# Marine communities associated with the frigate *Canterbury* and on nearby shores, eastern Bay of Islands, 2012

**Fish Forever**

Images ©Paihia Dive

**A report prepared for Ngati Kuta and Patukeha**
**December 2012**

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## Fish Forever*

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**Abstract**

The communities of animals and plants associated with the scuttled HMNZS *Canterbury*, and with the natural reefs of Maunganui Bay and other nearby shores in the eastern Bay of Islands, were examined by scuba divers and with still and video photography between 15 April and 26 May 2012. This sampling continued the time-series of observations required under the resource consent issued to the local Hapu to enable the sinking of the vessel in Maunganui Bay (Mountain Harte 2009a). The results of this sampling need to be considered in the light of the 2-year Rahui (ban on all fishing, except for the harvesting of kina) that was placed on Maunganui Bay in November 2009. Not all the sampling of previous years was repeated in 2012—for logistic reasons and because some was seen as unnecessary. On the other hand, new sampling—both method and area—was introduced. Most importantly, baited underwater video (BUV) drops gave standardised relative-abundance estimates of fish for sites within Maunganui Bay as well as on the nearby open coast.

The percentage cover by sessile organisms of both the vertical and horizontal surfaces of the *Canterbury* increased significantly between July 2011 and April 2012, reaching the full coverage possible. (Note though that more than a quarter of the horizontal surfaces were covered in non-living material.) Although 'species richness' (more accurately, taxon richness) changed little, there were large changes in community structure. Most noticeable between 2011 and 2012 were the large increases in sponge and tubeworm cover on all surfaces, with concomitant decrease in filamentous algae and lithothamnion paint.

Mean numbers of fish, and mean species richness, by diver fish-count (DFC) circumnavigations of the *Canterbury*, were much the same in 2012 as they were in 2011. However, the densities of an essentially unfished reef-associated generalist indicator species the leatherjacket *Parika scaber*, the planktivorous two-spot demoiselle *Chromis dispilus*, and the highly sought generalist snapper *Pagrus auratus* were lower around the *Canterbury* in 2012 than in 2011. There were more large snapper in 2012 compared with 2011. A crude estimate of the biomass of snapper associated with the *Canterbury* in 2012 was 118 g per 100 $m^{-2}$, compared with 157 g in 2011.

In DFC surveys of natural reefs in Maunganui Bay, mean numbers of fish and mean species richness were much the same in 2012 as they were in 2011. The densities of leatherjackets, two-spot demoiselle and snapper may have been greater in 2012. Snapper biomass was greater in Maunganui Bay than around the *Canterbury* in both years.

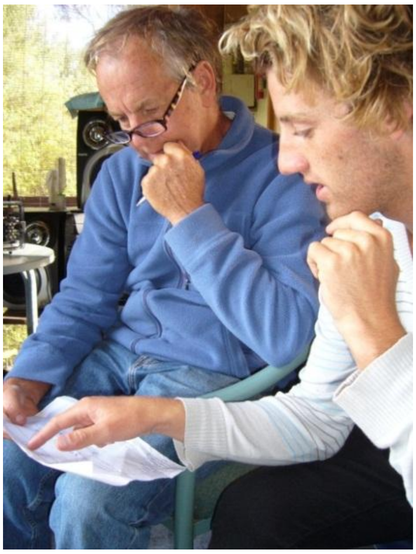
Introduction of the BUV allowed comparisons of relative fish abundance between the *Canterbury*, elsewhere in Maunganui Bay, and along the broader Cape Brett Peninsula—but only for species attracted to bait. The densities of snapper were similar throughout, whereas no leatherjackets were seen around the *Canterbury*.

- Fish Forever, a community group campaigning for marine protection in the Bay of Islands, offered to undertake the 2012 survey of HMNZS *Canterbury* and associated sampling required of Ngati Kuta and Patukeha under their resource consent for the sinking of the vessel in Maunganui Bay. Robert Willoughby of Ngati Kuta guided the project from the Hapu perspective; Vince Kerr and John Booth oversaw the science. Vince Kerr, supported by the Department of Conservation (DOC), organised all, and undertook a good portion of, the field work; other key contributors in the field were John Dawn, Laura Jerome, Darren Markin, Joe Moretti, Jane Shaw, Mark Taylor, Dave Wadsworth, Dean Wright, and Oliver Zemborski. Initial analyses of the observations, and entry of the data into Excel, were by Vince and Dianne Kerr, with the support of DOC. This report was prepared by John Booth, assisted by Tim Booth, based on information provided by the field teams and guided by the previous surveys. It was peer reviewed by John Dawn, Vicky Froude, Jeremy Gibb, Vince Kerr and Chris Richmond; blame them for any balls-ups!.

The epibenthic community on the *Canterbury* is still evolving. DFCs associated with the ship appear more stable, but the absence—to all intents and purposes—of variability data make any conclusions tenuous. The sampling of the *Canterbury* and surrounding areas should continue, but with the several changes recommended below. Note too that the sampling of the *Canterbury*, and the preparation of the report, is no trivial task. It is recommended that in future it be a joint project between (at least) local Hapu, Fish Forever, Bay of Plenty Polytechnic and Northland Dive.

No nasties such as the invasive laminarian kelp *Undaria* were recorded. Neither the Special Mark nor the moorings were inspected as part of this survey, but should be next time, as required under the resource consent.

Continuing the current Rahui is highly recommended—if for no other reason than that a natural state may be attained around the *Canterbury* and throughout the broader Maunganui Bay in the absence of (theoretically, any) interference from fishing.




**Vince Kerr (left) and Joe Moretti plan the day's sampling in Maunganui Bay (left; *Photo* John Booth); Maunganui Bay on the Cape Brett Peninsula (right; *Photo* © Salt Air). The *Canterbury* rests near the streak of white to the upper right of the island in the lower left-hand part of the photograph.**

## Introduction

This document continues the annual reporting of colonisation of the frigate HMNZS *Canterbury* since its scuttling in Maunganui Bay in the eastern Bay of Islands in November 2007. It also updates information on the fishes associated with the *Canterbury*, as well as with the nearby natural reef communities. (Additional sampling of fishes of Maunganui Bay and the broader Cape Brett Peninsula is also reported.)

The Northland Regional Council requires information concerning the biological colonisation and structural integrity of the vessel, together with the information on the ecology of surrounding natural reefs, for the resource consent issued under the Resource Management Act 1991 to sink the vessel. Conditions of CON20061660601 (01–02) (expires 2041) relevant to this document are as follows.

*16 The Consent Holder shall provide a Monitoring Plan for the approval of the Council (Coastal Monitoring Team Leader and Biosecurity Team Leader) within three months of the date of commencement of this consent. The Monitoring Plan shall cover the coastal marine area* *between Putahataha Island and White Rock, the seaward boundary of which shall be the 30 metre bathymetric contour and shall include:*

*(a) The methodology for the monitoring of changes to marine habitats and biodiversity;*

*(b) The methodology for monitoring for any unwanted organisms listed under the Biosecurity Act 1993;*

*(c) Inspection of the state of the vessel;*

*(d) The frequency of monitoring, which shall include a baseline survey at least one month before the sinking of the vessel, and monitoring surveys within three months of the sinking, six months after the sinking and at least annually thereafter;*

*(e) Reporting of the monitoring results;*

*(f) Written evidence of consultation with the Department of Conservation on the methodology for monitoring of changes to marine habitats and biodiversity and of consultation with Biosecurity New Zealand on the monitoring methodology for unwanted organisms.*

*23 The Consent Holder shall carry out annual visual inspections of the Special Mark and moorings to ensure their structural integrity, and provide a report to the Council, in writing, within one month following each inspection.*

Newcombe & Retter (2007) formulated the required Monitoring Plan. Results from the baseline survey undertaken in 2007 before the vessel's scuttling, and surveys in 2007 and in 2008 after the scuttling, were given by Mountain Harte et al. (2010). Bay of Plenty Polytechnic (BoPP) reports gave the background and rationale to the sampling that followed, and the results to date (Fairweather & McKenzie for 2008, McKenzie [2010] for 2009, Greene & Tuterangiwhiu for 2010, and Jacobs & Robertson for 2011), so only essential background is repeated here.

## Methods

In order for results to be comparable over time, methods used should ideally be the same, or there should be sufficient overlap using both methodologies to allow statistical comparison. However changes were made in 2011, without overlap, aimed at streamlining the sampling and to enable more robust analyses (Jacobs & Robertson for 2011). Most importantly, in contrast to previous years when the epifauna on the ship quadrats was assessed on-the-spot by divers, in 2011 it was photographed and analysed later in front of the fire, glass in hand. Also, variable-distance fish counts—instead of the standard belt transect—were used to estimate overall fish numbers, density of the indicator species leatherjacket (*Parika scaber*), and the density (and, in turn, biomass) of snapper (*Pagrus auratus)*. And the two-spot demoiselle (*Chromis dispilus*) became an environmental indicator species. (The relative abundance of an unfished planktivore such as this can be used to indicate changes in—possibly even the overall well-being of—ecosystems over time.) Each of the 600-m ship-circumnavigation dive surveys for fish was divided into twelve equal-length transects enabling direct comparisons with the 50-m natural-reef fish surveys around the edges of Maunganui Bay, at the same time providing information on variability in fish abundance. And surveys of the epifauna on the surrounding reef were scaled down because it was felt that the different depths, substrates and land-runoff-influences made comparisons between the ship and the natural reef essentially irrelevant.

The 2011 report—with these changes—was not available to us when the 2012 sampling was planned and undertaken. The 2012 sampling was based largely on the protocols of Greene & Tuterangiwhiu for 2010 – although we made changes of our own in 2012. Our changes included a) photographing the benthic quadrats on the ship surface instead of assessment by divers *in-situ* (as was done—as it turned out—in 2011), and using smaller quadrats (0.10 $m^2$ instead of 0.25 $m^2$) but with more of them; b) no visual surveys of the hangar, funnel, turret room, bridge or rear bunkroom (Zones J–N of Jacobs & Robertson for 2011); c) no visual surveys of the handrails (Zones O and P); d) no comparisons of epifauna between the *Canterbury* and natural reefs in Maunganui Bay; and e) use of a baited underwater video (BUV) for relative fish abundance and size estimates, not only around the

*Canterbury* but also in other parts of Maunganui Bay and out to Cape Brett, so enabling comparisons of fish density and size between the (nominally) protected Maunganui Bay and nearby fished areas.

The survey was undertaken between 15 April and 26 May 2012. For consistency, the data were analysed and are reported in much the same manner as in previous surveys. It is important to note that we used uncritically the historic data as presented by Jacobs & Robertson in 2011 (apart from correcting a few obvious errors).

## 1. Epifauna on the *Canterbury*

Photographs of the vertical and horizontal surfaces of the *Canterbury* gave information on the presence of, and extent of cover by, epifauna. Invertebrates and algae from established taxonomic groups, as well as new taxa and non-living categories, were recorded. These are collectively referred to, for convenience, as 'species richness'—although none of the taxa were identified to species level.

**Table 1. Epifauna/cover categories used in 2012 sampling of the *Canterbury* (*, new category).**

1. Uncolonised
2. Algae: *Lithothamnion* spp. (encrusting 'paint' algae); foliose algae (sedentary macroalgae with lamina and/or stipe); filamentous/turfing
3. Anemones: *Corynactis* sp. (jewel anemones)
4. Hydroids
5. General encrusting community (algae, hydroids, bryozoans ascidians etc.)*
6. Cup corals: *Monomyces rubrum* and others
7. Tube worms: *Pomatoceros* spp. (encrusting annelid)
8. Sponges: upright; encrusting
9. Molluscs: bivalves, gastropods*
10. Sand/silt substrate*
11. Shell fragments*

In 2012, seven vertical transects, and two horizontal, were sampled; in addition, one horizontal zone was sampled haphazardly (*see* Figure 1 and Table 2). The transects and the horizontal zone were the same as those surveyed by Greene & Tuterangiwhiu in 2010, but for the ditching of the vertical Transect I on the front of the bridge and the addition of the horizontal Transect R_2 (labelled R in the original 2012 data spreadsheet) on the foredeck. The quadrats—each 0.10 m²—were photographed using a Canon G12 camera in an Ikelite housing permanently fixed to, and focussed on, the centre of a 32 x 32 cm frame. Each photograph was then adjusted for light level and a 20x grid overlay placed in Photoshop from which the percentage cover of each of the grids for each quadrat was estimated.

For the vertical transects, the weighted transect line was unwound down the side of the vessel. The anti-foul line was the zero mark because of reduced benthic growth below this point. For the horizontal transects, the transect line was run between the respective structures, except for Zone Q which was sampled haphazardly (Table 2). The bottom left-hand corner of the 0.10 m² quadrat was placed at the bottom (beginning, in the case of the horizontal transects) of the transect line and a photograph taken ensuring that the entire quadrat was captured and in focus. This was repeated every 2 m until the top of the hull (other end) was reached.

Estimated percentage cover was the mean value over all quadrats, with its associated confidence intervals. 'Species richness' was the mean number of taxa over all quadrats.

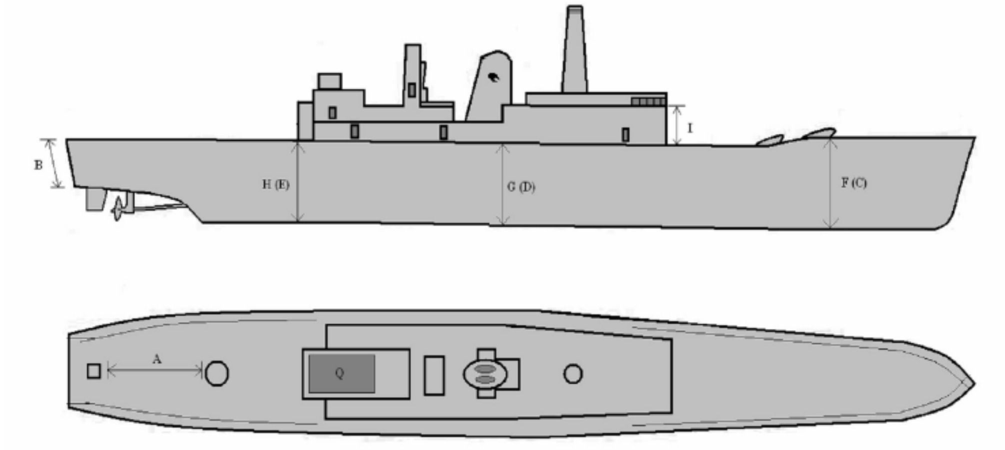



**Figure 1. Transects and zones of the *Canterbury* (*see* Table 2). Transect I was not sampled in 2012; R_2 was an additional horizontal transect sampled in 2012, running from the wheelhouse centre to the bow.**

**Table 2: Methods used in the 2012 epifuanal assessments of the *Canterbury* (based on Greene & Tuterangiwhiu in 2010 and Jacobs & Robertson in 2011, but with additional horizontal Transect R_2 on foredeck and the ditching of vertical Transect I on the front of the bridge; *see* Figure 1).**

| Method | Method description | Transect /Zone | Location | Site details |
|---|---|---|---|---|
| Horizontal transect | The transect line was positioned along a horizontal surface. The bottom left hand corner of the 0.1 m² quadrat was placed in line with the 0 m mark and a photograph taken. This was repeated at 2 m intervals along the transect line. | A | Aft deck | The transect line was run from the back winch to the entrance of the aft storage room along the centre line of the deck. |
| | ditto | R_2 | Foredeck | The transect line was run from the wheelhouse to the bow along the centre line of the deck. |
| Horizontal haphazard zone | A 0.1 m² quadrat was haphazardly placed 5 times within the zone and a photograph taken. | Q | Hangar roof | |
| Vertical transect | A weighted transect line was lowered from the top of the hull to the sea floor (or as stated in site details column). The bottom left hand corner of the 0.1 m² quadrat was placed in line with 0 m on the transect and a photograph taken. This was repeated at 2 m intervals along the transect line. | B | Stern Hull | Diver A was located at the top of the stern hull, in line with the centre line of the vessel, while diver B ran out the transect line along the centre line of the hull. The 0 m mark was the deepest point of the vertical surface of the hull. |
| | ditto | C | Port forward hull | The transect line was lowered in line with the forward bollards at the top of the deck incline and run to the sea floor. |
| | ditto | D | Port mid-ship hull | The transect line was lowered in line with the forward arm of the davit and run to the seafloor. |
| | ditto | E | Port aft hull | The transect line was lowered in line with the hanger entrance and run to the seafloor. |
| | ditto | F | Starboard forward hull | The transect line was lowered in line with the forward bollards at the top of the deck incline and run to the seafloor. |
| | ditto | G | Starboard mid-ship hull | The transect line was lowered in line with the forward arm (port side) of the davit and run to the seafloor. The location was identified by the cable tie on the top hand rail. |
| | ditto | H | Starboard aft hull | Transect was lowered in line with the hangar entrance to the seafloor. |

## 1. Fishes associated with the *Canterbury*

Fish surveys consisted of diver fish-count (DFC) circumnavigations of the vessel at a depth of 24 m, as well as at a depth of 1.5 m above the seafloor; the depth of the seafloor ranged between 32 and 36 m. (The survey at 15-m depth carried out in some previous years was not repeated in 2012.) DFCs were belt surveys (based on Greene & Tuterangiwhiu in 2010) undertaken by two divers, each recording the fish within 5 m of their side of the transect line. (DFCs were the same thing as the 'visual fish surveys' of Jacobs & Robertson in 2011, and are labelled 'underwater visual census [UVC]' transects in the original 2012 data spreadsheet.) Each was 600 m long and so had 6000 $m^2$ of ground shadow. (In 2011, each DFC circumnavigation was divided into twelve 50-m transects, but not in 2012.) Species present were recorded, together with estimates of their numbers. For certain fishes, fork lengths (≤10 cm, 11–20 cm, 21–30 cm, 31– 40 cm, 41–50 cm, >50 cm) were estimated; these size classes were slightly different to those of previous years (11–20 cm instead of 10–19 cm, etc.), but because this will have had no real impact, 11–20-cm fish are taken to be the same as 10–19-cm fish in the analyses that follow.

In 2012, baited underwater video (BUV) surveys of fish around the *Canterbury* were undertaken for the first time. The eight BUV drop sites were at fixed GPS waypoints over sand 30–50 m away from the *Canterbury* (Table 3). The standard minimum distance of 50 m between drops was followed in order to avoid overlap and interference (Willis & Babcock 2000). The camera, attached to its frame, was lowered onto the seabed and fish were filmed as they were attracted to the bait-pot filled with fresh pilchard. Later the footage was played back and the maximum number of each fish species in a frame over the 30-minute on-the-seafloor film sequence recorded. (A fish had to be fully revealed in order to be counted.)

## 2. Fishes associated with the shores of Maunganui Bay

Fish sampling in and around Maunganui Bay was, as in the past, by DFC transects, but also with BUV drops. All nine DFC transects—the same sampled in previous years—were close to shore around the perimeter of Maunganui Bay, each 50 m long and 10 m wide, giving a total 4500 $m^2$ of ground shadow (Table 4, Figure 2). They were standard belt transects 1.5 m above the seafloor, as per Greene & Tuterangiwhiu in 2010. Each start point was located by GPS, a weighted drop line established, and the transect surveyed according to its pre-assigned compass bearing (Table 4). The fish species present were recorded, together with their estimated numbers and fork lengths (≤10 cm, 11–20 cm, 21–30 cm, 31–40 cm, 41–50 cm, >50 cm). BUV drops were carried out at eight sites close to the shores of Maunganui Bay (Table 5, Figure 2). Each BUV drop was made over sand immediately adjacent to rocky reef.

**Table 3. Baited underwater video sites associated with the *Canterbury* sampled in 2012. All were over sandy seafloor, at 32–36 m depth and 30–50 m from the vessel. *See* Figure 2 for locations.**

| Site | Latitude °S | Longitude °E |
|---|---|---|
| 410 | 35.1940 | 174.2940 |
| 411 | 35.1942 | 174.2944 |
| 412 | 35.1944 | 174.2953 |
| 413 | 35.1938 | 174.2935 |
| 416 | 35.1944 | 174.2949 |
| 417 | 35.1937 | 174.2955 |
| 419 | 35.1934 | 174.2948 |
| 421 | 35.1935 | 174.2940 |

**Table 4: Maunganui Bay 2012 diver fish-count transects. Site location is the start-point of each transect, the same as in previous years (*see* Figure 2).**

| Transect/ Area | Site location Latitude S | Longitude E | Bearing | Depth (m) |
|---|---|---|---|---|
| 1 (NW) | 35° 11' 558" | 174° 17' 568" | 085° | 10 |
| 2 (NW) | 35° 11' 511" | 174° 17' 579" | 135° | 8 |
| 3 (NW) | 35° 11' 522" | 174° 17' 660" | 160° | 2 |
| 4 (N) | 35° 11' 568" | 174° 17' 917" | 230° | 6 |
| 5 (N) | 35° 11' 568" | 174° 17' 917" | 140° | 10 |
| 6 (N) | 35° 11' 609" | 174° 17' 980" | 220° | 6 |
| 7 (S) | 35° 12' 060" | 174° 17' 826" | 045° | 8 |
| 8 (S) | 35° 12' 091" | 174° 17' 790" | 280° | 4 |
| 9 (S) | 35° 12' 118" | 174° 17' 585" | 030° | 12 |

**Table 5. Maunganui Bay 2012 baited under-water video drop sites (*see* Figure 2).**

| Site | Latitude °S | Longitude °E | Depth (m) |
|---|---|---|---|
| 402 | 35.2013 | 174.2934 | 25 |
| 403 | 35.2014 | 174.2952 | 20 |
| 404 | 35.2010 | 174.2991 | 15 |
| 405 | 35.1940 | 174.2993 | 15 |
| 406 | 35.1931 | 174.2974 | 22 |
| 407 | 35.1922 | 174.295 | 11 |
| 408 | 35.1927 | 174.2934 | 18 |
| 409 | 35.1919 | 174.2934 | 9 |

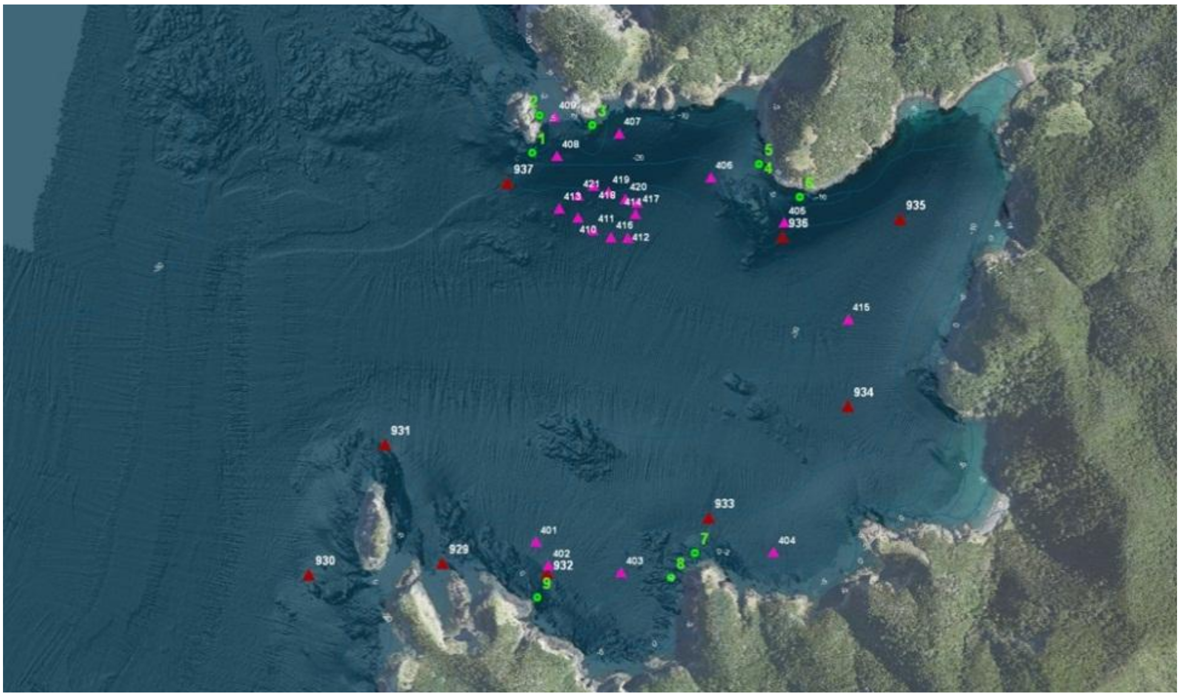



**Figure 2. Maunganui Bay showing the positions of the baited underwater video sites (red, existing sites [Buisson 2009]); pink, new sites established in 2012, the cluster in the northwest of the bay marking the position of the *Canterbury* [although only eight of those shown were sampled]), and the diver fish-count transect start-points (green).**

## 4. Fishes associated with the broader Cape Brett Peninsula

BUV drops were made at ten sites between Maunganui Bay and Cape Brett; substrates varied from mud to rock (Table 6, Figure 3). These were a subset of established sites from Buisson (2009), and it is expected that they will provide useful comparative fish-abundance and size data for the *Canterbury* and the broader area as time goes by.

**Table 6. Baited underwater video sites sampled in 2012 on the broader Cape Brett Peninsula (between Maunganui Bay and Cape Brett; *see* Figure 3).**

| Site | Latitude °S | Longitude °E | Depth (m) | Substrate |
|---|---|---|---|---|
| 930 | 35.2016 | 174.28723 | 38 | mud |
| 938 | 35.1888 | 174.29437 | 18 | sand |
| 940 | 35.1798 | 174.29652 | 33 | rock |
| 941 | 35.1828 | 174.30190 | 30 | sand |
| 942 | 35.1802 | 174.30697 | 35 | gravel |
| 943 | 35.1806 | 174.31583 | 27 | sand |
| 944 | 35.1815 | 174.32500 | 23 | sand |
| 945 | 35.1776 | 174.32866 | 23 | gravel |
| 946 | 35.1712 | 174.32992 | 20 | sand |
| 947 | 35.1660 | 174.33772 | 31 | gravel |

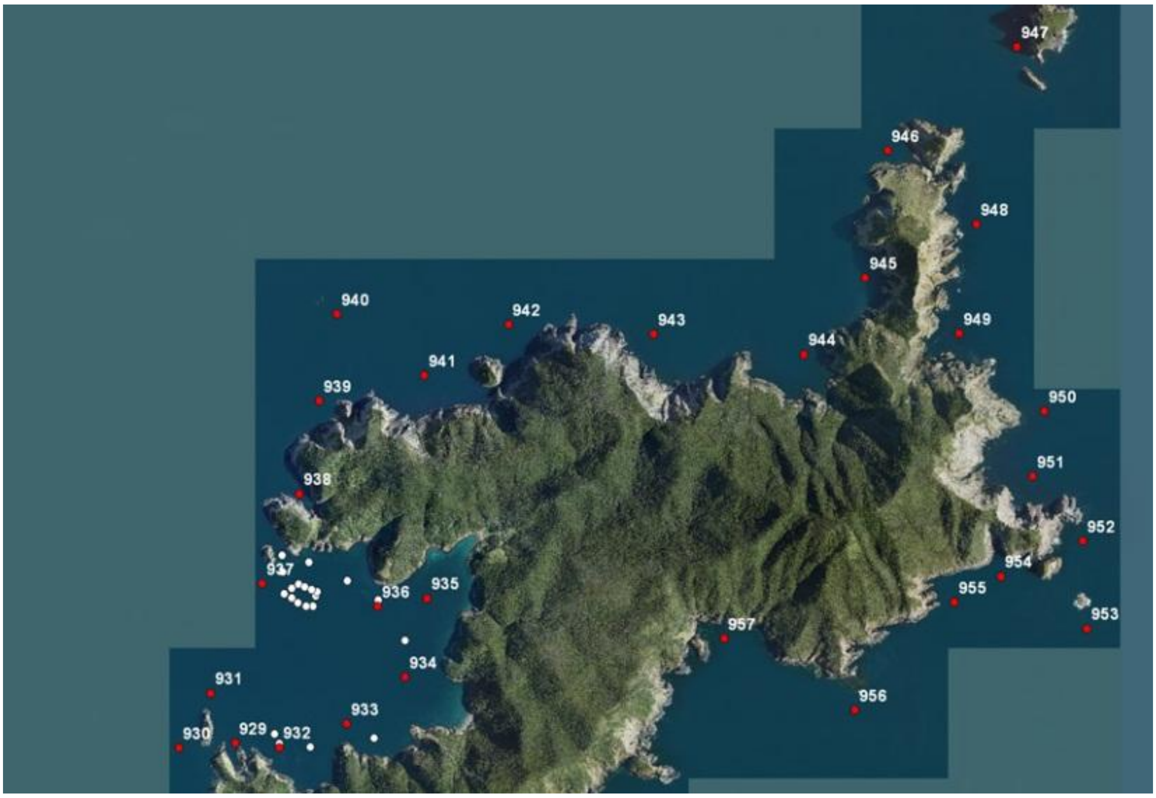



**Figure 3. Baited underwater video (BUV) sites for Maunganui Bay, as well as the broader Cape Brett Peninsula. The red dots show long-term BUV sites from Buisson (2009), but only those west of Cape Brett were sampled in 2012. The pink dots are the new BUV sites in 2012, the cluster in the northwest of Maunganui Bay being the drop sites around the *Canterbury* (eight of which were sampled). *See* Figure 2 for the other Maunganui Bay BUV sites.**

## 5. Density, size and biomass of indicator-fish species

The relative abundance of the indicator fishes—leatherjackets, two-spot demoiselles and snapper—were calculated from the DFC and BUV results. Snapper sizes were also estimated. For DFCs, it was in the 10-cm length classes described earlier. For each BUV station, the snapper in the one frame that contained the maximum number fully revealed was used. Fish-length (nose to fork of tail) was estimated to the nearest 1 cm using three-point calibration, but only for individuals at the same level as calibration marks of known length—either the top of the bait container (9 cm) or the bottom scale-bar (marked in 10-cm segments). Snapper biomass estimates used the DFC length information, converted to wet weight biomass using the same equation (to allow comparisons) as Jacobs & Robertson used in 2011: $W = a{*}L^b$ where W is weight (g), L is length (cm), $a$ is 0.04467, and b is 2.793. The midpoint of each 10-cm length class was used as in the previous estimates (e.g., fish estimated to be 11–20-cm long (≡ 10–19) were taken to be 14.5 cm).

# Results

## 1. Epifauna on the *Canterbury*

### 1a. Percentage cover

All vertical surfaces were fully colonised by epifauna, a significant increase in cover from the mean value of 80% in 2011—and part of the general progression since the scuttling of the vessel (Figure 4). Colonisation of the horizontal surfaces was less straightforward to interpret: all ship steel was covered, but not necessarily by living material. In 2012, non-living items (silt, sand and shell fragments) covered an average 27.8 ± 7.1% (95% CI) of horizontal surfaces. (The 2009–11 surveys also spoke of sedimentation of horizontal surfaces.) Percentage cover on the horizontal surfaces has fluctuated much more over the years than that on the vertical surfaces.

### 1b. Species richness

Species richness on both the vertical and horizontal surfaces increased slightly between July 2011 and April 2012, reaching mean values of 3.79 and 3.55 respectively (Figure 5). Not surprisingly given the breadth of the taxa, species richness has changed little over the years, even though the predominant taxa have changed.

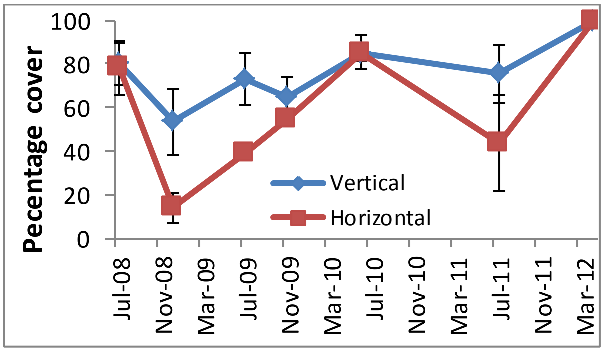



**Figure 4. Mean total percentage cover of vertical and horizontal surfaces on the *Canterbury* from July 2008 to April 2012 (± 95% C.I.).**

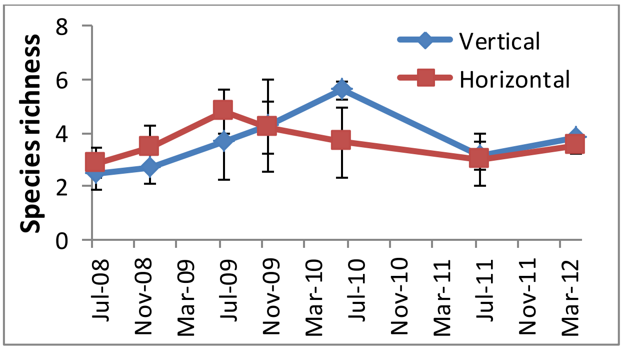



**Figure 5. Mean species richness on vertical and horizontal surfaces of the *Canterbury* from July 2008 to April 2012 (± 95% C.I.).**

### 1c. Species succession

There were significant changes in the predominant taxa on the vertical surfaces between June 2010 and April 2012, some shifts suggesting a trend, while for others the change appeared non-systematic (Figure 6). The most remarkable changes were the large increases in the cover of sponges and tubeworms, mainly at the expense of the filamentous algae and lithothamnion paint. (No sampling of Transect I may have been part of the reason for less filamentous algae—the shallower transects can be expected to contain most algae; there are also difficulties in recognising filamentous algae.) There was also significant reduction in cover by cup corals. A similar story for the horizontal surfaces (Figure 7).

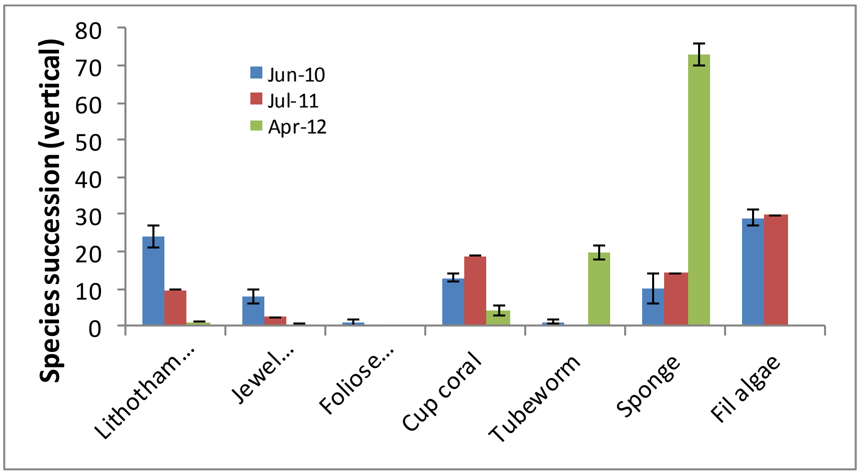



**Figure 6. Percentage cover by epifauna on vertical surfaces of the *Canterbury*, 2010 to 2012 (± 95% C.I.).**

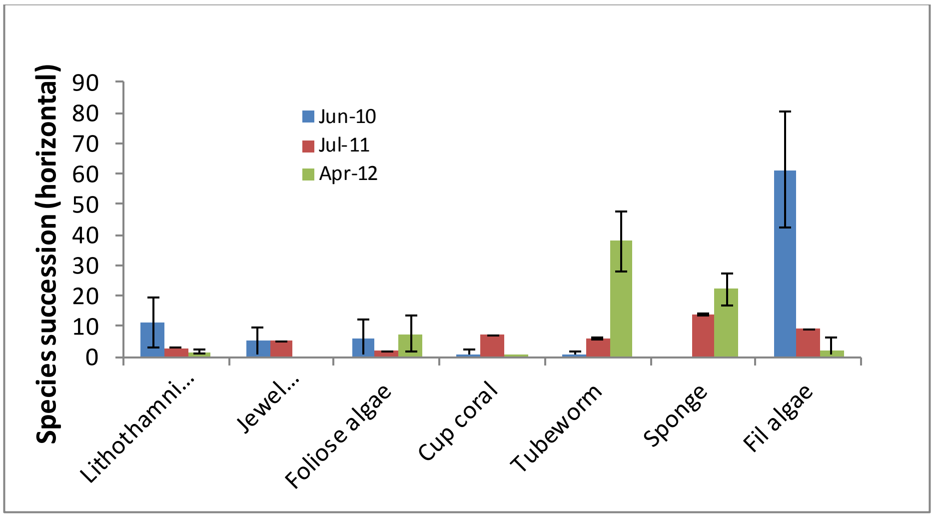



**Figure 7. Percentage cover by epifauna on horizontal surfaces of *Canterbury*, 2010 to 2012 (± 95% C.I.).**

## 2. Fishes associated with the *Canterbury*

### 2a. Diver fish-counts

The species seen in DFCs in 2012, and their numbers by depth, are listed in Table 7. Total fish counts near the seafloor were the lowest seen, whereas at 24 m they were the second highest (Figure 8), but species richness was much the same throughout (Figure 9). (The absence of any sampling-variability information is important and is discussed later.) Species apparently more at home higher in the water column were butterfly perch, two-spot demoiselles, koheru, leatherjackets and sweep; all but leatherjackets are strongly schooling pelagics. Only snapper, blue maomao and tarakihi were clearly more abundant near the seabed.

The number of fish species associated with the *Canterbury*—irrespective of depth—has remained pretty stable throughout (Figure 10), although there may well have been changes in the species present. Total fish numbers have also, on the face of it, been stable over recent years, but—not surprisingly given the small amount of data and the clumped distribution of many of the species—the variability is high (Figure 11).

**Table 7. Fish counts by species for the diver-circumnavigations of the *Canterbury* at 24 m depth and near the seabed (which ranged between 32 and 36-m depth), 3 May 2012. Scientific and Maori names are given in Appendix 1. Total fish numbers were 790 and 64 for 24 m and near the seabed respectively; the number of fish species present were 14 and 13 respectively.**

| Species | 24 m | Seabed | Species | 24 m | Seabed | Species | 24 m | Seabed |
|---|---|---|---|---|---|---|---|---|
| Banded wrasse | 1 | 0 | Kingfish | 1 | 0 | Sandagers wrasse | 2 | 2 |
| Bigeye | 0 | 1 | Koheru | 80 | 0 | Scarlet wrasse | 0 | 0 |
| Blue cod | 0 | 1 | Leatherjacket | 65 | 3 | Scorpion fish | 1 | 0 |
| Blue maomao | 0 | 15 | Parore | 0 | 3 | Snapper | 5 | 20 |
| Butterfly perch | 162 | 0 | Pigfish | 5 | 4 | Spotty | 4 | 2 |
| Demoiselle 2 spot | 41 | 0 | Porae | 0 | 1 | Sweep | 412 | 0 |
| Goatfish | 6 | 4 | Red moki | 5 | 1 | Tarakihi | 0 | 7 |

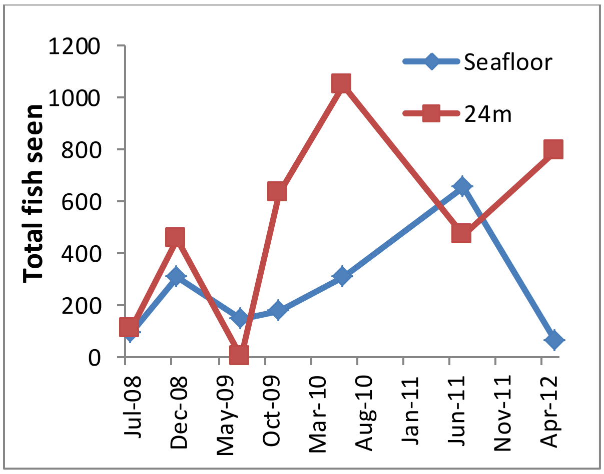



**Figure 8. Total numbers of fish seen (all species) during diver-circumnavigations of the *Canterbury* at 24 m depth and near the seafloor.**

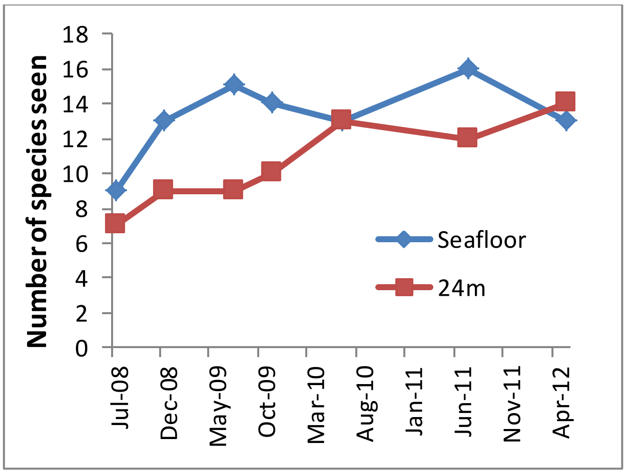



**Figure 9. Numbers of fish species seen during diver-circumnavigations of the *Canterbury* at 24 m depth and near the seafloor.**

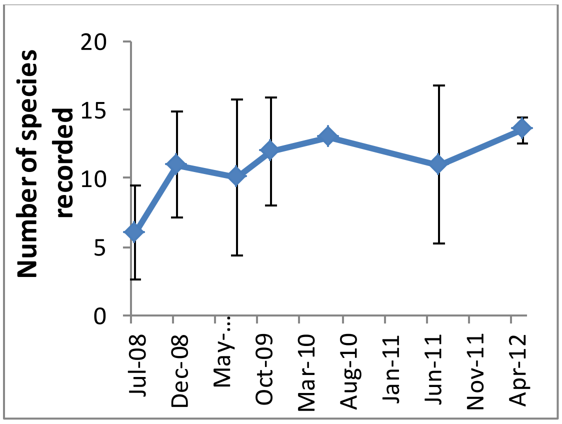



**Figure 10. Numbers of fish species seen during diver-circumnavigations of the *Canterbury* (± 95% C.I.). In some surveys (including July 2011), the sampling included a circumnavigation at 15 m, in addition to those at 24 m depth and near the seafloor.**

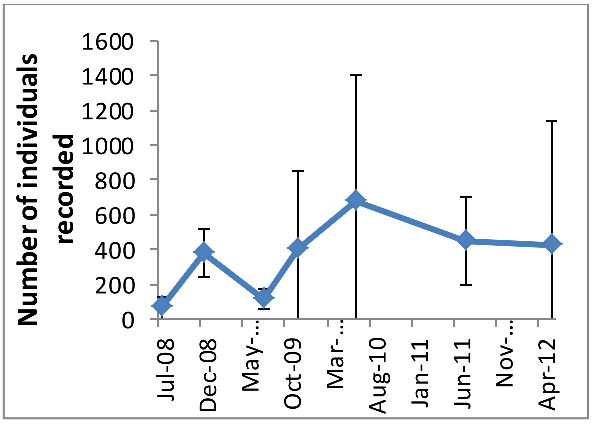



**Figure 11. Numbers of individual fish (all species) seen during diver-circumnavigations of the *Canterbury* (± 95% C.I.). In some surveys (including July 2011), the sampling included a circumnavigation at 15 m, in addition to those at 24 m depth and near the seafloor. (Corrected data for 2010 and 2011 were used.)**

## 2b. Baited underwater video fish counts

The maximum number of any particular fish species seen in any one frame for each BUV drop was recorded (Table 8). By far the most common species was snapper, followed distantly by trevally. On average there were 2.63 ± 0.64 (95% CI) species of fish at each BUV site.

## 3. Fishes associated with the shores of Maunganui Bay

### 3a. Diver fish-counts

The most abundant fishes by far in the DFCs were koheru and two-spot demoiselles—both vigorous schooling species (Table 9). Others with total counts >100 were goatfish, jack mackerel, leatherjacket, parore, sandagers wrasse and snapper. The DFC transects with greatest total fish counts (> 600) (Transects 1, 2 and 6–8) were spread throughout Maunganui Bay, but these results were strongly influenced by the presence of shoals of schooling fish. Highest species richness (Transects 1, 2, 6, 7 and 9) could not be pinned to any particular sectors of the bay either. In 2012, both the number of fish species and the total fish counts were similar to those in 2011. Changes in densities of three individual species—leatherjackets, two-spot demoiselles and snapper—are dealt with later.

**Table 8. Baited underwater video (BUV) fish counts around the *Canterbury*, 3 May 2012. For location of BUV sites, *see* Figure 2. SD, standard deviation; CI, 95% confidence intervals; nc, not calculated. Scientific and Maori names are given in Appendix 1.**

| **BUV site** | **410** | **411** | **412** | **413** | **416** | **417** | **419** | **421** | **Total** | **Mean** | **SD** | **CI** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Snapper | 13 | 13 | 15 | 9 | 26 | 1 | 1 | 14 | **92** | **11.50** | **8.11** | **5.62** |
| Trevally | 2 | 1 | 3 | 1 | 2 | 5 | 0 | 1 | **15** | **1.88** | nc | nc |
| Pigfish | 3 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | **5** | **0.63** | nc | nc |
| Longtail stingray | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** | **0.13** | nc | nc |
| Shark | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | **1** | **0.13** | nc | nc |
| Kingfish | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | **1** | **0.13** | nc | nc |
| **No. fish species** | **4** | **3** | **2** | **3** | **3** | **2** | **1** | **3** | | **2.63** | **0.92** | **0.64** |
| **Total fish** | **19** | **15** | **18** | **11** | **29** | **6** | **1** | **16** | **115** | **14.38** | **8.55** | **5.93** |

### 3b. Baited underwater video fish counts

A total 152 fish were captured in the frames, across 10 (average 3.75) species (Table 10). By far the most common species was snapper, followed by leatherjackets. There was no spatial pattern immediately obvious in the snapper numbers or in the fish diversity.

## 4. Fishes associated with broader Cape Brett Peninsula: baited underwater video fish counts

A total 287 fish were captured in the frames, across 23 (average 6.80) species (Table 11). By far the most common species was snapper, followed by trevally and then leatherjackets. There was no spatial pattern immediately obvious in the fish numbers or diversity—in total or for any species in particular; nor was there any clear link with bottom type.

## 5. Comparisons of baited underwater video (BUV) results

The BUV results indicated greater fish numbers on the broader Cape Brett Peninsula than either around the *Canterbury* or throughout the broader Maunganui Bay, where there was no significant difference (Figure 12). Fish variety too was greater on the broader Cape Brett Peninsula than elsewhere (Figure 13), but note that the BUV drops made there were over a variety of substrates, not just sand.

## 6. Densities of a reef-associated indicator species: leatherjacket

The leatherjacket is a reef-associated generalist (although sponge-focussed) species that can, in our waters, be considered to all intents and purposes unfished.

Leatherjacket densities by DFC around the *Canterbury* were much lower in May 2012 than they were in July 2011, at both depths sampled (Figure 14). In both years they were far more abundant at 24 m than near the seafloor. Leatherjacket densities on the natural reefs in Maunganui Bay were, however, greater in 2012 (Figure 15). (Recall though that the surveys in 2011 used variable-distance fish counts—instead of standard belt transects—which may or may not have made any difference.) Densities around the *Canterbury* and in the broader Maunganui Bay were of similar order.

The BUVs provided an additional measure of leatherjacket abundance in 2012. None was seen associated with the *Canterbury*, while numbers in Maunganui Bay and on the broader Cape Brett Peninsula were similar (Figure 16).

**Table 9. Diver fish-counts by species and transect, Maunganui Bay, 2012. (*See* Figure 2 for locations; Transects 4–6 were sampled on 15 April 2012, the others on 5 May 2012.) Each transect had 500 $m^2$ of ground shadow (50 m long, 10 m wide). SD, standard deviation; CI, 95% confidence intervals; nc, not calculated. Scientific and Maori names are given in Appendix 1.**

| **Transect** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **Total** | **Mean** | **SD** | **CI** | **Density (No per 100 $m^2$)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Depth (m)** | **7-14** | **6-9.5** | **4-12** | **6-13.5** | **5-7** | **6-13.5** | **7-13.5** | **7-16.5** | **6-22** | | | | | |
| 1/2 Banded perch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | **1** | **0.11** | nc | nc | **0.2** |
| Banded wrasse | 8 | 8 | 11 | 4 | 5 | 9 | 11 | 1 | 6 | **63** | **7.00** | nc | nc | **12.6** |
| Bigeye | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | **17** | **1.89** | nc | nc | **3.4** |
| Blackspot goatfish | 0 | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | **4** | **0.44** | nc | nc | **0.8** |
| Blue maomao | 0 | 3 | 29 | 0 | 0 | 0 | 0 | 0 | 0 | **32** | **3.56** | nc | nc | **6.4** |
| Butterfish | 1 | 0 | 1 | 0 | 0 | 3 | 0 | 0 | 0 | **5** | **0.56** | nc | nc | **1.0** |
| Butterfly perch | 17 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | **19** | **2.11** | nc | nc | **3.8** |
| Combfish | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **2** | **0.22** | nc | nc | **0.4** |
| Crimson cleaner | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **4** | **0.44** | nc | nc | **0.8** |
| Demoiselle 2-spot | 400 | 125 | 30 | 33 | 30 | 18 | 1172 | 182 | 117 | **2107** | **234.11** | **371.81** | **242.91** | **42.14** |
| Eagle ray | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | **1** | **0.11** | nc | nc | **0.2** |
| Goatfish | 21 | 55 | 8 | 0 | 0 | 23 | 4 | 2 | 11 | **124** | **13.78** | nc | nc | **24.8** |
| Hiwihiwi/kelpfish | 2 | 4 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | **9** | **1.00** | nc | nc | **1.8** |
| Jack mackerel | 0 | 0 | 0 | 0 | 0 | 100 | 1 | 0 | 0 | **101** | **11.22** | nc | nc | **20.2** |
| Kahawai | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 21 | 6 | **34** | **3.78** | nc | nc | **6.8** |
| Kingfish | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | **6** | **0.67** | nc | nc | **1.2** |
| Koheru | 300 | 250 | 160 | 80 | 130 | 450 | 900 | 830 | 300 | **3400** | **377.78** | nc | nc | **680.0** |
| Leatherjacket | 25 | 29 | 13 | 2 | 5 | 20 | 18 | 16 | 17 | **145** | **16.11** | **8.64** | **5.65** | **29.0** |
| Longtail stingray | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | **1** | **0.11** | nc | nc | **0.2** |
| Marblefish | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 2 | **6** | **0.67** | nc | nc | **1.2** |
| Parore | 3 | 110 | 69 | 51 | 10 | 5 | 0 | 1 | 14 | **263** | **29.22** | nc | nc | **52.6** |
| Pigfish | 5 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 7 | **16** | **1.78** | nc | nc | **3.2** |
| Porae | 2 | 2 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | **8** | **0.89** | nc | nc | **1.6** |
| Red moki | 13 | 9 | 8 | 4 | 10 | 10 | 10 | 8 | 9 | **81** | **9.00** | nc | nc | **16.2** |
| Sandagers wrasse | 26 | 52 | 18 | 12 | 11 | 10 | 15 | 2 | 11 | **157** | **17.44** | nc | nc | **31.4** |
| Scarlet wrasse | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **2** | **0.22** | nc | nc | **0.4** |
| Snapper | 26 | 40 | 13 | 14 | 5 | 7 | 3 | 17 | 4 | **129** | **14.33** | **12.15** | **7.94** | **25.8** |
| Spotty | 11 | 16 | 14 | 2 | 5 | 9 | 5 | 7 | 17 | **86** | **9.56** | nc | nc | **17.2** |
| Sweep | 4 | 0 | 0 | 2 | 4 | 0 | 36 | 0 | 0 | **46** | **5.11** | nc | nc | **9.2** |
| Trevally | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** | **0.11** | nc | nc | **0.2** |
| Yellow moray | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | **2** | **0.22** | nc | nc | **0.4** |
| **No. fish species** | **21** | **15** | **13** | **10** | **12** | **17** | **15** | **11** | **17** | | **14.56** | **3.47** | **2.27** | |
| **Total fish** | **880** | **705** | **376** | **204** | **220** | **678** | **2181** | **1087** | **541** | **6872** | **736.56** | **606.87** | **396.48** | |

**Table 10. Baited underwater video (BUV) fish counts Maunganui Bay, 2012. SD, standard deviation; CI, 95% confidence intervals; nc, not calculated. For location of video sites, *see* Figure 2. Scientific and Maori names are given in Appendix 1.**

| **BUV site** | **402** | **403** | **404** | **405** | **406** | **407** | **408** | **409** | **Total** | **Mean** | **SD** | **CI** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Snapper | 7 | 18 | 20 | 12 | 18 | 15 | 10 | 8 | **108** | **13.50** | **5.00** | **3.47** |
| Goatfish | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | **3** | **0.38** | nc | nc |
| Leatherjacket | 5 | 3 | 4 | 3 | 0 | 2 | 3 | 6 | **26** | **3.25** | **1.83** | **1.27** |
| Blue cod | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | **4** | **0.50** | nc | nc |
| Pigfish | 2 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | **6** | **0.75** | nc | nc |
| Porae | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | **1** | **0.13** | nc | nc |
| Scarlet Wrasse | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | **1** | **0.13** | nc | nc |
| John Dory | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | **1** | **0.13** | nc | nc |
| Tarakihi | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | **1** | **0.13** | nc | nc |
| Red moki | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | **1** | **0.13** | nc | nc |
| **No. fish species** | **5** | **4** | **3** | **3** | **2** | **2** | **6** | **5** | | **3.75** | **1.49** | **1.03** |
| **Total fish** | **18** | **23** | **25** | **16** | **19** | **17** | **17** | **17** | **152** | **19.00** | **3.25** | **2.25** |

**Table 11. Baited underwater video (BUV) fish counts for the broader Cape Brett Peninsula, 2012. For location of sites, *see* Figure 2. M, mud; S, sand; R, rock; G, gravel; SD, standard deviation; CI, 95% confidence intervals; nc, not calculated. Scientific and Maori names are given in Appendix 1.**

| **BUV site** | **930** | **938** | **940** | **941** | **942** | **943** | **944** | **945** | **946** | **947** | **Total** | **Mean** | **SD** | **CI** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Substrate** | **M** | **S** | **R** | **S** | **G** | **S** | **S** | **G** | **S** | **G** | | | | |
| Snapper | 3 | 21 | 6 | 5 | 10 | 4 | 21 | 9 | 7 | 5 | **91** | **9.10** | **6.62** | **4.10** |
| Trevally | 0 | 0 | 1 | 31 | 4 | 24 | 4 | 0 | 0 | 0 | **64** | **6.40** | nc | nc |
| Goatfish | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | **5** | **0.50** | nc | nc |
| Leatherjacket | 5 | 3 | 10 | 0 | 0 | 0 | 0 | 18 | 3 | 2 | **41** | **4.10** | **5.80** | **3.60** |
| Blue cod | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | **2** | **0.20** | nc | nc |
| Pigfish | 2 | 2 | 3 | 0 | 1 | 0 | 0 | 2 | 1 | 4 | **15** | **1.50** | nc | nc |
| Porae | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | **2** | **0.20** | nc | nc |
| Scarlet wrasse | 1 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **4** | **0.40** | nc | nc |
| Short tail stingray | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** | **0.10** | nc | nc |
| Shark | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | **2** | **0.20** | nc | nc |
| Red moki | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **2** | **0.20** | nc | nc |
| Orange wrasse | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | **2** | **0.20** | nc | nc |
| Grey moray | 0 | 0 | 5 | 0 | 1 | 0 | 0 | 0 | 2 | 3 | **11** | **1.10** | nc | nc |
| Yellow moray | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | **4** | **0.40** | nc | nc |
| Eagle ray | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | **2** | **0.20** | nc | nc |
| Sandagers wrasse | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | **3** | **0.30** | nc | nc |
| Mottled moray | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **2** | **0.20** | nc | nc |
| Half banded perch | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | **4** | **0.40** | nc | nc |
| Butterfly perch | 1 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **8** | **0.80** | nc | nc |
| Demoiselle | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | **12** | **1.20** | nc | nc |
| Pink maomao | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | **6** | **0.60** | nc | nc |
| Sweep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | **3** | **0.30** | nc | nc |
| Mado | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** | **0.10** | nc | nc |
| **No. fish species** | **12** | **6** | **12** | **2** | **6** | **3** | **3** | **4** | **10** | **10** | | **6.80** | **3.88** | **2.41** |
| **Total fish** | **30** | **29** | **40** | **36** | **18** | **29** | **26** | **30** | **21** | **28** | **287** | **28.70** | **6.38** | **3.95** |

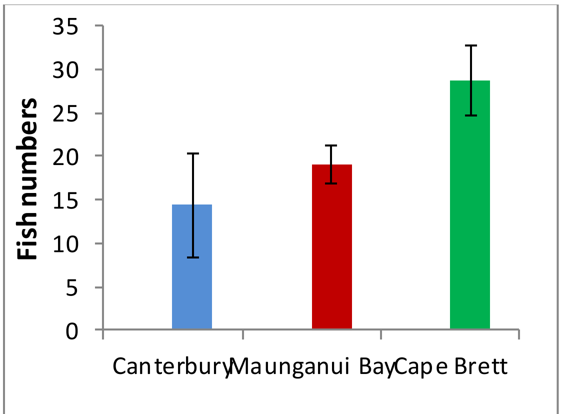



**Figure 12. Baited underwater video total fish counts around the *Canterbury*, elsewhere in Maunganui Bay, and on the broader Cape Brett Peninsula, 2012 (± 95% C.I.).**

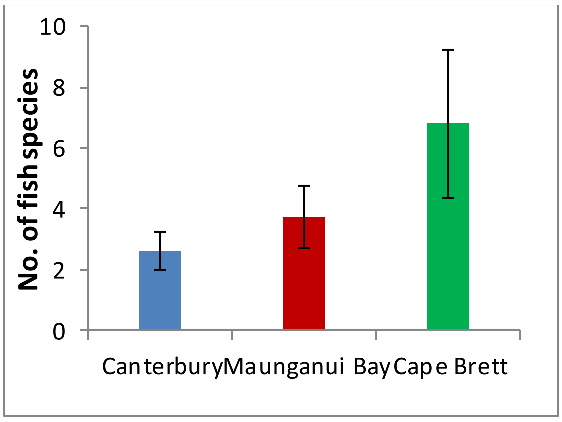



**Figure 13. Baited underwater video fish species richness around the *Canterbury*, elsewhere in Maunganui Bay, and on the broader Cape Brett Peninsula, 2012 (± 95% C.I.).**

## 7. Densities of a plankton-feeding indicator species: two-spot demoiselle

The two-spot demoiselle is an unfished, strongly schooling, planktivorous species. Their densities by DFC around the *Canterbury* were much lower in May 2012 than in July 2011 (Figure 17). Densities on the natural reefs in Maunganui Bay were around an order of magnitude greater than those around the *Canterbury* (comparing Figures 17 and 18), but such comparisons are probably pretty meaningless, given the species' clumped distribution and the low sampling intensity.

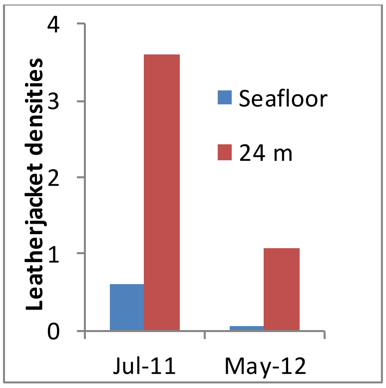



**Figure 14. Densities of leatherjackets (numbers per 100 square metres) seen during diver-circumnavigations (each 6000 m$^2$ of ground shadow) of the *Canterbury*, July 2011 and May 2012 (but using different survey methods).**

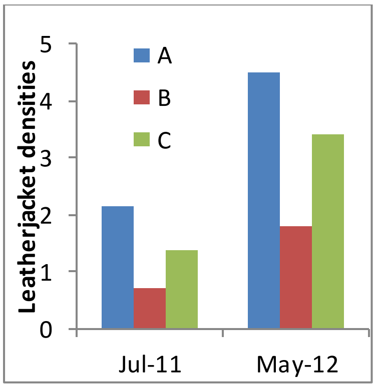



**Figure 15. Densities of leatherjackets (numbers per 100 square metres) seen on reefs in Maunganui Bay (± 95% C.I.). A, Transects 1–3; B, Transects 4–6; C, Transects 7–9 (*see* Figure 2), July 2011 and April/May 2012. Each transect had 500 m$^2$ of ground-shadow.**

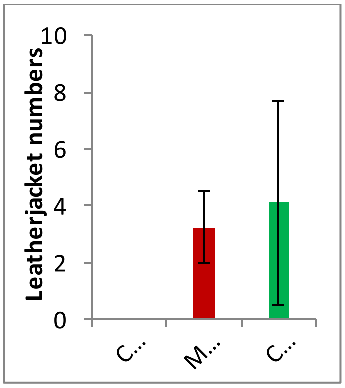



**Figure 16. Baited underwater video counts of leatherjackets in Maunganui Bay (M) and around the broader Cape Brett Peninsula (C), 2012 (± 95% C.I.). (There was none at the *Canterbury*.)**

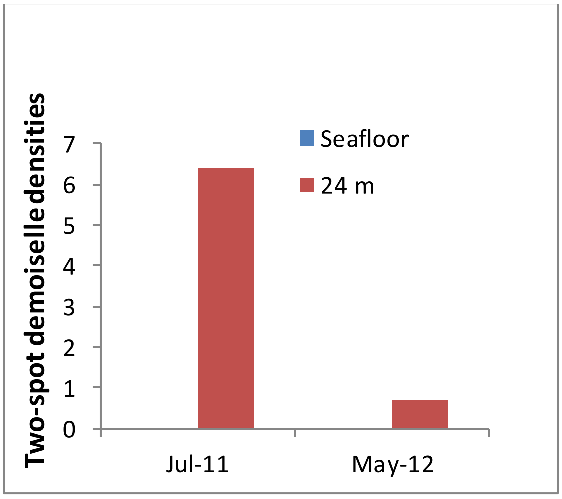



**Figure 17. Densities of two-spot demoiselles (numbers per 100 square metres) seen during diver-circumnavigations (each 6000 m$^2$ of ground shadow) of the *Canterbury*, July 2011 and May 2012 (but using different survey methods). None was observed at the seafloor.**

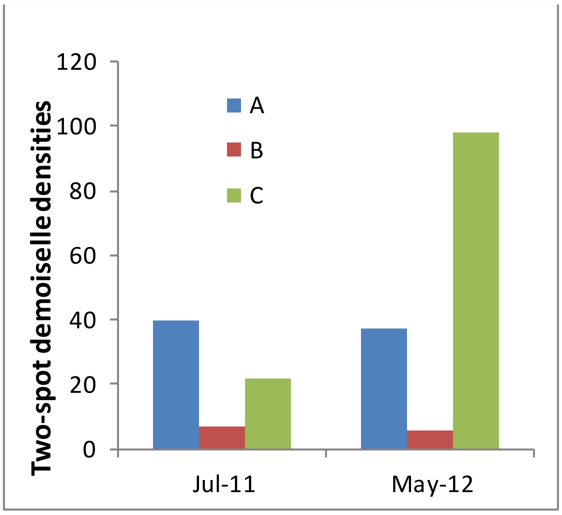



**Figure 18. Densities of two-spot demoiselles (numbers per 100 square metres) seen on reefs in Maunganui Bay. A, Transects 1–3; B, Transects 4–6; C, Transects 7–9 (*see* Figure 2), July 2011 and April/May 2012 (± 95% C.I.) (but using different survey methods). (Each transect had 500 m$^2$ of ground shadow.)**

## 8. Densities of a fished generalist species: snapper

Snapper are a highly sought generalist species. Their densities by DFC around the *Canterbury* were greater on the seafloor in May 2012 than in July 2011, but only 5 were recorded at 24 m in 2012 compared with quite high numbers there in 2011 (Figure 19). Snapper densities by DFC on the natural reefs in Maunganui Bay were greater in 2012 than in 2011 (Figure 20), and in both years greater than around the *Canterbury* itself (comparing Figures 19 and 20). Whereas DFC sites in the northeast part of Maunganui Bay had highest counts in 2011, those in the northwest were highest in 2012. Overall, snapper densities were highest in 2012 on natural reefs, but there was much variability (Figure 21).

The BUVs provided an additional measure of relative snapper abundance in 2012. Densities recorded by this method around the *Canterbury* were similar to those on the natural reefs in Maunganui Bay and to those on the broader Cape Brett Peninsula (Figure 22).

## 9. Size and biomass of snapper

Numbers by size from the DFC surveys enable an estimate of the biomass of snapper associated with the *Canterbury*. The cumulative column graph of proportion by estimated-size-class of fish (in 10-cm bands) observed in the diver-circumnavigations of the vessel was updated to 2012 (Figure 23; the 2012 DFC results for elsewhere in Maunganui Bay are shown too).

The biomass of snapper associated with the *Canterbury* and with the surrounding shores was calculated as previously: $W = a*L^b$ where W is weight (g), L is length (cm), $a$ is 0.04467, and b is 2.793. The values for 2012 compared with the previous year are shown in Figure 24: they were 118 g per 100 $m^2$ compared with 157 g in 2011 for the *Canterbury*; and 319 and 379 g for Maunganui Bay.

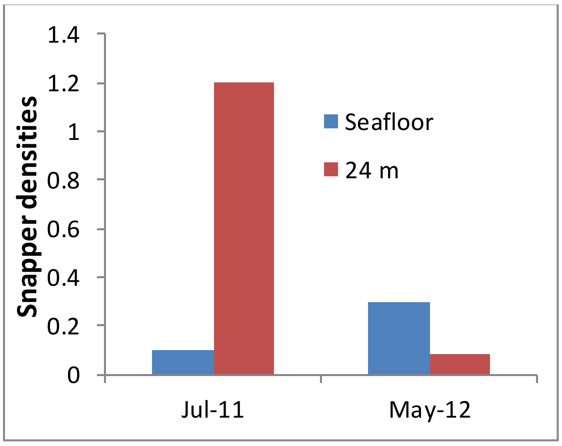



**Figure 19. Densities of snapper (numbers per 100 square metres) seen during diver-circumnavigations (each 6000 $m^2$ in ground shadow) of the *Canterbury*, July 2011 and May 2012 (but using different survey methods).**

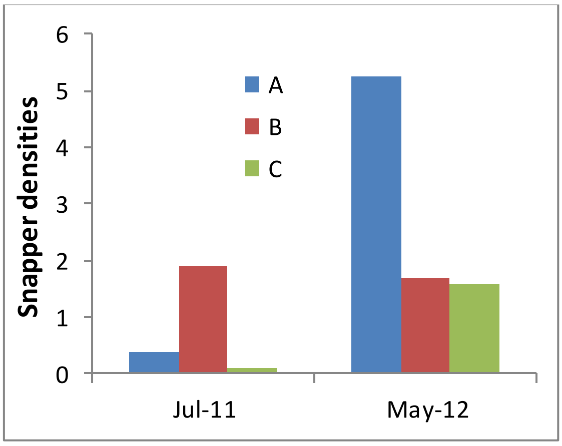



**Figure 20. Densities of snapper (numbers per 100 square metre) seen on reefs in Maunganui Bay. A, Transects 1–3; B, Transects 4–6; C, Tran-sects 7–9 (*see* Figure 2), July 2011 and April/May 2012 (± 95% C.I.) (but using different survey methods).**

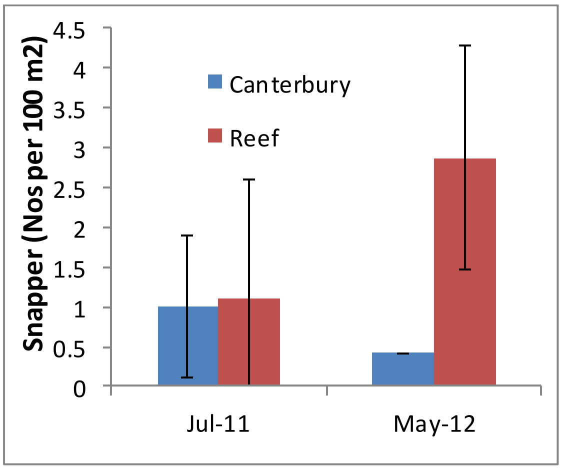



**Figure 21. Densities of snapper (numbers per 100 square metres) seen on natural reefs in Maunganui Bay compared with around the *Canterbury*, July 2011 and April/May 2012 (but using different survey methods). Confidence intervals (95%) are available for the *Canterbury* sampling in July 2011 because each diver-circumnavigation was divided into twelve transects of equal length.**

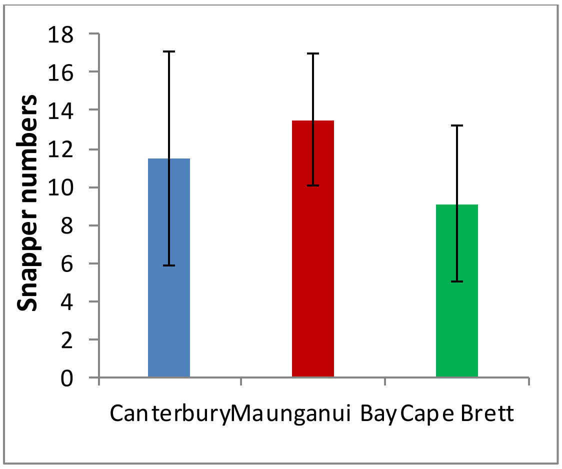



**Figure 22. Baited underwater video counts of snapper around the *Canterbury*, elsewhere in Maunganui Bay, and around the broader Cape Brett Peninsula, 2012 (± 95% C.I.).**

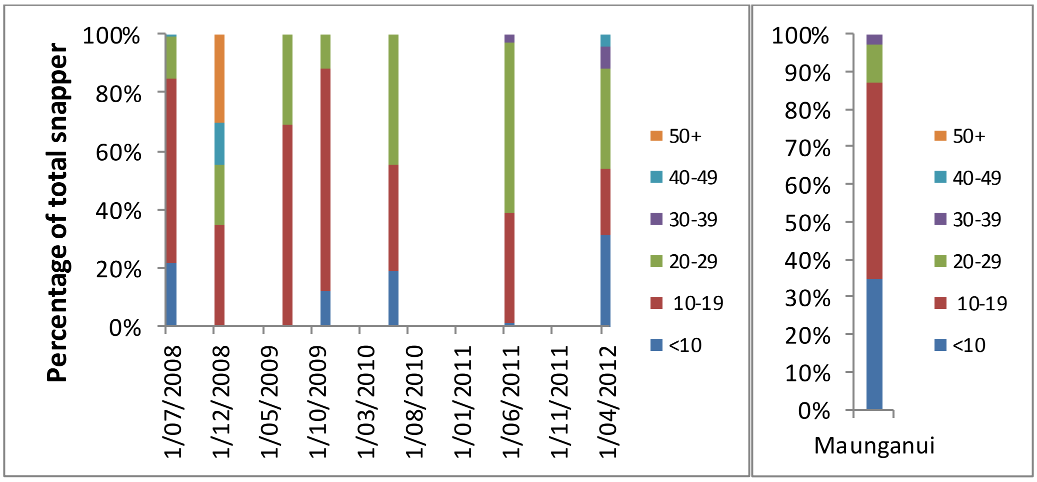



**Figure 23. Proportions of snapper by estimated size (cm) in the diver fish-count sampling of the *Canterbury* 2008–12 (left), together with the sizes in April/May 2012 of snapper elsewhere in Maunganui Bay (right). Fish-sizes in 2012 were estimated in slightly different classes (11–20 cm instead of 10–19 cm, etc.), but this will have had no real impact and so are shown in a manner consistent with the previous results.**

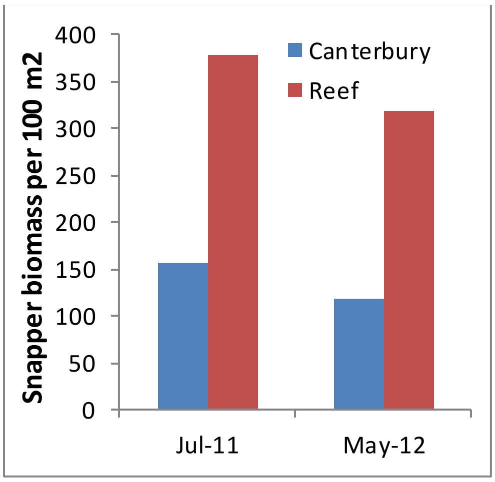



**Figure 24. Biomass (g) per 100 square metres of ground cover for the *Canterbury* and for nearby reefs in Maunganui Bay from the DFCs, July 2011 and April/May 2012.**

Numbers by size for snapper from the BUVs are shown in Figure 25. The only place where snapper >30 cm were observed was around the *Canterbury*; fish in other parts of Maunganui Bay were on average smaller, and similar in size to those on the broader Cape Brett Peninsula. When compared to the DFCs, the BUVs appear to bias against observing small (<10 cm) snapper, presumably because the larger fish exclude smaller ones. Otherwise the results from the two methods are comparable.

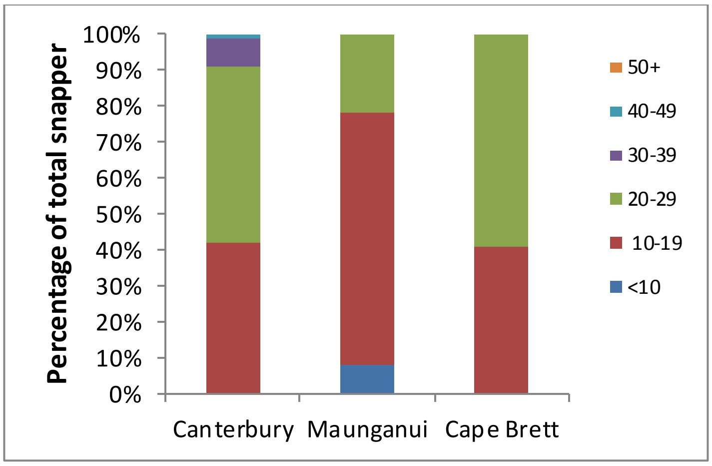



**Figure 25. Proportions of snapper by estimated size (cm) from the baited underwater video sampling of the *Canterbury*, elsewhere in Maunganui Bay, and around the broader Cape Brett Peninsula, 2012.**

## Discussion

For consistency, the 2012 data were analysed and reported in much the same manner as the previous surveys, even though there had been some changes to the sampling protocols. Some very general observations around the project and its results follow. It is important to remember that we used uncritically the historic data as presented by Jacobs & Robertson in 2011 (but for correcting a few obvious errors). The dataset is becoming one of the longer-continuing of its type in the country, and may soon justify more rigorous treatment.

1. Epifauna on the *Canterbury*

Epifaunal changes on the *Canterbury* are progressing as one might expect from the literature (e.g., Wendt et al 1989; Figley 2003), particularly the increase in sponges and decrease in filamentous algae. It is very doubtful that this is yet a climax community. It's a great step forward to photograph the quadrats. Using photography rather than diver assessment *in situ* means that underwater time is greatly reduced; divers do not need to be proficient in identifications; and the images can be analysed at any time to any taxonomic level. But it is unclear what (if any) implications there are in using a much smaller quadrat (albeit more of them) than in the past. Take note that Jacobs & Robertson in 2011 decided that foliose algal cover should be measured by the area within the quadrat covered by the holdfast (i.e., ground % cover), not by how much of the quadrat is covered by the leaf blade—which seems sensible.

2. Diver fish-count surveys

The DFCs associated with the vessel, unlike the epifaunal observations, provide little more than a snapshot of fish numbers and fish size. The problem is that fish presence varies according to many variables including short-term ones such as the time of day and the strength of tidal currents (Kingsford & Battershill 1998). Furthermore, several of our species are strong schoolers. So, it's unclear just what one observation each year is telling us—if anything much, unless the annual monitoring is standardised to a much greater extent with regard to the key variables. There really should be several snapshots throughout the year, or over a particular sampling period. The use of two-spot demoiselle as an indicator species makes sense—except that they are so jolly clumped in their distribution that detecting real change in abundance is very difficult unless there is more sampling. The fortunes of other individual fish species should be analysed too.

The DFCs in 2011 used variable-distance fish counts (Labrosse et al. 2002)—instead of the standard belt transect used in 2012 (and before 2011) (Kingsford and Battershill 1998). Which one should we continue with? Also, ideally the same divers should do the DFCs each time. If this is not possible, all divers should be trained and calibrated before each survey. And the DFC circumnavigations of the *Canterbury* should be divided into twelve 50-m transects, as in 2011, leading to information on variability and the data being more directly comparable with the near-shore DFC transects.

The 2012 sampling were undertaken in April/May, rather than the more usual July. Whereas this was probably not an issue for the epifaunal observations, some of the fishes of interest (including snapper and two-spot demoiselles) are known in places to make seasonal movements (often into deeper waters as winter approaches) We need to decide which time(s) of the year and states of the tide to sample, and stick to them.

3. Baited underwater video surveys

The BUV allows relatively easy comparison within and between fished and unfished places—at least for species that are attracted to bait—and should continue.

4. General

With more larger fish present in 2012 than in 2011 (Figure 23), mean snapper size may be increasing around the *Canterbury*, whereas in other parts of Maunganui Bay it remains much the same as in 2010–11. But only about 10% of the snapper observed around the *Canterbury* were larger than the average-sized snapper in the much longer-established marine sanctuary at Leigh (almost 32 cm—Anon 2011). The discrepancies between the relative fish counts from the DFC versus BUV sampling are of concern, and they probably mean we will need to increase sampling effort (including the number of replicates)—particularly temporally.

It is no trivial task to undertake and report the sampling. Interested parties (at least Hapu, Northland Dive, Fish Forever, and BOPP) might in future join forces so that the sampling and reporting proceed most expeditiously. One option is to reduce the frequency of the sampling while increasing the detail of the reporting— but this would require a change to the terms of the resource consent. Eventually, it may be possible to decide which changes in fish/invertebrate diversity and abundance can be attributed to the placement of this artificial reef—the ship—and which are the result of rules prohibiting harvest of all marine life apart from kina.

No *Undaria* or similar invasive was reported. Future sampling should specifically include searches for such alien species, as well as the checking of the Special Mark and moorings for structural integrity, as required under the resource consent.

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**Appendix 1. Scientific and Maori names of fish species referred to in the text. Scientific names are based on Paulin et al. (2001). Maori names are based on Mountain Harte (2009b) (bold) and Strickland (1990) respectively.**

| Common name (Maori name) | Scientific name | Common name (Maori name) | Scientific name |
|---|---|---|---|
| 1/2 Banded perch (**puaihakarua**) | *Ellerkeldia* sp B | Longtail stingray (**ngu**) | *Dasyatis thetidis* |
| Banded wrasse (**tangahangaha**) | *Notolabrus fucicola* | Mado | *Atypichthys latus* |
| Bigeye | *Pempheris adspersus* | Marblefish (kehe) | *Aplodactylus arctidens* |
| Blackspot goatfish (**ahuruhuru**) | *Parupeneus signatus* | Mottled moray | *Gymnothorax prionodon* |
| Blue cod (**rawaru**) | *Parapercis colias* | Orange wrasse | *Pseudolabrus luculentus* |
| Blue maomao (**maomao**) | *Scorpis violaceus* | Parore | *Girella tricuspidata* |
| Butterfish (mararii) | *Odax pullus* | Pigfish (**pakurakura**) | *Bodianus vulpinus* |
| Butterfly perch (oia) | *Caesioperca lepidoptera* | Pink maomao | *Caprodon longimanus* |
| Combfish | *Coris picta* | Porae | *Nemadactylus douglasi* |
| Crimson cleaner | *Suezichthys aylingi* | Red moki | *Cheilodactylus spectabilis* |
| Demoiselle 2 spot | *Chromis dispilus* | Sandagers wrasse | *Coris sandageri* |
| Eagle ray (**whai keo**) | *Myliobatus tenuicaudatus* | Scarlet wrasse (pau) | *Pseudolabrus miles* |
| Goatfish (ahuruhuru) | *Upeneichthys lineatus* | Scorpionfish (rarai) | *Scorpaena papillosus* |
| Grey moray | *Gymnothorax nubilus* | Short tail stingray (**ngu**) | *Dasyatis brevicaudatus* |
| **Hiwihiwi** | *Chironemus marmoratus* | Snapper (**tamure**) | *Pagrus auratus* |
| Jack mackerel (hauture) | *Trachurus declivus* | Spotty (**pakirikiri**) | *Notolabrus celidotus* |
| John dory (pukeru) | *Zeus faber* | Sweep (hui) | *Scorpis lineolatus* |
| **Kahawai** | *Arripis trutta* | **Tarakihi** | *Nemadactylus macropterus* |
| Kingfish (**haku**) | *Seriola lalandi* | Trevally (**ara ara**) | *Pseudocaranx dentex* |
| Koheru | *Decapterus koheru* | Yellow moray (puhikorokoro) | *Gymnothorax prasinus* |
| Leatherjacket (**kőkiri**) | *Parika scaber* | | |