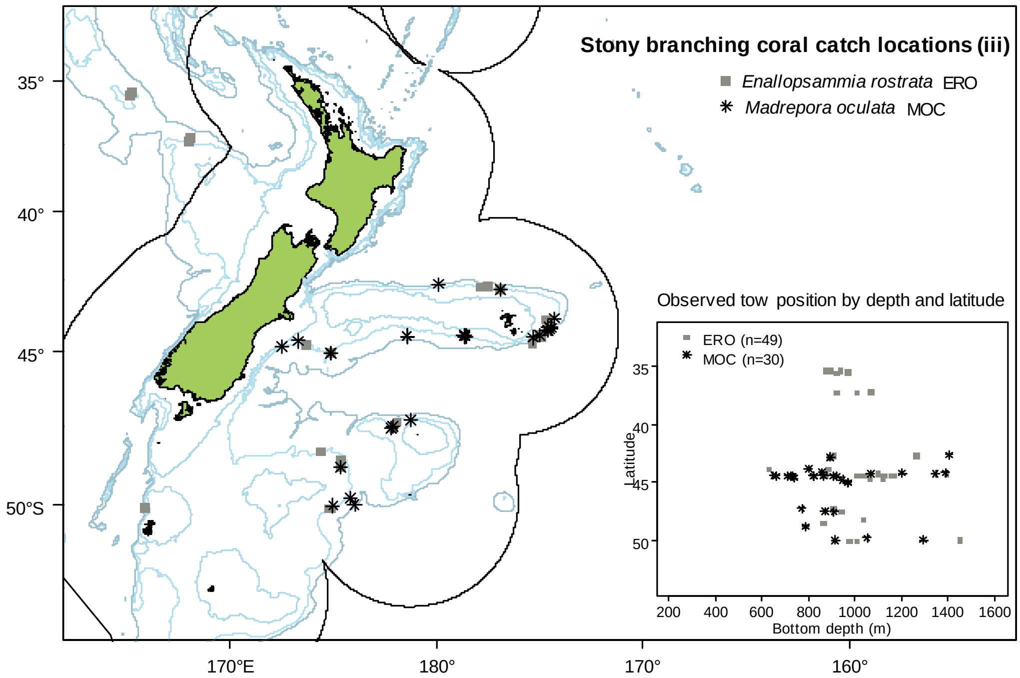


Figure 21: Locations and depth distribution of observed tows from which samples of *Enallopsammia rostrata* and *Madrepora oculata* were returned, 2007–08 to 2009–10.

Stony cup corals

Stony cup corals were returned from areas similar to those for stony branching corals (Table 9, Figure 22). 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 23).

Table 9: 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
Scleractinia													
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

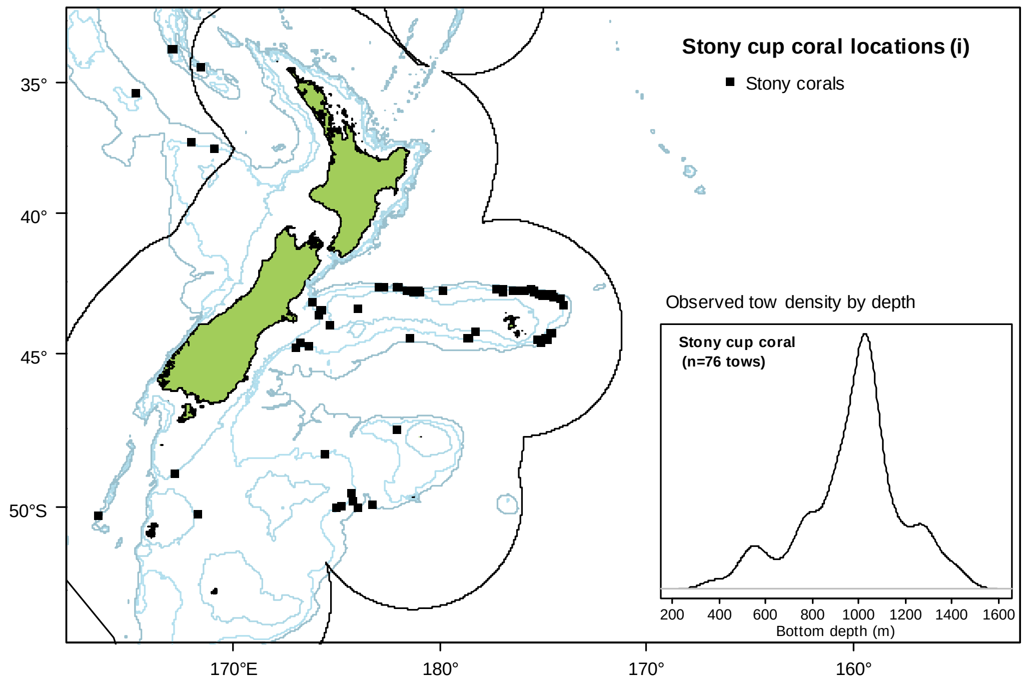


Figure 22: Locations and depth distribution of observed tows from which samples of stony cup corals were returned, 2007–08 to 2009–10. The contours are at 500 m, 1000 m, and 1500 m.

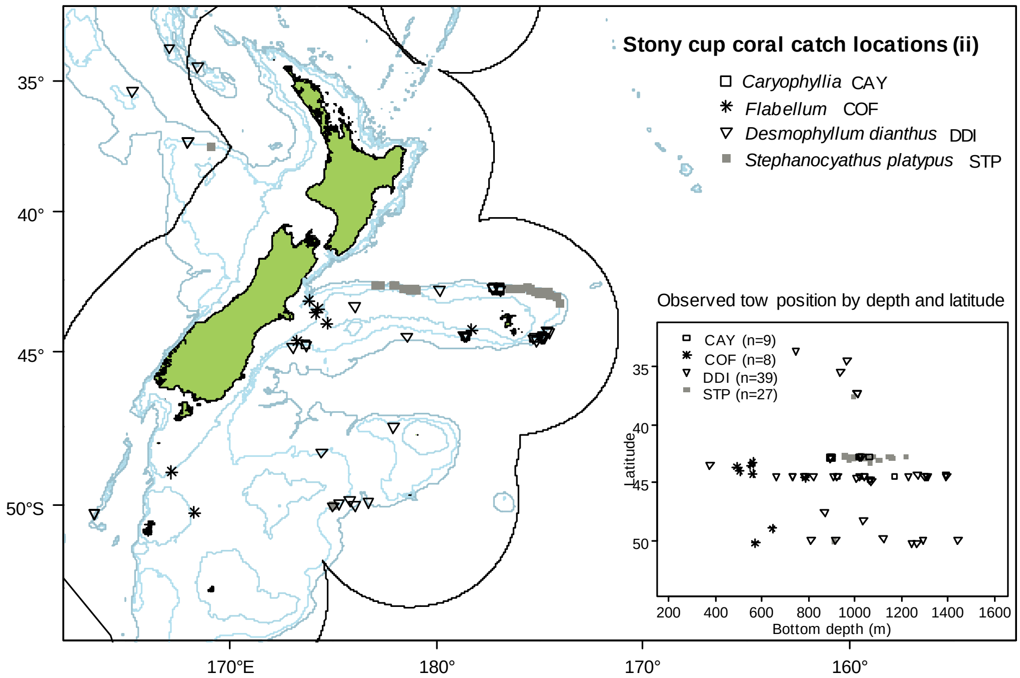


Figure 23: Locations and depth distribution of observed tows from which samples of stony cup corals were returned, 2007–08 to 2009–10. The contours are at 500 m, 1000 m, and 1500 m.

Gorgonian corals

Gorgonians were returned from 136 deepwater tows in all areas outside the EEZ and all FMAs except FMA 8 (Figure 24, Table 10), 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.

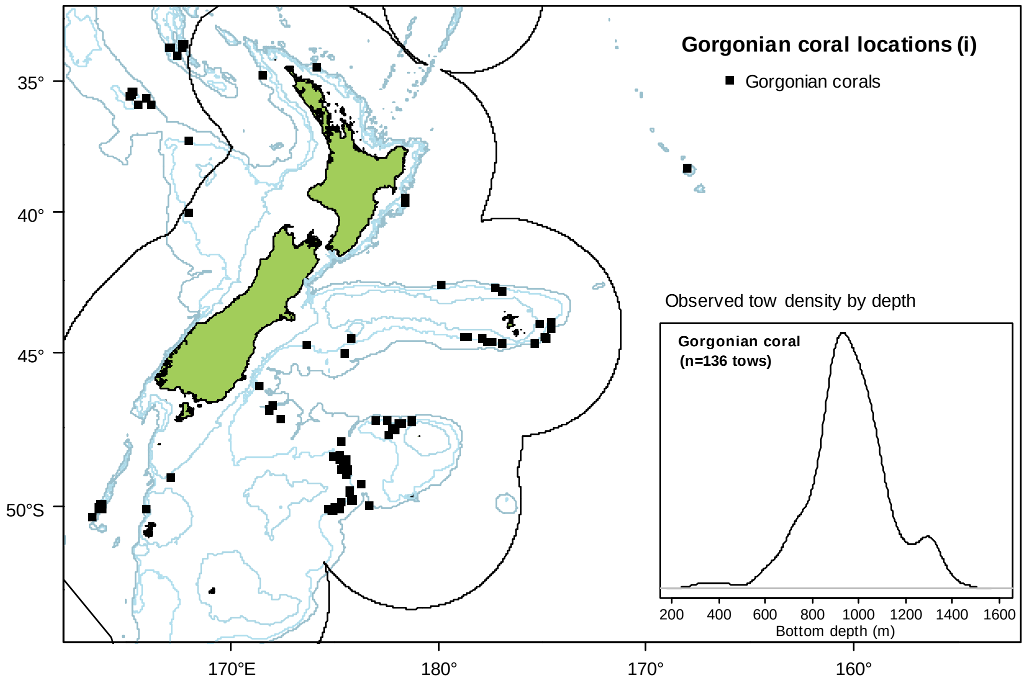


Figure 24: Locations and depth distribution of observed tows from which samples of gorgonian corals were returned, 2007–08 to 2009–10. The contours are at 500 m, 1000 m, and 1500 m.

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.

Table 10: 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

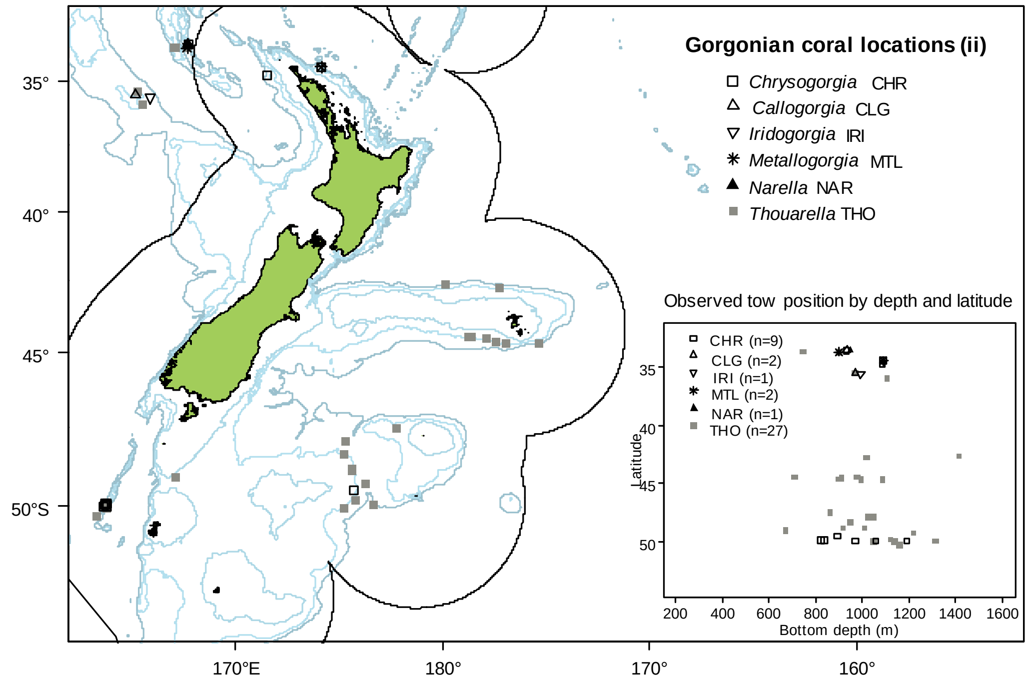


Figure 25: Locations and depth distribution of observed tows from which samples of gorgonian corals were returned, 2007–08 to 2009–10. The contours are at 500 m, 1000 m, and 1500 m.

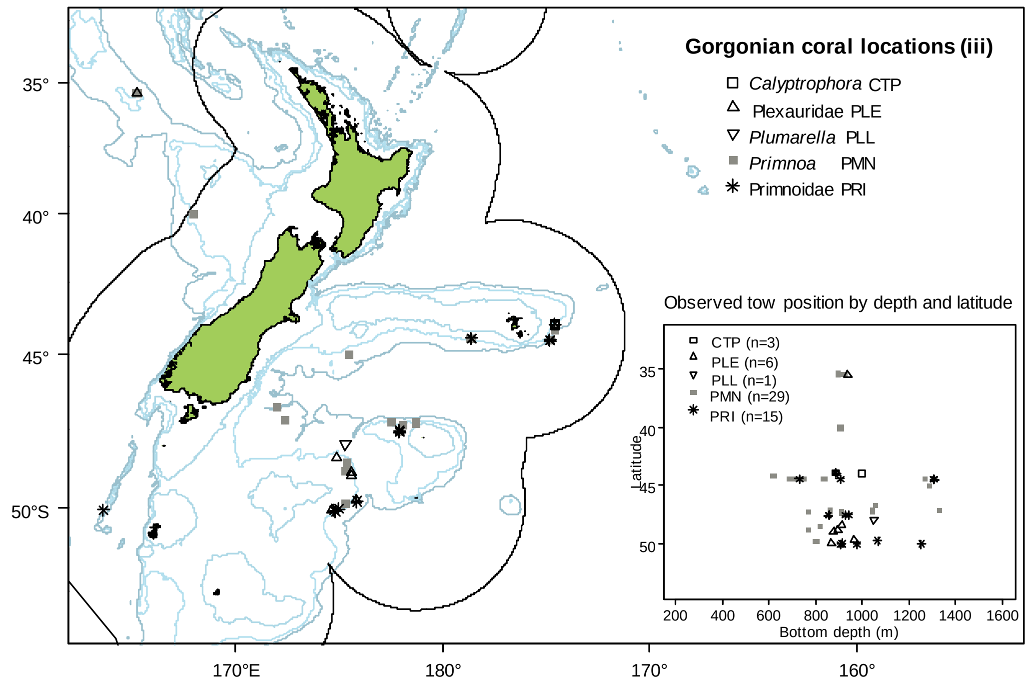


Figure 26: Locations and depth distribution of observed tows from which samples of gorgonian corals were returned, 2007–08 to 2009–10. The contours are at 500 m, 1000 m, and 1500 m.

Bamboo corals)

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 27), 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 28). *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 11: 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

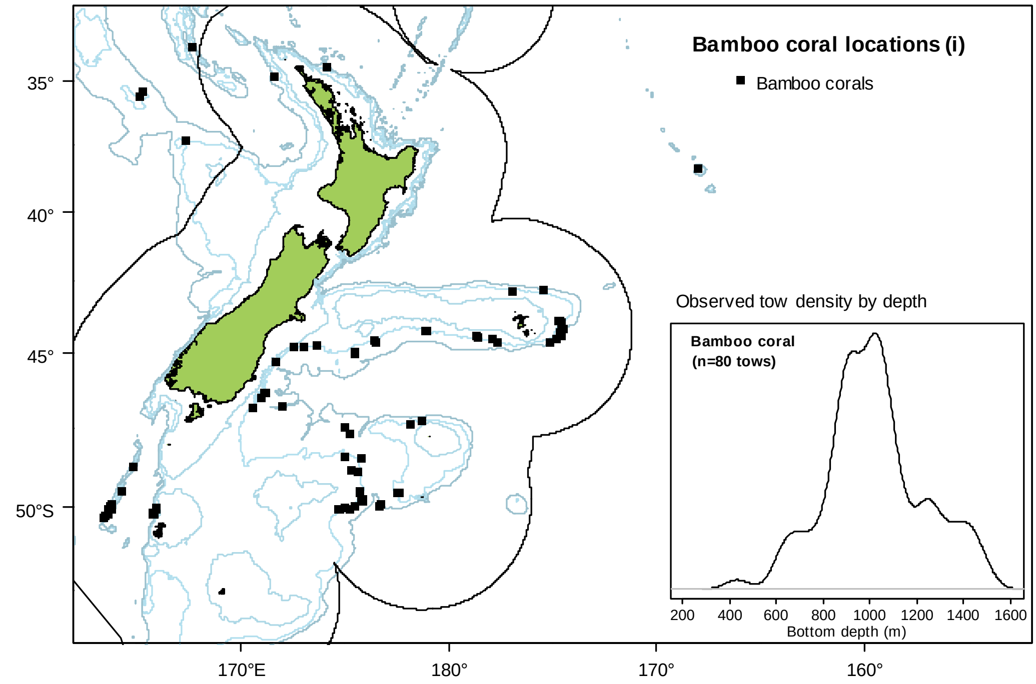


Figure 27: Locations and depth distribution of observed tows from which samples of bamboo corals were returned, 2007–08 to 2009–10. The contours are at 500 m, 1000 m, and 1500 m.

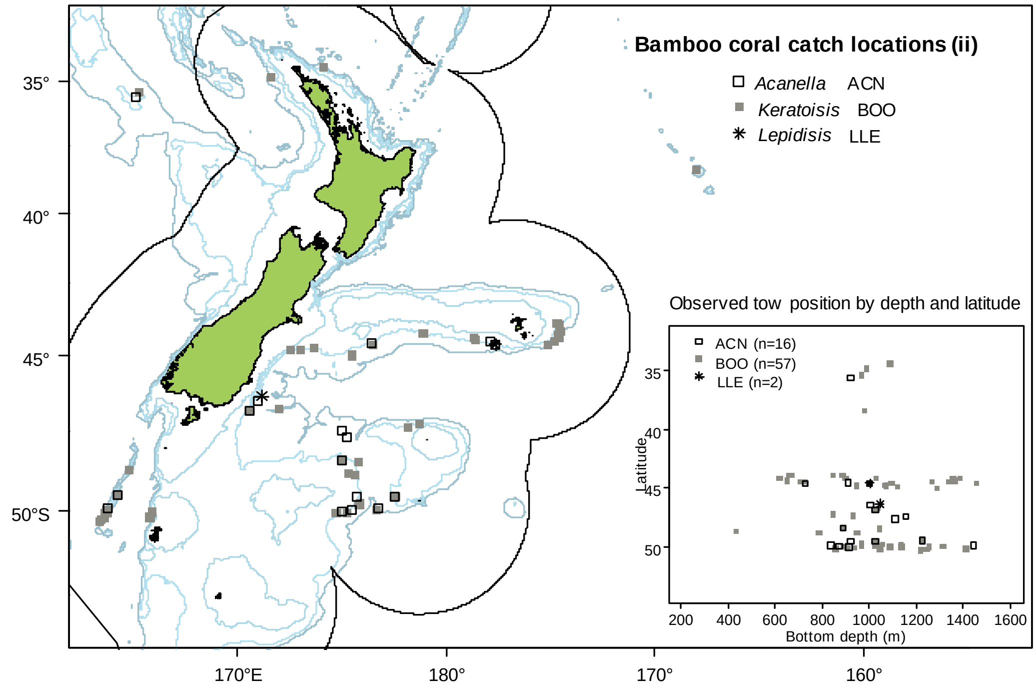


Figure 28: Locations and depth distribution of observed tows from which samples of bamboo corals were returned, 2007–08 to 2009–10. The contours are at 500 m, 1000 m, and 1500 m.

Bubblegum corals

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 12, Figure 29). 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 12: 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

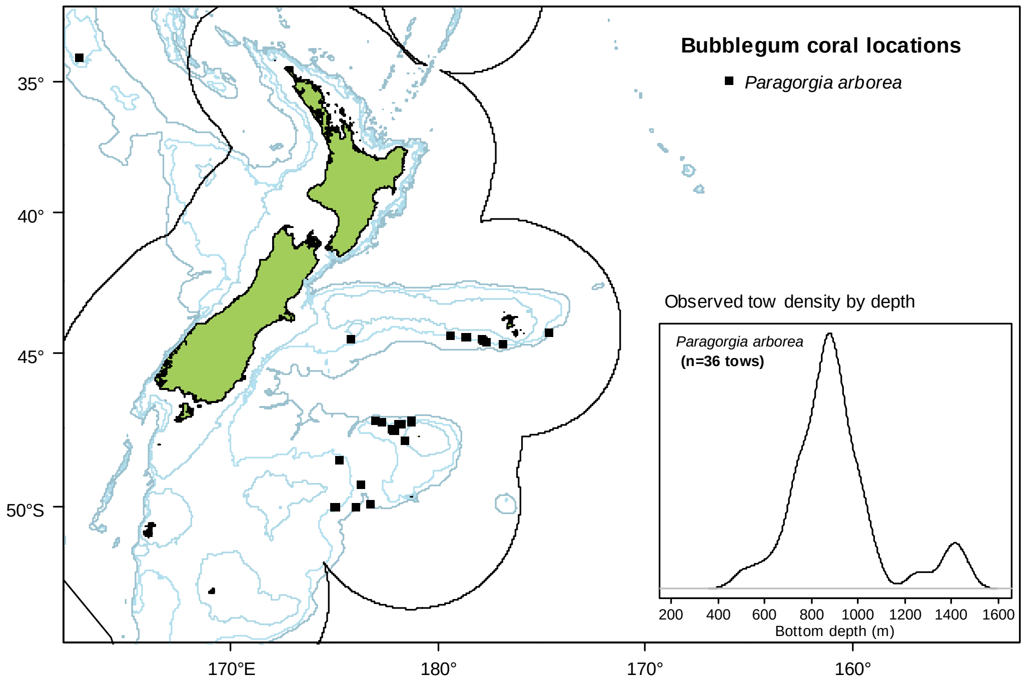


Figure 29: Locations and depth distribution of observed tows from which samples of bamboo corals were returned, 2007–08 to 2009–10. The contours are at 500 m, 1000 m, and 1500 m.

Hydrocorals

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 30 & 31).

Table 13: 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

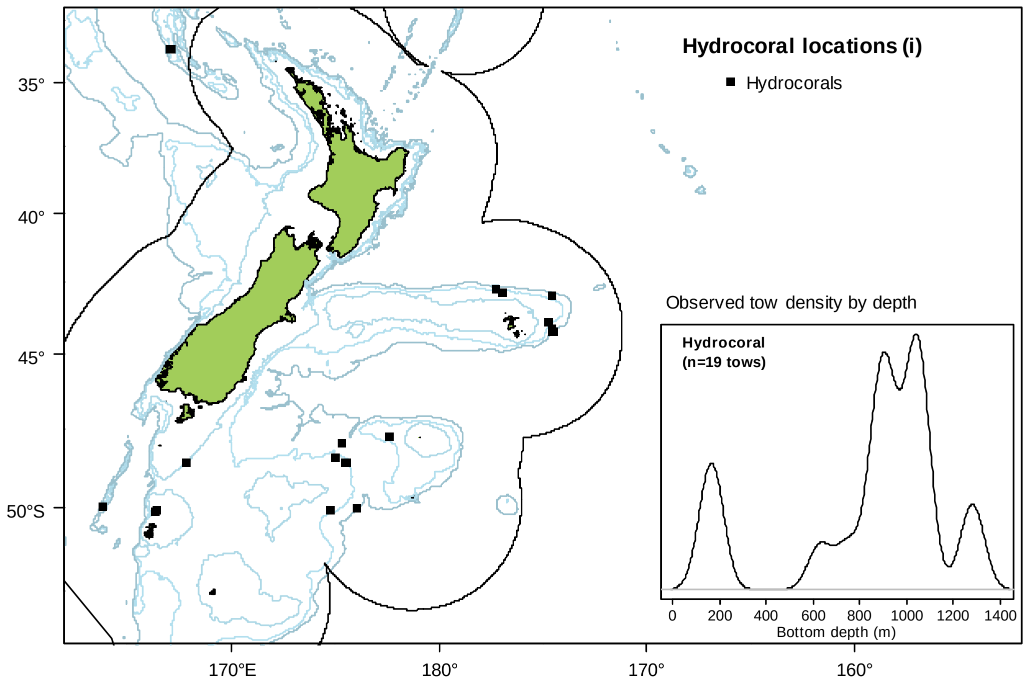


Figure 30: Locations and depth distribution of observed tows from which samples of hydrocorals were returned, 2007–08 to 2009–10. The contours are at 500 m, 1000 m, and 1500 m.

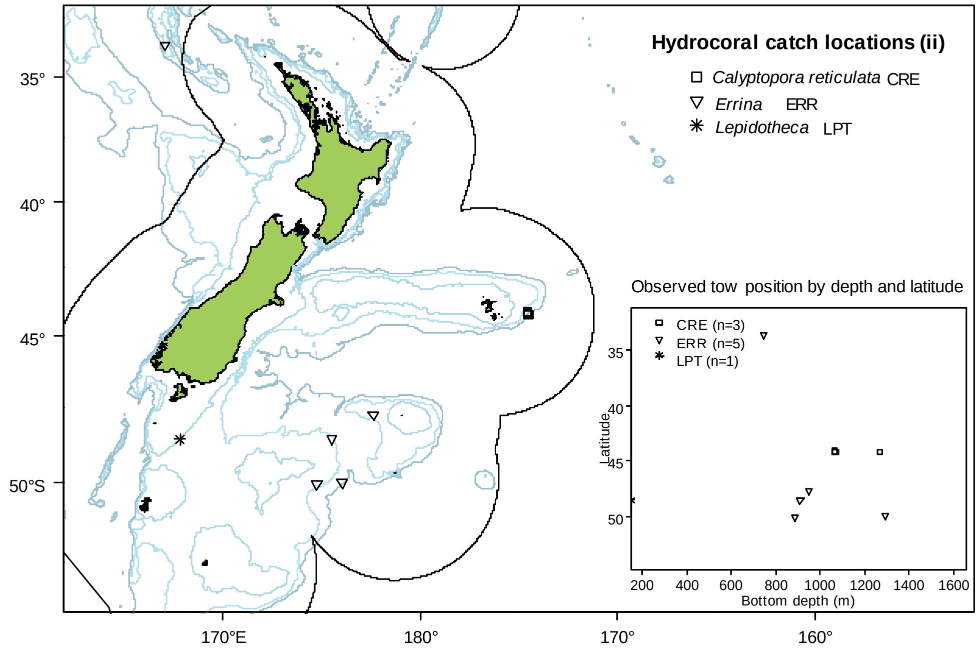


Figure 31: Locations and depth distribution of observed tows from which samples of hydrocorals were returned, 2007–08 to 2009–10. The contours are at 500 m, 1000 m, and 1500 m.

Brief description of observed bottom longline effort and coral catch, 2008–10

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 stony 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).

Specific Objective 2: Assessment of accuracy of observer coral identification

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. This objective will aid in deciding which fauna should continue to be retained for later expert identification ashore.

Some example images of coral specimens are shown in Figure 32.

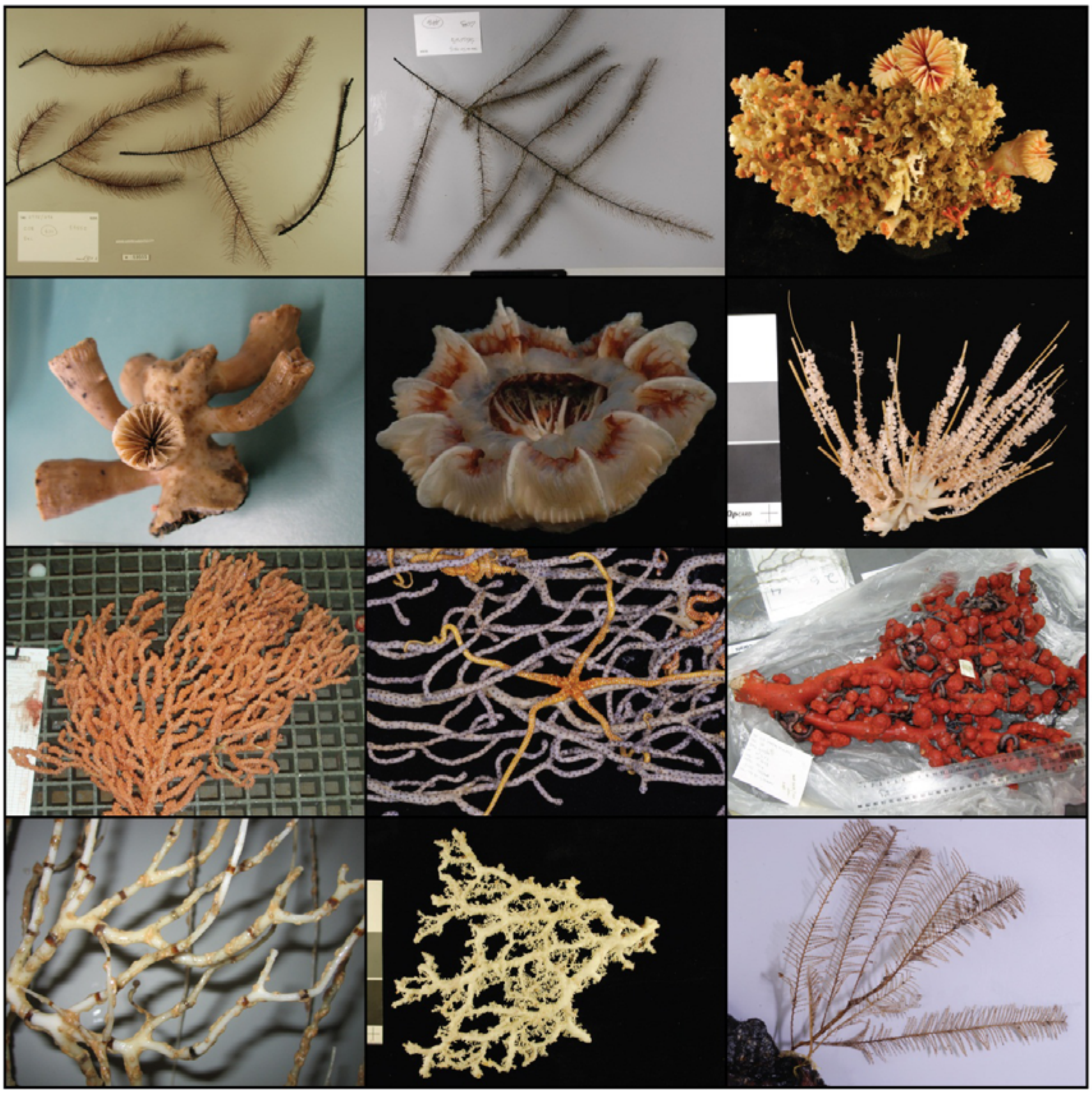


Figure 32: Examples of protected deepsea coral specimens. Top panel L to R: Black corals *Bathypathes* spp., and a stony branching coral *Goniocorella dumosa* with attached cup corals *Desmophyllum dianthus*. 2nd panel L to R: Stony branching coral *Euguchipsammia japonica* and cup coral *Stephanocyathus platypus,* gorgonian primnoid "Rasta" coral *Narella* spp. 3rd panel L to R: Gorgonian corals - sea fans *Primnoa spp.* and Family Plexauridae with associated ophiuroids, and bubblegum coral *Paragorgia arborea*. Bottom panel L to R: Gorgonian bamboo coral *Keratoisis* spp., stylasterid hydrocoral *Calyptopora reticulata* and stylasterid hydroid. Photo credits: NIWA and observers.

To meet the requirements of this objective a method of accuracy of observer classifications 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 key coral groups.

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:

<u>Code 1</u>
Code 1 indicates that the record was unable to be used in the comparison analysis because the coral code was clearly wrong (either a misuse of coral code or a database entry error unable to be addressed), or the coral record is from an expert's identification of an attached sample on the "host" specimen (on a large coral, sponge, or rock), and hence no coral code had been allocated to the attached specimen by the observer. In the following instances we coded the record as a '1' in the extracted dataset.

<u>Selected examples of code category 1 allocation are as follows:</u>
1. Observer has used incorrect code, e.g., observer code SEO (seaweed) expert code MOL (Molluscs), or observer code KWH (Knobbed Whelk) expert coral code HDR (Hydroid). The taxon code represents a different group, was an obvious error, and unable to be resolved.
2. Observer used a coral code that may have been written incorrectly, e.g., MUD for *M. oculata* instead of MOC. If we were unsure if 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.
3. There was a specimen attached to the coral that wad identified by the expert but there was no corresponding observer code.

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

<u>Code 2</u>
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%).

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 gone 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.

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. (2009) 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.

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.

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 14). 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 14.

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. For the gorgonian coral grouping we need to bear in mind that the observers identified some of the gorgonian corals as bamboo and bubblegum coral, and as these two families belong to the gorgonian coral group, the overall result to level gorgonian is reasonable. While noting that the sample sizes are small certain taxa are being confused: hydroids with black corals, gorgonian corals, and or with 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 14: Plot to compare grouped coral codes. The numbers in each row represent a count of the number of times the observer used a particular code. Grouped verified coral codes are listed in the columns and grouped observer coral codes in the rows. 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).

	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				

Discussion (to be completed)

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). 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 (Clark & Tittensor 2010). A previous 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 spatial distribution of the observer coral data reflects interactions with trawl gear and locations of target fishery areas. Observer data can present some data reliability issues, so another aim of this research 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.

Distribution of corals relative to observed trawl fishing effort

Data collection on the presence of protected corals in the catch of commercial fishing vessels was a priority for observers on vessels targeting 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.

Certain known discrete target fishery areas are highlighted by the distribution of the coral catches, from larger fishery areas such as the Stewart-Snares shelf for squid to the feature-based fisheries for orange roughy. For some fishery areas, such as off the west coast of the New Zealand mainland, few protected coral were recorded, despite large numbers of tows. The fisheries here occur largely in waters shallower than about 500 m and are fished predominantly with midwater trawl gear. For hoki targeting off the South Island west coast, this may mean the midwater net is fished very close to the seafloor. For jack mackerel, vessels will fish with the net in the water column, and generally in relatively shallow water. It appears that the low catches in these depths are either 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 lack of corals could be reflect the true distribution of protected corals (e.g., lack of suitable bottom type for species to attach), or that coral cover on the seafloor in may have been removed already through fishing activity. The coral catches off the west coast South Island appear to be restricted to the western edge of the fishing effort close to the 500 m contour.

When the observed trawl data are plotted by target species, the individual fisheries are readily defined, and some showed a notable lack of coral catch. For example, two of the main trawl fishing areas for scampi – in the Bay of Plenty and the southeastern edge of the Auckland Islands Shelf – had no coral catch records.

These coral records represent seafloor trawling in areas where fishers return repeatedly within a season or from season to season following historic trawl tracks. Many of the seafloor areas and features will have been regularly fished for many years (O'Driscoll & Clark 2003, Baird et al. 2011), but few or no data exist to provide an idea of historic coral catch.

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 some fisheries may have a more limited effect on a coral group than others. For example, black corals were not recorded for any 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.

When the positions of the tows from which samples were collected and returned for verification of the observer identification, the distributions by genus or species within each broader group can be described. 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 both shallow-middle depths waters and deep waters. 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.

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. Publications that include distribution data for protected corals (see Sanchez (2005); Consalvey et al. (2006); 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.

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. Certainly 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 and in collaboration with DOC and MFish, NIWA have recently 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).

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 this highlights labelling issues and 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.

Identification to species level by observers (Appendix 5) had a low level of accuracy particularly for the identifications for the four stony branching coral species. We note that branching stony coral species are difficult to identify. Identification of hydrocorals (and hydroids) was also poor although the small sample sizes indicate this is a lesser problem overall. Also from the results it was clear that it would have been more appropriate if the observer had used a higher taxonomic level for bamboo corals (ISI), not species codes such ACN (*Acanella* spp.). If the observer is confident with their identification we have encouraged identification to species level (see Invertebrate Guide Instructions to Observers (Tracey et al. 2007)), and suggest it is best to err on the safe side and go up a level to Family or Order when not confident of identifying the species. An update to ‘A guide to common deepsea invertebrates in New Zealand waters (Tracey et al. 2007) is underway (MFish Project ZBD201039). This will provide additional sheets for deepsea coral families to help improve at-sea identification.

The results of the level B analysis show that observer identifications at the higher taxonomic level were reasonably accurate for black corals and all stony corals (cup and branching groups). Certain gorgonian corals (those excluding the identifications of the bamboo and bubblegum corals) were often identified incorrectly (70% wrong). A high number were confused with 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 (88%), however, here there was also a problem in distinguishing hydrocorals.

Summary

The research described in this report contributes important knowledge of the region’s coral biodiversity, improves our understanding of the ecosystem effects of trawling, and indicates areas of risk. The dataset used is large and provides very good information both at key coral group level and at the lowest taxonomic level possible from the ground-truthed 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 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.

At the data grooming level, there are some issues with the data extracted from *cod* e.g., apportioning realistic weights when reloading weight data from our ground-truthed expert identifications. If the observer has not provided proportions of the various corals in the catch we rely on the instructions provided by RDM MFish and on weights of the ground-truthed samples to apportion weights to 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. In these situations the database manager needs to seek advice from the expert and / or not use the information. To help strengthen our confidence in the dataset and to aid this grooming process we extracted minimum and maximum data values for each group to pick up any obvious outliers.

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.

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.
- **(b)** The draft MCS Annual Plan 2011/12 recommends that, in addition to collecting sub-samples of corals for identification from nominated fisheries, the coral distribution data for the region be expanded by combining the observed data from this project with coral research data from biodiversity and research trawl surveys (see http://www.doc.govt.nz/getting-involved/consultations/current/draft-marine-conservation-services-annual-plan/).We also recommend we include earlier observer data, those that pre-date 2007, in this dataset. Published distribution data for certain protected coral species highlight the benefits of using various sources to describe their geographic and depth distributions. Using a single database and subsequent plots of combined data will provide a more complete understanding of the spatial distribution of protected coral fauna to species level.

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) in order to better assist observer's in making accurate identifications.
- **(b)** More expert participation in the briefings given to observers with regard to sample identification and collection. This would include providing clearer instructions on actual specimen identification, on what to retain, and on what to record on the benthic forms and labels. Clearer instructions relating to sub-sampling may have enabled the use of more records in the analysis.These briefings could address the identification of all invertebrates, not just the protected corals.
- **(c)** The proportion of mis-identifications highlights the need returning samples, sub-samples for expert identification and molecular verification of morphological identifications. This will continue to monitor the reliability of the data - improvements or declines? It is worth noting that the branching stony coral species are difficult to identify and identification to the higher stony branching coral level (CBR) where observer accuracy is very good would be more appropriate.

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.

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, Mark Fenwick, Kareen Schnabel, expert 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 helpful 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.

References (to be completed)

Althaus F, Williams A, Schlacher TA, Kloser RK and others (2009) Impacts of bottom trawling on deep-coral ecosystems of seamounts are long-lasting. Mar Ecol Prog Ser 397:279–294

Anderson OF, Clark MR (2003) Analysis of bycatch in the fishery for orange roughy *Hoplostethus atlanticus*, on the South Tasman Rise. Mar Freshw Res 54:643–652

Baird SJ, Wood BA, Bagley NW (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.

Ballara, SL O'Driscoll RL Fu D (2010) Catches, size, and age structure of the 2007–08 hoki fishery, and a summary of input data used for the 2009 stock assessment. New Zealand Fisheries Assessment Report 2010/18. 98 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 MR, Rowden AA (2009) Effect of deepwater trawling on the macro-invertebrate assemblages of seamounts on the Chatham Rise, New Zealand. Deep-Sea Res I 56:1540–1544

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 JA, Gowlett-Holmes K, Lowry JK, O'Hara T, Poore GCB, Williams A (2001) Seamount benthic macrofauna off southern Tasmania: community structure and impacts of trawling. Mar Ecol Prog Ser 213:111–125

Parker, S. J., Penney, A.J., Clark, M.R. 2009. 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.

Parker, S.J., S. Mormede, D. Tracey and M. Carter. 2009. 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.

Rowden A, Tracey D, Mackay K, Leathwick J 2008. Distribution of Structure-Forming Scleractinian Corals in the New Zealand Region. Presentation to the Deepsea Coral Symposium 2008. Theme: Coral Ecosystems and Habitats associated with Seamounts. 1 p.

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.

Sanchez 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.

Townsend A, de Lange P, Duffy C, Miskelly C, Molloy J, Norton D (2008). New Zealand Threat ClassificationSystem 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.; 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., 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. 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.; 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., 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. 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.

Tracey, D., Baird, S. J. (2011). Identification of Protected Corals. NIWA Unpub. Progress Report prepared for Marine Conservation Services, Department of Conservation | Te Papa Atawhai. Project: MCSINT 2010/03 / DOC11302 (Objective 1, Milestone 1. 16 p.

Tracey D, Rowden, A., Mackay K, Compton T. (2011). Habitat-forming coldwater corals show affinity for seamounts in the New Zealand region. Mar Ecol Prog Ser 430, 1–22.

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.]

Appendix 5: Plot to compare_species_codes.xls (attached)

Appendix 1: Codes listed by group or species. Those highlighted were identified by observers and experts, 2007–10.

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**	

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 2.2.

	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

Appendix 2: — *continued*

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

Appendix 2: — ***continued***

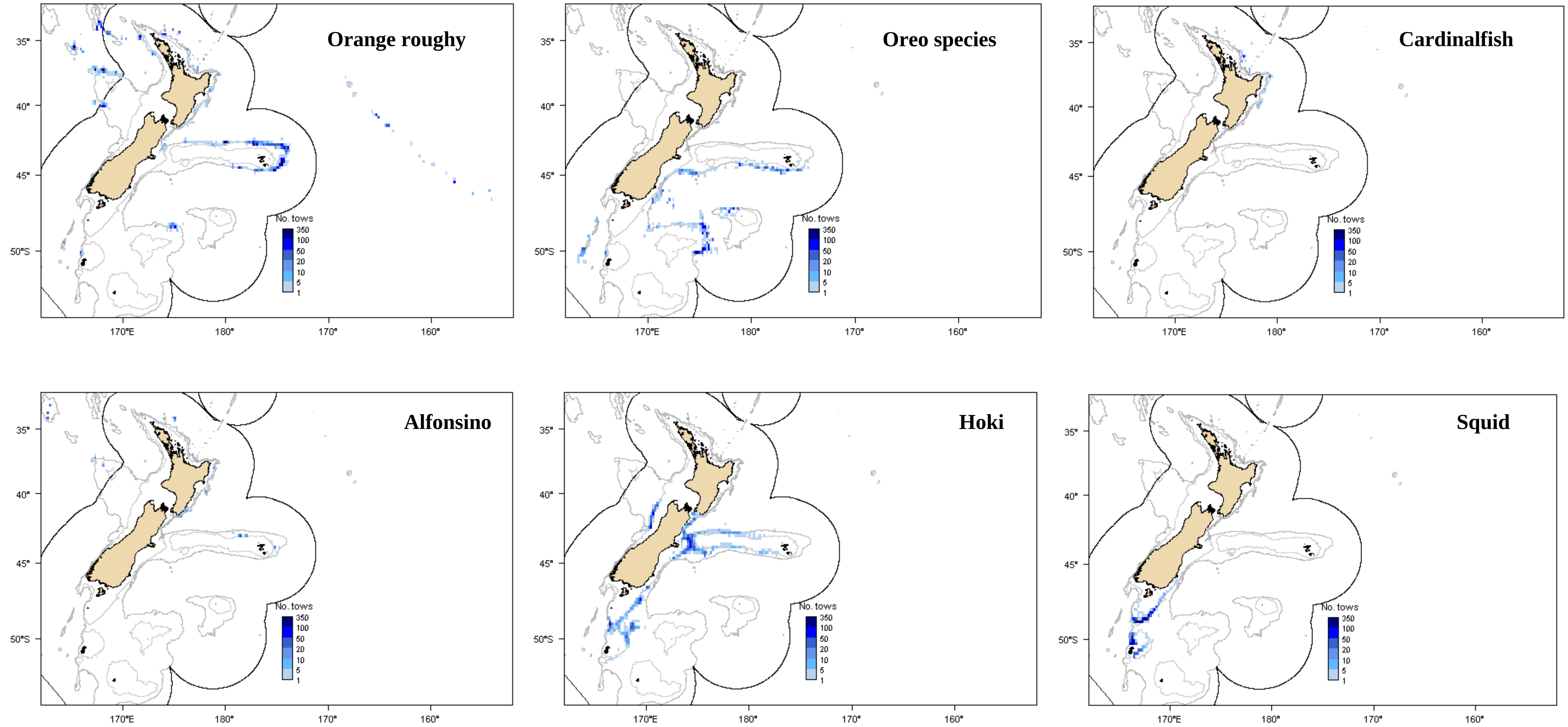


Figure 2.1: Distribution of observed tows in 0.2° latitude x 0.2° longitude cells, where orange roughy, oreo species, cardinalfish, alfonsino, hoki, and squid were targeted, for 2007–08 to 2009–1 0 [subset of data shown in Figure 2].

Appendix 2:— *continued*

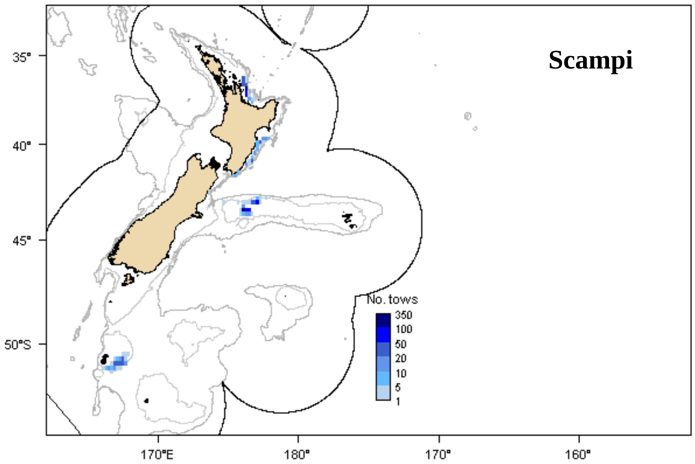


Figure 2.2: Distribution of observed tows in 0.2° latitude x 0.2° longitude cells, where scampi was targeted, for 2007–08 to 2009–10 [subset of data shown in Figure 2].

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.

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: 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