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Biogenic habitats on New Zealand's continental shelf. Part I: Local Ecological Knowledge

New Zealand Aquatic Environment and Biodiversity Report No. 174

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Fishers develop detailed knowledge of their fishing grounds, often built up over many years. Known as Local Ecological Knowledge (LEK), this information about the environment and the fish they catch is often different but highly complementary to scientific data about localized marine eco-systems, and in some cases, exceeds it. Fifty trawl fishers around New Zealand were interviewed to record their knowledge of biogenic habitat, with charts being marked by the fishers themselves before being digitised and collated to provide a national map of fisher-drawn areas of possible biogenic habitat. A total of 496 areas were digitized, along with a further 92 observations that were not marked on charts. Many of these sites were memorable for the distinctive habitats/species that were caught as bycatch, sometimes in sufficient amounts to damage gear or make cleaning the net difficult. Of the areas marked on charts, 66% were classed as potential biogenic habitat (327) with a further 15% classed as "Foul" or "Reef". The most commonly mentioned biogenic habitats were corals (likely to include bryozoans), sponges, kelp, horse mussels and bryozoans. Many of the areas marked on charts were overlapping or spatially clustered in certain areas: e.g. Cape Reinga/North Cape/Three Kings; East Cape, offshore North and South Taranaki Bight; Stewart Island / Foveaux Strait / Fiordland and the Oamaru to Dunedin continental shelf. In some areas, temporal and spatial reduction in the habitats/species were noted, usually attributed to fishing activity, e.g. the "*wire-weed*" fields (chaetopterid tubeworms) off the North Canterbury; the "*tarakihi weed*" (also chaetopterid tubeworms) / sponge assemblage of the "*Hay Paddock*" off Oamaru, large beds of sea-pens off the west coast South Island, and an unidentified organism called "*spongeweed*" in the South Taranaki Bight.

The inherent uncertainty and bias in these data are acknowledged. The non-random approach of selecting interviewees potentially created a bias in the expert pool interviewed, and despite using multiple starting points in our expert selection, the knowledge-base for some regions was possibly under-represented. However, with the aim being to collect very specialized and location-specific knowledge, potentially only possessed by a few individuals, the purposive and "snowball" sampling methods were believed to be the best way to overcome the difficulties of engaging an expert group (commercial fishers), where a significant number were unsurprisingly wary, or unwilling to divulge the information being sought. Steps to increase the confidence in certainty of the observations collected included defining "Key Sites" as those being repeatedly and consistently described by multiple fishers, and / or consistent with scientific information if available. When all fisher-drawn areas were overlaid together, a total of 65 sites were identified around the country where multiple fishers (up to 9) described the same or similar habitats at overlapping locations, or in close proximity. For nearly half of these sites (30), scientific information was identified (varying from large-scale surveys to isolated stations or samples) that provided some level of corroborative evidence. From the 65 sites, 47 were suggested as "Key Sites" for consideration for future empirical sampling. These included areas where scientific surveys have already characterized biogenic habitats, (e.g. Separation Point, Otago Shelf and Foveaux Strait bryozoan assemblages, and sponge gardens of North Cape), sites where more limited scientific data corroborates fisher information, but the spatial extent and / or the biological communities remain unquantified, (e.g. Canterbury tube worm fields, Ranfurly Bank) and sites where no scientific information was identified (e.g. west coast North Island canyons, "*Coral Patch*", Hauraki Gulf).

With the aforementioned caveats in mind, the maps and site descriptions presented here represent a valuable, but in many places, unverified indication of where biogenic habitats might exist on the New Zealand continental shelf, and are intended only to inform the design of future field sampling.

INTRODUCTION

1.1 Overview

A central theme to emerge from the move towards Ecosystem Based Fishery Management (EBFM) is the role of habitat in supporting sustainable fishery production (Armstrong & Falk-Petersen 2008, Caddy 2014). Different habitat types vary in their complexity, represented by the heterogeneity in physical structure, which may be geological, or of biological form. Evidence from a wide range of studies on different marine system components indicates that as habitat complexity increases (at multiple scales), so does a given unit of area's value for biodiversity (species richness, abundance, age / length composition, provision of settlement surfaces, juvenile survivorship / growth, bentho-pelagic coupling, and base trophic production) (e.g. Heck & Wetstone 1977, Connell 1978, Luckhurst & Luckhurst 1978, Dean & Connell 1987, Connell & Jones 1991, Tupper & Boutilier 1995, Klitgaard 1995, Rooker at al. 1998, Charton & Ruzafa 1998, Lindholm et al. 1999, Cummings et al. 2001, Norkko et al. 2001, Buhl-Mortensen et al. 2010, Beazley et al. 2013, Caddy & Defeo 2003, Rogers et al. 2014). Biogenic habitats are defined as those formed by living species that create emergent three-dimensional structure, have been shown to be especially important to many fish species (e.g. Luckhurst & Luckhurst, 1978, Bell & Galzin 1984, Ebeling & Laur 1985, Roberts & Ormond 1987, Carr 1989, Connell & Jones 1991, Rooker et al. 1998, Heifetz 2002, Gratwike & Speight 2005, Abookire et al. 2007, Pérez-Matus & Shima 2010, Rabaut et al. 2010, Humphries et al. 2011, Baillon et al. 2012, Laman et al. 2015). In the context of marine ecosystem management, more diverse assemblages are likely to be more productive, sustainable, and / or more resilient (Millennium Ecosystem Assessment 2005, Worm et al. 2006, Sala & Knowlton 2006, Palumbi et al. 2008). Unfortunately much of this understanding has come from studies assessing the impact of habitat loss on species diversity. Structurally complex habitats are becoming rarer in many parts of the world (Airoldi et al. 2008). For example, less than 15% of the coastline in Europe is considered to remain in good condition, with near elimination of many productive and diverse coastal habitats (Airoldi & Beck 2007). Similarly, a comparison of 12 estuarine and coastal ecosystems in North America, Europe, and Australia found human impacts to have depleted 90% of formerly important species (including many habitat-builders), destroyed 65% of seagrass and wetland habitat, degraded water quality, and accelerated species invasions (Lotze et al. 2006).

In New Zealand, biogenic habitats include coral and bryozoan reefs, sponge-dominated habitats, horse mussel, oyster, scallop and dog cockle beds, kelp forests, rhodoliths beds, sea grass meadows, and tube worm fields (for a review see Morrison et al. 2014a). Key studies characterizing some of these habitats on the continental shelf (about 5–250 m water depth) include the epifaunal biodiversity hotspot of Spirits Bay (Cryer et al. 2000, Tuck & Hewitt 2011); the "sponge garden" off Goat Island, Cape Rodney to Cape Okakari Marine Reserve (Battershill 1987); bryozoans off Separation Point (Tasman/Golden Bay) (Grange et al. 2003), the South Taranaki Bight (Gillespie & Nelson 1996), Otago Peninsula (Probert at al. 1979, Batson & Probert 2000, Wood & Probert 2013), and Foveaux Strait (Cranfield et al. 1999, 2003, 2004); rhodolith beds of northern New Zealand (Nelson et al. 2012, Neill et al. 2015); macroalgal communities (Shiel 1990, Shiel & Hickford 2001, Shears & Babcock, 2007). Similar to other parts of the world, the close proximity to land renders these habitats highly vulnerable to the effects of fishing, land-derived sedimentation, sediment dumping and spoil dispersal, pollution, invasive species and other human impacts (Morrison et al. 2009, 2014a). Currently, our understanding of the extent and magnitude of biogenic habitats on the shelf is highly limited in the context of scientific studies, e.g., high biodiversity areas of Spirits Bay were only discovered in the 1990s (Cryer et al. 2000). It is difficult to manage threats to important biodiversity resources without having fundamental information on their identity and spatial locations (Diaz et al. 2004).

1.2 Value of Local Ecological Knowledge (LEK)

While scientific information on coastal shelf biogenic habitats is limited, there is a nation-wide pool of information on where different habitats are (and were) to be found, currently extending back in time about fifty years; that of fishers, especially retired commercial fishers, who, as resource users, necessarily develop detailed knowledge of their fishing grounds. Known as Local Ecological Knowledge (LEK), this information about the environment and the fish that are caught is often different, but highly complementary to scientific data, and in some cases, exceeds it. Compared to scientific information such as fishery-independent surveys, LEK generally concerns smaller spatial scales, but derives from a potentially larger observational base and usually over wider time frames (Dawe & Schneider 2014). It is generally non-standardized, largely anecdotal and may be biased by selective or limited memory. However, such knowledge can provide unique, fine-scale historical information through the recollections of different generations, and can be used to complement scientific information or provide information in its own right.

An increasing number of researchers have recognized this, and studies have demonstrated the value of LEK in terms of: improved understanding of local fish stock structure and migration (Neis et al. 1996, Murray et al. 2008); perception of environmental and population change (Sáenz-Arroyo et al. 2005a, Rochet et al. 2008, Parsons et al. 2009, Taylor et al. 2011, Morrison et al. 2014b, Thurstan et al. 2016); mapping resource use by fishers including their 'home patches' (Martin 2008, Hall et al. 2009); and broad scale habitats and 'seascapes' mapping for better marine spatial planning (Pederson & Hall-Arber 1999, Bax & Williams 2001, Bergmann et al. 2004, Gass & Willison 2005, Williams & Bax 2006). As an example, LEK was used to reconstruct 2800 km^2 of historical cod spawning grounds in the Gulf of Maine that are now fished out (Ames 2007) and in their simple but eloquent paper, Sáenz-Arroyo et al. (2005b) illustrated rapid inter-generational changes in the perception of the state of Mexico's Gulf of California. By interviewing three generations of fishers they found young fishers were largely unaware that the large species such as Gulf of Mexico grouper, had ever been common (older fishers caught up to 25 times more on their best days fishing), or that near shore sites were ever productive. Fisher's knowledge has also been used within New Zealand in a number of contexts; e.g., to document the development of the trawl fishery and Wairoa Hard closure in Hawke's Bay (Tai Perspectives 1996), to map the activity of the Bluff oyster fishery (Hall et al. 2009), to examine the recreational exploitation history of snapper, *Pagrus auratus* (Parsons et al. 2009), and to assess fisheries and environmental change in the Kaipara Harbour (Morrison et al. 2014b).

Gaining access to hard-won information about the location of good fishing grounds and habitat can be more difficult to achieve than more general recollections of 'best ever catches'. This is often due to a mistrust of scientists and managers by fishers, and understandable feelings that it is proprietary information upon which an individual's competitive advantage lies, or that such information will lead to negative management outcomes such as closed areas and other restrictions that will impact on livelihoods (Pederson & Hall-Arber 1999). However, in a number of instances, LEK has been used with success to increase understanding of seabed habitats. Gass & Willison (2005) combined scientific and local knowledge to assess the distribution of deep-sea corals in Atlantic Canada. The scientific sources were opportunistic presence data from survey trawl and observer databases and this was supplemented with 26 interviews with fishermen, some of whom had memories as early as the late 1940s and early 1950s. Using photographs and specimens, location information by species was achieved over a wide geographic range. The authors found that the three data sources provided both unique and overlapping information, with each method enhancing the combined knowledge. Slacum et al. (2008) used information from two experienced commercial fishers (40 years fishing combined) to learn about areas of varying productivity within their fishing grounds, and help identify geographic strata for a trawl survey designed to assess the relationship between summer flounder abundance and specific habitat features, and identify Essential Fish Habitat (EFH). Bergmann et al. (2004) asked fishers to describe the location of grounds and key habitat features they thought were important for gadoids in the Irish Sea, and compared this with standard ground fish surveys from the region. Not all fishers participating in that study were willing to mark locations on charts, but those that did identified a wide range of habitats that were broadly compatible with scientific survey data. Although fishers were not always aware of the species' names of non-target invertebrates, and were sometimes cautious about offering information that might prove incorrect, the interviews revealed valuable biological information that was consistently cross-referenced by different individuals. For example, a number of fishers noted the association of one gadoid species, haddock with '*wigs*' (identified as brittle star beds by the authors), suggesting the fish used the beds to "*clean themselves*". The authors reported that haddock are known to feed on brittle stars post spawning. Similarly, in south-east Australia, LEK was used to inform a process of mapping the structure, ecology, and use of the sea-scape by fishers (Williams & Bax 2006). The authors built up relationships over a period of five years through port visits, commercial fishing operations and management meetings; resulting in fishers supporting the project as a means to have an input into the spatial management and regional marine planning and any potential area closures. Detailed information on distribution, productivity, seabed biology and geology, and oceanography effectively provided a course-scale habitat map, with 'fishing grounds' as units and a mixture of information on geomorphological features such as sediment plains, rocky banks, and substrate patches dominated by a particular species / community.

1.3 Objectives

The overall objectives of the project were to characterise and map the occurrence of significant areas of biogenic habitat forming hotspots and associated biodiversity in New Zealand's near-shore coastal zone (about 5–150 m). There were four specific objectives:

1. To collect and integrate existing knowledge on biogenic habitat-formers in the <5–150 m depth zone of New Zealand's continental shelf, from sources including structured fisher interviews, primary and grey literature, and other sources as available.
2. Using the findings of Objective 1, design and deploy a series of sampling voyages to selected locations, to map and characterise locations of significant biogenic structure (either still existing, or historical), and collect relevant biological samples (both through visual census, and physical collection).
3. Process and analyse the samples collected in Objective 2, to provide a hierarchical, quantitative description of the biogenic habitats and associated species encountered.
4. Using the findings from Objective 1–3, assess the present status, likely extent, ecological role, and threats to, biogenic habitat formers in the <5–150 m depth zone. This should include a spatial modelling and risk assessment framework. Integrate (as appropriate) with other information sources and/or approaches that may exist by the year 2010/11.

This report covers Specific Objective 1, with a companion report, "Biogenic habitats on New Zealand's continental shelf. Part II: National field survey and analysis." (Jones et al., in review) covering Objectives 2–4.

2. METHODS

In order to map and characterise the occurrence of significant areas of biogenic habitat forming hotspots, we required information on their location. A mixed-method sequential exploratory strategy (Creswell, 2009) was employed, where qualitative data from nationwide fisher interviews (Specific Objective 1) were collected and used in combination with available scientific data to select appropriate target sites for further study (Specific Objectives 2-4).

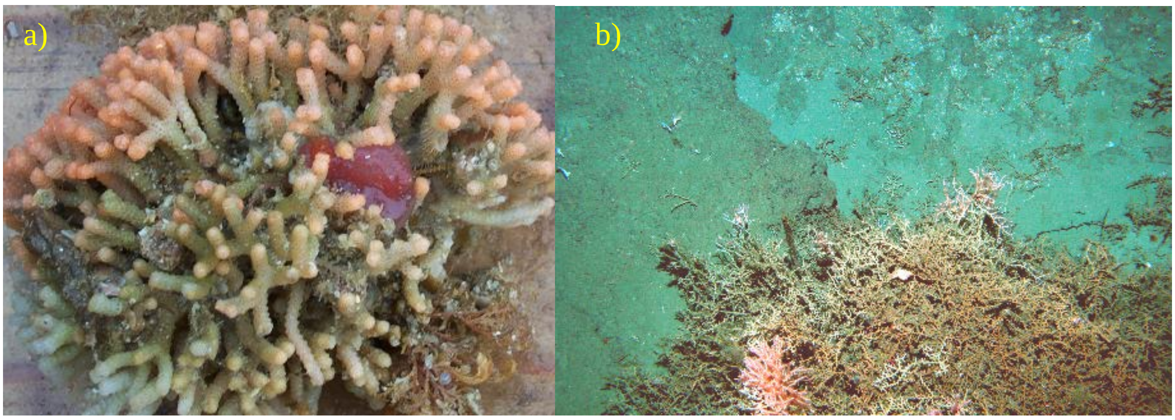
2.1 Interview approach

The issue of eliciting, evaluating and applying expert knowledge has received some attention in the LEK and Traditional Ecological Knowledge, (TEK) literature, as well as more broadly around the use of scientific experts in forums (e.g., Huntington 2000, Davis & Wagner 2003, Drew 2004, Davis & Ruddle 2010, Drescher et al. 2013). Drescher et al. (2013) addresses the rigorous use of expert knowledge in ecological studies in detail (note: their use of the word "expert" is not confined to those with formal science training); while Davis & Wagner (2003) offer robust critiques of the LEK field in general (largely focussed on terrestrial examples). Drescher et al. (2013) discuss the sampling bias that can occur when experts included in the elicitation process are not fully representative of the entire population, due to some or all individuals being difficult to access. If a large enough expert pool was accessible, then random or stratified random strategies could be used, but non-random sampling methods such as 'Chain referral sampling' (snowball sampling) were noted as being commonly used where the expert pool may be less visible; an initial expert was selected, with that person nominating further suitable experts. Multiple independent starting points (i.e. selecting initial experts from different places or groups) was seen as one way to maximise representative selection from the overall pool. Correctly identifying experts is a challenge (Huntington 2000, Drew 2004). Davis & Wagner (2003) suggest that the best approach is through systematically gathered peer recommendations, using a structured sampling technique, where experts were rank-ordered depending on their peer's views of them (see also Davis & Ruddle 2010). However, Drescher et al. (2013) observed that peer selection could potentially lead to selection bias or 'underestimated knowledge variance' due to the nominating of 'like-minded people' (population clustering). These authors also highlighted the issue of participants being polarized by social or political debates central to their expert contributions, particularly where the topic involved resource allocation.

Despite these drawbacks, researchers in social science research have argued the advantages of non-random selection techniques. Non-random, or purposive sampling is widely used in qualitative research to identify and select individuals or groups of individuals that are especially knowledgeable or experienced with the phenomenon of interest (Bernard 2002, Patton 2002). Support for these techniques focuses on being able to select the right participants to achieve a depth of understanding or detail about the phenomenon of interest, rather than a breadth of knowledge that allows generalization of the results (i.e. a representative sample). As noted by Drescher et al. (2013), where exceptionally local knowledge is required, only very few individuals may possess this knowledge and sample size may be irrelevant as long as one knowledgeable expert is involved (e.g. Bart 2010: "*finding effective knowledge is not the same as finding commonly held knowledge*"). Davis & Wagner (2003) however, note that such knowledge can only be classed as anecdotal and cannot be seen as representative of the knowledge system as a whole, stressing the requirement for understanding the nature of the information collected, and limitations of its use, unless verification can take place.

For this project, the primary knowledge being sought was location-specific presence (current and / or past) of what would most likely be unusual habitats in the context of the largely "flat", soft sediment fishing grounds familiar to most fishers. This knowledge may be held by a few or just one individual, come from a one off encounter rather than repeat observations, and might depend on an individual's propensity to fish in uncharted territory, and / or a longer fishing history that encompassed a previous era of explorative and expanding fisheries. Such information would fall within the "specific knowledge" end of the continuum of knowledge contextualization described by Drescher et al. (2013) with "synoptic knowledge" representing the other end of a spectrum of increasing integration and value assessment of individual knowledge pieces. The purpose of collecting these data was to contribute to hypotheses of potential biodiversity hotspots, and to inform an empirical data collection strategy to validate these observations, rather than to generate conclusions about biogenic habitats themselves. Given the nature of the knowledge sought, and these aims, it was felt that a combination of 'purposive' and 'snowball' sampling techniques were the most appropriate; the former where individuals were selected because they are believed to be capable of contributing the most comprehensive or reliable information; the latter where initial participants were asked for recommendations of further knowledgeable participants. Initial potential participants were identified through professional networks of multiple colleagues, supplemented with personal contacts, and contacts obtained from approaching professional fishermen's associations. Trawl fishers were targeted as the main focus group, as this fishing method was believed more likely to retain substantial by-catch of biogenic habitat type fauna compared to other methods. The fisher interview survey was conducted at the national scale, resulting in a range of independent contact approaches through multiple channels. As already mentioned, such methods run the risk of creating a bias in the pool of expertize elicited, but it was hoped that using multiple starting points would minimize this bias, by maximising our chances of reaching as many experts as possible. However, some regions proved to have fewer potential interviewees than others, and / or required a greater effort to secure participants, whilst other areas, with a larger pool, were undoubtedly under-sampled due to limited resources.

An initial phone call to introduce and outline the project and its purpose, ascertain the spatial and temporal scope of the individuals experience and willingness to participate, was followed up with an information pamphlet (see Appendix 1) sent to those who were positive about being involved, before being contacted again to arrange a full interview. The initial phone call identified some individuals who were perceived as being unable to meet the criterion of offering reliable or useful information. It is also recognized that those individuals who were unwilling to participate may represent a valuable pool of knowledge that we were unable to tap into.. All interviews were carried out by two NIWA staff, who travelled to Auckland, Tauranga, Napier, Gisborne, Wellington, Wanganui, New Plymouth, Nelson, Lyttelton, Westport, Oamaru, Timaru, Port Chalmers and Bluff. The questionnaire used was based on a literature review of wider LEK interview approaches (e.g. for other objectives such as fisheries catch and size trends), but specifically focused on seafloor habitats, ranging from well-known fishing grounds to one-off memories or 'unusual places or catches'. The questionnaire was semi-structured to elicit a wider range of possible answers, and a greater level of detail and context; as compared to more restrictive yes/no, or multiple choice options. While the level of detail may vary between respondents and the results can be more difficult to quantify, this process allows for potentially unanticipated findings (Neuman 2005). Questions were divided into three parts; the first concerning individuals' history in the industry, the second (and main) section concerning the location and characteristics of biogenic and other habitats (effectively a free-listing process), and the third finishing with any other comments about changes they had observed in the environment and memorable catches. A selection of visual aids (photographs, and specimens of some calcareous groups) were used to familiarize or remind the fishermen of the kinds of 'habitats of interest' (e.g., Figure 1). Regionally relevant nautical charts were provided and used as the framework for the interview. Following a brief summary of the individuals fishing history, the fishers were asked to go through all the areas that they had fished recently or in the past, and to outline areas of 'unusual' habitats. Memories were encouraged by looking at the photos and asking fishers to think of times when they had picked up large volumes of material in the trawl, or they had damaged, snagged, or even lost a net. Where an area was identified, we encouraged them to mark this area on the chart and then asked specific questions about that area; the species they would have been targeting, when they last fished it, whether they remembered catching undersized fish, the occurrence of unusual water temperatures or currents in the area. In some instances these sites were relatively large and well known to the individual, in other cases they were one-off tows. Along with the markings on the chart, one of the two interviewers recorded notes during the interview, relating the information to the various marked areas. Where permitted, interviews were also recorded for the purposes of making sure all details were captured and later transcribed. The logistics of arranging multiple interviews in a day, and in some cases, interviewee "fatigue", limited most interviews to around one hour. In many cases, the final section of the interview concerning historical changes in environments was not covered, as the main part of the interview took up the time available.



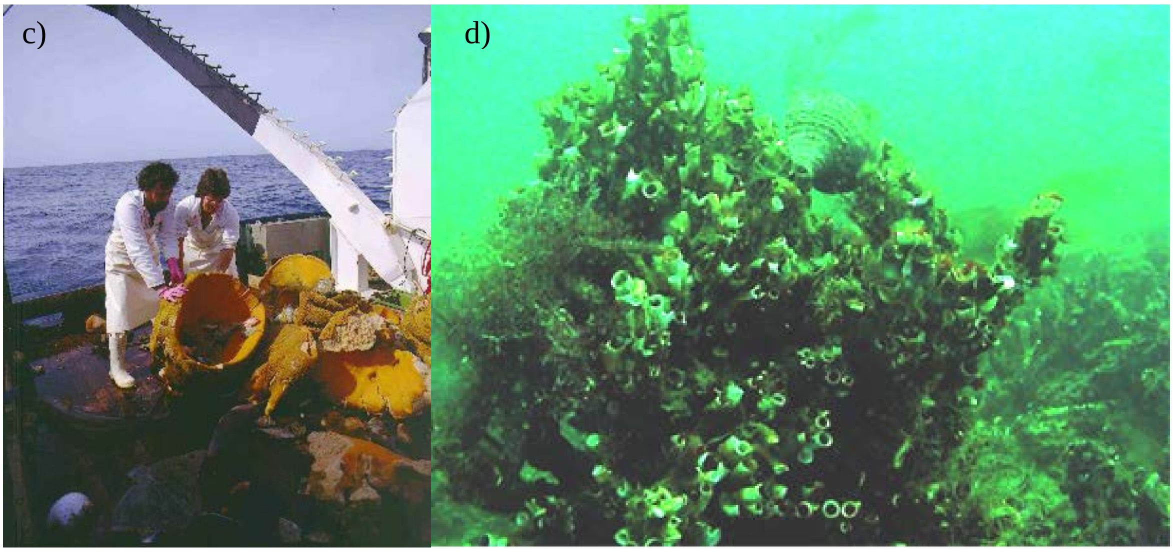


Figure 1: Examples of visual aids used: a) the bryozoan *Cinctipora elegans*; b) deep-water coral *Solenosmilia variabilis*; c) sponge by-catch from a research trawl, 1980s, Cape Reinga region; d) tubeworm mound, *Galeolaria hystrix* (Source: R. Davidson, Davidson Environmental Ltd).

2.2 Data digitization and organization

Following the interviews, the data were digitized into two formats (Figure 2). The areas marked by fishers on the chart were scanned as high quality JPEG images, including the nearby coastline. These scanned charts were then added as layers to a GIS database. The charts were geo-referenced by aligning the coastline from the nautical chart to the relevant sections of an independent national GIS coastline shape file as closely as possible, using up to eight geo-reference points. This was considered to be the best way of digitising the data, as fishermen had drawn their areas by relating chart features to terrestrial landscape features that they remembered from trips (NB: many of the data collected pre-dated the arrival of GPS; radar and visual sightings were the main means of position-fixing).

Once scanned, charts were geo-referenced, and polygons were traced over the areas drawn by fishers. Within the attributes table, each polygon was assigned the relevant fisher identification tag and a habitat type, or other category (e.g. fishing, spawning or nursery ground) were assigned. Assigning these categories was sometimes a straightforward selection from an existing list of known habitat categories (e.g. “Kelp forest”, “Sponges” or “Coral”), whilst other categories were generated during the synthesis of the interview data, some with a known scientific classification (e.g. “Wireweed” was assigned to “Tubeworms”), while others remained unidentified (e.g. “Spongeweed” and “Cauliflowers”). In this way a series of fisher layers were built containing the scanned jpegs and different habitat areas located on the chart. Where no areas were drawn, but site or general location was mentioned, these were added as points. The conversion of areas marked on nautical charts into a GIS database also required re-projection from a chart’s non-linear geographic co-ordinate system (Datum: D_WGS_1984) to a planar projection (World Mercator). This was done when the individual fisher layers were merged to create a data master-layer with all polygons included and all the data merged into one dbf file (shape-file). At the same time, the written notes and audio files from the interviews were transcribed into an excel spreadsheet, as much of the information associated with each polygon, including lengthy descriptions, was considered too cumbersome for input into GIS tables. These additional data are linkable to the GIS database through the fisher and polygon unique ID identifiers.

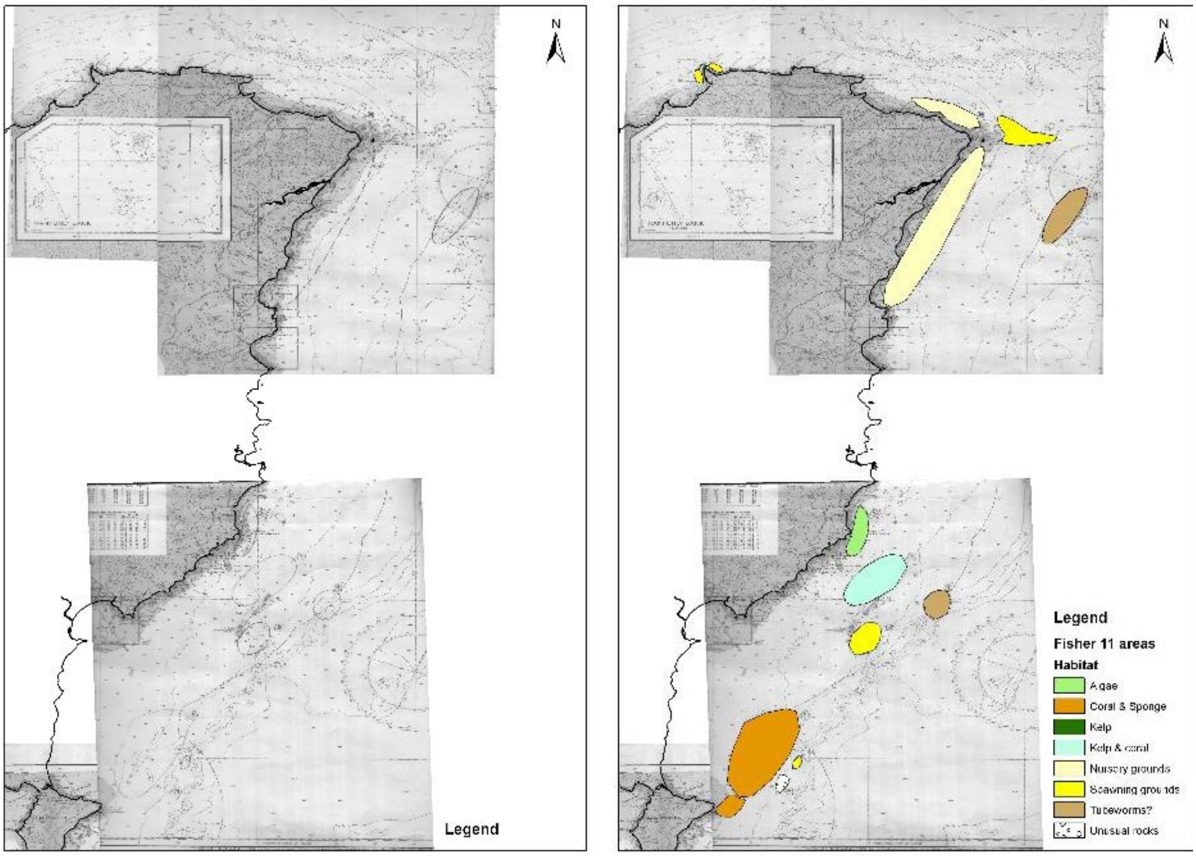


Figure 2: left) Charts marked up with LEK scanned to coastline; right) polygons created by tracing over the fisher-drawn areas, and assigning habitat type ID and other information in the GIS database.

2.3 Supporting scientific data sources

To assist in interpretation of fisher's descriptions, scientific literature was reviewed where available, and some selected data sources were collated. The published science literature for New Zealand on biogenic habitats and fisheries species linkages has been recently reviewed (Morrison et al. 2014a), and was used to provide science based information. In addition to fishers, several scientists were also interviewed in areas known to be the focus of active scientific research; in particular Foveaux Strait/Stewart Island, and Otago Peninsula. Total commercial catch data for relevant species (supplied by MPI), were summed into 5 km squares, and plotted to identify catch hot-spots for selected species such as tarakihi and golden snapper (not given in this report due to spatial catch data resolution restrictions). Selected invertebrate/by-catch records from the 'AllBioSea' and 'Specify' databases were also plotted. These by-catch and other records were very variable in terms of regions covered, whether by-catch was recorded, and the level of taxonomic resolution used; and were used as a qualitative indication of species presence only (see Baird et al. (2015) for a detailed discussion of such data's limits). Included in these extracts, were records from two *Tangaroa* voyages that were carried out following the interviews as part of this project, which targeted some of the sites identified by fishers. For a full description of these voyages, see Jones et al. (in review). Maps of areas of predicted rocky reef habitat (less than 50 m) developed by the Department of Conservation, based on expert knowledge and analysis of hydrographic faring sheets, were also compared with fisher records of 'Foul" and other bycatch likely to be associated with hard substrate.

2.4 Regional descriptions and Key site selection

Once digitized, composite maps were generated for nineteen regions around New Zealand (Figure 3 regions A–S), with all polygons for a given region overlaid. This process revealed areas drawn by different fishers that were in the same geographic locality, or overlapped. Where these area descriptors were the same, similar, or at least not inconsistent (e.g., one described as "Foul", or "unusual rock", and another described as "Coral"), sites were given a greater weighting in terms of likely validity, and suitability for further exploration. Some areas were mentioned by up to nine individuals (including verbal comments that were not specifically geolocated), although this number was dependant on how many fishers had knowledge of that particular region, which varied between regions. At some sites, the validity of fisher's knowledge, was further strengthened by existence of converging scientific data, but absence of this criterion did not necessarily lessen potential validity. Through this process, a subset of sites were identified; defined as being repeatedly and consistently described by multiple fishers, and / or consistent with scientific information if available, or considered especially unusual and interesting (as arbitrarily defined by the report authors). We chose not include any criteria relating to minimum size of fisher-drawn areas, recognizing the relatively coarse scale at which information was provided, the variation in how individuals recorded their information, and the potential for mismatch to actual habitat coverage. These were called "key sites", and provided the basis for planning two sampling voyages on board R.V. *Tangaroa*, with the aim of mapping and characterizing locations of significant biogenic structure, which are described further in Jones et al. (in revision). In addition to maps of regional LEK-derived biogenic habitat diversity, national scale maps were also generated for particular habitat types.

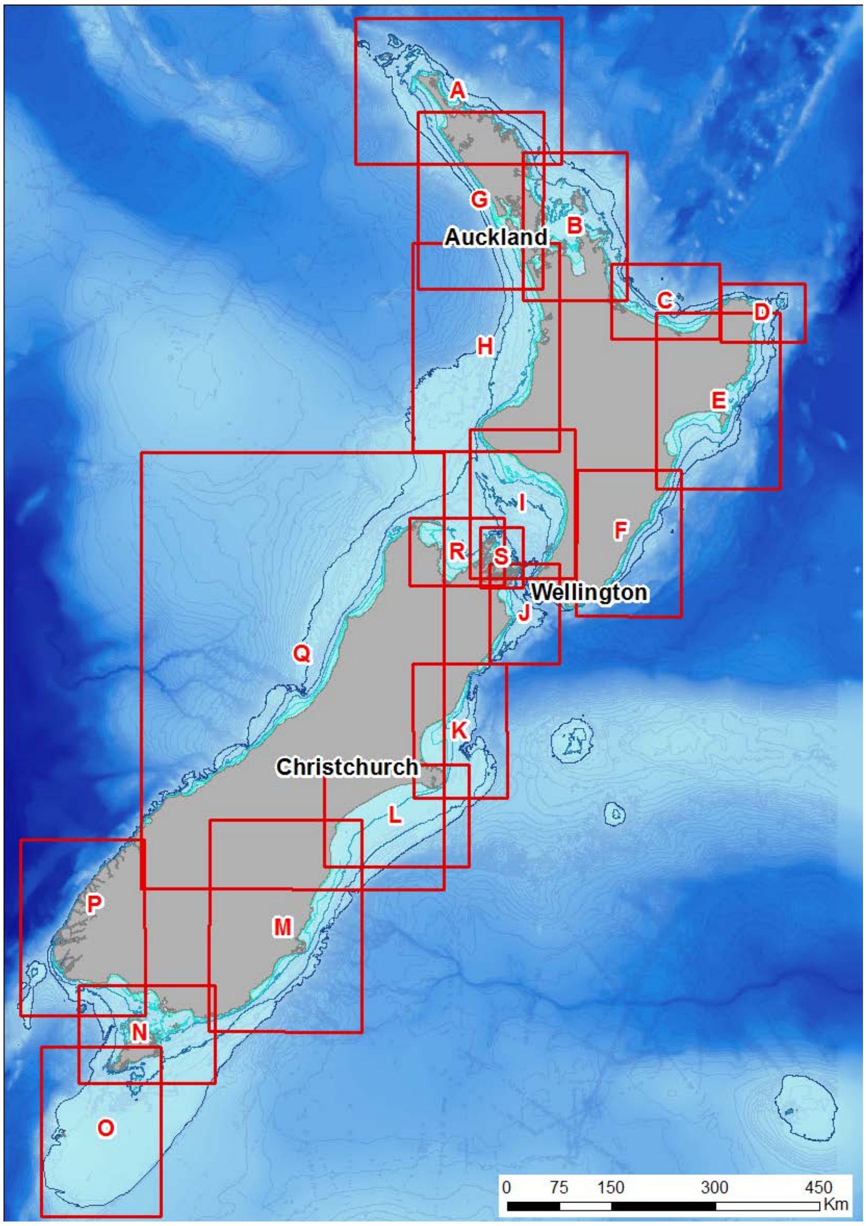


Figure 3: Master map of the LEK descriptions by region.

3. RESULTS

3.1 Fisher demographics

A total of 70 commercial fishers were contacted for interview. Sixty-three percent (44) were retired or semi-retired (i.e., still had some involvement in the industry). All were male, most operated demersal trawls, with some also fishing with or having previously fished with Danish seine, long-line, dahn line, and set net (north-east North Island); and/or rock lobster pot and oyster/scallop dredge (South Island). Of those contacted, ten individuals either declined to be contacted further, or declined when contacted a second time to arrange an interview. Of the remaining 60 fishers that indicated a willingness to be interviewed; 55 were contacted a second time and of these, 5 interviews did not proceed for various reasons; leaving a total of 50 individuals interviewed in full (71%). The final age composition of the interviewees is given in Table 1.

Table 1: Age composition of fishers interviewed.

Age group (years)	<50	50s	60s	70 +	Total
Fishing	5	4	7		16
Retired / ex-fishers		2	18	14	34
Total	5	6	25	14	50

3.2 Overall summary of LEK information collected

In total, fishers outlined 496 areas on charts all around New Zealand, and made a further 92 observations about locations that they recalled, but were unsure of the extent, or exact location, and did not mark on the charts. In only one interview, were no valid geo-located observations recorded, with nearly 85% of interviews providing between 5 and 38 observations, and 60% providing over 10 observations. The geographic range of information from any one interview was varied, with some individuals having fished many different regions, whilst the fishing history of others was more localized. For ease of presentation, the LEK information is split into nineteen regions. These vary considerably in area of continental shelf they include, but the spread of information between them indicates some areas that were likely to have been under-sampled in terms of fisher knowledge. In most regions, between 5 and 10 fishers provided some knowledge of habitats, recording between 10 – 52 observations. In some, up to 14 fishers provided information (Foveaux Strait and Stewart Island, South Taranaki Bight, Timaru to Foveaux Strait), whilst in two regions, the number of interviewees who had knowledge was less; 4 fishers for the Canterbury Bight, and only 1 for the Traps and Snares region.

The range of information gathered varied from single locations to mega-habitat features corresponding to fishing grounds. The biogenic habitat fishers were asked to think about were often what they thought of as undesirable "*rubbish*" that would have to be shovelled overboard or cut from the net. Observations were based on recollections of bycatch that was frequent or unusual or substantial enough to be memorable; for instance, many fishers recalled nets being damaged by large catches of coral and / sponges, or the difficulty of removing large volumes of kelp and "*tarakihi weed*" (chaetopterid tubeworms) from meshes. A large array of fisher descriptions were recorded along with local nicknames that originated from the colour, size, shape, texture of the organisms such as "*plumb duffs*" (large sponges), "*elephants ears*" (sponges, possibly referring to shape rather than colour), "*white straw*' (most likely tube worms), "*cow-pads*" (juvenile rays) "*sea apples*" (sea tulips), "*snapper biscuits*" (sand dollars), "*bulls wool*" (bleached *Ulva*?), "*cauliflowers*" (ascidians/sponges/sea cucumbers?), and '*corn-flakes*' (bryozoans). Nearly 66% of the areas marked on the charts were classed as potential biogenic habitat, (63% of the observations overall). The top five most frequently mentioned categories were Corals, Sponges, Horse mussels, Kelp and Bryozoans. The combined observations of corals, bryozoans and sponges represented around 30% of all observations (170). These were not necessarily at different locations; in many instances, multiple fishers identified the same areas as the same, or similar, habitat.

Other biogenic categories described by fishers included shellfish beds (e.g. dog cockles, scallops, oysters), sea tulips (kāeo), sea pens, eelgrass, rhodoliths and tubeworms (identified as chaetopterid tubeworms). Fishers also noted large numbers of other species such as kina, sea cucumbers and bristle worms. In addition, 70 observations of "*Reef*" or "*Foul*" areas were located, where the fishers knew the area was untrawlable and might contain epifauna of some sort. There were also observations of picking up unusual rock formations, "*petrified wood*", thermal vents and areas of shell hash and rubble. Some fishers outlined particular fishing grounds as well as areas they believed to be important nursery and spawning sites for species such as flatfish, tarakihi, and snapper. These were also included in the report as appropriate, as a step towards better understanding fish (fisheries) habitat inter-relationships (Morrison et al. 2014c).

Not all interviewees were willing to mark all the places they had knowledge of on a chart due to the perception that such information might lead to 'negative' management outcomes, such as the designation of Marine Protected Areas (MPAs). This concern was shared by almost all individuals interviewed, whether still fishing or retired.

4. DESCRIPTIONS BY REGION

In this section, the LEK information from the nineteen regions shown in Figure 3 is presented in more detail. For each region, a map of the fisher-drawn areas is provided, along with a table summarising the main areas and habitat types described, evidence of fishing impacts where noted, and the number of fishers who reported each feature, (either with or without drawing on the charts). For more literal information, the reader is referred to the narrative sections given in the Appendices. As described in Section 2.4, key sites were defined as locations (of any size), that were repeatedly and consistently described by multiple fishers, and / or consistent with scientific information if available, or considered especially unusual and interesting (as arbitrarily defined by the report authors). These sites are highlighted in bold in the regional tables. These key sites are suggested as higher priority for any subsequent empirical sampling programme. They are also shown as named features on the regional maps, using the fisher/s feature name where possible. At the end of each regional section, scientific information that provided species or other context relevant to the fishers LEK is summarised.

4.1 Three Kings Islands to East Northland.

Twenty nine LEK areas were marked by seven fishers in this northern New Zealand region. A further five sites were mentioned verbally by survey participants, but not marked on the charts (Table 2, Figure 4). The most commonly mentioned biogenic bycatch categories in these areas were corals (including black corals) and sponges, with some being able to recall distinctive colour, shape and / or texture of what are likely to be species of glass sponge (fibre-glass texture, sticking to hands), *Stelleta* ("*nest-like*"), and *Ancorina* sponges ("*elephant ears*"), as well as gorgonians ("*skeleton corals*").

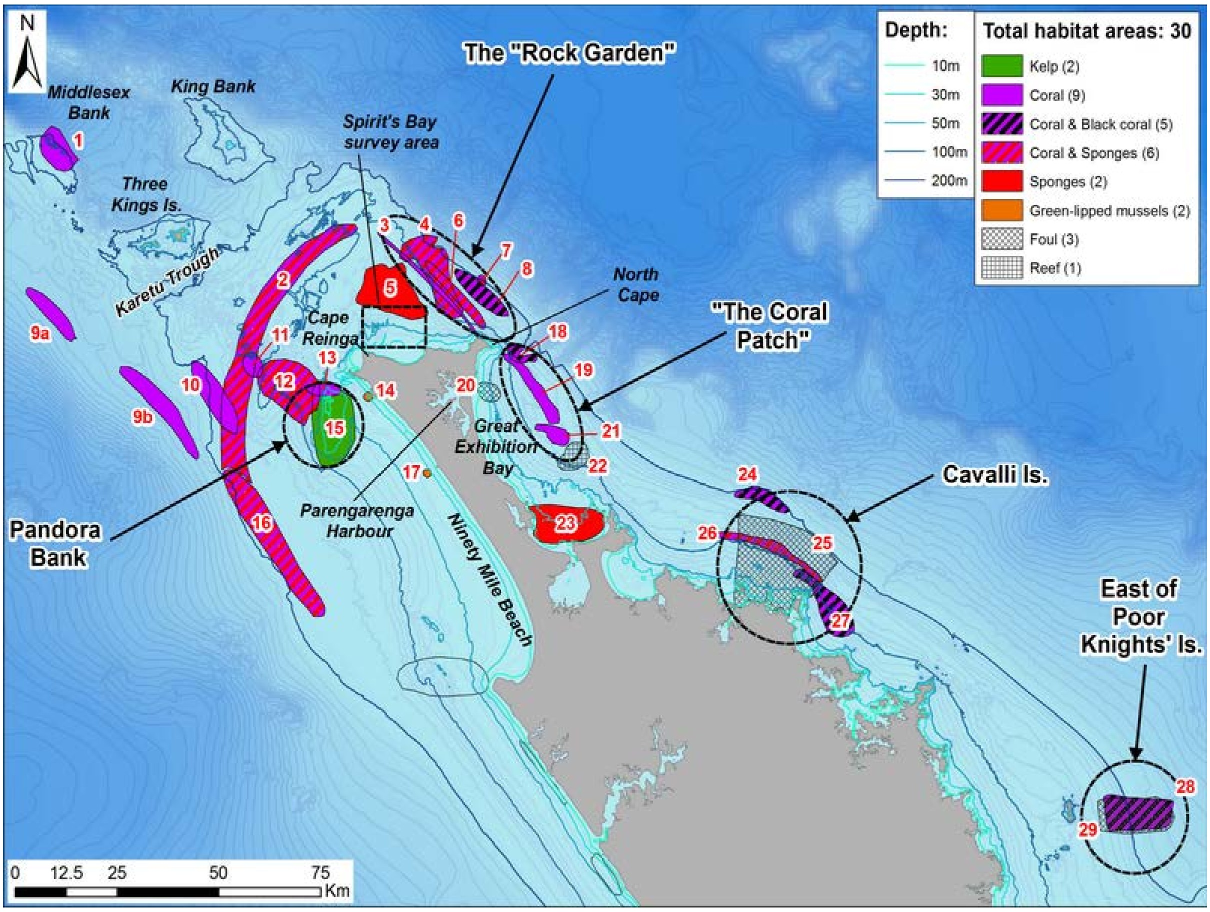


Figure 4: North Cape region LEK map (Region A of Figure 3). Each fisher-drawn area has been assigned a unique number, specific to this regional section (in red). Some key sites are circled and labelled as black text on white background.

The areas around the North Cape, (called the "*Rock garden*"), the Cavalli Islands and Pandora's Bank were most frequently talked about in relation to snagging or losing gear, and bringing up corals, sponges and other bycatch. Table 2 summarises these and the other key sites described. In several areas, such as Middlesex Bank and The Rock Garden, fishers made comments about a decline in occurrence of these types of bycatch, or that they were aware that early fishing activities had resulted in the destruction of these habitats.

Table 2: Summary table of sites described by fishers in the North Cape region with the area identification numbers, brief description, fishing impacts where mentioned, and the number of fishers who described verbally, or identified overlapping or very close areas. Key sites in bold.

Sites	Area ID no.	Description	Fishing Impacts observed?	Frequency of ID
Middlesex Bank	1	Targeted packhorse lobsters and hapuka in the 1970s. Brought up orange, red and pink coral, some "*fern-shaped*". Believed coral habitat had declined	yes	1
"The Rock Garden"	3,4,5,6, 7,8	A trawlable strip subject to strong tides and surrounded by rich coral and sponge habitat. Bright yellow *Stelleta*-like and grey sponges identified as well as "*lacey*" glass sponges.	yes	5
Offshore Cape Reinga	2, 9, 10, 11, 16	Sponges and gorgonians found offshore from Cape Reinga in waters deeper than 100 m; yellowy-white fibre-glass textured (glass sponges), grey "*elephant ears*", orange "*nest-like*", and tall "*skeleton*" and "*staghorn corals"* of multiple colours.		4
Pandora's Bank	12, 13, 15	Sandy bottom, swept by strong tides with patches of foul (coral and sponges mentioned), as well as seasonal algal occurrences likely to be *Caulerpa* and *Durvillea* spp.		4
"Coral Patch"	18, 19, 21, 22	Offshore reefs in Great Exhibition Bay (70 – 150 m), still fished today. Pick up sponges ("*shiny yellow balls*") and black coral described as having 5–7 cm trunk diameters		3
Ranganu Bay	23	Sponges, algae and fan-corals found in 10 – 40 m when fished in the 1950s and 60s	yes	2
Cavalli Islands	24, 25, 25, 27	An area of strong tides and rocky ground with canyons and peaks where gear had been lost. Corals and sponges were found here.	yes	5
East of Poor Knights	28, 29	An area of rugged terrain and strong tides where corals and sponges were found.		2

Scientific data sources

The Three Kings Plateau (including The Three Kings Islands, Pandora Bank, and the area between Cape Maria van Diemen and North Cape) has been described as a hotspot of bryozoan biodiversity, particularly Spirits Bay (Rowden et al. 2004), with the complex biogenic sediments in this region identified as an important factor in this high diversity. A study of the composition and origin of carbonate sediments of the South Maria Ridge found these to be largely composed of clean skeletal carbonate gravels and sand with over 80% (generally over 90%) calcium carbonate ($CaCO_3$), mainly calcite (one of several forms $CaCO_3$ can take) (Nelson & Hancock 1984). This dominance was attributed to very low levels of terrigenous (land-derived) sediments, the presence of rocky substrates for dense epifaunal assemblages, and strong upwelling of nutrient rich waters. Analysis of the superficial sediments found them to be composed of species-diverse bryozoan colonies (10–74% volume), with lesser amounts of mainly infaunal bivalves (2–20%), gastropods (2–10%), ahermatypic corals (0–18%), calcareous red algae (1–16%), and benthic foraminifers (3–15%), along with small contributions from serpulid worms, barnacles, echinoids, brachiopods, sponges, and pteropods (Nelson & Hancock 1984). Based on the appearance of material (fresh/relic) they concluded that modern material (*i.e*., present day $CaCO_3$ production) occurs down to 150 m water depth, around the Three King Islands and Middlesex Bank (and likely also King Bank), but is less important at the same depths on the adjacent, more coastally influenced Reinga Shelf.

At Spirits Bay, an unusual and very diverse invertebrate assemblage was 'discovered' during a scallop stock assessment dredging survey. Examination of the specimens collected during this and a subsequent survey in 1997, found the fauna of this area to be highly unusual, with a very high proportion of new and/or endemic species. In response to this, a targeted biodiversity and mapping survey of the area was carried out in 1999 (Cryer et al. 2000), followed by the closure of some of the area to commercial fishing. The area of the survey is marked in Figure 4 (‘Spirits Bay survey area’), and is located inshore of the areas marked by fishers. Cryer et al. (2000) used a combination of acoustic, photographic, and dredge sampling to assess the Reinga Cape–North Cape area, recording over 300 bryozoan species, and over 200 sponge species, as well as a range of other groups, including two gorgonian and two coral species in the deeper part of the study area (65–100 m), and black coral. The highest species richness was found at 30–80 m water depth. Six stations each recorded more than 100 bryozoan species (station average 61, range 0–140). Of these, the largest and dominant frame-building species was *Celloporaria agglutinans*, found at 33% of the stations sampled, although these colonies were smaller and less common that seen in Tasman Bay, where they are seen as important juvenile fish habitats. A further ten frame-building species were also present. The specific area sampled by Cryer et al. (2000) supported high biomass scallop harvests for several years following its discovery, but by the time of sampling in January 1999, few adult scallops were found, and no scallop spat.

Two inshore trawl surveys were carried out along the east Northland coast in the early 1990s but no by-catch records were found in the TRAWL database. The 2009 Bay Of Islands OS2020 survey also surveyed the shelf between North Cape and the Poor Knights Islands, in 50 to 200 m water depths with a number of stations falling within the fisher polygon sites such as the “Rock Garden”, the northern end of the “Coral patch” and the Cavalli Islands region. An overview of the surveys and initial analysis of data was undertaken as part of the OS2020 project (Bowden et al. 2010). Biogenic substrates such as shell hash and coral rubble were found around North Cape, with muddy substrates dominating the shelf further south, interspersed with areas of exposed bedrock and other hard substrates, e.g. offshore of Whangaroa harbour and the Cavalli Islands. Diversity (number of taxa present in DTIS transects, and how evenly distributed relative abundances are) was highest around North Cape and to the south of Whangaroa with lower diversity observed between North Cape and Doubtless Bay. A variety of sessile fauna including sponges, bryozoans and anthozoans (corals, anemones and sea pens grouped) were recorded in the more heterogeneous areas. A trawl survey was also completed, which found that the soft sediment fish communities were largely similar to those reported by the previous trawl surveys. Diversity and relative abundance of fish communities sampled by towed and baited video were also reported with some preliminary analysis of patterns of fish communities associated with different substrate and habitat types, including reef habitats (Jones et al. 2010).

Along the east Northland coast there have been a number of smaller scale habitat surveys of inshore areas such as Doubtless Bay and Mimiwhangata, which have documented subtidal reefs, kelp forests and sponge and gorgonian-dominated deep reefs (Kerr & Grace 2005; Grace & Kerr 2005). A broadscale habitat map from Ahipara on the west coast to Mangawhai on the east coast, covering the intertidal out 12 nautical miles has been produced for the Department of Conservation using multibeam data from various sources. Fine and “undefined” sediments made up nearly 80% of the total area, with reefs (from shallow intertidal to deep reefs) making up around 14% (Kerr 2009). The rocky reef habitats and fish populations of the Poor Knights Islands Marine Reserve have also been documented (e.g. Ayling & Shiel 2003; Taylor et al. 2011, NIWA, unpublished data).

There is overlap of LEK with scientific research in this region, with the data from surveys carried out in Spirits Bay, North Cape and the coast of east Northland broadly matching fisher-identified descriptions of biogenic habitat sites such as the “Rock Garden”, the “Coral Patch”, and around the Cavalli Islands. Areas of predicted rocky reef habitat (less than 50 m), based on expert knowledge and analysis of hydrographic faring sheets, also indicate reef in the Cavalli Island area, and west of Cape Reinga and Pandora’s Bank (DoC, unpublished). The latter area is also known from taxonomic records to support abundant lithistid and other sponges (M. Kelly, pers comm.). In some areas, fisher information extends further offshore than scientific information, such as the marked areas offshore of Cape Reinga, Ninety Mile beach and the Poor Knights. There was a lack of fisher information between the Cavalli Island region and the Poor Knights, which coincides with potentially extensive areas of deep reef (Bowden et al. 2010, Kerr 2009). The lack of fisher-drawn areas along this stretch of coast possibly reflects a gap in coverage, i.e. the fishers we interviewed did not have detailed fishing experience of this coast.

4.2 Greater Hauraki Gulf and Coromandel Peninsula

Twenty-nine LEK areas were marked on charts, along with six unmarked sites (mentioned verbally, but not located on the chart), by seven fishers (Table 3, Figure 5). A wide variety of biogenic habitats were mentioned, including sponges and corals, tubeworms, bivalve beds, and both green and red algae.

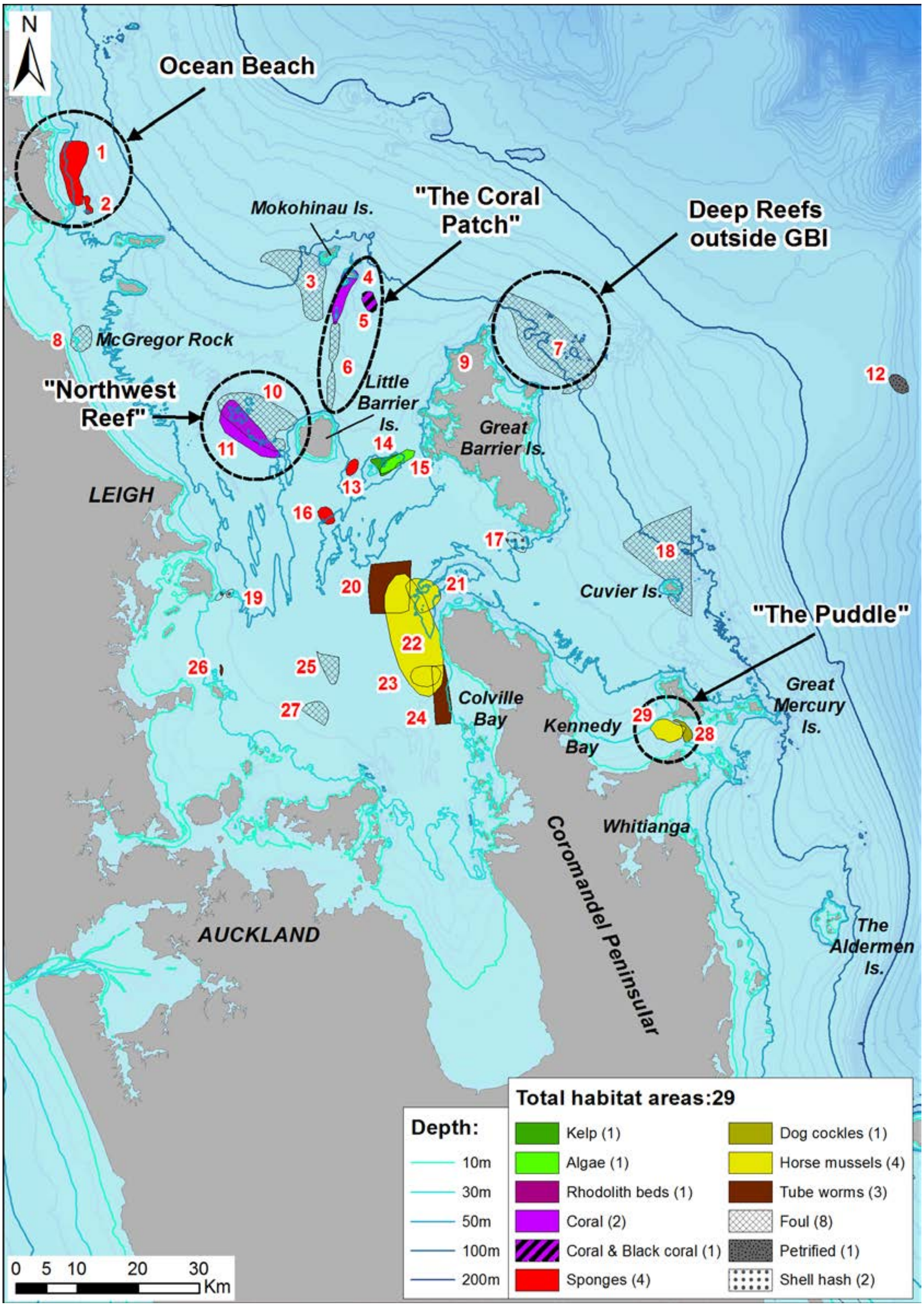


Figure 5: Greater Hauraki Gulf LEK map (Region B of Figure 3). Each fisher-drawn area has a unique number, specific to this regional section (red). Key sites are circled and labelled as black text on white background.

The most commonly mentioned habitat was "foul"; areas that were untrawlable due to the rugged terrain, such as rock pinnacles and rocky reefs. Large areas of foul ground were located in the outer Hauraki Gulf, along the 100m contour off the Mokohinaus Islands, Great Barrier and Cuvier Island, as well as around Little Barrier Island and some smaller patches further inshore (see Figure 5 and Table 3). Fishers had known tow paths that passed as close to these areas as possible, most commonly targeting snapper, but also noted the occurrence of "*small*" (undersized) and "*rubbish*" (non-target) fish in some of these areas. Some foul patches were associated with characteristic bycatch such as sponges and corals, e.g. the area off Ocean Beach and around Little Barrier Island. Several fishers described the sponges as orange and black "*pumpkins*" (possibly *Stelleta* and *Ancorina* spp) and "*cauliflowers*" (no known likely identification). One fisher described catching coral that was "*black and spikey*", another as brown/black and "*fern-like*" (likely gorgonian coral). Others recognized pictures of deepsea stony corals and gorgonians. Horse mussel beds were described by several fishers off the Coromandel Peninsula and Great Mercury Island, and small patches of shell hash to the east of Kawau (19) and south of Great Barrier Island (17) were noted as being made up of mainly horse mussel shells. Tubeworm beds were marked in shallower depths off Tiri tiri Matangi (26) and Coromandel Peninsula (20, 24). One fisher described them as "*soft and rubbery, found in little patches*" (probably a chaetopterid worm). Off Miners head, Great Barrier Island, one fisher described what he believed to be a rhodolith bed (9), but had not visited this site for 20 years.

Table 3: Summary table of sites described by fishers in the Hauraki Gulf region with the area identification numbers, brief description, fishing impacts where mentioned, and the number of fishers who described verbally or identified overlapping or very close areas. Key sites in bold.

Sites	Area ID no.	Description	Fishing Impacts observed	Frequency of ID
Ocean Beach	1, 2	Rugged terrain with perceived high fish abundance, that was avoided due to the bycatch of "*pumpkin and cauliflower sponges*"		2
"*The Coral Patch*" (south of Mokohinau Islands, Simpson Rock and north of Little Barrier.)	3,4,5, 6	A narrow strip from south of the Mokohinau Islands, to north of Little Barrier, including around the pinnacle "Simpson Rock" (4 and 6); a series of mounds sitting 6 m above surrounding seabed. High snapper catches, presence of small fish noted, and a bycatch of coral. Patches of foul, coral and black coral also reported either side of this strip (3, 5)		3
Deep reefs, **Great Barrier** and Cuvier Island	7, 18	Large areas of foul northeast of Great Barrier Island and north of Cuvier Island in 100 m + of water. Some clear tows closer inshore targeting snapper, hapuka, gemfish and bluenose. No bycatch described. G.B.I. foul known of by 2 fishers but not marked.		GBI (3), Cuvier (1)
The "Petrified Forest" and other deep water environments off G.B.I.	12	Located about 60 miles east of Great Barrier Island, in 400 m depth a "Petrified Forest" with shell and rock embedded together in unusual formations was described. The site was targeted for hapuka. "Pinnacles" in depths of 250–300 m where "black spikey corals and orange sponges" were snagged were also mentioned in this area, and patches of "*slimies*" (pink-coloured sea pens), "*slimey*" soft corals and sponges on muddy grounds also mentioned (neither marked on the chart).		2 (Petrified forest)
North-west Reef (west of Little Barrier Island)	10, 11	Described as "Foul", "Reef" and with corals resembling deep-water stony corals. Targeted		3

Sites	Area ID no.	Description	Fishing Impacts observed	Frequency of ID
		mainly for snapper, associated with catches of small fish.		
Craddock Channel, "The Pumpkin patch" and Horn Rock.	13, 14, 15, 16	An area of sponge on the edge of the Craddock channel (13) and a pinnacle further south (16) were both close to trawl tows targeting snapper, with a bycatch of "*pumpkin sponges" / "black pumpkin sponges*" reported. On the eastern side, tows close to these areas (14 and 15) targeting spawning snapper could come up clogged with kelp.		4
Inshore Reefs	8, 25,27	McGregor's Rock off Bream Tail had been heavily fished for snapper, but was previously an area where "sponges and weed" were caught as a bycatch. Several other patches of "Foul" were located by a second fisher in under 50 m depth.	yes	1
North-west coast of Coromandel Peninsula	20,21,22, 23,24	Horse mussel beds and tubeworm patches along the Coromandel coast from Colville Bay north. Described as "workable" when inshore trawling was permitted, being targeted for snapper, but had been "*fished down*". A current fisher mentioned only tube worms in two distinct patches to the north and south of the horse mussel area.	yes	5
"The Puddle", Mercury Islands	28, 29	Overlapping areas, one described as horse mussels with undersized snapper, the other as dog cockles with sponges growing on them. Kennedy Bay and the Aldermen Islands were also mentioned as fish nursery grounds, but not marked.		2

Scientific data sources

There have been a large number of trawl surveys of the greater Hauraki Gulf (e.g., Morrison et al. 2002b), but by-catch was not recorded in these; direct observations during the last two surveys in 1996 and 1999 surveys found very low by-catch volumes (MM, pers. obs.). Some limited reef fish survey work has been undertaken in approximately 50 m water depth within the North-West reef area, which falls inside the Hauraki Gulf Cable Protection Zone (Shears & Usmar 2003). Fish assemblages were assessed by Baited Underwater Video (BUV) on patch reefs to the west of Great Barrier Island, and in a shallower soft sediment area south of Whangaparoa Peninsula. Diving on the shallowest part of the reef system (about 33 m), a diverse encrusting invertebrate assemblage was reported, including the sponge species *Ancorina elata*, *Stelletta crater*, *Dendrilla rosea*, *Raspailia* sp. and *Aaptos aaptos*. Soft corals (*Alcyonium aurantiacum*) and hydroids (e.g. *Solanderia ericopsis*) were also present. The deep reef systems (50–120 m water depth) off Arid and Great Barrier Island have been surveyed, and a range of sponge species, as well as some black coral reported (Morrison et al. 2001a, Sivaguru & Grace 2002). More recent video camera surveys in the proposed marine reserve area off Great Barrier Island have produced a baseline seabed habitat map, with a "rocky-seaweed" biotope found in the shallow subtidal to 40 m zone, and large areas of boulders and hard substrate in deeper waters, which were characterized by a diverse fauna of sponges and bryozoans (Lee et al. 2015). Limited drop camera work by DOC also identified areas of broken foul off the eastern end of Coromandel Peninsula (DOC, unpublished), which matches broader multibeam records of the general area. Higham (2014) digitized some historic records of bycatch from trawl surveys carried out in the Hauraki Gulf in the early 1900s (Ayson, 1901; 1908), which suggested the historical presence of patches of low lying reef and shell hash in the outer Gulf, with notes of "bottom coral and shell" collected from trawls to the south of Little Barrier and Great Barrier Islands, and horse mussels, sponges and "rough bottom" noted from tows to the west of the tip of Coromandel Peninsula. This latter area was also the location of a scallop survey where bycatch records indicate the presence of sponge in many samples, and horse mussels in some (MPI data presented in Higham 2014). To the west of the Coromandel, and around Great Mercury Island the same scallop surveys have recorded the widespread occurrence of kelp and sponges, and more restricted presence of horse mussels and dog cockles. In the inner parts of the Gulf, Battershill (1987) has described the "*Sponge Garden*" in the Leigh Marine reserve (further south than the one described by fishers), and also commented on at least 20 other shallow water reef sites around the wider Hauraki Gulf with similar habitat. The previous widespread occurrence of historical green-lipped mussel beds (about 500 km^2) in the inner Hauraki Gulf and Firth of Thames has been mapped, but were fished to extinction by the 1960s (Greenway 1969, Reid 1969), and were not found during targeted acoustic and video surveys in the early 2000s (Morrison et al. 2002a, 2003). Horse mussel beds of varying densities are widespread in the inner Hauraki Gulf (Compton et al. 2012), including around Kawau island (Backhurst & Cole 2000), Martin's Bay and Mahurangi harbour (Cummings et al. 1998). However, their distribution has not been systematically mapped. Recent studies of the communities associated with dog cockle shell and rhodolith beds found around Otata island (The Noises), Rakino and Motuihe Islands in the inner Hauraki Gulf have documented a rich small-body invertebrate fauna dominated by amphipoods, oligochaetes and nemerteans (Dewas, 2008; Dewas & O'Shea, 2012).

There has generally been a lack of broadscale scientific sampling of the benthic communities in the deeper parts of the Hauraki Gulf (more than 50 m), with the exception of the targeted sampling of the North-west Reef and Great Barrier Island deep reef systems, and bycatch records from scallop surveys. These studies overlap with the fisher areas and corroborate their descriptions in these sites, except for the areas of tubeworms to the west of the Coromandel. Recent multibeam mapping of the area between the Mokohinau Islands, Little Barrier Island and west/south-west of Great Barrier Island has further confirmed the fisher descriptions of "foul" and patch reefs in these areas (NIWA unpublished) . There was less fisher knowledge in the inner Hauraki Gulf, where trawling has been banned since the 1930s, and therefore no overlap with documented biogenic habitats such as the historical greenlip mussel beds, dog cockle beds, seagrass and other inshore habitats, such as rocky reefs, which have been relatively more studied, particularly within diver depths.

4.3 Bay of Plenty

Eighteen LEK areas, were marked on charts, along with three unmarked sites (mentioned verbally, but not drawn on the chart), by six fishers (Table 4, Figure 6). A number of offshore sites between 100–200 m, several described as “*drop-offs*” and “*canyons*”, were places where the fishers had brought up sponges, corals, unusual types of rock, “*riverstones*” (smooth round stones) and an unidentified organism described as “*cauliflowers*” (see Table 4). In these areas, fishers had known clear tows targeting mainly tarakihi. Further inshore on the western side of the bay, several areas of “*hard brown sponges*” were described (no known identification). Inshore habitats noted by fishers in this region included beds of red algae, kelp and horse mussels, as well as patches of foul and greenlip mussels. Both fish spawning (snapper and blue moki) and nursery (tarakihi and snapper) grounds were also mentioned.

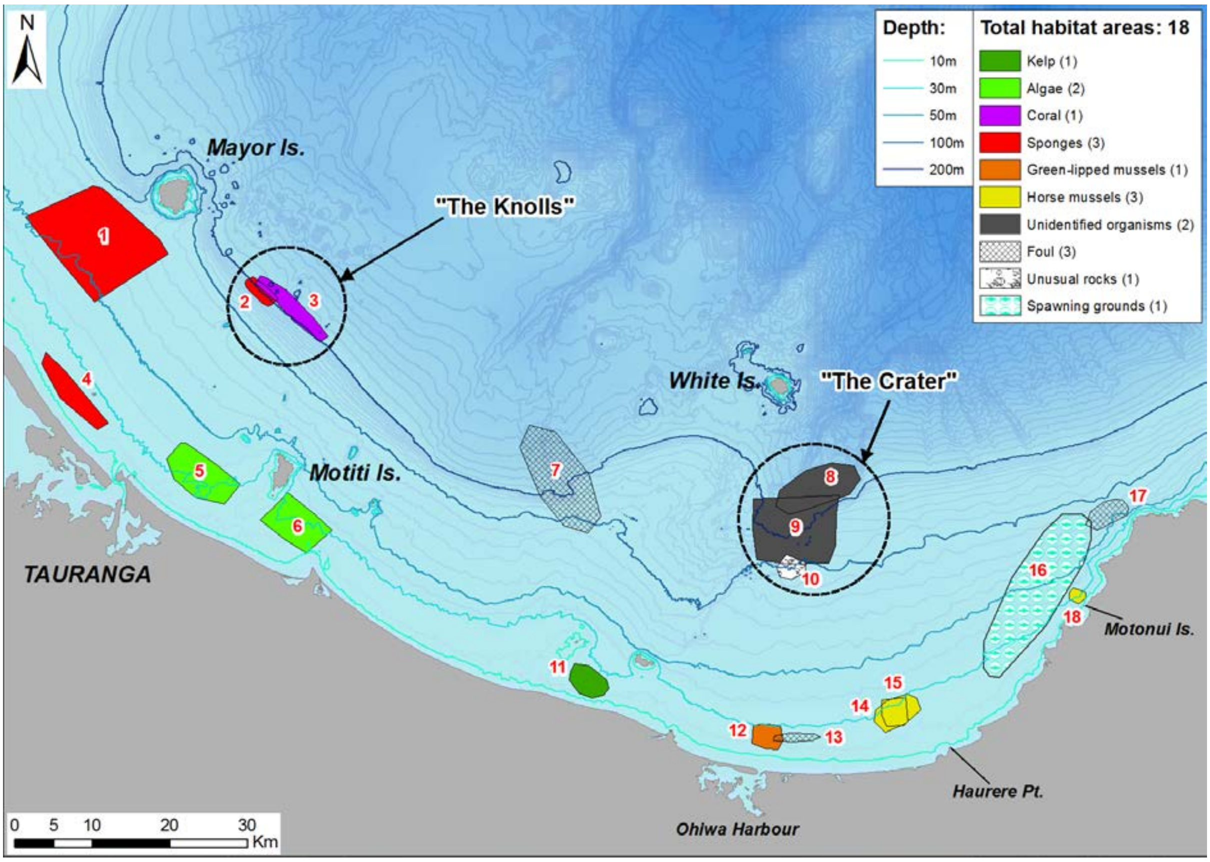


Figure 6: Bay of Plenty LEK map (Region C of Figure 3). Each fisher-drawn area has been assigned a unique number, specific to this regional section. Key sites are circled and labelled as black text on white background.

Table 4: Summary table of sites described by fishers in the Bay of Plenty region with area identification number, description, note of fishing impacts where mentioned and the number of fishers who identified overlapping or very close areas. Key sites in bold.

Sites	Area ID no.	Description	Fishing Impacts observed?	Frequency of ID
The “Knolls”, south-east of Mayor Island	2,3	Low density sponge or coral bycatch, where juvenile tarakihi were caught. Coral described as “*finger-fat, hollow, yellowy white coral with veins*”.		2
south-west of Mayor Island	1 ,4	Sponge bycatch; “*small, hard, brown sponges*” picked up when targeting snapper and trevally.		1
Inshore algal beds	5, 6, 11	Red algae and papa rock in about 25 to 35 m water depth (5, 6) and further east an area where		1

Sites	Area ID no.	Description	Fishing Impacts observed?	Frequency of ID
		detached kelp was picked up after westerly storms (11), associated with small snapper.		
Offshore drop-offs: "The Crater"	7,8,9,10	One area described as a steep-sided canyon with shaley rock and course sand and strong currents where tarakihi were abundant (7). "The Crater" (8,9,10); another canyon feature with large pumice-like rocks. Two overlapping areas noted for bycatch of "*cauliflower-shaped*" organisms that were white in colour, soft, and which, when squashed oozed an "*acid-like*" liquid that stung. Two other fishers verbally mentioned this as an area that was currently fished, with patches of foul and a "coral" bycatch.		4 (The Crater)
Horse mussel beds	14,15, 18	Horse mussel beds on muddy grounds off Haurere Point and Motonui Island. These were fished for flounder and snapper.		2
Inshore reefs / foul	12,13,17	Foul offshore of Ohiwa harbour (13), described as low relief (only 0.5 m off the bottom), but known to snag trawl gear. Greenlip mussel beds also indicated (12). A small patch of "foul" off Waikawa Point was thought to be a potential snapper spawning ground.		2
Spawning grounds	16	A large area off the eastern Bay of Plenty coast noted as a spawning ground for Blue moki.		1

Scientific data sources

A series of trawl surveys was completed in the Bay of Plenty in the 1980s and 1990s (Morrison et al. 2001b), but by-catch records were only collected in the 1999 survey, and were very modest (Morrison & Parkinson 2000). Surveys of intertidal and shallow subtidal rocky reef sites have been carried out around Mayor (Tuhua) Island, White Island and Volkner Rocks, and along the eastern coastline as part of regional and national scale surveys of subtidal reef communities and reef fish (e.g. Smith et al. 2013; Shears & Babcock 2007; Roberts & Stewart 2006; Smith, 2004). The sessile invertebrate fauna of White Island and Volkner Rocks was found to be highly diverse, dominated by sponges, bryozoans, hydroids and ascidians (Smith 2004). Reefs north of Opotiki were described as dominated by grey bracket sponges (*Ancorina* sp.) and red turfing algae (Mead et al. 2005). A classification of the coastal environment of the Bay of Plenty region, from Tauranga to Cape Runaway compiled a variety of data sources including surveys of seagrass, rocky reefs, and interpretation of sediment maps, (Haggitt et al. 2008), with areas of biodiversity interest subsequently identified (Haggitt et al. 2009). In depths less than 30 m, the authors reported that sandy substrate was the dominant habitat, interspersed with rocky reefs and gravel habitats, which were particularly prevalent offshore from Tauranga, around Motiti Island, and formed an almost continuous band along the coastline east of Opotiki out to Cape Runaway. These habitats overlap with areas described by fishers as sites of sponge and kelp bycatch (4, 5, 6, and 11) and marked as foul (17). In depths below 30 m, sand was again described as the dominant habitat by Haggitt et al. (2008), but with areas of deep reef noted around offshore islands and outcrops, which overlapped fisher-drawn areas such as 2 and 3, and patches of gravel, which overlapped fisher areas 1, 7 and 10. Since the grounding of the MV *Rena* in 2011, extensive surveys of subtidal rocky reefs in the vicinity of the Astrolabe Reef and Motiti Island have also been carried out (Battershill et al. 2013). The shallow hydrothermal vents that occur around Moutohora (Whale) Island, White Island and an area in between these sites, known as the Calypso Zone, have also been the subject of targeted studies (Kamenev et al. 1993). In the outer Bay of Plenty, the biodiversity of deepwater habitats along the southern Kermadec Ridge have recently been explored (NIWA, unpublished data). Most of the detailed studies in this region are either shallower or deeper than the fisher knowledge, with minimal overlap between scientific data on biogenic habitats and the fisher knowledge.

4.4 East Cape

Seventeen LEK areas were marked on the charts around East Cape, along with three unmarked sites (mentioned verbally, but not drawn on the chart), by eight fishers (Table 5, Figure 7). This region was dominated by the large areas of foul ground, sponge and coral bycatch, mainly on and around Ranfurly Bank. Soft mud sediments characterized the rest of the area, with fishers commenting that nets were liable to become bogged down in the mud in deeper areas. A series of tarakihi spawning and snapper and tarakihi nursery areas were also marked along the coast of East Cape and Cape Runaway. To the south of Ranfurly Bank, a bycatch of tubeworms and sea pens on the softer mud were described.

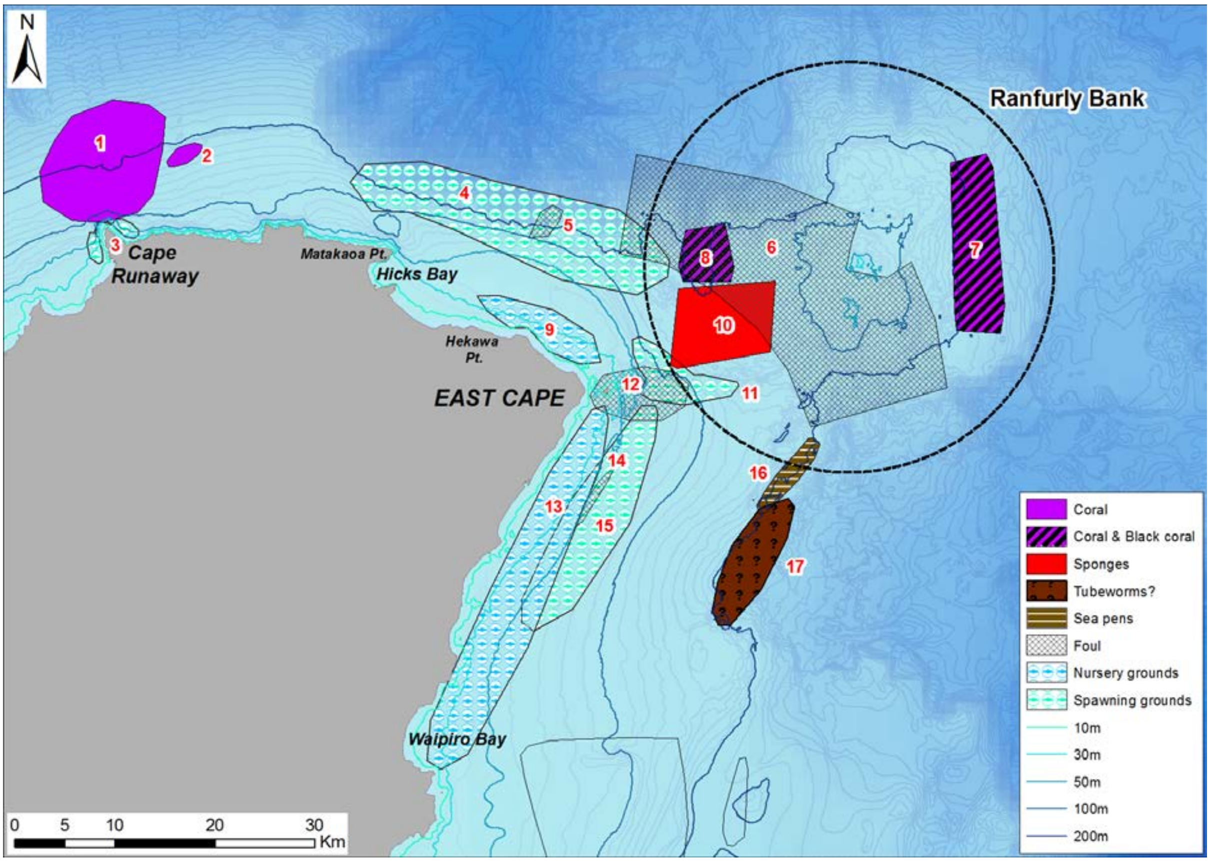


Figure 7: East Cape LEK map (Region D of Figure 3). Each fisher-drawn area has been assigned a unique number, specific to this regional section (red). Key sites are circled and labelled as black text on white background.

Table 5: Summary table of sites described by fishers in the East Cape region with area identification number, description, note of fishing impacts where mentioned and the number of fishers who described verbally, or identified overlapping or very close areas. Key sites in bold.

Sites	Area ID no.	Description	Fishing Impacts observed	Frequency of ID
Cape Runaway	1, 2	A large area from 50 m+ depth, described as "*a hole with coral in it*" (1). Another fisher described the deep "valley contour marks" as untrawlable, but marked a smaller site to the east inside the 200 m contour where coral and "*lace coral*" (bryozoans) were picked up.		2
Ranfurly Bank	5, 6, 8, 10, 7	Avoided by the retired fishers and marked only as "Foul". Is being "*opened up*" by current fishers, who reported a bycatch of yellow sponges, coral and black coral on the deeper slopes of the bank	yes	4

Sites	Area ID no.	Description	Fishing Impacts observed	Frequency of ID
		where they targeted tarakihi (7, 8, and 10). To the west of the main bank, an isolated patch described as a "*big rock*" surrounded by soft mud was also avoided (5)		
East Cape	12, 14	Inshore of Ranfurly Bank, tows passing along the 100 m contour were clear, but inside of this was described as "*all foul*". Further south off Whakariki Point was another bank of low-lying foul was targeted with handliners for grouper and tarakihi.		1
East Cape Spawning grounds	3, 4, 11, 15	Tarakihi spawning grounds in 50 – 200 m+, historically heavily targeted by trawlers (4, 11, 15). Blue moki spawning grounds (August – September) were marked either side of Cape Runaway (3).	yes	1
East Cape nursery grounds	9, 13	Inshore of the spawning grounds, areas where large numbers of "juvenile" tarakihi and snapper were caught around June were described.		1
Soft sediment habitats	16, 17	Fishing grounds with a bycatch of what were thought to be sea pens (16); "*glowed green in the dark*". Further south (17), what was believed to be tubeworms were caught as a bycatch, coming up in clumps, described as "*white straw, yellowy-white in colour, about 1–2 feet long, solid, but bendy and slimy".*		1

Scientific data sources

This region has received very little scientific research in relation to habitat mapping, although it is known to be an important biogeographic feature influencing the distributions of many taxa (Roberts & Stewart 2006 and references therein). The fish communities of inshore reefs along the coastline were sampled by Roberts & Stewart (2006), who described the reefs as hard sandstone and softer mudstone (papa), supporting a variety of macroalgae, sponges and bryozoan clumps, although some areas were noted to be heavily sedimented. Cole et al (2003), sampled four sites for reef-fish fauna on either side of Cape Runaway as part of a wider survey of the Bay of Plenty, and greater sediment loads on the western side, along with a lack of *Lessonia variegata*. A bathymetry and drop-camera survey mapping the reef habitats down to 40 m has also been carried out, with particular focus on sponge communities found there (Mead et al. 2003). Offshore, Ranfurly Bank was highlighted by the WWF Spotlight Report (Arnold 2004) as an area of unusual / unexpected occurrence of some species, such as endemic red algae (Phillips 2002). The fisher observations of foul along the East Cape coastline (e.g. 12 and 14) overlap predicted reef presence (DOC, unpublished), and the descriptions of coral found in deepwater off Cape Runaway (1 and 2), fit with the known occurrence of deep reef habitat in this area. The fisher observations of juvenile tarakihi agree with data discussed by Vooren (1975), although fisher knowledge suggests that the nursery grounds here may be more significant than previously thought. Similarly, fisher observations of spawning tarakihi match those of Robertson (1978), and observations of blue moki spawning match the general conclusions of Francis (1981).

4.5 Gisborne and Hawke's Bay coast

Nine fishers marked a total of forty-nine areas, along with three unmarked sites mentioned verbally (Figure 8, Table 6). The most commonly mentioned categories were kelp, "corals", and foul. A series of offshore areas of foul were described as banks or pinnacles where "coral" and sponges were picked up in the nets. Many of these areas were sites that had been targeted by gillnetters for blue moki. Fishers variously described coral as "*bushes*", "*fern-like*" and "*twisted and very fragile*", often being retrieved attached to flat papa rock, and recognized images of a variety of corals, including black corals (*Leiopathes* spp), stony branching and cup corals, and gorgonians. Soft yellow sponges, and pale yellow finger-like sponges with a stalk and large grey sponges "*like elephants feet"* were also described. The most frequently mentioned locations were Ariel Bank, "*The Cabbage Patch*", and the "*Wairoa Hard*" and "*Clive Hard*" in shallower depths in Hawke Bay. These inshore reefs, along with others further north, were characterized mainly by the presence of sometimes dense kelp, along with patches of greenlip mussels and scallops. One fisher did not mark the chart but described being able to collect greenlip mussels with a pitchfork from a reef at the entrance to Napier harbour. See Table **6** for more details.

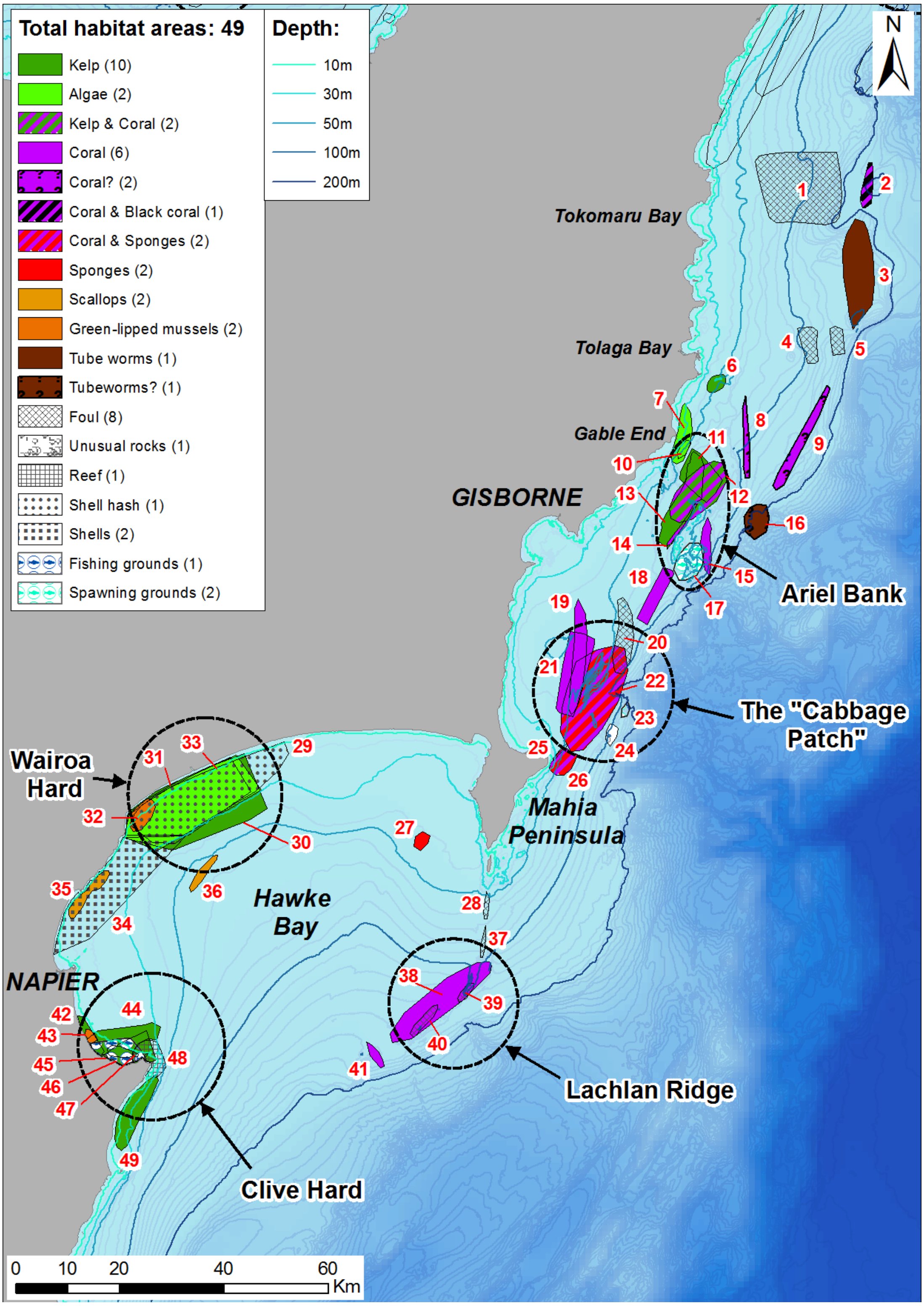


Figure 8: Hawkes Bay/Gisborne region LEK polygon features map (Region E of Figure 3). Each fisher-drawn area has been assigned a unique number, specific to this regional section (red). Key sites are circled and labelled as black text on white background.

Table 6: Summary table of sites described by fishers in the Gisborne and Hawke's Bay region, with area identification number, short description, note of fishing impacts where mentioned and the number of fishers who described verbally, or identified overlapping or very close areas. Key sites in bold.

Sites	Area ID no.	Description	Fishing Impacts observed	Frequency of ID
East Cape Reefs/ Banks	1,2, 4,5,8,9	Banks, pinnacles and untrawlable ground off Tokomaru Bay, Tolaga Bay and Gable End, mostly in 100+m depth. Coral was mentioned as a bycatch from these areas that were targeted by gill netters for blue moki.	yes	1
Tubeworms	3, 16	Areas where "white straw" was picked up, believed to be either tube worms or sea pens.		1
Inshore reefs	6, 7	In shallower depths (< 50 m) where seaweed including kelp was picked up in trawls.		1
Ariel Bank	11, 12, 13, 14, 15, 17, 18	Ariel Bank itself was noted as a moki spawning site that had been "*hammered*" by gill-netters. Adjacent to the bank were trawlable areas where "*coral*", sometimes attached to slabs of rock and kelp were brought up in the nets.	yes	4
The "Cabbage Patch"	19, 20, 21, 22	There were known tows through or inside this feature, others avoided altogether. Grey sponges "*like elephant feet*" were described, and fishers identified pictures of stony corals, bryozoans and gorgonian fans. Further offshore, two small areas were also marked as moki spawning grounds (23) and a site where pumice-like "*barrels*" were picked up (24).		4
Table Cape / Mahia Peninsula	25, 26	One fisher described this area as being similar to the Cabbage Patch, another described only a "drop off" where tun shells were abundant.		1
Lachlan Ridge	28, 37, 38, 39, 40, 41	Hard ground surrounded by muddy substrate that was fished, occasionally picking up "*coral*".		2
Wairoa Hard	29, 30, 31, 32, 33	A well-known area of hard ground, closed to fishing since 1981. Several fishers described dense kelp forests that clogged the net, others noting the presence of greenlip mussels and shell hash, all commenting on the wide variety of species caught and its importance as a nursery ground for snapper, trevally and blue moki.	yes	5
Clive Hard and Cape Kidnappers	42, 43, 44, 45, 46, 47, 48, 49	Another well-known fishing ground for snapper, flounder, rig and moki, many describing kelp, also red algae, some noting the presence of greenlip mussels. Off Cape Kidnappers, one fisher noted a reef where he had caught a large amount of crayfish (48), and another area of reef and kelp just outside Hawke Bay to the south.	yes	4

Scientific data sources

A number of studies have been made of the seafloor ecology of Hawke Bay focusing on the soft sediment communities (e.g. McKnight 1969; Knox & Fenwick 1978), and shallow subtidal rocky reefs (Duffy 1992). A history of the coastal fisheries of the area documented fisher descriptions of the Wairoa Hard (Tai Perspectives, 1996), mapping areas of low ridges of cobbles and pebbles, and some areas of larger boulders. This report also documented the removal of kelp forests from the Wairoa Hard through the 1960s and 70s. Some limited ROV and side-scan surveys of the Wairoa and Clive Hard found areas of muddy sands and sandy muds, mega-rippled areas of cobbles and gravel, with some brown macroalgae, patches of horse mussels and sponges, but in general little epifauna was present (Thrush et al. 1997). Horse mussels may have been historically more widespread within the bay; Hay (1990), noted that "*vast beds of horse mussels were exposed when the west shore of the Ahuriri Lagoon was uplifted 0.5–1 metre*" after the 1931 earthquake. The Clive Hard was found to be largely muddy sediment, with areas of cobble rubble and bedrock found towards Cape Kidnappers (Thrush et al. 1997). Trawl surveys in the region in the 1960s and 1970s found sufficient juvenile snapper (less than 25 cm) in inshore areas, particularly Hawke Bay and East Cape, for them to be defined as nursery grounds (Paul & Tarring 1980). This suggests the presence of biogenic habitat such as seagrass, horse mussels and shallow reefs, which snapper are known to associate with (Parsons et al. 2014), at least historically, although these surveys, and more recent ones along the east coast (Stevenson, 1996), did not record bycatch. Battershill (1993) reported on observations of the area after Cyclone Bola, with a huge volume of mud being washed into the bay, and associated implications for the loss of biogenic and other seafloor habitats.

The coastline either side of Hawke's Bay was noted in the WWF Spotlight Report for its extensive intertidal rock platforms and seagrass beds (Arnold 2004), and both inshore and offshore subtidal reefs are believed to be widespread. A national scale map of predicted subtidal reefs less than 50 m depth has been produced by the Department of Conservation from hydrographic faring sheets, and this indicates the presence of reefs along much of the coastline north of Hawke's Bay, and also offshore at sites such as Ariel Bank, the Tokomaru Bay foul, the Cabbage Patch, and along the Lachlan Ridge (DOC, unpublished data). Broadscale surveys of shallow subtidal reef communities across New Zealand sampled a number of inshore reefs along this coastline, noting the highly exposed nature of locations such as Mahia peninsula and Gisborne (Makarori, Baldy and Pouawa reefs) (Shears & Babcock, 2007). Overall, these sites had the highest mean biomass of *Carpophyllum* spp and "dense forests" of *Ecklonia radiata* were noted. Other sampling of inshore reefs has focused on the fish communities, including those at Te Tapuwae o Rongokako Marine Reserve, 16 km north of Gisborne (Freeman 2005), and inshore of Ariel Bank, around the Mahia peninsula and Clive Hard (Smith 2008; Smith et al. 2013. Acoustic mapping has been undertaken off Table Cape and other sites around the Mahia peninsula, along with some towed video surveys targeting Te Māhia rohe sites between 16 and 100 m depth (NIWA, unpublished data). The video surveys revealed patch reefs with sponge-covered boulders, as well as evidence of sedimentation (Miller & Ormond, 2007).

A qualitative comparison of the existing scientific information and fisher knowledge in this area corroborates the existence of the reefs indicated by fishers off Tokomaru and Tolaga Bay, the Cabbage Patch, Ariel Bank, Mahia peninsula, Lachlan Ridge and Cape Kidnappers and the existence of patches of hard substrate within the Clive and Wairoa Hard sites. At much greater depths, the region (including the Wairarapa coast) is known to support convergent margin cold seep fauna (Arnold, 2004), but between the shallow subtidal and these deep-sea habitats, there is no known significant scientific information on biogenic habitats.

4.6 Wairarapa Coast

Along the Wairarapa coast, thirteen LEK areas were drawn, along with seven unmarked sites described verbally, by five fishers (Table 7, Figure 9). Biogenic habitats were concentrated along the narrow continental shelf south of Castle Point, where foul ground, shell hash, kelp (*Ecklonia)*, sponges and oyster beds were located by various fishers between Uruti Point and Kahau Rocks. Another *Ecklonia* reef and possible rhodolith bed were noted further south (12, 13), and some rocky outcrops where a coral bycatch was recalled were located in deeper waters (10, 11). North of Uruti Point was mainly described as soft muddy fishing grounds for red gurnard and tarakihi; "Cooks Teeth", north of Cape Turnagain (described as "cleaned out") and another between Uruti and Castle Point. The only area of potential biogenic habitat, was a patch of horse mussels (1) that a fisher associated with good tarakihi catches, noting that smaller "juveniles" were caught to the north. Two further fishing grounds were mentioned, but not marked on charts to the south off Pahaoa River and Te Kaukau Point.

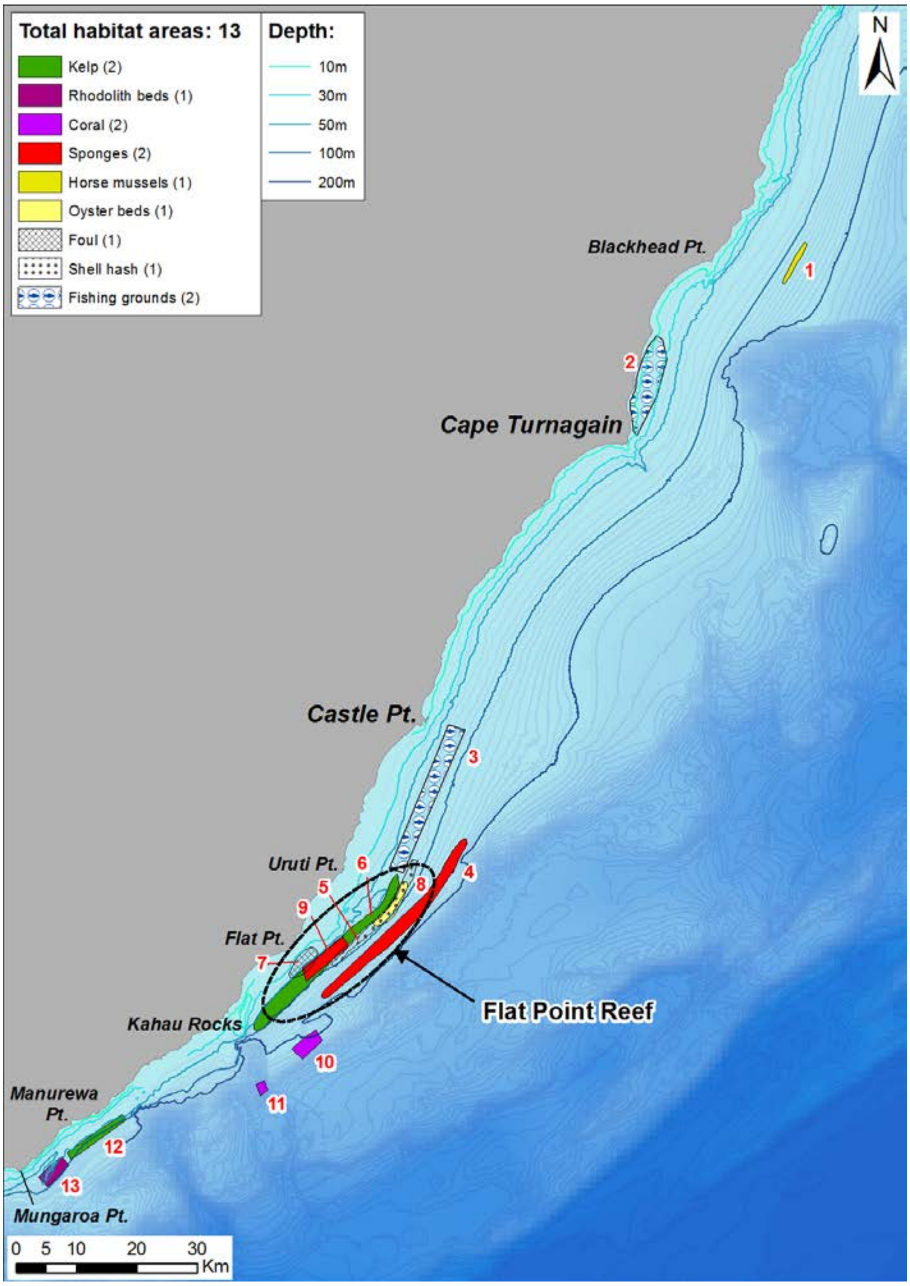


Figure 9: Wairarapa coast LEK map (Region F of Figure 3). Each fisher-drawn area has been assigned a unique number, specific to this regional section (red). Key sites are circled and labelled as black text on white background.

Table 7: Summary table of sites described by fishers along the Wairarapa coast, with the area identification numbers, brief description, fishing impacts where mentioned, and number of fishers who described verbally, or identified overlapping or very close areas. Key sites in bold.

Sites	Area ID no.	Description	Fishing Impacts observed	Frequency of ID
Flat Point Reef	6, 7, 9	Described as low-lying foul that was not fishable (7). Offshore of this area, an extensive and partially overlapping area classed as rocky reef with *Ecklonia* beds (6), and another site where what were possibly sponges were picked up in the trawl; black on the outside, buff on the inside, with fine, sharp spines and a distinctive smell (9).	yes	3
Shell hash / oyster beds	5,8	An area of shell hash and oysters, partially overlapping the *Ecklonia* reefs of Flat Point.		2
Offshore of Flat Point	4	Occasional white finger sponges caught in small amounts		1
Rock outcrops with ”coral”	10, 11	Occasional pink and white coral snagged when lining for grouper (gorgonians?)		1
Te Kaukau Reef and rhodolith beds	12, 13	One fisher indicated a reef where he sets pots along (13), and believed he found “coral rubble” similar to images shown of rhodoliths. Another marked an area (12) where large amounts of kelp got snagged in his trawl net after a southerly.		2

Scientific data sources

In general, scientific information is sparse along this coast, and where it exists it is focused on shallower intertidal / subtidal rocky reefs, and in the deepwater habitats outside the experience of the fishers we interviewed (although some had spent time fishing for orange roughy along this coast and mentioned the deepwater banks that were targeted). Subtidal rocky reefs and kelp beds, including *Ecklonia radiata*, *Lessonia variegate* and *Durvillaea* spp, are known to occur along this coast, particularly around the major headlands (MacDiarmid et al. 2012). The subtidal habitats between Blackhead and Tuingara Points, including the Te Angiangi marine reserve, have been mapped, and identified multiple areas of reef, comprising mixed algal beds in the shallowest depths (< 20 m), *Ecklonia* forests (10 – 20 m depth), and encrusting invertebrate and sponge flats further offshore (15 – 50 m) (Funnell et al. 2005). This region has been impacted by sedimentation from a recent coastal landslide (Macpherson 2013). An inshore bottom trawl survey was carried out along the east coast of the North Island in the 1990s, but bycatch data were not recorded (Stevenson, 1996). At greater depths along this coast (more than 700 m), cold seep communities have been located and characterized. Along with typical, symbiont-bearing taxa such as siboglinid (tube) worms, vesicomyid clams and bathymodiolin mussels, the presence of coldwater corals was noted around the periphery of seeps, and a new species of encrusting sponge that harboured a diverse macrofaunal epibiont community (Baco et al. 2010). Overlap between scientific data and the LEK areas was found for the fisher-drawn areas between Flat Point and Kahau Rock, which coincide with predicted rocky reef distributions along this coast (DOC, unpublished data), and the occurrence of coral bycatch in deeper waters are located around the edge of one of a series of shelf edge canyons which have been mapped during recent *Tangaroa* voyages (NIWA unpublished data).

4.7 North Island West Coast

Seventeen LEK areas were identified along this coast, by seven fishers (Table 8, Figure 10). The most frequently mentioned area was the "*Petrified Forest*", where fishers described picking up "*black petrified wood*" or "*lignite*". Offshore of the "forest", fishers marked the heads of a number of canyons, which were targeted for tarakihi and were known for unusual rocks and encrusting sponges and corals.

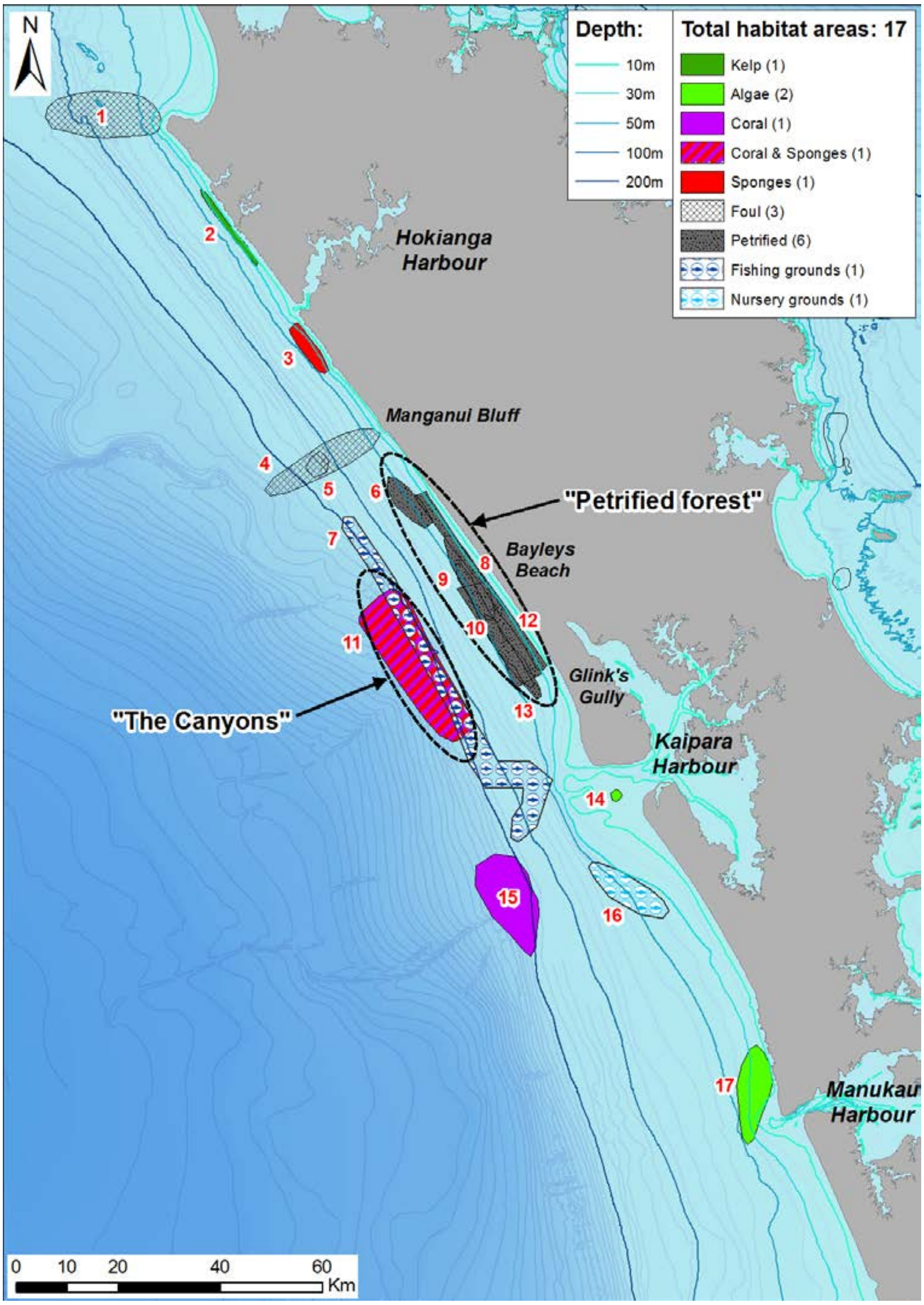


Figure 10: West Coast North Island LEK map (Region G of Figure 3). Each fisher-drawn area has been assigned a unique number, specific to this regional section (red). Key sites are circled and labelled as black text on white background.

Table 8: Summary table of sites described by fishers along the West coast, North Island, with the area identification numbers, brief description, fishing impacts where mentioned, and number of fishers who described verbally, or identified overlapping or very close areas. Key sites in bold.

Sites	Area ID no.	Description	Fishing Impacts observed	Frequency of ID
The "Petrified Forest".	6, 8, 9, 10, 12, 13	Between Manganui Bluff and Glinks Gully, fishers picked up what was described as "*black petrified wood*" "black like coal", in an area that was characterized by an abundance of small snapper (less than 10 cm or 6") and trevally.		5
Algal beds	2, 14, 17	Outside of west coast harbours, algae (kelp and Caulerpa recognized), sometimes in high volumes, was caught in the trawls.		1
Reef Point and Manganui Bluff	1, 4, 5	Foul ground. The Manganui Bluff foul described as pinnacles.		2
"The Canyons" / "The Trenches"	7, 11, 15	Canyons dropping from around 100 to 200–300 m depth, targeted for large tarakihi. A bycatch of light black pumice that could be encrusted with organisms such as small sparse feathery trees less than 10 cm high, possibly bryozoans, corals and "*elephants ear*" sponges 2–3 ft in size. Another similar feature, called the "*Kaipara trench* offshore of the Kaipara harbour where "coral" was found.		3

Scientific data sources

A series of trawl surveys have been carried out along the west coast, but only the more recent one in 1999 recorded by-catch (Morrison & Parkinson. 2001). Volumes were very modest; the only catch of note was clumps of small green-lipped mussels in close to shore south of Hokianga Harbour, most of which were associated with large branches, and a small tree trunk. A sampling stratum with relatively high numbers of smaller sized snapper (2–3 year old fish) is located on the northern side of the Kaipara Harbour coastline, but trawls did not extend up into the 'Petrified Forest' area. Whilst the habitats of the Kaipara and Manukau harbour have been studied in some detail (e.g. Morrison et al. 2014b, d), there is little known information for continental shelf habitats along this coastline. The only known convergence between LEK and scientific information was the overlap of several of the fisher-drawn areas marked as foul / sponge habitat (1, 3, 4, 5) with predicted subtidal reefs (DOC unpublished data).

4.8 North Taranaki Bight

Twenty-one LEK areas were marked on charts, and five sites mentioned verbally, identified by seven fishers along this part of the coast (Table 9, Figure 11). The most commonly mentioned categories were "*Coral*" (could also include bryozoans) along with sponges and foul. Sites marked by fishers were clustered along the edge of the continental shelf; they had noted areas of distinctive rock formations at the shelf break where they picked up coral and sponges. The shelf itself was described as mainly featureless sand although some areas where sea pens, tube worms and "gatherer shells" were common were noted. Another cluster of sites described as hard ground occurred between 50 – 100 m, just to the north of New Plymouth, and inshore reefs were marked along the coastline around and to the north of Cape Egmont.

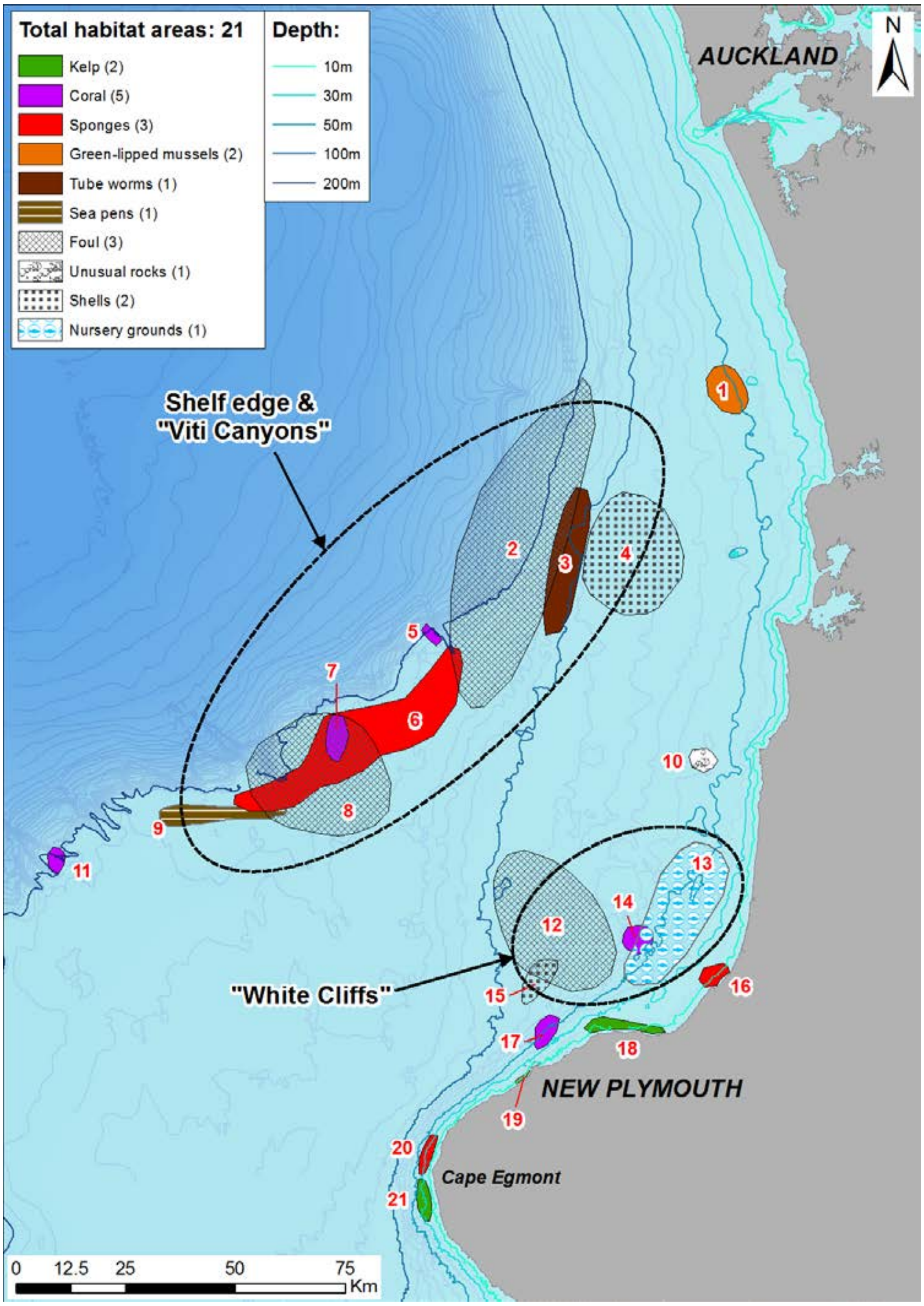


Figure 11: North Taranaki Bight LEK map (Region H of Figure 3). Each fisher-drawn area has been assigned a unique number, specific to this regional section (red). Key sites are circled and labelled as black text on white background.

Table 9: Summary table of sites described by fishers in the North Taranaki Bight region, with the area identification numbers, brief description, fishing impacts where mentioned, and number of fishers who described verbally, or identified overlapping or very close areas. Key sites in bold.

Sites	IDs	Description	Fishing Impacts observed	Freq. of ID
Shelf edge canyons	2, 5, 6, 7, 8, 11	Series of areas along the shelf break between 100–250 m described as pinnacles and foul ground around canyon heads. Distinctive rock formations were mentioned; "*concrete-like pillars, up to 1.5 m long by 12–15 cm diameter, that break off in square-shaped pieces..*", and "*papa-like rocks that were like swiss cheese with holes all in same direction*". Bycatch also included grey elephants ear sponges, yellow sponges, "*weed*", "*big trees of coral*" and "*lacey coral*". These foul grounds were targeted by long liners for hapuka, school shark and blue nose. Trawlers targeting snapper, tarakihi and trevally on nearby fishing grounds caught splendid and butterfly perch close to the foul areas.		5
Tubeworm / seapen areas	3, 9	On soft substrate fishers mentioned both sea pens (described as "*pencil thickness*", white in colour, widening out at one end and slimey) and tubeworms.		
"White Cliffs" and other subtidal reefs	10, 17, 15, 12, 14, 13	Areas of hard ground offshore of New Plymouth; "*White Cliffs*" an area of limestone rock ledges believed to be a snapper nursery ground, previously heavily fished (13). The "*Motonui bricks*" an area of boulders and gravel where "*coral*" was picked up (14), "*One way Foul*" consisted of "*swiss cheese*" rock that could only be fished in one direction (10), and "The Acre", known for frilly, razor sharp "*coral*" that tore nets (17). Another large area of foul (12) that was associated with catches of small fish was also located between 50 – 100 m in this area.	yes	2
Inshore reefs	16, 18, 19, 20, 21	Inshore reefs noted as areas of kelp and sponge, and some patches of greenlip mussels		1

Scientific data sources

Little information is available for this coastline, outside of surveys undertaken at the Sugarloaf Islands Marine Protected Area, offshore of the Port Taranaki breakwater, New Plymouth. The work there has focused on shallow rocky reef fish assemblages, and the effects of marine protection. The habitats inside the reserve include steep rock faces, caves and crevices, pinnacles and boulder fields. Habitat-forming species mentioned by such surveys include the brown kelps *Ecklonia radiata* (down to greater than 15 m water depth) and *Carpophyllum maschalocarpum* (to about 6 m water depth), and 'abundant sponges' at one site (Miller et al. 2005). Located on the North Taranaki coastline, the Parininihi Marine Reserve (overlapping the fisher-drawn area 16) is noted for its dense and diverse sponge assemblage on Pariokariwa reef, (Battershill & Page, 1996). The authors described a shallow (10–15 m) boulder and rock outcrop sponge garden characterized by "remarkable densities" of *Polymastia crassa* (occupying up to 70% of the available surface), *Ecklonia* forests, and "Axinellid gardens" in 10 – 20 m depth, where dense (up to 10 per m^2) communities of finger sponges (*Raspailia* and *Axinella* spp.) and *Ancorina alata* were found. Many of the inshore reefs located by fishers (16, 18, 19, 20, 21) were also identified as sites predicted to be rocky subtidal reefs (DOC unpublished data).

4.9 South Taranaki Bight and Kapiti Island

Thirty-nine LEK areas were marked on charts, along with nine unmarked observations (mentioned verbally only) by 14 fishers in the South Taranaki Bight (Table 10, Figure 12). Fishers described a wide range of habitats dominated by descriptions of "*coral*" (likely to include bryozoans), large sponges, and live and dead dog cockles found across large areas of the inner shelf. Further south, horse mussel beds and areas of kelp forest were also outlined. Several fishers talked about "*spongeweed*", described as orange or brown in colour, one believed it to be an algae, but the areas described included depths of up to about 100 m depth. It was thought to be previously much more widespread than present day, due to heavy fishing.

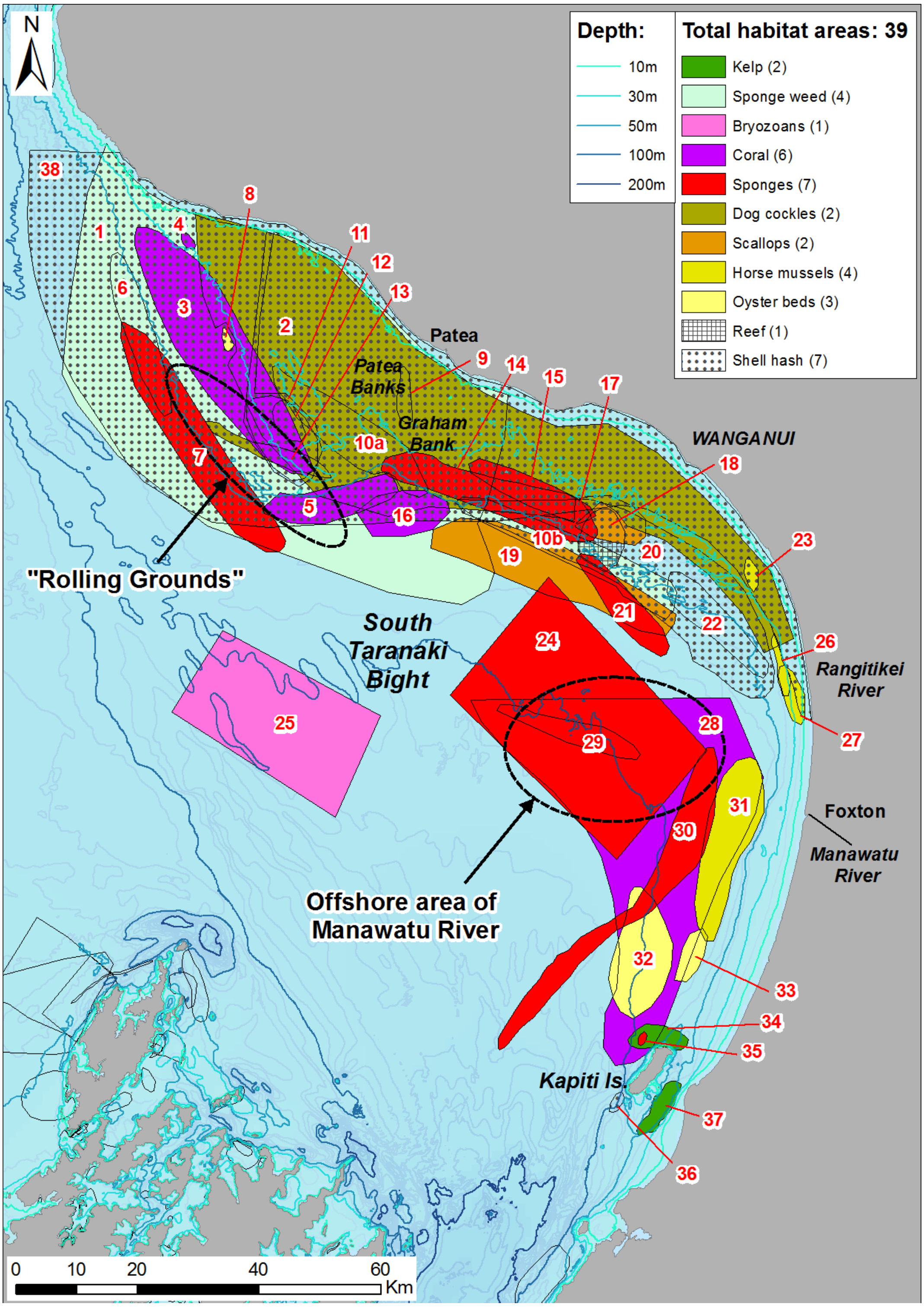


Figure 12**: South Taranaki Bight and Kapiti Island LEK map (Region I of Figure 3). Each fisher-drawn area has been assigned a unique number, specific to this regional section (red). Some key sites are circled and labelled as black text on white background.**

Table 10**: Summary Table of sites described by fishers in the South Taranaki Bight and Kapiti Island region, with the area identification numbers, brief description, fishing impacts where mentioned, and number of fishers who verbally described, or identified overlapping or very close areas. Key sites in bold.**

Sites	**Area ID no.**	**Description**	**Fishing Impacts observed**	**Freq. of ID**
Inshore of Rolling grounds / Patea Shoals	1, 2, 4, 6, 9, 38	One retired fisher marked a very large area encompassing a wide depth range of what he described as "*sponge weed*" (1); brown spongey weed growing on shells, with little tubes about the thickness of a pencil, like a coral, but spongey and smelling strongly of iodine. Trawl gear brought up so much of the weed it needed to be cut from the sweeps with a machete and "*gave your hands hell*". Heavy fishing had removed this weed. A current fisher marked a small area (6) where large volumes of orange "sponge weed" could damage the net. In shallower water, a large area was described as untrawlable, with dog cockles, scallops, patches of bare rock, rock lobster, kina (2). A small area of rock / gravel in about 30 m was located where "coral" was found (4), and patch where shell hash (dog cockle and scallop shells) accumulated in undulations (9).	yes	3
Patea Shoals/ The "Rolling grounds"	3, 5, 7, 10, 11, 12, 13, 38	This area was marked by multiple fishers, many noting it as a large area of shell hash (10, 12), including dog cockles (13), also some patches of hard ground (11), and coral described as hard, white / cream coloured and "*lumpy*" (3, 5), another recognizing pictures of bryozoans (16). In deeper water, the trawl net could pick up very large (1–2 ft across) grey / brown sponges, called "*plumb duffs*", which had a lot of "growth" on them.	yes	9
Wanganui shelf – North and South Traps and Graham Bank	14, 15, 17, 18, 19, 20, 21, 22	Fishers marked a variety of habitats on this part of the shelf, including an area where large sponges were found, sometimes in great abundance (14, 15); a current fisher noted that droppers were used on the net to avoid picking them up. Further south, another area was described as sand hills with grey or cream coloured finger sponges ("*like trees*") being picked up (21). Overlapping areas of reef, shell hash, scallop beds, "*sponge weed*" and "*lacey corals*" were also noted.		3
Bryozoan patch	25	Thought to be bryozoans, associated with leatherjacket catches.		1
Offshore sponge and coral	24, 28 29, 30	This area was noted by three fishers for a high bycatch of both large grey / black sponges, called "*puddings*" and "*coral*" that was described as "*thin, grey clumps…gets quite large*". Nets could get badly damaged in this area.		3
Shellfish beds	23, 26, 27, 31, 32, 33	Two adjacent areas of oyster beds on "hard packed sand" were described by two fishers, one recalling getting 8–9 sacks per tow. Further north substrate was muddier and several areas of horse mussels was drawn along the coast.		1
Kapiti Island Reefs	34, 35, 36, 37	Around Kapiti Island, two areas of Ecklonia beds to the north and in the Rauoterangi Channel were described (34, 37); these reefs were the start of the "*kelpy areas*" which extended south along the coast, where good catches of John Dory were noted. A small area to the south west of the island was thought to be a spawning ground for spotted dogfish (36) and to the northwest of Kapiti another fisher mentioned picking up brown finger sponges in deeper water (35)		2

Scientific data sources

In their study of the sediment facies of the Wanganui Shelf, Gillespie & Nelson (1996) defined three groups of skeletal components found in the shelf sediments. The areas described by fishers as shell hash, dog cockle beds and scallop beds roughly coincided with their "*Assemblage C*" (*Glycymeris*, *Scalpomactra*, *Tucetona*), whereas the sponge and coral areas tend to overlay "*Assemblage A*" (bryozoan, *Talochlamys*, *Tucetona*). Gillespie & Nelson further described five surficial sediment facies, of which Facies 2 was high-carbonate dominated by skeletal-carbonate material, the bulk of which was described as being fresh and originating from bryozoans and bivalves. In their assessment of bryozoan biodiversity in New Zealand, Rowden et al. (2004) highlighted this region as an area with samples displaying a wide range of biodiversity values from high to low. In a baseline environmental report, MacDiarmid et al. (2010) summarized previous benthic surveys in the region and describe a rugged, high energy environment, with a seabed dominated by sandy substrate, being generally species poor. Surveys in the Kupe South development area, to the west of Wanganui found inshore subtidal reefs, boulder and cobbled habitat supporting encrusting and turfing algae, bryozoan and sponge communities (Haggitt et al. 2004). Further offshore, extensive areas of low-relief hard reef, and exposed mudstone, with encrusting red algae, turfing red and brown algae and sponges was recorded (McComb et al. 2005). In a report on the South Taranaki-Whanganui marine area, Rush (2006) reviewed published information and gathered knowledge from the community through workshops, interviews and mailed questionnaires to boat and dive clubs. The report describes offshore reefs, of "*rubble strewn platforms…supporting corals, sponges and bryozoans*" and the North and South Traps are noted by divers as important features supporting stands of *Ecklonia*, corals and increasing numbers of unidentified tropical fish. The DOC Wanganui Conservancy Strategy (1997) describes some relevant offshore habitat features in the region, which, whilst not based on known quantitative surveys, match many of the fisher-drawn areas; *"A large reef known as the North and South Traps, offshore south of Patea, are of particular interest because of the abundant marine life and tall underwater pinnacles. At a depth of 100 m, the seabed between Foxton and Wanganui supports extensive sponges and numerous characteristic finger-like growths of striking pink and white coralline alga. Several new or previously rare crustacea have also been found in depths of 40–60 m off Manawatu, rubble platforms with a low elevation (25–30 cm above the surrounding bottom) occur. These are a few hundred metres to several kilometres in width. A gravel boulder accumulation with a low elevation is located about 12 km off Wanganui and is well-known to recreational users. Geological survey confirms that these gravels are also found in the Nelson area and on the gravel plain just south of the Waitotara River. Rich fauna of branching corals, bryozoans, sponges, ascidians, crustacea, mollusca, polychaetes and small demersal fish are frequently associated with this type of bottom.*

Recent, extensive surveys have been carried out in the Patea Shoals / Rolling Grounds region as part of environmental assessments for iron sand mining (Beaumont et al. 2013). Video observations identified seven habitat types. Rippled sand was common across the inner to mid-shelf areas out to 50 m depth, with some sand-wave bedforms and isolated low relief rocky outcrops. Wormfields characterized by patches of high density sabellid tubeworms (*Euchone* sp) were found in the northern mid-shelf and deeper areas, with the authors noting the association of a characteristic orange Catenicellid bryozoan with these wormfields (possibly known to fishers as "spongeweed"). In deeper areas (more than 45 m), live dog cockle beds and dead shell rubble were found, with bryozoans (along with sponges, ascidians and other sessile invertebrates) colonizing the shell rubble below 60 m (Beaumont et al. 2013). These descriptions broadly match fisher descriptions of the habitats, particularly if what fishers described as coral could also include bryozoans.

Further south around Kapiti Island, there have been a number of surveys documenting the subtidal reef assemblages (e.g. Shears & Babcock 2007, Battershill et al. 1993), which are also known to occur along much of this coastline (MacDiarmid et al. 2012). Rhodolith beds in 20–25 m depth to the east of the island are believed to be the largest aggregation anywhere in the country (Battershill et al. 1993).

4.10 Cook Strait

Eighteen LEK areas were marked on charts, and five sites described verbally, by seven fishers (Table 11, Figure 13). The Canyon itself was one of the main fishing grounds in the area, with fishing focusing around the edge of the canyon and sponge and "coral" bycatch if tows went too deep. The unusual rocks retrieved by some fishers indicate the presence of hydrothermal vents in this canyon. In shallower depths along the coast of the South Island, horse mussel beds were a memorable feature of certain grounds for retired fishers, although not all were believed to be still in existence, whilst the upper part of the South Island east coast was noted for extensive areas of hard ground and "foul" with clear tows described, targeting tarakihi and stargazers.

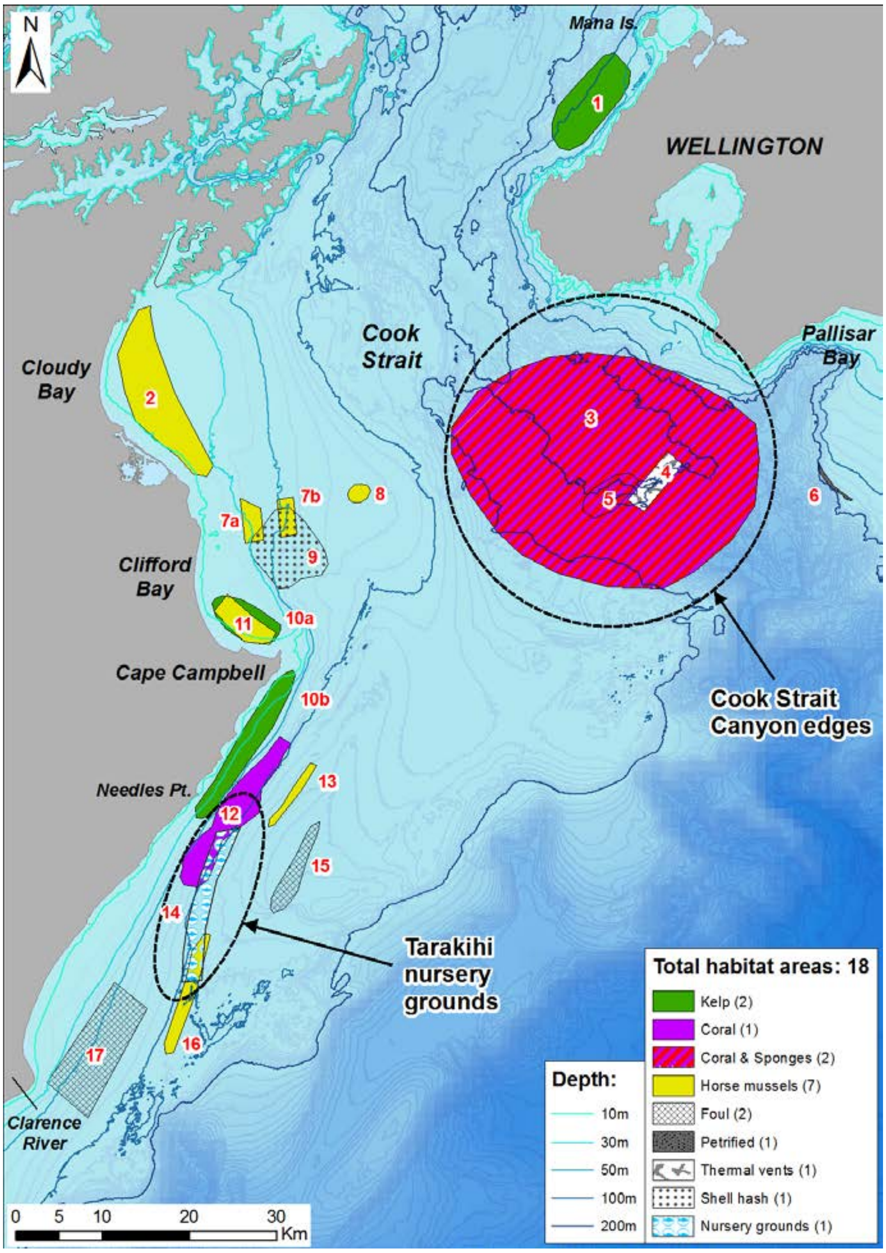


Figure 13: Greater Cook Strait region LEK map (Region J of Figure 3). Each fisher-drawn area has been assigned a unique number, specific to this regional section (red). Key sites are circled and labelled as black text on white background.

Table 11: Summary table of sites described by fishers in the Cook Strait and Cape Campbell region with the area identification numbers, brief description, fishing impacts where mentioned, and the number of fishers who described verbally, or identified overlapping or very close areas. Key sites in bold.

Sites	IDs	Description	Fishing Impacts observed	Freq. of ID
Kapiti Coast rocky reef	1	The coastline south of Kapiti Island was described as "*kelpy*" with many reefs where John dory catches were good. Kelp was reported in nets to 60 fathoms (110 m) (NB: this might have been drift algae).		1
Cook Strait Canyon	3, 4, 5, 6	The edges of the canyon were productive fishing grounds for tarakihi and warehou, with "*coral*" and sponge bycatch when fishing deeper. Certain areas (4, 6) known for "*petrified wood*"; hollow, tubular rock likely to be thermal vents.		2
Horse mussel beds, S. Island east coast, Clifford and Cloudy Bay	2, 7, 8, 11, 13, 16	Previously dense horse mussel beds that damaged trawl gear, but were not thought to exist now (2, 7 and 11). Small warehou (6–8") were associated with the mussels in Clifford Bay. A smaller patch in deeper water (8) was a present day occurrence. Historical beds along the east coast were associated with tarakihi and warehou when fished more than 30 years ago.	yes	1
Cape Campbell and east coast South Island – Tarakihi nursery grounds	10, 12, 15, 17	This coast was described as having lots of foul / hard ground, with two patches noted on the chart (15, 17). Fishing in the area targeted tarakihi and stargazer, with known clear tows through the extensive foul. A possible tarakihi nursery ground to the south of Needles Point (14), where fish under 6" were sometimes caught. Inshore, kelp was picked up when gillnetting for blue moki (10) and "*coral rubbish*" caught in tows further offshore (12).		1

Scientific Data Sources

The occurrence of various algal habitats along the Wellington region coastline has been reviewed by MacDiarmid et al. (2012), noting subtidal reefs and beds of various kelp species occur throughout the region(Adams 1972; Shears & Babcock 2007,Smith 2008), and *Adamsiella* algal meadows inside Wellington harbour (discovered during Biosecurity surveys). In the offshore regions, the existing biological knowledge of the Cook Strait canyon system has been summarized by Lamarche et al. (2012), who described the faunal assemblages associated with different geomorphic habitats. The occurrence of sponges, scleractinian corals, bryozoans and ascidians from exposed hard substrates on the canyon walls, gullies and bank crests was described, as well as the presence of cold seeps. Both the presence of kelp beds along the Kapiti coast, and the bycatch described by fishers from the Cook Strait canyon are corroborated by the scientific information available. Information available for the Cape Campbell region was limited. An assessment of sites of ecological significance in Clifford Bay noted subtidal reefs in the lee of Cape Campbell, scattered patches of giant kelp, and further offshore, shellfish beds and bryozoans are noted (Davidson et al. 2011). South of Cape Campbell, offshore giant kelp beds were mentioned, although it was acknowledged that little information exists about habitats beyond the intertidal in this region (Davidson et al. 2011). This information broadly matches fisher-drawn areas.

4.11 Kaikoura to Banks Peninsula

Twenty-nine LEK areas were identified by five fishers; with four additional habitat polygons identified around Kaikoura by Scientist 3 (Table 12, Figure 14). Along this coastline, areas of tubeworms were the most commonly mentioned habitat, occurring between 50 and 200 m depth, with some areas of sponges and corals indicated to the north around the Conway Trough and Ridge. Papa rock with coral and sponges attached, scallops and foul were also noted along the edge of the shelf in this region. Inshore patch reefs were marked as foul between Point Gibson and Double Corner, with a large area of bryozoans located offshore of this. Otherwise, the bay was described as soft mud with several patches of horse mussels between 10 and 50 m depth. The tube worms were believed by all fishers to be an algae, described as "*weed*" and "*grass like*", clogging the meshes of the net so that they sometimes filled up with mud. One current fisher described the wireweed as *"6 - 8 inches long, fine, like grass with a smooth, non slimey texture, pale white to brown in colour and about 2mm diameter"*.

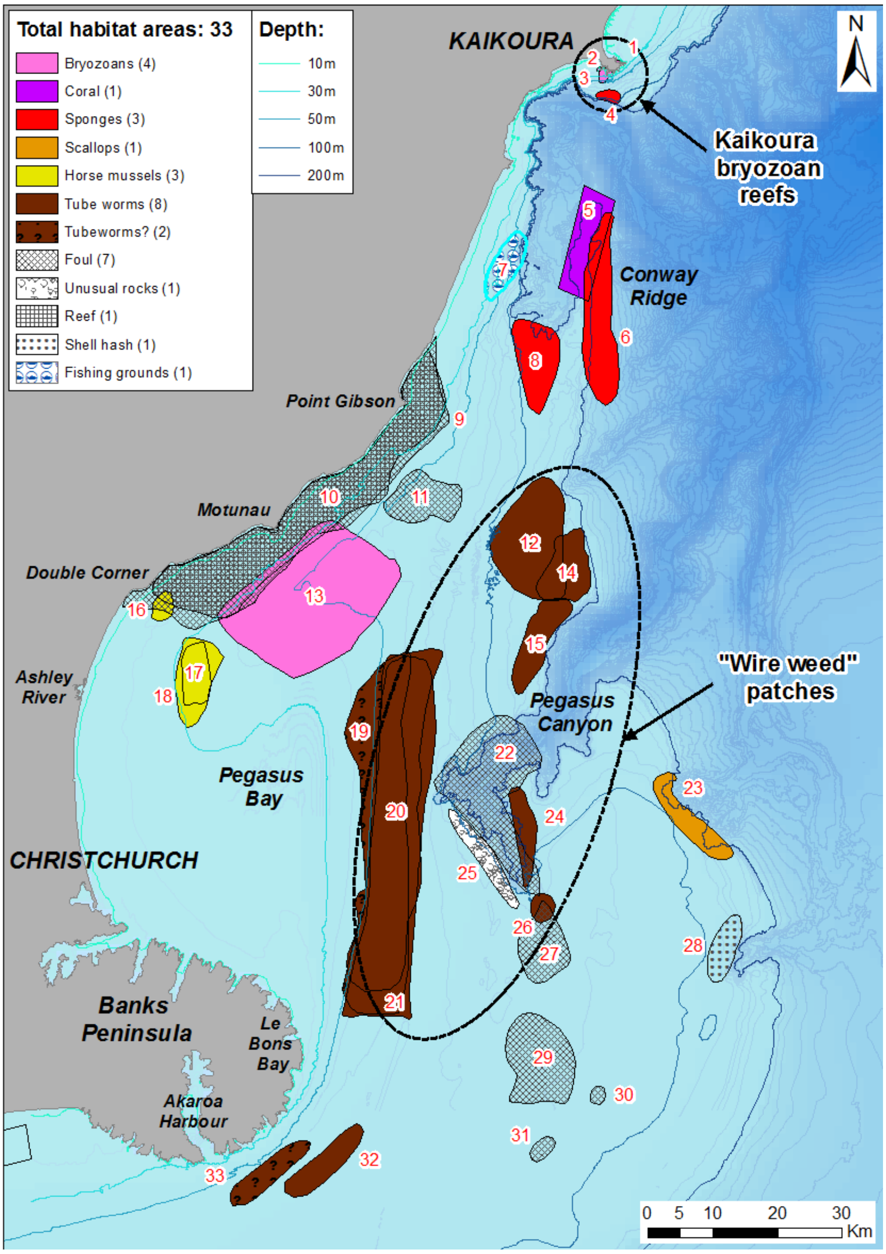


Figure 14: Kaikoura to Banks Peninsula LEK map (Region K of Figure 3). Each fisher-drawn area has been assigned a unique number, specific to this regional section (red). Key sites are circled and labelled as black text on white background.

Table 12: Summary table of sites described by fishers in the Kaikoura to Banks Peninsula region with the area identification numbers, brief description, fishing impacts where mentioned, and the number of fishers who described verbally, or identified overlapping or very close areas. Key sites in bold.

Sites	IDs	Description	Fishing Impacts observed	Freq. of ID
Conway Ridge	5, 6, 7, 8	Areas marked around the edge of the shelf break as being papa rock that could only be fished in one direction, with sponges and corals caught attached to rock fragments brought up in the net; described orange sponges that were cylinder or cup-shaped, and large branched corals on occasion. This area was infrequently fished, but tarakihi were targeted on certain phases of the moon and bellowsfish also caught (identified by photo).		3
"Wireweed": Tubeworm beds	12, 14, 15, 19, 20, 21, 24, 26, 32, 33	A series of areas marked by 4 fishers along the coast from Banks Peninsula to just south of Point Gibson, described as "*wireweed*"; all believed this to be an algae, "*like grass*". The largest area is in the outer part of Pegasus Bay. Retired fishers who marked this area "*just clipped the edges*" of the habitat to avoid clogging up their nets with the "weed" and soft mud; nets had been lost here. They believed more recent fishing activity using bobbin rigs had probably destroyed much of this habitat; one estimated just 30% remained. Another overlapping area to the north had been fished by them less often, and smaller areas also marked around Pegasus Canyon and off Banks Peninsula. These areas were mainly targeted for tarakihi, and thought to be important for juvenile tarakihi, red cod, warehou, stargazer and barracoutta. Sea cucumbers were also associated with the wireweed, coming up in the nets "*hanging onto the weed*".	yes	3
Pegasus Canyon and offshore foul	22, 25, 27, 29, 30, 31	Rocky outcrops / papa rock were described around the edges of Pegasus Canyon, although no associated bycatch noted. (Areas of "wireweed" were also indicated on the shelf.)		3
Inshore reefs	9, 10, 11, 13	Inshore patch reefs with kelp surrounded by hard packed sand were described along the coast between Double Rocks and Shag Rock, with small patches of shell hash and oyster beds that "come and go". Offshore of these reefs, another fisher described an area of "cornflakes" identified as bryozoans. He described dragging bobbins through the area to break up the cornflakes.	yes	3
Pegasus Bay horse mussel beds	16, 17, 18	Two areas of horse mussels were marked in 20 – 40 m of water in Pegasus Bay. These beds were thought to "come and go", but the offshore area was thought to have been quite extensive. The shells tore the nets, so to avoid damage one fisher towed an old net through the bed before returning the next day to fish for elephantfish.	yes	2

Scientific data sources

Aside from an extensive body of research on the intertidal and nearshore subtidal rocky reefs and kelp beds in this region, particularly around Kaikoura (e.g. Schiel & Hickford, 2001, Shears & Babcock, 2007), little scientific data on habitats (biogenic or otherwise) could be found for this part of the shelf. None of the commercial fishers interviewed gave information about Kaikoura Peninsula, although the area is thought to be fished by both commercial and recreational fishers for sea perch. Benthic habitats have been mapped using sidescan and single-beam sonar supplemented with sediment samples, between Kaikoura Peninsula and Haumuri Bluff (Carter et al. 2004). Extensive areas of subtidal reef and boulder rock aprons were mapped around the peninsula, as well as along the coast south of Pinnacle Rock. These areas of reef were interspersed with areas of both fine and course rippled sand, and muds. The muddy sediments occupying the deeper shelf and slope produced a speckled acoustical signal, which was attributed by the authors to beds of horse mussels. The reefs around the peninsula have been documented by Schiel & Hickford (2001), who described fucalean algae as the dominant canopy forming species at shallower depths, giving way to genticulate coralline algae below 15 m. Sponges and bryozoans were found to make up to 15 and 10% of the cover at all depths (down to 20 m) respectively. Coarse shelly sand with a mixture of coralline algae, bryozoans, and molluscs are known to occur out to 50m depth (1, 2, 3) (Mike Page, NIWA, pers. comm.). On the shelf to the southeast of the peninsula, Carter et al. (2004) identified large areas of pebble gravel pavement. A previous survey in this area used ROVs and dredges to sample the benthic community (4) (Page et al. 1993). Across a depth range of 70 – 100 m, substrate varied from areas of shell (including oyster shells), and cobbles, to boulders of up to 0.75 m, with a benthic community dominated by sponges including *Lissodendoryx* and *Iophon* sp.

Between 1978 and 1980 a continual trawl survey from Cape Campbell to Nugget Point was carried out by the Fisheries Management Division vessel *W.J. Scott* (Fenaughty & Bagley, 1981). Invertebrate bycatch was not formerly reported, but the authors noted that tarakihi catches were best off Point Gibson and the Conway Ridge area where "*The seafloor in much of this region is covered in huge tracts of polychaetes referred to by some fishermen as "tarakihi weed*". The original scanned charts show tow positions in many of the areas outlined by fishers as "wireweed", and the presence of "mud", "weed" and "rough" are frequently noted. Rough ground is also noted on the Conway Ridge and around Pegasus Canyon. Vooren (1975) also referred to a single station from this survey between Christchurch and Kaikoura (station J07/032/72, 45 m water depth), citing the comment "*Included 120 kg of molluscs (Atrina*) [horse mussels] *and 45 kg of starfish".* Subsequent geological surveys in this area have also noted the presence of tubeworms; Carter & Carter (1985) mapped a 255 km^2 area of ridges and gullies on the mid to outer shelf off Canterbury which closely overlaps the northern cluster of fisher-drawn areas. They attributed the topography to mass failure along an unconsolidated sand horizon beneath, which compressed the mud layer into ridges and gullies. These have been eroded by currents, except in areas "*as a consequence of biological stabilization by dense colonies of chaetopterid worm tubes or associated biota*". This area was sampled by van Veen and box Core, and two samples were reported as "dominated by the polychaete *Phyllochaetopterus socialis* Claparede." (Probert & Anderson 1986).

What the fishers described as "wireweed" in the interviews was assumed to be tubeworms, based on the *WJ Scott* observations, and discussions with a scientist who was formerly a fisher in this region; he described what he knew as "*tarakihi weed*" to be "*many interwoven noodles, approx. 25 – 30cm long, probably a polychaete of some description*". The fishers' description of inshore reefs between Double Rocks and Shag Rock match the predicted occurrence of subtidal rocky reefs, as mapped by DOC, (DOC, unpublished data).

4.12 The Canterbury Bight

Nine LEK areas were identified by four fishers in the Canterbury Bight (Table 13, Figure 15), described as being mainly flat, hard-packed sand. The main habitat feature were the "kāeo" (sea tulip) beds, noted by three fishers in the shallow waters of the Bight. To the north of the kāeo beds, an elephantfish spawning ground was described, and in deeper water a patch of horse mussels were recalled by one retired fisher. Beyond 50 m several foul areas were drawn; one reef ("Top Rocks") within a larger fishing ground where tarakihi are targeted; the fisher described using a larger mesh to avoid catching the undersized fish caught in this area.

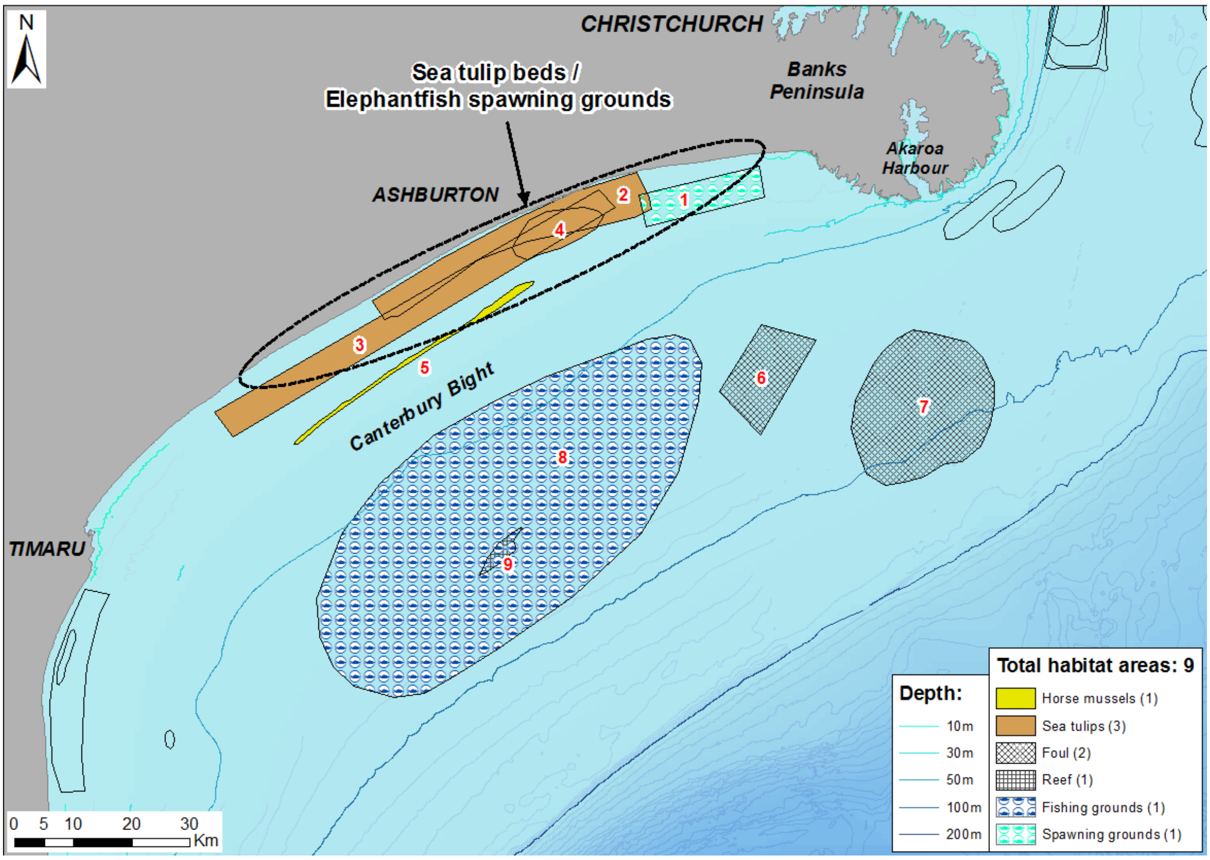


Figure 15: South Canterbury Bight LEK map (Region L of Figure 3). Each fisher-drawn area has been assigned a unique number, specific to this regional section (red). Key sites are circled and labelled as black text on white background.

Table 13: Summary table of sites described by fishers in the Canterbury Bight region with the area identification numbers, brief description, fishing impacts where mentioned, and the number of fishers who described verbally, or identified overlapping or very close areas. Key sites in bold.

Sites	IDs	Description	Fishing Impacts observed	Freq. of ID
Sea Tulip beds	2, 3, 4	Beds of sea tulips found on coarse gravel / boulder substrate, more dense further south		3
Offshore foul	6, 7, 9	Untrawlable ground between 50 – 100 m; sea perch are caught nearby and one area (9) associated with undersized tarakihi.		1
Horse mussels	5	Many patches were previously present along the coast from Timaru north, but not believed to be there now	yes	1

Scientific data sources

No information on biogenic habitats was found for this area. The original *WJ Scott* charts indicate "rocks" and "foul" in approximately the same areas as noted by the fishers (Fenaughty & Bagley, 1981). Elephant fish are a particular target of the East Coast South Island trawl survey, with 41% of the recorded biomass caught in the 2014 survey from the shallow (10 – 30 m) strata that overlap the sea tulip beds indicated by fishers (Beentjes et al. 2015). The trawl survey has also recorded the presence of the sea tulip *Pyura pachydermatina* in its catches (see Figure 25).

4.13 Timaru to Foveaux Strait

Fifty-two LEK areas were identified, along with thirteen verbal descriptions, by fourteen fishers in this region (Table 14, Figure 16). There were many distinctive habitats described by the fishers, including the kāeo beds (sea tulips) found off Oamaru and Dunedin, the "*Hay paddock*" (tubeworm beds), offshore of Oamaru, and the Otago bryozoan thickets that retired fishers avoided due to the damage they caused their nets. Horse mussels were found in 40 – 60 m between Taieri Head and "North Reef" (Karitane Canyon) and scallops in patches out in deeper water (more than 100 m). Closer inshore a number of reefs were noted, fishers describing dense stands of giant kelp (*Macrocystis pyrifera)* in some places, and beds of blue mussels (Blueskin and Molyneaux Bays).

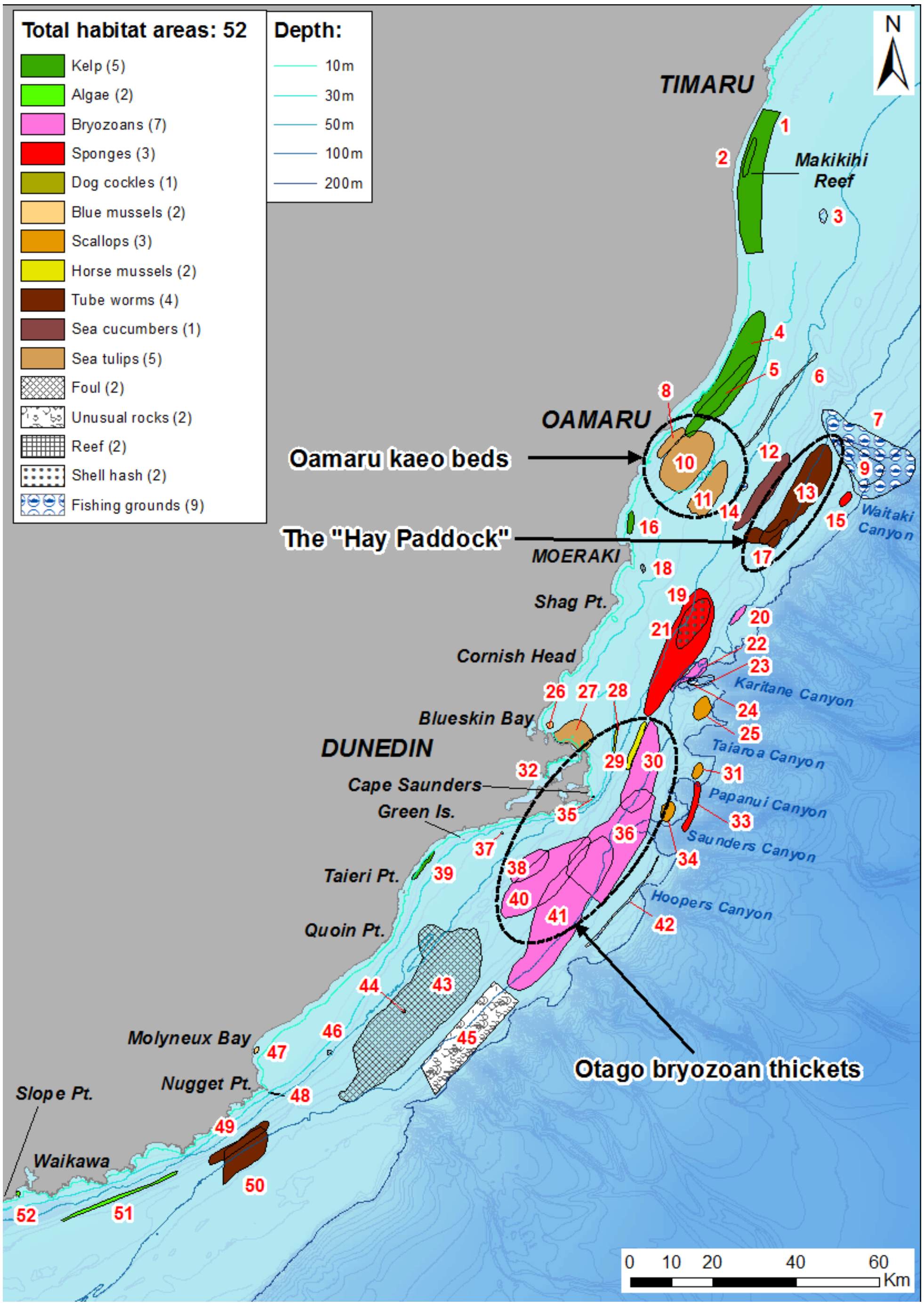


Figure 16: Timaru to Foveaux Strait LEK map (Region M of Figure 3). Each fisher-drawn area has been assigned a unique number, specific to this regional section (red). Some key sites are circled and labelled as black text on white background.

Table 14: Summary table of sites described by fishers in the Timaru to Foveaux Strait region with the area identification numbers, brief description, fishing impacts where mentioned, and the number of fishers who described verbally, or identified overlapping or very close areas. Key sites in bold.

Sites	IDs	Description	Fishing Impacts observed	Freq. of ID
Inshore Reefs, kelp beds and mulloch	1, 2, 4, 5, 16, 39	Makikihi Reef (1, 2) from which drift kelp can accumulate after a swell. Mulloch beds were also believed to exist here (around "*North Rocks*", Timaru), but the charts were not marked. Further south, very dense, untrawlable stands of giant kelp on gravelly substrates were thought to "come and go" (4, 5 16, 37). Noted as a nursery area for tarakihi.		2
Oamaru and Dunedin kāeo beds	8, 10, 11, 27, 32	The "kāeo patch" off Oamaru; the sea tulips come up attached to pebbles / rock. Deeper area marked (11) was not thought to be present anymore. Also found inside Dunedin harbour (32) and Blueskin Bay (27).		3
"The Hay Paddock"	12, 13, 17	An area of dense "*tarakihi weed*" or the "*hay*", described as being pale yellow, with kinks, straw-like, and coming up in clumps. Another noted "*like straw, thickness was less than a drinking straw*". Was believed to still exist, but not so extensive, with pockets of "weed" in deeper water also. Tarakihi were associated with this habitat. This site was also mentioned verbally by several others, one describing "*spongey rubbish and shell hash between 60 – 100m*".	yes	4
Otago Shelf canyons	7, 9, 15, 19, 21, 22, 23, 24, 33	Waitaki Canyon, known locally as "*The crack*", was targeted for bluenose, ling and squid (7, 9). Large temperature gradients here, and a bycatch of grey-green "*fingery sponges*" described. Further south, the shelf around Karitane canyon was a targeted fishing ground (23, 24), where tarakihi were "*just of size*" or undersized; called "*North Reef*" by one, another describing a "*cornflake patch*" along the northern edge (22). Inshore of the canyon, a large area where brown sponges were commonly brought up was noted, also marked as an area of shell hash (19, 21).		2
The "*Cornflakes*"; Otago bryozoan thickets	20, 22, 30, 36, 38, 40, 41	Bryozoan patches were noted by fishers from as far north as Shag Point (20) to Quoin Point in the south (41). Patches north of the Otago peninsula were smaller and in more than 100 m depth, with a more extensive area outlined by multiple fishers in 60 – 120 m offshore of the peninsula. Retired fishers commented that the cornflake patches were avoided or fished infrequently (for tarakihi) due to the damage they caused to nets, but were targeted by set netters. Other bycatch associated with the bryozoan included finger sponges, horse mussels, scallops and shell hash.	yes	5
Shellfish patches	25, 28, 29, 31, 34, 35	Inshore of the bryozoan thickets, horse mussel shells were commonly caught (28, 29), and patches of queen scallops indicated offshore of the bryozoan thickets towards the shelf edge (25, 31, 34). A small dog cockle bed was also marked just north of Cape Saunders (35).		1
Areas of foul / papa rock and crayfish spots	43, 44, 45, 46	Between Quoin Point and Nugget Point, some large areas of foul / papa rock were marked (43, 45) & mentioned verbally, along with several small patches of reef / pinnacles noted as good spots for crayfish (44, 46).		2
"Corally tubeworms"	49, 50	South of Nugget Point, areas of shelly bottom and foul where blue cod are more common were described verbally, but not marked. Two areas were marked as areas of shell hash, "*corally broken material*" and different tubeworms. Soft ones were described as '*tubes of sand*" that came up in		2

Sites	IDs	Description	Fishing Impacts observed	Freq. of ID
		the net after a blow. Harder cases were described as "*corally stuff*", not in clumps.		

Scientific data sources

The marine habitats along this coastline have been relatively well studied, both historically and in the present day. Graham (1962) described the Oamaru region and divided the area into different zones; in 'Zone 2', from 9–55 m, he described kelp dominating down to 27 m water depth, apart from one small strip immediately north of Oamaru Harbour. Sediments were composed of coarse brown gravel and then muddy shell-sand, with a lot of sponge, barnacle and polyzoan-encrusted shells, as well as colonies of mytilids (mussels) infested with polychaetes and stalked ascidians (kāeo). Beyond 55 m was the "*Hay Paddock*", "*...a vast meadow of so-called "tarakihi weed" and numerous other species… bobbins must be used otherwise the net will fill with debris*". Graham identified the worms as *Phyllochaetopterus socialis* (NB: this species assignment has never been confirmed by a taxonomist). At greater depths, small orange finger sponges were mentioned at the south end, but apart from that "*it is excellent for trawling*". Graham also quoted a Timaru trawler man who said that 30 years earlier, they got "*large quantities of shells in their nets, but seldom now find a specimen of erstwhile common species*". In Vooren's description of tarakihi nursery grounds (Vooren 1975), the Hay Paddock is also described; "*… concentrations of young tarakihi there tend to be associated with areas of a rich invertebrate benthic epifauna containing a variety of sponges, worms, echinoderms, and molluscs. The area around Stn J08/041/69, off Oamaru, for example, is locally infamous for the great quantities of sponge usually brought up by trawl nets and. is therefore known among the fishermen as the "Hay Paddock*". In Vooren's appendices, station J08/041/69, in 65 m of water, had a tarakihi catch rate of 1445 fish per hour, with the catch notes describing the by-catch as an "*immense quantity of sponge, with many starfish, molluscs, worms, etc*". The areas drawn by the fishers at the Hay paddock overlapped the station(s) mentioned in Vooren (1975), but are deeper than the area described in Graham (1962). Graham's description of Zone 2, out to 55 m includes sea tulips, corroborating the kāeo beds described by fishers

The Otago Peninsula bryozoan beds have been well studied by researchers and students of Otago University, with two of the fishers interviewed having had spells skippering the University research boat, with their knowledge influenced by this. Informal interviews were also carried out with three scientists from Otago University, who gave general descriptions of the key areas. Probert et al. (1979), Batson (2000), Batson & Probert (2000), Wood (2005) and Jones (2006) have sampled, mapped and described the species composition of these patchy "thickets". Up to 16 different species of bryozoan have been recorded, with the main habitat-formers including *Cinctipora elegans, Hornera robusta, Hornera foliacea*, *Hippomenella vellicata, Celleporina grandis, Celleporaria agglutinans, Cellaria immersa, and Adeonellopsis spp.* Two assemblages have been described on the mid- to outer-shelf between 45 and 130 m, with a rich associated fauna including ascidians, sponges, polychaetes, anemones, brittle stars and asteroids. The bryozoan dominated habitat is thought to be limited to being roughly parallel with Otago Peninsula, (Wood & Probert 2013), with Batson & Probert (2000) reporting that scallop fishers occasionally caught significant quantities of bryozoans south of Hoopers Canyon. The fisher-drawn areas from this survey overlap the scientific maps, but imply bryozoans may extend, or have previously extended further south than this (areas 40 and 41). Some sampling has been carried out at the shelf edge and in the network of canyons in this region; Probert et al. (1979) defined three major epibenthic macrofaunal groupings, and recorded a number of bryozoan species and a chaetopterid worm identified as *Phyllochaetopterus socialis* in the "Upper canyon" assemblage.

4.14 Foveaux Strait and Stewart Island

Twenty-nine LEK polygons were identified, along with thirteen areas described verbally, by twelve fishers (Table 15, Figure 17). Due to the extensive existing scientific knowledge of this region, sensitive fisheries politics, and previous interviews already carried out (e.g., Hall et al. 2009, and unpublished), only three fishers with some oyster dredging experience in the Foveaux Strait itself were interviewed. One of these declined to mark areas on the charts, referring us to the historical maps from Stead (1971). We also interviewed a NIWA research scientist familiar with the area, and four general habitat areas have been included (Keith Michaels, pers comm.).

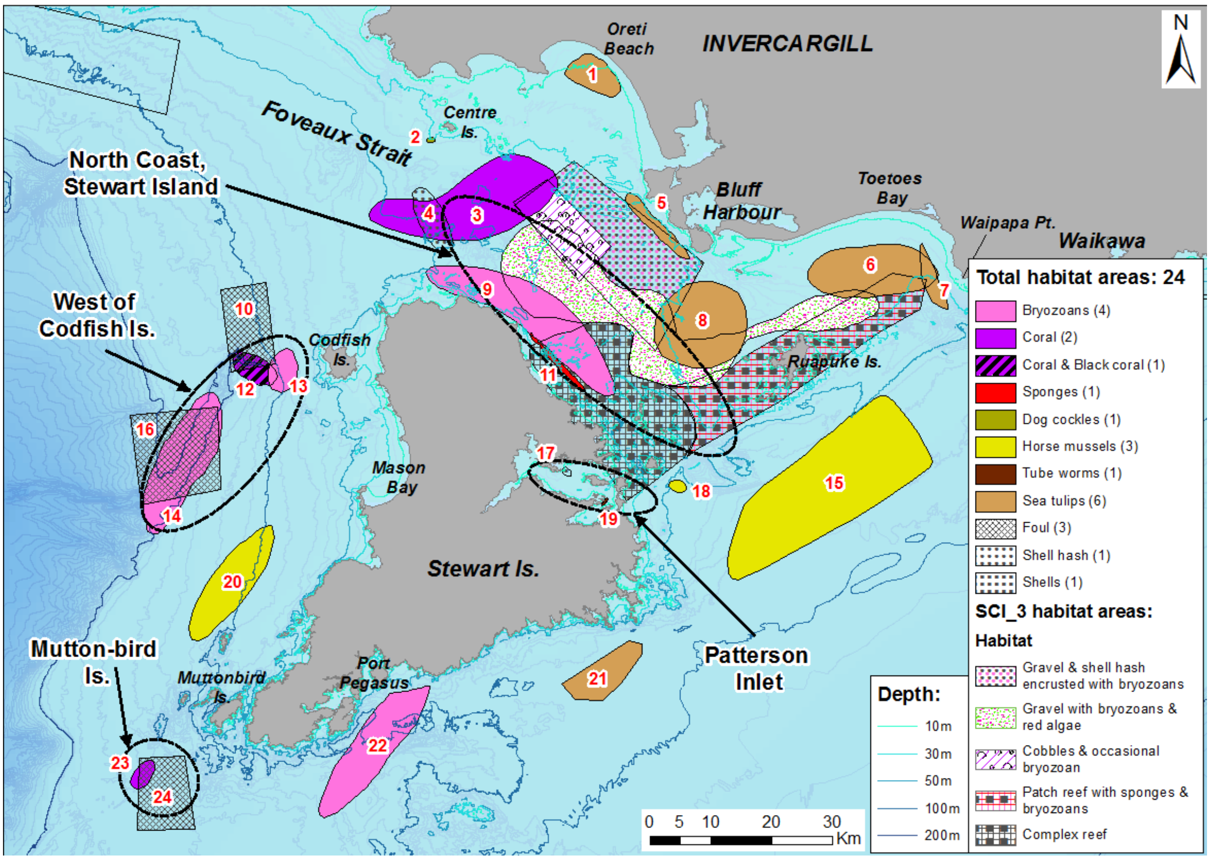


Figure 17: Foveaux Strait and Stewart Island LEK map (Region N of Figure 3). Each fisher-drawn area has been assigned a unique number, specific to this regional section (red). Some key sites are circled and labelled as black text on white background.

Table 15: Summary table of sites described by fishers in the Foveaux Strait and Stewart Island region with the area identification numbers, brief description, fishing impacts where mentioned, and the number of fishers who described verbally, or identified overlapping or very close areas. Key sites in bold.

Sites	IDs	Description	Fishing Impacts observed	Freq. of ID
Kāeo patches	1, 7, 9, 10, 12, 26	Sea tulips (kāeo) were mentioned by many fishers, mainly in inshore regions of the mainland; Oreti beach (1), outside Bluff Harbour (7), Toetoes Bay / Waipapa Pt (9, 10), and the central eastern Foveaux Strait (12). A verbal reference to "sea apples" found south of Waipapa Pt, along with coral and sponges. Occurred over cobble / shingle seabed, but seemed to "*come and go*", associated with elephant fish and flatfish.		3
Foveaux Strait bryozoans and oyster beds	3, 5, 13 and 16	A large area off the northern coast of Stewart Island was noted as rich in bryozoans with large amounts of dead oyster shells (13). A smaller overlapping site (16) was noted for grey/brown sponges. Further west into the Strait, other fishers marked areas of oyster shell debris (5) and "coral" that was believed to refer to encrusting bryozoans (3).	yes	2
Horse mussel beds	20, 23, 25	East of Stewart Island, patches just outside Paterson Inlet and further east off Ruapuke Island were described as shelly seabed, the fishers picking up horse mussels, sponges, and oyster shells.		1
Paterson Inlet	22, 24	One fisher described towing here before restrictions and being unable to bring the net aboard is was so full of "*mussels, horse mussels, shells, scallops, cockles, starfish and other stuff*". The large tubeworm mounds in the entrance of Glory Bay were mentioned (not from fishing them), and another recalled picking up sponges attached to scallop shells off Port Adventure		1
Mutton-bird Islands (southern chain)	28, 29	Described as an untrawlable patch of reef by one, another had fished and brought up red and black coral.		2
West of Codfish Island; Mason Canyon and Mason Bay	14, 17, 18, 19, 21	A steep-sided canyon "*full of bryozoans and cows horns*" (no known id for the latter), with one fisher describing once trawling up a black coral "*the size of an apple tree*" (14, 17, 18) Further south another area of foul and bryozoans was identified (19, 21). The western coast of Stewart island, particularly Mason Shallows, was mentioned verbally; reefs, "coral" patches (bryozoans?) and sponges.	yes	3

Scientific data sources

There is a relatively rich science literature for this area. In Foveaux Strait, the bryozoan reefs, known locally as "mulloch", and their associated Bluff oyster and blue cod fisheries have been extensively researched, yielding a good understanding of the different habitat distributions in this area (e.g., Fleming 1952, Stead, 1971, Jiang & Carbines 2002, Carbines & McKenzie 2004, Carbines & Cole 2009, Cranfield et al. 1999, 2001, 2003, 2004, Jiang & Carbines 2002; but see Michael 2007). An approximate representation of those habitats was supplied for this project (areas 4, 6, 8, 11, 15). In the main channel, area 8 contained prolific red algae, stalked ascidians, (*Pyura pachydermatina*), *Evechinus chloroticus* encrusting bryozoans, and small patches of sponge (*Crella incrustans and C. chondropsis*). To the north, area 4 was described as gravel and shell encrusted with a thin layer of bryozoans, occasional sea squirts and sponge patches at southern boundary, though not prolific. In the north-western corner, there were occasional patches of hard encrusting *Celloporaria* sp. The eastern end of the Strait was characterized by complex reef and patch reef, heavily encrusted with ascidians, sponges and bryozoans, and interspersed with sand and gravel (Areas 11 and 15).

Around Stewart Island, a number of sites have been surveyed by the University of Otago; mulloch beds were still present off Chew Tobacco Point and Port Pegasus on the eastern side of the island; a variety of sponges and bryozoans were recorded around the Mutton Bird islands to the south; mussels and bryozoans north of Codfish Island, with a lower bryozoan diversity recorded at stations in the vicinity of Mason Canyon (A. Smith, unpublished data). Paterson Inlet (Figure 17) holds a diversity of biogenic habitats, including fields of tube-worm mounds (*Galeolaria hystrix*) (see Smith et al. 2005); red algal meadows of *Adamsiella chauvinii* (formerly *Lenormandia chauvinii*) and similar algal species, bryozoans (especially *Cintopora elegans*) forming large thickets, bivalves (*Chlamys gemmulata*), and abundant and diverse brachiopod 'pavements' (Willan 1981). Hard bottom habitats also include lush forests of giant kelp (*Macrocystis pyrifera*), particularly abundant around Ulva Island (Grange & McKnight 1987). The authors reported that unpublished data collected from Port Pegasus and Port Adventure suggested that similar habitats, particularly the brachiopod and bivalve communities on soft sediment, were present in these inlets also (Grange & McKnight 1987). Fisher descriptions of bryozoan beds and areas of sponge along the northern coast of Stewart Island overlapped with the scientific area descriptions, although fishers also marked areas further west that were not covered by the habitat maps. The available scientific information also corroborated the areas around the Muttonbird Islands.

4.15 The Traps, south of Stewart Island, and the Snares Plateau

South of Stewart Island, the only information available was anecdotal descriptions of bycatch and designated foul areas from *Tangaroa* trawl surveys (Figure 18). An area of unusual sponge habitat (1) was identified south of South Trap (raised rocky reef feature) in 100–400 m. Large areas east and south of the Snares Island were described as unknown foul (flat but foul, possibly rock formations) (2, 4) and a smaller area was thought to have coral (3). A commercial fisher with potting experience in this region talked about The Snares being an area with a lot of coral. They sometimes recovered lost pots from previous years which had coral growing on them. This didn't occur at The Traps, which the fisher believed had no coral and few sponges

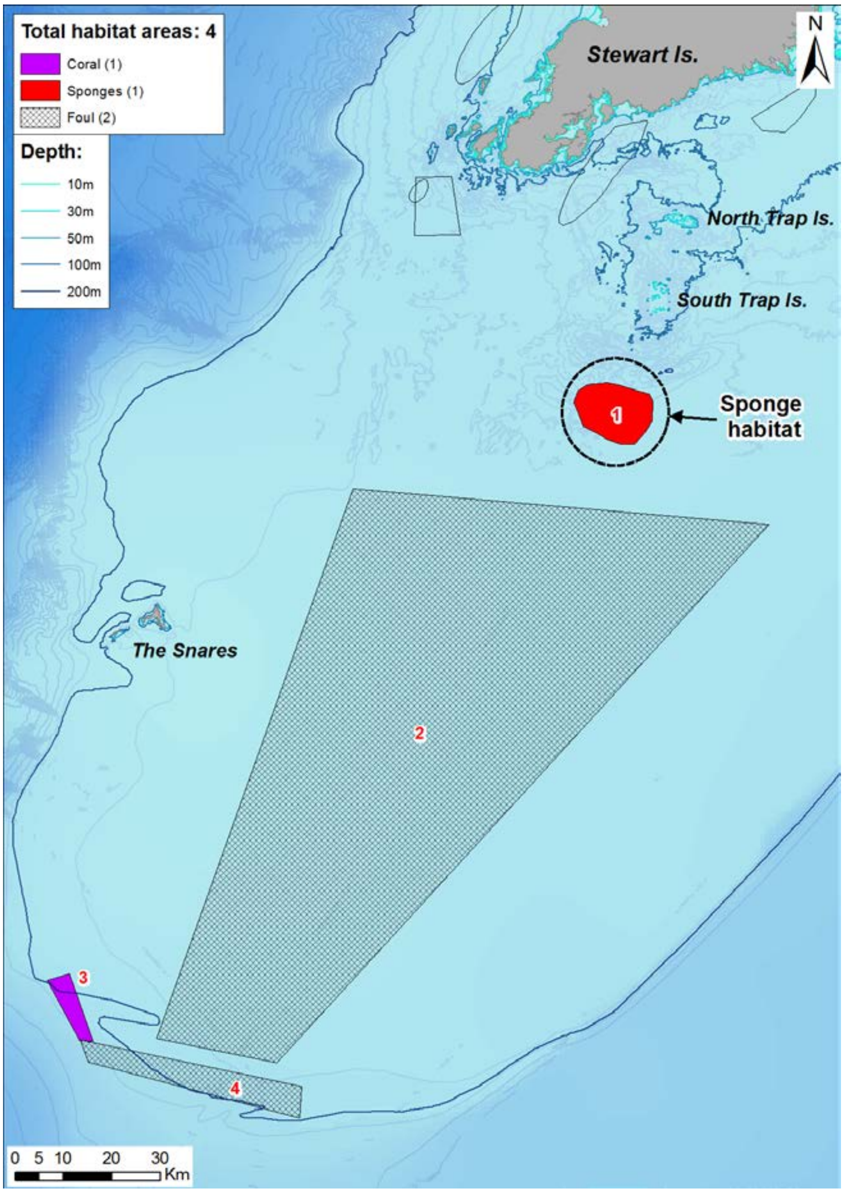


Figure 18**: The Traps, south of Stewart Island and the Snares Plateau LEK map (Region O of Figure 3). Each fisher-drawn area has been assigned a unique number, specific to this regional section. Key sites are circled and labelled as black text on white background.**

Scientific data sources

Aside from the anecdotal information of known foul areas and bycatch records, little biogenic habitat information is available for this region. At Hoho Bay, Snares Islands, schools of juvenile tarakihi have been filmed in 10–20 m water depth (April 2008), in association with a thick layer of leaf litter washed off the island making the fish ‘very well disguised’ (Debbie Freeman, DOC, pers. comm.; figure 45a in Morrison et al. 2014a). In addition to leaf litter, large *Lessonia adamsiae* ‘trees’ (endemic to the Snares) were present as the main canopy plant, along with lower height patches of *Caulerpa brownie* (a green algae). Some benthic sampling has been carried out by the University of Otago on the Snares platform, which was described as full of biogenic areas with diverse mulloch beds found in 120–160 m depth (A. Smith, unpublished material). The presence of habitat-forming corals has been recorded at a small number of sites between around 200–300 m across this area and the wider Campbell plateau region, including the recently mapped “Squires Coral Coppice” to the east of the Auckland Islands (Tracey et al. 2011; Mackay et al. 2014).

4.16 Fiordland Region

Of the fishers interviewed that were based in Port Chalmers and Bluff, many had some previous experience of fishing or rock lobster potting in Fiordland. Sixteen LEK areas were drawn, with a further 12 sites described verbally, by seven fishers (Figure 19, Table 16). Certain inlets were described as clean sandy bottom that could be trawled for red gurnard, rig, and skate, – e.g., Milford Sound, Poison Bay (mentioned by two fishers), Looking Glass Bay, Breaksea Sound (one fisher would trawl half way up this sound, although did not mention which arm), and Coal River. Other inlets were avoided; Bligh Sound was described as too muddy, others were too rugged, targeted by cray potters, and known for their coral bycatch (see Table 16). One fisher described "*sea trees*" as having round trunks, like a tree, but like coal, very hard with leaves that were pink and slimey (likely a species of black coral). Offshore of the coast between Puyseger Point and Te Waewae Bay was generally avoided due to the known foul, but no bycatch was mentioned.

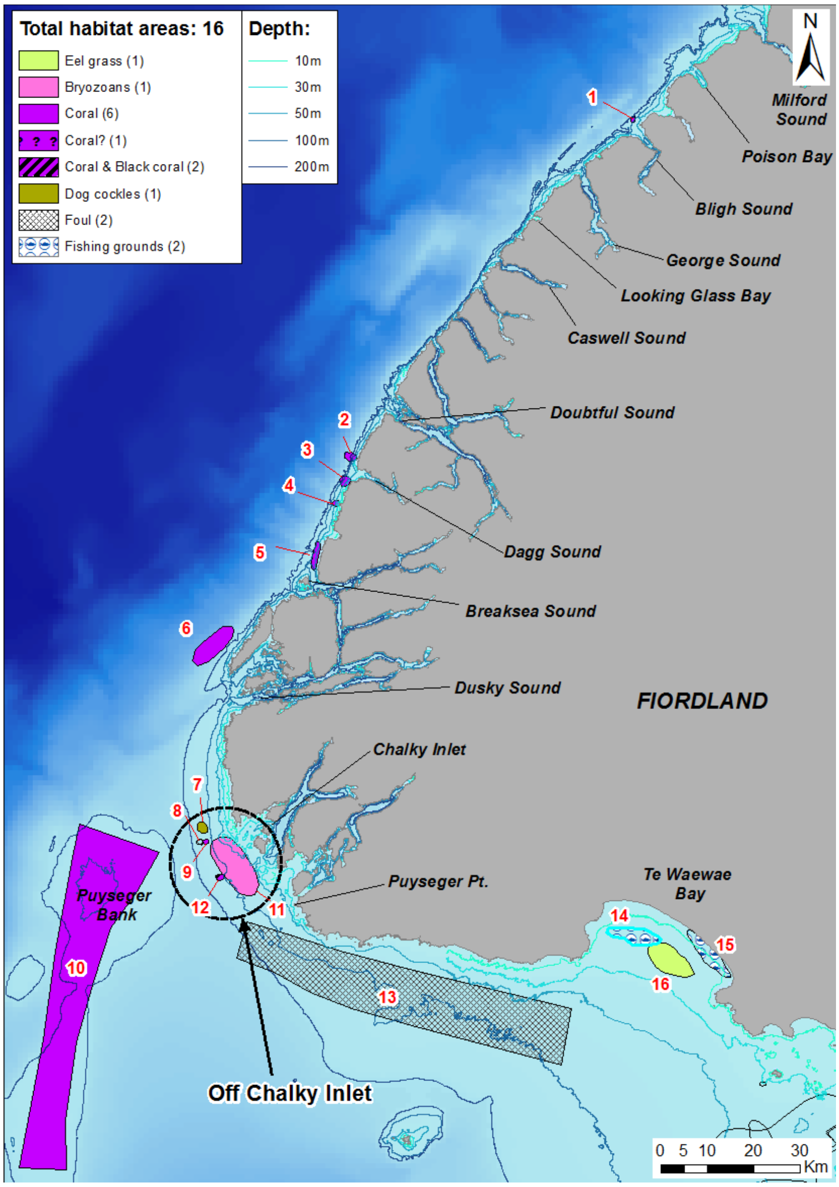


Figure 19: Fiordland region LEK map (Region P of Figure 3). Each fisher-drawn polygon has been assigned a unique number, specific to this regional section. Key sites are circled and labelled as black text on white background.

Table 16: Summary table of sites described by fishers in the Fiordland region with the area identification numbers, brief description, fishing impacts where mentioned, and the number of fishers who described verbally, or identified overlapping or very close areas. Key sites in bold.

Sites	IDs	Description	Fishing Impacts observed	Freq. of ID
George and Caswell Sound		Targeted by crayfish potters; the sides of the fiords were steep and fishers aimed for the ledges. Black coral trees were frequently snagged on the lines.	Yes	1
Doubtful Sound		Was targeted with pots for crayfish. A shallow sill in Crooked Arm was noted as having abundant corals, and a 10 ft black coral tree was once pulled up with a cray pot from this inlet.	Yes	2
Breaksea – Dusky Sound coast	2, 3, 4, 5, 6	Along the coast outside these fiords (about 50 m depth), were areas of hard ground, where broken pieces of coral are picked up in cray pots. In some areas, the fishers believe they can pick up large trees of coral on the sounder (or could also be pinnacles).	Yes	1
Offshore of Chalky Inlet	7, 8, 9, 11, 12	Outside Chalky Inlet, a large area (about 13 km long by 6 km wide) was described as having "plate corals" (11), which might be large coralline algae plates (e.g. Freeman et al. 2011), or rock encrusted with bryozoans and other species. Just offshore of this, a smaller site was noted for its rugged terrain (12), where pots had been lost; the fisher believed he could see the large trees of coral on the sounder. To the north, another smaller spot, "*The Porky patch*" was also described as rugged, with 6–8 m high rock ridges and "coral rubble". (8, 9). A small patch of dog cockles and shell hash was marked nearby (7).	Yes	3
Puyseger Point to Te Waewae Bay	13	Much of the coastline described as very rugged and avoided by trawlers; one fisher had fished for rock lobster a few seasons, and believed the area to be different to the west coast fiords. No specific bycatch mentioned.		2
Te Waewae Bay	14, 15, 16	A sandy bay targeted for flats and elephant fish, known for its abundance of sand dollars. One fisher also marked an area he thought was seagrass.		2

Scientific data sources

A large amount of science research has been undertaken inside the Sounds, initially focusing on the intertidal communities and soft sediment bottoms, which were regarded as being similar to those found elsewhere on the New Zealand continental Shelf (Grange 1990). In 1978, diving surveys discovered the unique communities found on the fiord walls (Grange 1990), and subsequent research has focused on black coral (Grange & Singleton 1981, Grange 1985), red corals (Miller & Mundy 1999), algal diversity (Nelson et al. 2002), blue cod (e.g., Carbines & McKenzie 2004, Rodgers & Wing 2008, Beer et al. 2011), sea perch (Francis & Ling 1985, Lawton et al. 2010), development of habitat maps (Wing et al. 2005), and the "China Shops", discrete areas where epifaunal diversity is thought to be extremely high (Willis et al. 2010). The fiords recalled by fishers as places with memorable coral bycatch (George, Caswell and Doubtful Sounds), have also been sampled in a number of studies and the presence of coral communities confirmed at certain sites (Grange 1985, Miller & Mundy 1999), with 10 "China Shop" sites found within Doubtful Sound (Willis et al. 2010). Milford and Breaksea Sounds were described as having "clean" fishing tows and Bligh Sound as too muddy to trawl, although all three are known to contain coral communities on the walls at certain locations, with Grange (1985) reporting that Breaksea Sound had a significantly greater density of black coral colonies than all other fiords sampled. Unlike the fiords themselves, no scientific information was readily available for the areas identified by fishers outside on the coast. Further south, Puyseger Bank has been identified by scientists as a known coral and sponge region (10), and inshore of the bank, live and dead bryozoans have been collected in dredge samples which overlap the fisher-drawn areas outside Chalky Inlet (A. Smith, unpublished material).

4.17 West coast, South Island

Twenty-seven LEK areas were identified, and four sites described verbally, by seven fishers (Table 17, Figure 20). Along the narrow shelf, areas of clean hard packed sand were interspersed with known foul grounds, such as the "*Kahurangi Shoals*" to the north and patches of sponge and coral bycatch between Big Bay and Jackson bay, which was known as a good crayfishing area. Between Abbey Rocks and Greymouth, a number of areas were drawn by two fishers and verbally mentioned by another as "*tarakihi weed*". The descriptions and photos of this "weed" identified it as a sea pen, possibly *Acanthoptilum longifolium*. Historically, these beds, which were fished for tarakihi, were particularly dense at the shelf edge, especially around the edges of Hokitika and Cooks Canyons, but one fisher described them as having disappeared.

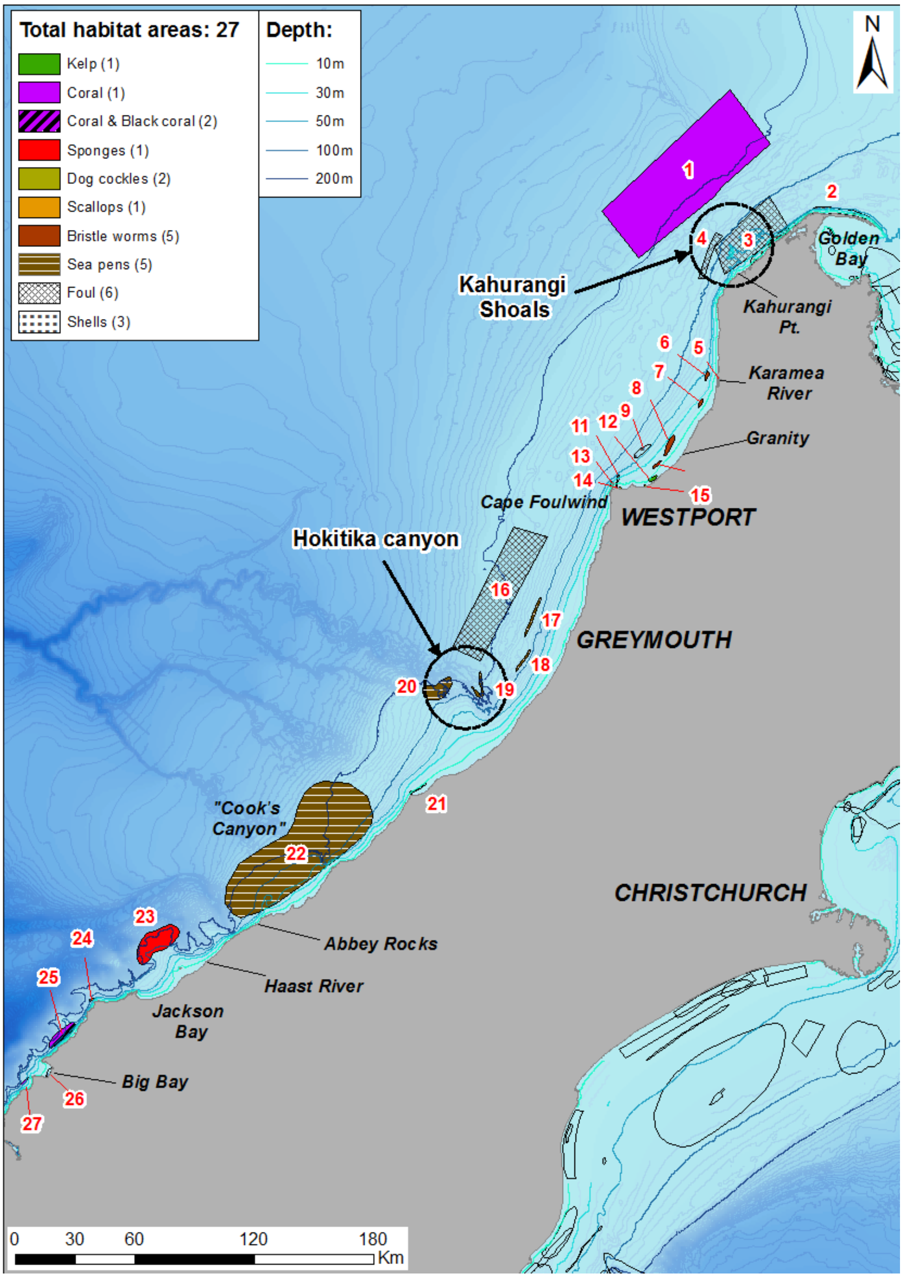


Figure 20: West coast South Island LEK map (Region Q of Figure 3). Each fisher-drawn area has been assigned a unique number, specific to this regional section. Key sites are circled and labelled as black text on white background.

Table 17: Summary table of sites described by fishers in the West coast South Island region with the area identification numbers, brief description, fishing impacts where mentioned, and the number of fishers who described verbally, or identified overlapping or very close areas. Key sites in bold.

Sites	IDs	Description	Fishing Impacts observed	Freq. of ID
Kahurangi Shoals and "*Heaphy Valleys*"	1, 3, 4	Areas marked as foul, with the offshore area known for coral bycatch (1). Have been targeted by longliners for grouper. John dory also associated with these areas.		1
Cape Foulwind and north	5, 6, 7, 8, 10, 11, 12, 13, 14, 15	Small patches of foul, kelp (11, 12, 13), and dog cockles (14, 15) around Cape Foulwind. Clear mud/sand to the north, fished for flatfish, with dense patches of bristleworms mentioned (5, 6, 7, 8, 10).		1
"Tarakihi weed" / sea pen patches of Hokitika and Cooks Canyon	17, 18, 19, 20, 22	Beds of sea pens associated with hard packed sand in depths of 80–160 m, but around the edges of canyons and drop-offs this "*tarakihi weed*" tended to be denser and associated with rougher terrain and boulders. Offshore was thought to be a large area of untrawlable foul. The weed in this case was described as "*beige coloured, slimey, like a quill, thicker at the base*", and "*several feet long, snotty, with nodules thicker at the base and getting thinner towards the tip*".	yes	2
Foul / Coral / Sponges	23, 25, 27	Offshore areas of reef or foul ground where red finger sponges associated with *Ecklonia* (23) were found, or coral / black coral fragments (25, 27).		2

Scientific data sources

Intertidal and shallow subtidal reefs and their fish communities have been studied at some locations along the coast (e.g. Shears & Babcock 2007, Neale & Nelson 1998, Roberts et al. 2005), but information on biogenic habitats in greater depths was not found. The continental shelf along this coast is characterized by high rates of sedimentation (Carter 1975) and largely dominated by soft sediment habitats, becoming finer and more uniform in texture to the south (Probert & Swanson 1985). A regular inshore trawl survey is carried out along this coast, with some large areas of untrawlable grounds defined as part of the survey strata, particularly south of Cape Foulwind (Stevenson & MacGibbon 2015). Many of these areas are associated with the heads of the many canyons that intersect the continental shelf along this coast, as well as the gravel beds of the Kahurangi Shoals further north. Apart from this mapped information, which overlaps in places with fisher-drawn areas, virtually nothing is known of these habitats. No scientific information on the tarakihi weed described from this coast was found, apart from anecdotal observations of a scientist who had worked in this area; "*Years ago when fishing 60–80 fathom (always outside of 60) between Hokitika and Greymouth, used to catch lots of 'Tarakihi weed', looks like barley, about 2 foot long stalks, khaki colour, very slimy. Has a grain-like head on stalk and long leaves, like marron grass. The beds were extensive, the net coming in 'saturated' from wings to bag, but hasn't seen a stalk since 1975–1980. The reason it was called tarakihi weed is because it was a good spot to get good hauls of TAR.*" (D. Robertson, pers. comm. to MM) (NB: possibly Long-leaf sea pen, *Acanthoptilum longifolium*).

4.18 Tasman Bay and Separation Point

Thirty-two areas and one unmarked site were described by eight fishers (Table 18, Figure 21). Overlapping areas were marked at two main locations where fishers described picking up "coral", which was likely to refer to bryozoans; the bryozoan reefs of Separation Point, and an area to the west of D'Urville Island, where sponge bycatch was also mentioned. In shallower water, a variety of shellfish beds (mainly horse mussels), and areas of shell hash were marked, particularly in Tasman Bay. In the deeper part of the bay, a fishing ground notable for high catches of leatherjackets was marked (8).

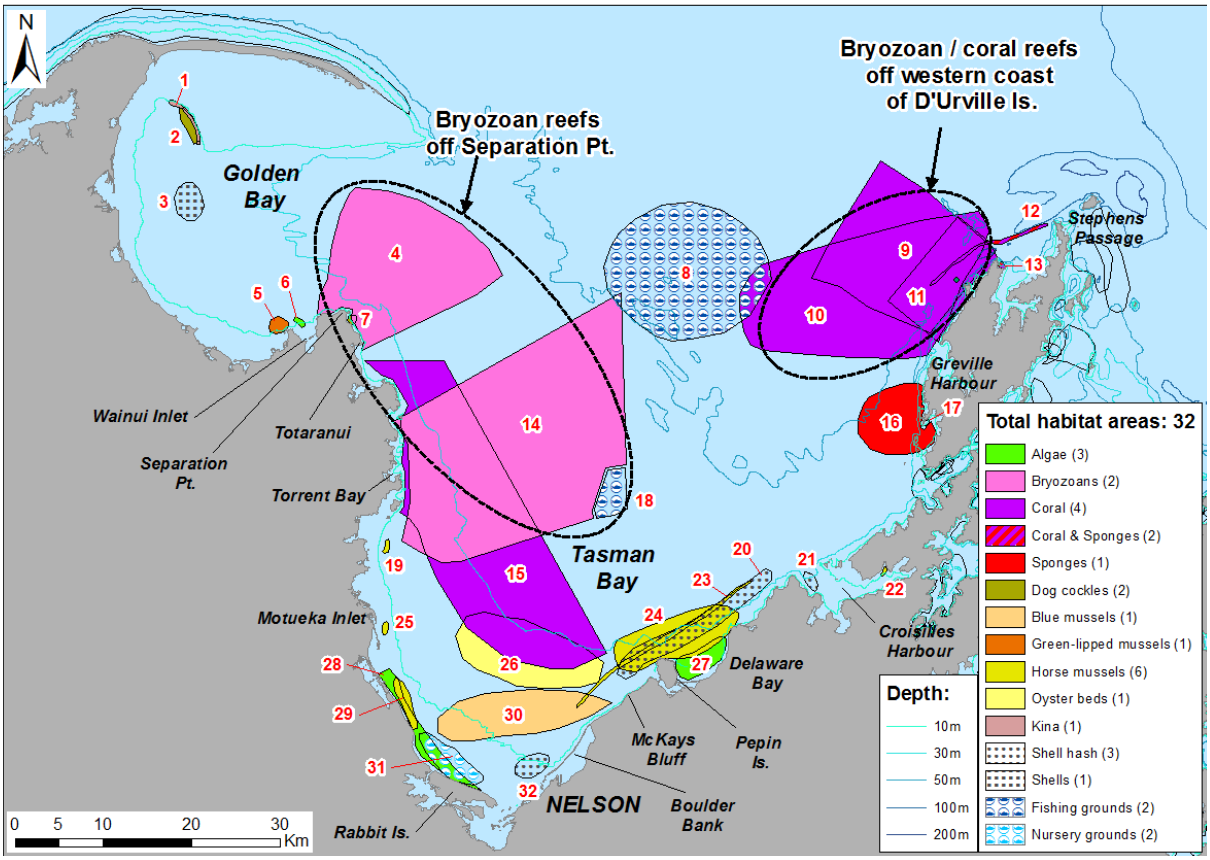


Figure 21: Tasman Bay and Separation Point LEK map (Region R of Figure 3). Each fisher-drawn area has been assigned a unique number, specific to this regional section Key sites are circled and labelled as black text on white background.

Table 18: **Summary table of sites described by fishers in the Tasman and Golden Bay region with the area identification numbers, brief description, fishing impacts where mentioned, and the number of fishers who described verbally, or identified overlapping or very close areas. Key sites in bold.**

Sites	IDs	Description	Fishing Impacts observed	Freq. of ID
Golden Bay	1, 2, 3, 5, 6, 7	Mainly described as sandy / shelly with small patches of shell hash and shellfish noted in places.		1
Bryozoan reefs of Separation Point	4, 14, 15	A large area (4) outlined from Wainui Bay in an arc through to Totaranui, extending out for 12 nautical miles. There was a "*natural corridor*" between this and another area (14, 15), where the "*coral beds*" were more rubble compared to the bryozoan clumps in the closed area of Separation Point. The corridor and a small area called Harvey's Bight (outer corner as shown) were "*clean*" and fishable for snapper, John dory, trevally, and tarakihi before closure in 1980.	yes	2
Shellfish beds, inner Tasman Bay	19, 20, 21, 22, 23, 24, 25, 26, 29, 30, 31, 32.	Fishers indicated various shellfish beds and areas of shell hash in the shallow inshore Tasman Bay, including horse mussels in under 10 m, blue mussels and a historic oyster bed that was "*long gone*". Adjacent to one horse mussel patch (29) a snapper nursery that was avoided by fishers was marked (31), with another overlapping area marked by a third fisher as an area of dense seasonal lettuce weed (28).	yes	3
Bryozoan / coral reefs off D'Urville Island	9, 10, 11, 12,	A large area off the western coast of D'Urville Island marked by three fishers as "coral" (likely to be bryozoans), and described was "*hard to tow over*". A fourth fisher drew a narrow overlapping strip (12), where he believed he had been the first trawler to "*break in*" this area; he recalled sandy coloured finger sponges and corals. It was noted for abundance of leatherjacket as well as "*charity*" tarakihi (25–30 cm)	yes	4
D'Urville Island sponge patches	13, 16, 17	A small patch of abundant sponge and "coral" was indicated at the northern end of D'Urville Island (13), another larger area at the SW end was noted for large, round orange sponges called "*pumpkins*" (16). A tiny area was marked as an area of high numbers of juvenile leatherjacket (17).		1

Scientific data sources

Separation Point and its bryozoans have been the focus of several studies/reports (Saxton 1980a, b, Bradstock & Gordon 1983), with Grange et al. (2003) using side-scan sonar to map the extent of the bryozoan beds, along with some limited ROV drops to ground-truth the different seafloor types. The area currently closed to fishing, where Grange et al. (2003) estimated bryozoan communities (main species *Celleporaria agglutinans*) covered of around 55km^2 overlaps with area 4. The bryozoan beds were more widespread historically (Saxton 1980a & b), extending south to Torrent Bay, which overlaps the fisher-drawn areas 14 and 15. These beds were described as less dense than the Separation Point beds, probably composed of the more fragile *Hippomenella vellicata* (Grange et al. 2003). They were largely destroyed by fishing (Saxton 1980b), although subsequent surveys have recorded scattered small mounds inside the Tonga Island Marine Reserve (Grange et al. 2003). Bradstock & Gordon (1983) also provide a species list of 94 bryozoan species collected at a single station, 75 m depth, located within the areas marked by fishers in north eastern Tasman Bay off D'Urville Island.

4.19 Marlborough Sounds

Forty-five LEK habitat areas and one unmarked site (mentioned verbally, but not drawn on the charts) were described by six fishers (Table 19, Figure 22). This area was rich in biogenic habitats. The most commonly mentioned bycatch types were sponge and "*coral*". The latter most likely to be the hard bryozoan species found in Tasman Bay. Multiple areas of both sponges and corals were noted along the coat of D'Urville Island, and areas of sponge were also mentioned along the inner Pelorus and Queen Charlotte Sound (39). Horse mussel beds were also frequently noted. Some areas were mentioned by multiple fishers, such as the east and southern coast of D'Urville Island, but these were recollections from 20–30 years ago, and some comments were made about areas being discovered and "*cleaned out*". Another fisher thought that sponge habitat in the inner Pelorus Sound may have been impacted by mussel farms.

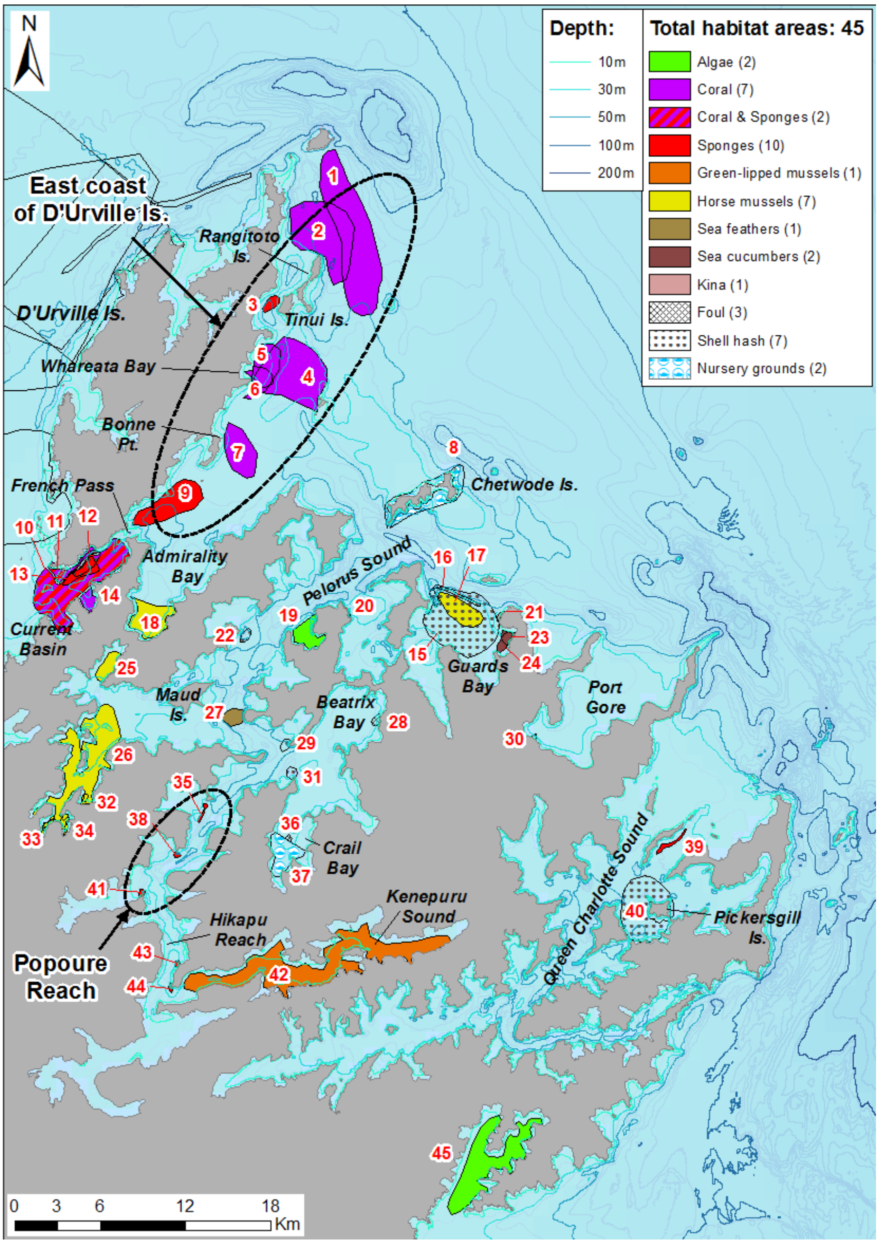


Figure 22: Marlborough Sounds LEK map (Region S of Figure 3). Each fisher-drawn area has been assigned a unique number, specific to this region section. Some key sites are circled and labelled as black text on white background.

Table 19: Summary table of sites described by fishers in the Marlborough Sounds region with the area identification numbers, brief description, fishing impacts where mentioned, and the number of fishers who described verbally, or identified overlapping or very close areas. Key sites in bold.

Sites	IDs	Description	Fishing Impacts observed	Freq. of ID
East coast D'Urville Island	1, 2, 3, 4, 5, 6, 7	Multiple fishers marked areas along the eastern coast of D'Urville Island, as "*coral rubble*", one noting its similarity to Separation Point (probably the bryozoan *Celleporaria agglutinans*). These were based on recollections from 20 to more than 30 years ago, with several noting that the areas were hard to fish, due to net damage, and were associated with large catches of juvenile blue cod on occasion.	yes	3
French Pass	9, 10, 11, 12, 13, 14,	The channel south of French Pass was noted as an area of hard ground covered in sponges and '*corals*", with the densest sponge cover in shallow water along the D'Urville Island coast (11), and Waikawa Bay (14) known more for *"corals"*. One fisher noted that this area had been "*cleaned out*" since it was first fished in the 1960s. To the north of French Pass, another fisher marked an area where soft, yellow, dinner plate sized sponges (8–9 inches high) were found, called "*spongey cheeses*".	yes	3
Horse mussel beds; Admiralty Bay and Tennyson Innlet	18, 25, 26, 32, 33, 34	Areas of horse mussels on sand / mud substrate. Beds may not be so extensive now.		2
Inner Pelorus Sound - Popoure Reach	35, 38, 41, 43, 44	Multiple areas within Popure Reach where "*sponge material*" was found. This was an area targeted for scallops.		1
Pelorus Sound, Crail Bay and Beatrix Bay	19, 20, 22, 27, 28, 29, 31 , 36, 37	Small areas of shell hash (22, 29, 31), rock pinnacles / untrawlable areas (28, 36), sea feathers and starfish (*Coscinasterias muricata*) (27) and red algae and scallops (19), with a snapper nursery area also noted in Crail Bay (37)		1
Greenlip mussel beds – Kenepuru Sound	42	Found along the entire coastline of this area. Not known if beds are still this extensive	?	1
Chetwood Island	8	Noted as a blue cod nursery grounds		1
Guards Bay / Alligator Head	15, 16, 17, 21, 23, 24	Large overlapping areas of shell hash and horse mussels (15, 16, 17). Closer to shore, a kina bed (21) and an area nicknamed "*sea cucumber alley*" was described; fish catches were good, but high numbers of sea cucumbers and kelp were also brought up in the nets.		3
Queen Charlotte Sound	39, 40	Small area of sponge and larger area of shell hash associated with large numbers of brittle stars		1

Scientific data sources

Detailed work on the biogenic habitats of the Marlborough Sounds, across a range of habitat type and sites (including maps) has been carried out by Davidson et al. (2010), with sites of ecological significance described (Davidson et al. 2011). Habitats identified included horse mussels, rhodoliths, mound or mat-forming tubeworm species, red algae, dog cockles, bryozoans, and sponges. Bryozoan sites included an area of *Celleporaria. agglutinans* and *Galeopsis pocellanicus* growing on isolated rocky outcrops in the passage between D'Urville and Rangitoto Islands (surveyed using spot dives), which overlaps fisher-drawn areas 3 and part of 2, and Davidson et al. (2011) describe "*compact, tightly* *branching colonies [of Galeopsis porcellanicus] that can cover almost the entire substratum"* in French Pass, where multiple fishers noted sponges and coral. Patches of mixed biogenic assemblages including bryozoans, sponges, horse mussels and ascidians were found to the east and west of the Trio Islands (overlap with fisher-drawn area 4), and around Chetwode Island, which was thought to be a blue cod nursery ground (8). In Tawhitinui Reach, sponges and hydroids were recorded on patches of cobbles, boulders, bedrock and adjacent soft sediments in discrete areas, one of which overlapped with the fisher-drawn area 27, recalled for its abundance of sea feathers and *Coscinasterias muricata*. Horse mussel beds identified by Davidson et al. (2010) included Waitui Bay, Port Gore (not mentioned by fishers), and Crail Bay, thought by one fisher to be a snapper nursery (27). The fisher-drawn horse mussel bed in Guards Bay (17) was mentioned by Davidson et al. (2011), but recent surveys have failed to locate them. Davidson et al. (2010) also described areas of bryozoan mounds that were not located by fishers in this study, and the presence of areas of large tube-worm (*Galeolaria hystrix*) mounds in Port Underwood (see figure 41 in Morrison et al. 2014a), with recent sampling by dropped underwater video showing blue cod of all sizes to be strongly associated with these habitats in Port Underwood (G. Carbines, Stock Monitoring Services, pers. comm.).

5. HABITATS IDENTIFIED AT THE NATIONAL SCALE

In this section, some national-scale information is presented, by combining regional section material for key species/groups. Selected species records from taxonomic databases (Specify, AllSeaBio) are plotted alongside the fisher-drawn areas as appropriate for reference. Some of the more common records are given at a species, or species group taxonomic level, with others grouped as "other species". Included in these data, were the records collected from two *Tangaroa* voyages carried out as part of this project, which targeted areas identified by the fishers. Records from these voyages are numbered to identify them from the historical records. For full details of the voyages, please refer to Jones et al (in review).

5.1 Coral

Coral was identified by many fishers (Figure 23), including in a number of cases, the selection of particular images as provided in the interview. Black coral was specifically mentioned by many, and is thought to be distinctive enough to be a correct identification (however, note that there are 18 different New Zealand species). In some instances, given existing science knowledge, it seems that bryozoan colonies were also almost certainly described as corals, e.g., in the South Taranaki Bight (Gillespie & Nelson 1996), Tasman Bay (Saxton 1980a, b), D'Urville Island (Mace 1981), and Foveaux Strait (Cranfield et al. 1999, 2003). In many cases, fishers identified corals as part of a biogenic habitat mixture e.g. 'Coral & sponge'; these were left as described by fishers. Figure 23 shows where fishers reported coral areas, alongside coral presence records collated from multiple scientific sources (lower depth cut-off of 250 m). The main distribution pattern of 'cold-water' corals in New Zealand is off the continental shelf, in depths greater than 200 m (Tracey et al. 2011). Most of the potential coral habitat areas reported by fishers were deeper than 100 m, with many of them falling on the edge of the shelf. Many of the seafloor types which coral species grow on are composed of rougher rock terrain, not vulnerable to trawl, and a number of the LEK areas presented here came from fishers using other fishing methods such as rock lobster potting, and long-lining/drop-lining.

5.2 Sponges

Sponges were present across all regions of New Zealand (Figure 24). In a number of areas they were reported as part of biogenic habitat mixture, including coral/black coral, and bryozoans. There were too many potential habitat-forming species to plot taxonomic records for. Large sponge habitat areas were reported off North Cape, Rangaunu Bay, the Poor Knights Islands, Mayor Island, East Cape, Mahia Peninsula, Kaipara Harbour, the North and South Taranaki Bights, Wellington, Otago, Foveaux Strait, and north of Jackson's Bay, west coast South Island. Many species are likely to have contributed to these areas, based on the fisher's accounts, with different species assemblages in different geographic regions.

5.3 Tube worms

Tubeworms were reported as patches from around most regions of New Zealand (Figure 25), although the species involved almost certainly varied between regions, based on descriptions. As with sponges, there are too many potential habitat-forming species to plot. Fisher-drawn areas were identified off the North Taranaki Bight, the area south of East Cape, and in the inshore Karamea Bight (north-west South Island). The largest tube-worm habitat extents were described off the North Canterbury Bight, and Timaru). The terms "*Tarakihi-weed*" and "*Wire-weed*" were used by a number of fishermen to describe these areas. Off Oamaru, two fishers marked overlapping areas known locally as "*The Hay Paddock*". The "*tarakihi weed*" here was described as "*pale yellow colour, with kinks, straw-like, came up in clumps*." "*It may grow on humps of substrate*" and "*like straw, thickness was less than a drinking straw*". The Hay Paddock was also mentioned verbally by one other fisher but as he wasn't navigating, he wouldn't say where exactly. He described the "*hay*" as gritty with shellfish attached.

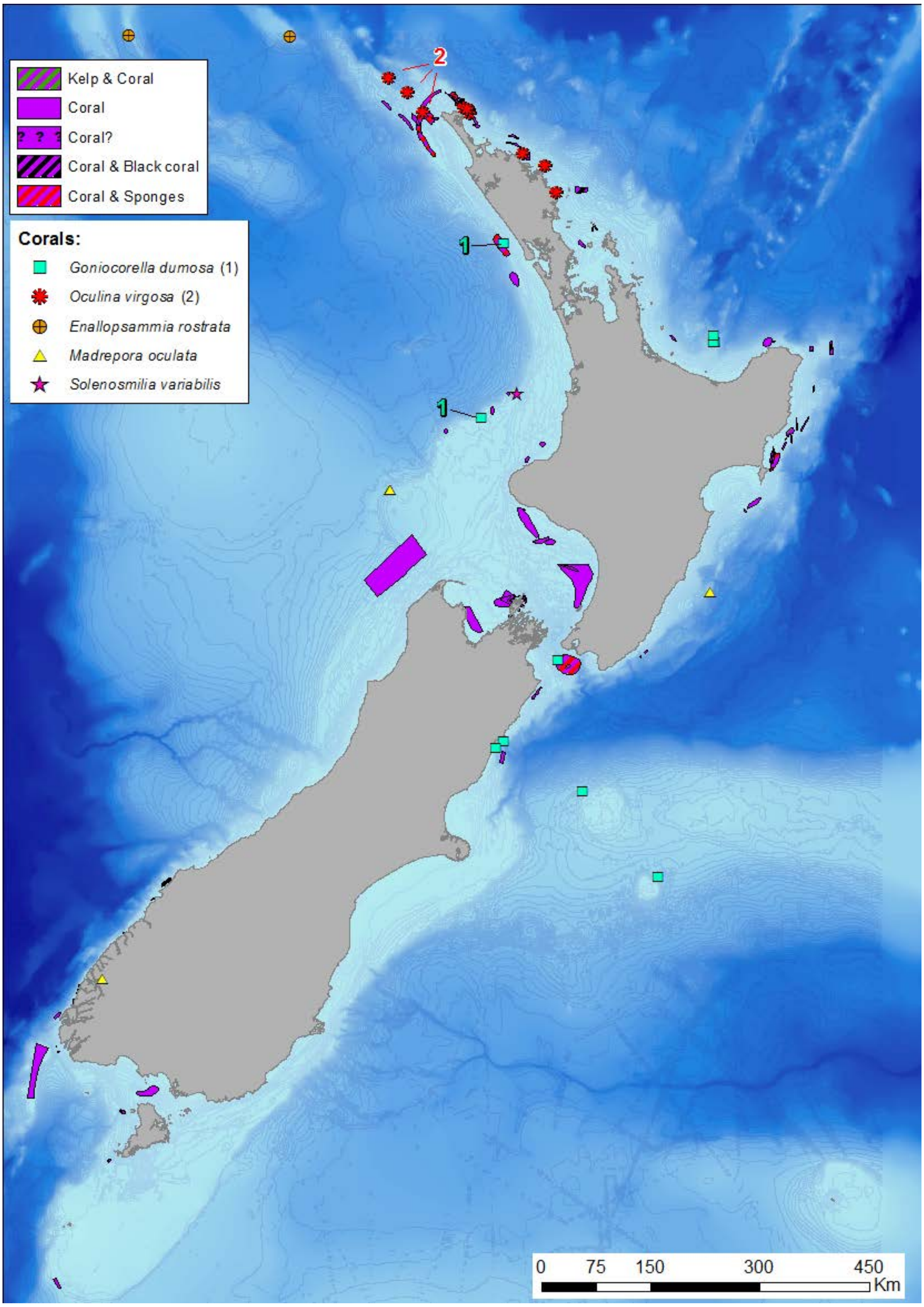


Figure 23: LEK coral habitats at the national scale (NB: some habitats identified as corals are actually bryozoans; South Taranaki Bight, Tasman Bay, Foveaux Strait). Note that the Chatham Rise shallower areas (e.g. Mernoo Bank) were not included in the LEK interviews. Taxonomic records for selected coral species likely to be found on the shelf (< 250 m) are also plotted, with records numbered where they were sampled as part of this project.

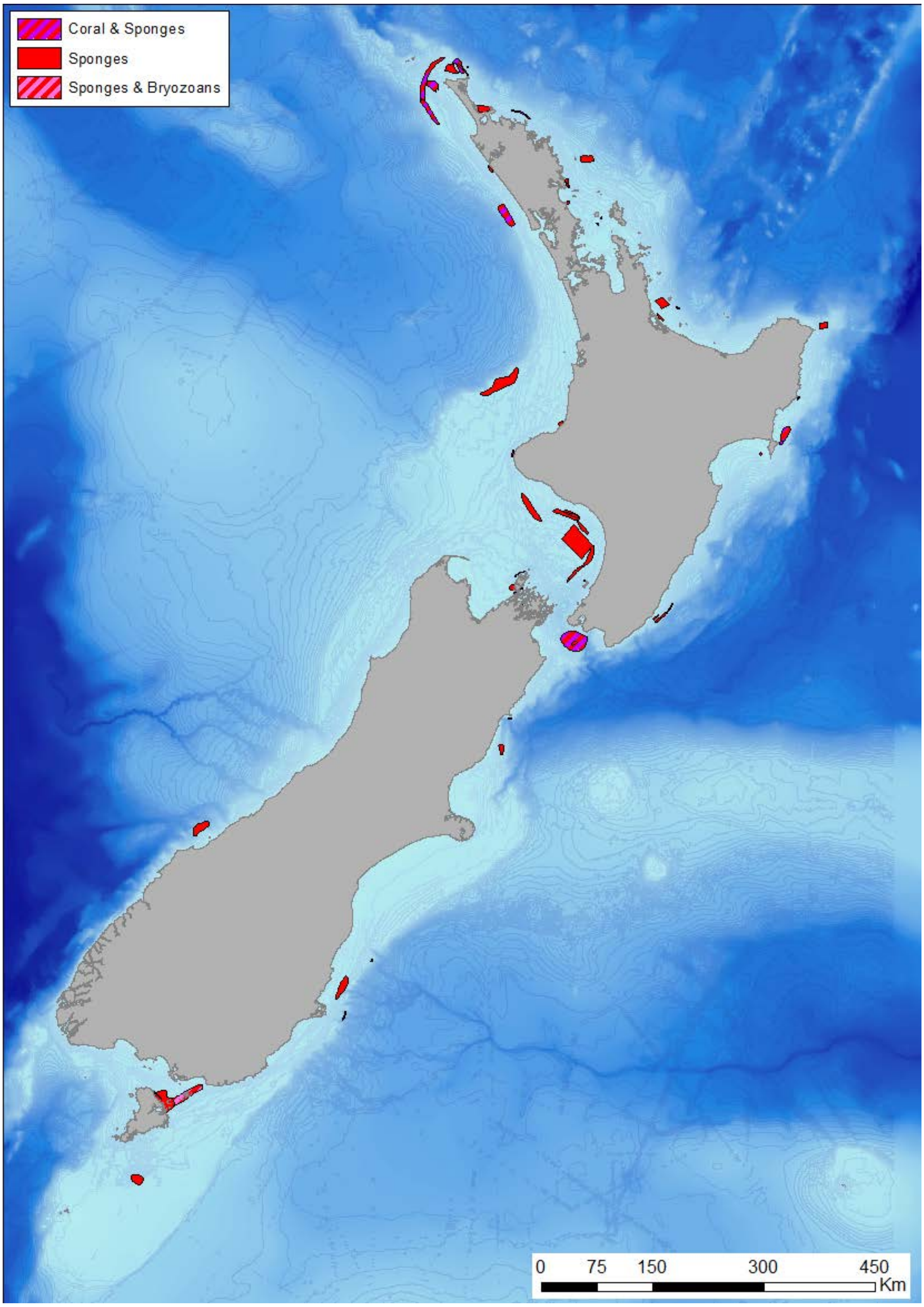


Figure 24: LEK map for sponges at the national scale. Note that the Chatham Rise shallower areas (e.g. Mernoo Bank) were not included in the LEK interviews.

Off Banks Peninsula, local fishers marked patches of what they called "*wire weed*". One believed it to be "*a grass product*" but described it as "*clumpy, hard, with a sandy feel*". He marked four discrete areas (see region section). A second local fisher believed the worms to be different at different sites. A third fisher marked an approximate site close by, but shallower (80–100 m), that he described as a place where you get "*tarakihi weed*" but was not sure of extent. He described it as "*6–8 inches long, fine, like grass with a smooth, non-slimey texture, pale white-brown in colour and about 2 mm diameter*." He believed there were similar areas off Cape Campbell and near Wellington although he could not mark areas. Another fisher also believed this habitat to occur up at Kaikoura, south of Cape Campbell, but no definite areas were marked on the charts. These fishing grounds were described as being very muddy and that the trawl net could easily become very bogged down with the weed clogging the meshes and the net filling up with mud. In some cases fishers had lost their nets.

A second form of "*tarakihi weed*" was described by one fisher from an area off Waikawa Harbour, Southland (fisher-drawn area 52, Figure **16**), as a pink weed that appeared sporadically and could get so thick it would bog down the trawls. He described it as "*wee low bushes, very fine and pretty*". It was not very long and not like a whip and was not slimy. It didn't occur shallower than 30 fathoms. This was probably an algae or bryozoan species. A third habitat also called "*tarakihi weed*" was sea pen fields off the west coast, South Island (see below).

5.4 Sea feathers, sea pens, and sea tulips (kāeo)

Sea feathers were identified by one fisher from the Marlborough Sounds, in about 70 m water depth, associated with the large starfish *Coscinasterias muricata*. There are about 20 species that have been reported as present in less than 250 m water depths in New Zealand. In Figure 25, records of *Argyrometra mortenseni*, *Cenolia novaezealandiae,* two high level groups, and all other species combined are plotted.

Sea pens were identified by five different fishers. In the North Island, sea pens were reported from north of Great Barrier Island (Hauraki Gulf), where they were known as "*slimies*", and described as pinkish in colour with a slimy membrane that could be peeled back. They occurred in 100 fathoms (about 180 m), along with soft corals and sponges, on mud substrates. South of Ranfurly Bank, the catching of "*stalks only*" animals (possibly a whip-like species) was reported from depths of 150–200 m, on soft muds; with these animals glowing green when seen in the dark. In the North Taranaki Bight, animals were described as being pencil-thickness, white in colour, widening out at one end, and slimy. They were caught along the edge of the shelf in 150–160 m water depth, and seemed to be caught on a certain tide.

On the west coast of the South Island, sea pens were reported from Cook Canyon, Hokitika trench and Kumara Junction, where they are known locally as "*Tarakihi Weed*" (confirmed by a photo). This species covered the flat areas, and was thickest on the edge of drop-offs. It was abundant in the 1970s, but greatly reduced by the 1980s according to anecdotal observations (D. Robertson, pers. comm.)

As sea pens can be feather-like, club-like, radiating or even whip-like in form, it is quite likely that there may be misidentifications with some tube worm and other species groups, outside of the descriptions above. Figure 25 shows taxonomic records for two species (*Acanthoptilum longifolium*, *Anthoptilum grandiflorum*) and a higher taxonomic group, sampled during the two subsequent *Tangaroa* voyages, as well as all other species combined. With some exceptions (Marlborough Sounds, Banks Peninsula, Fiordland) most were reported from the outer shelf.

Sea tulips (kāeo) are solitary ascidians, with long wrinkly, purple bodies attached to a long tough stalk, with large animals growing to a metre long. Known as kāeo (*Boltenia pachydermatina*), they are filter feeders, and occur in coastal waters where they can form extensive beds, with the greatest depth they occur in being about 80 m. Fourteen fishers identified kāeo areas, all from the South Island: including the Canterbury Bight, Oamaru, Dunedin Harbour, Bluff and Foveaux Strait. Most records were from shallower waters, down to around 30 m water depth. A number of fishers said that there were not usually many fish associated with them, and that they tended to avoid these patches (apart from those targeting elephant fish off the South Canterbury coast). Many also commented that the beds seemed to come and go, and that they were often associated with gravel and rubble, coming up attached to stones and rocks. They were not common in the taxonomic data records (Figure 25), thought to be more a lack of collecting in shallower southern coastal waters than being rare (taxonomic records averaged 18 m water depth, range 8 to 32 m).

5.5 Kelp and algae

Kelp and other macroalgae were reported by fishers from a range of locations (Figure 26), although the main distributions of algae on shallow rocky reef areas or deeper rugged bottom areas are less available to trawling (*Ecklonia radiata* is now known to grow down to more than 70 m water depth where water clarity permits, e.g. Ranfurly Bank, Jones et al., in review). Kelp forests are probably generally avoided by trawlers, though there are clear accounts of their removal historically in some areas as part of 'conditioning' fishing grounds. Large kelp areas were reported from Pandora Bank, two areas inshore of Mayor Island, the Wairoa and Clive Hards', and around Timaru and Oamaru, as well as smaller polygons scattered around the lower North Island (Figure 26).

Red (and green) algae growing on soft sediment seafloors was reported from a number of regions, and is probably a more common and widespread habitat on coastal soft sediment seafloors than currently acknowledged, especially in regions with higher water clarity. This included the South Taranaki Bight, where two forms of "*Sponge-weed*" were reported, of which one appears to be an algal species.

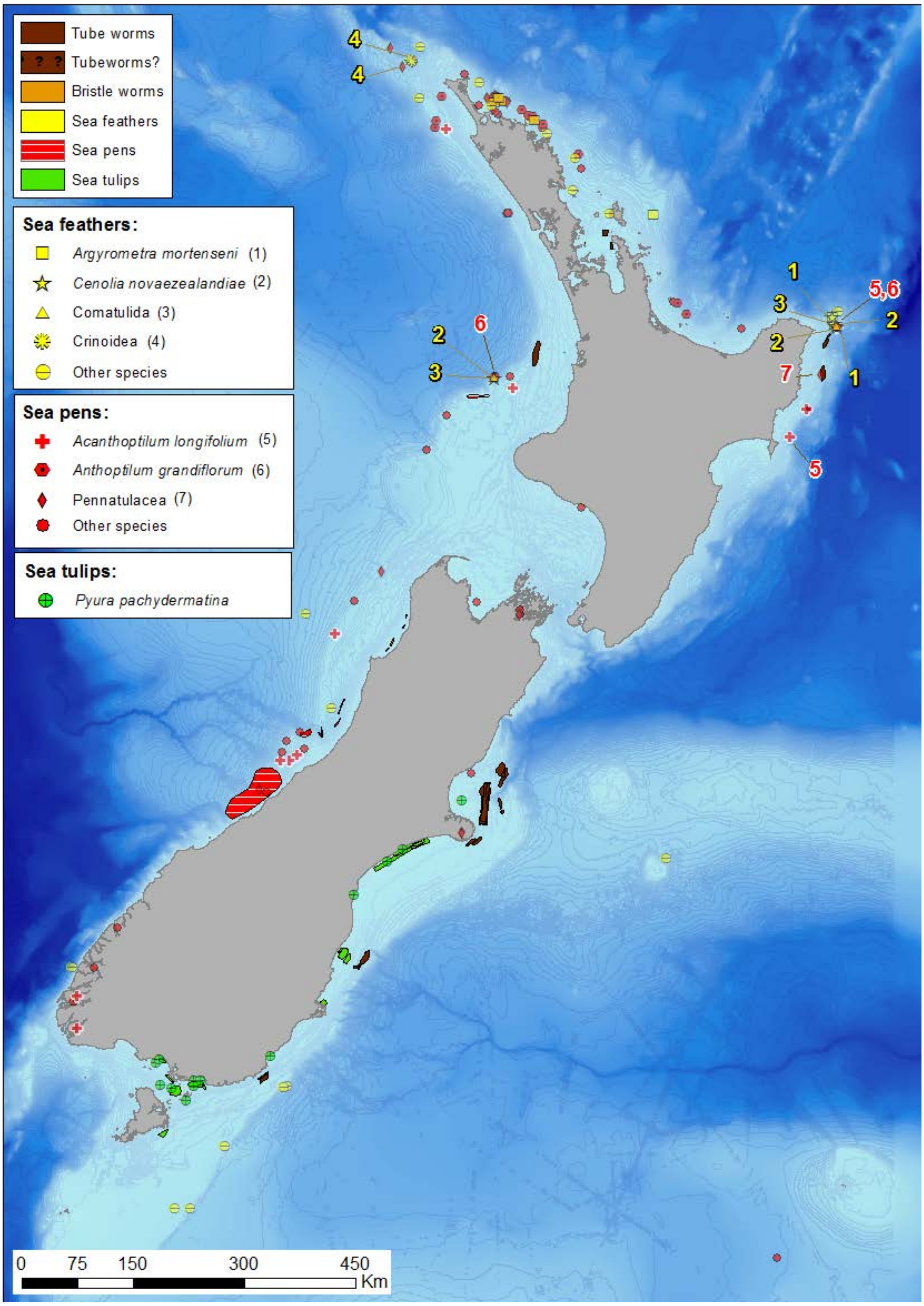


Figure 25: LEK map at the national scale, for tube-worms, bristle-worms, sea pens, sea feathers, and sea tulips. Note that the Chatham Rise shallower areas (e.g. Mernoo Bank) were not included in the LEK interviews. Taxonomic records for selected species of sea feathers, sea pens, and sea tulips are also plotted, with those records collected as part of this project numbered.

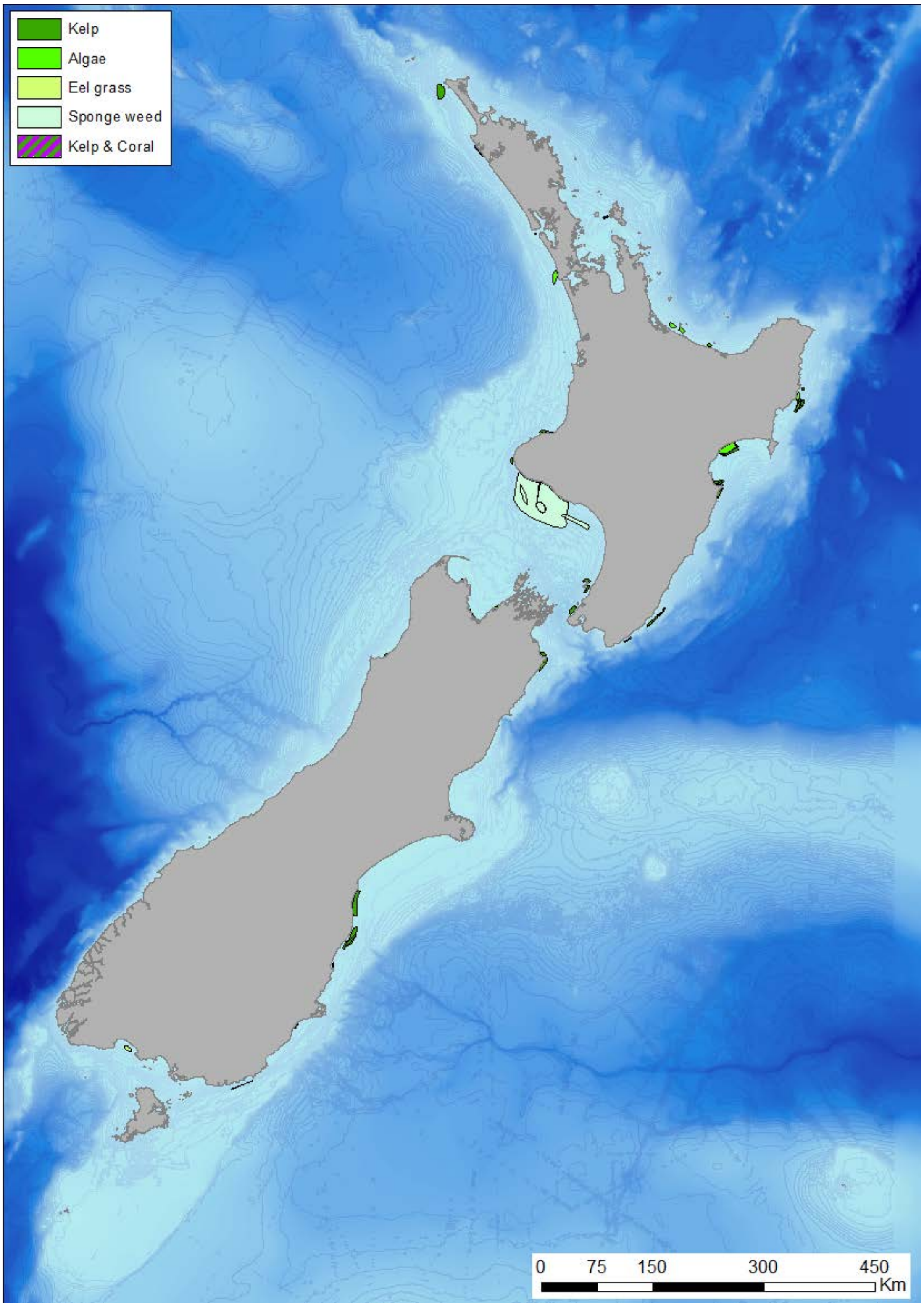


Figure 26: LEK map of kelp and algal habitats at the national scale. Note that the Chatham Rise shallower areas (e.g. Mernoo Bank) were not included in the LEK interviews.

5.6 Bivalves: horse mussels, dog cockles, scallops, mussels

Bivalves were reported as by-catch, although we did not interview fisheries from shellfish dredge fisheries (e.g. scallops and oysters), apart from several fishers in Foveaux Strait. Horse mussels were reported from around much of the New Zealand coast out to at least 80 metres water depth (Figure 27).

Taxonomic records also showed them to be present around the country, with some notable gaps between the Manukau Harbour and Ninety Mile Beach, along almost the entire east coast of the North Island, and from Fiordland to Farewell Spit. While the last area mentioned may be due to heavy natural sediment erosion inputs from the Southern Alps, the other gaps are likely to simply represent a lack of taxonomic collection, with for instance numerous horse mussel beds known to exist in the Greater Hauraki Gulf and East Northland regions (e.g., M. Morrison, pers. obs.; Morrison et al. 2014a). Dog cockles were reported by fishers at a number of places, including both small discrete areas (e.g. off Fiordland), and as large extensive areas (e.g., the Rolling Grounds, South Taranaki Bight). Taxonomic records were widespread, from the Three Kings Island region to East Cape, South Taranaki Bight and Marlborough Sounds, and the lower South Island (both coasts), as well as from shallower areas of the Chatham Rise. However, they were not reported from the west coast North Island (New Plymouth to Ninety Mile Beach), Mahia Peninsula to north of Otago, and the entire west coast of the South Island, excepting Fiordland. *Tawera spissa*, a small infaunal bivalve species that can form extensive very high density beds along with associated dead shell cover (Taylor & Morrison 2008), was distributed around the New Zealand coastline, including some records from the Mernoo Bank area, Chatham Rise (Figure 27). Scallops (several species) and mussels (blue and green-lipped) were occasionally reported as low levels of by-catch, with some relatively small patches of green-lipped mussels observed (very small, compared to historical distributions in the inner Hauraki Gulf, and Marlborough Sounds, e.g., Greenway 1969, Reid 1969).

5.7 Foul and/or unusual rock

Foul ground was reported from most regions (Figure 28), although it was much more common in some regions (e.g. Cape Reinga to Three Kings Islands, East Northland, Stewart Island region) than others (e.g. Tasman and Golden Bays; South Canterbury Bight). It is likely that some of these foul areas hold abundant coral / sponges, but others may be just unfishable rock formations or rocky reefs with low biogenic habitat cover. A number of reports of unusual rocks and other features may also be of value for geological purposes, including: several "*petrified forests*" (possibly geological formations) reported off northern New Zealand; very heavy, smooth polished possible river stones (inshore of White Island, Bay of Plenty); "*gun barrels*" (brown-coloured, pumice-like barrels, hollow, with nothing growing on them) off Mahia Peninsula; Swiss cheese rock (e.g. outer shelf edge of North Taranaki Bight), and rock chimneys (off Wellington). A national scale map of subtidal reefs less than 50 m depth has been produced by the Department of Conservation, predicted from expert knowledge combined with interpretation of hydrographic faring sheets (DOC, unpublished data), and these data are included in Figure 28. Two areas are highlighted; Ariel bank, offshore of Gisborne, and the coastline between Christchurch and Kaikoura, where LEK areas (foul or other categories such as "Sponges", "Coral" etc) overlapped with predicted subtidal reefs.

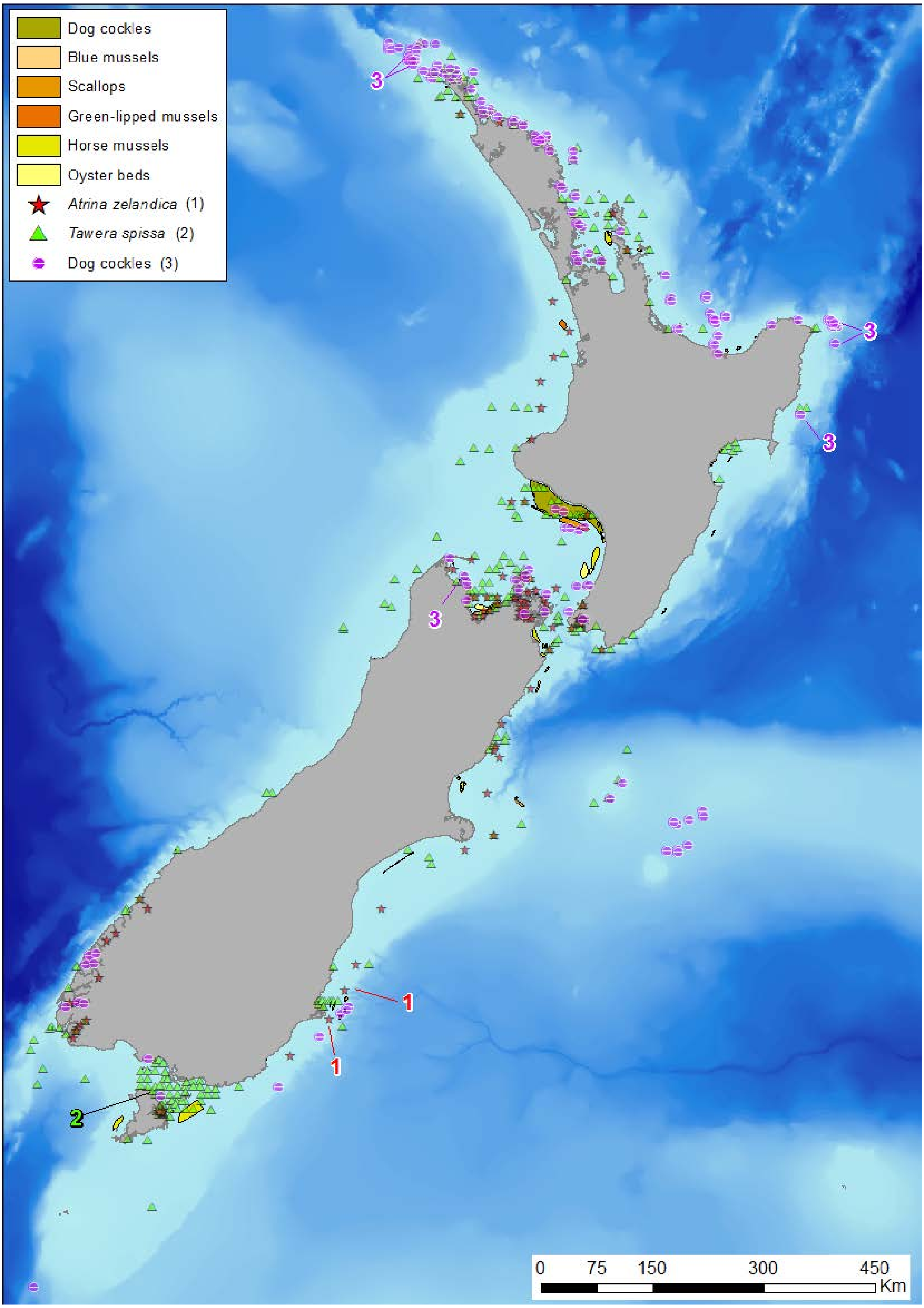


Figure 27: LEK map at the national scale for selected bivalve habitats. Note that the Chatham Rise shallower areas (e.g. Mernoo Bank) were not included in the LEK interviews. Taxonomic records for horse mussels (*Atrina zelandica*), morning star shells (*Tawera spissa*) and dog cockles (*Tucetona laticostata*) are also plotted, and numbered where collected on voyages as part of this project. Dog cockle records include material collated from Te Papa collections.

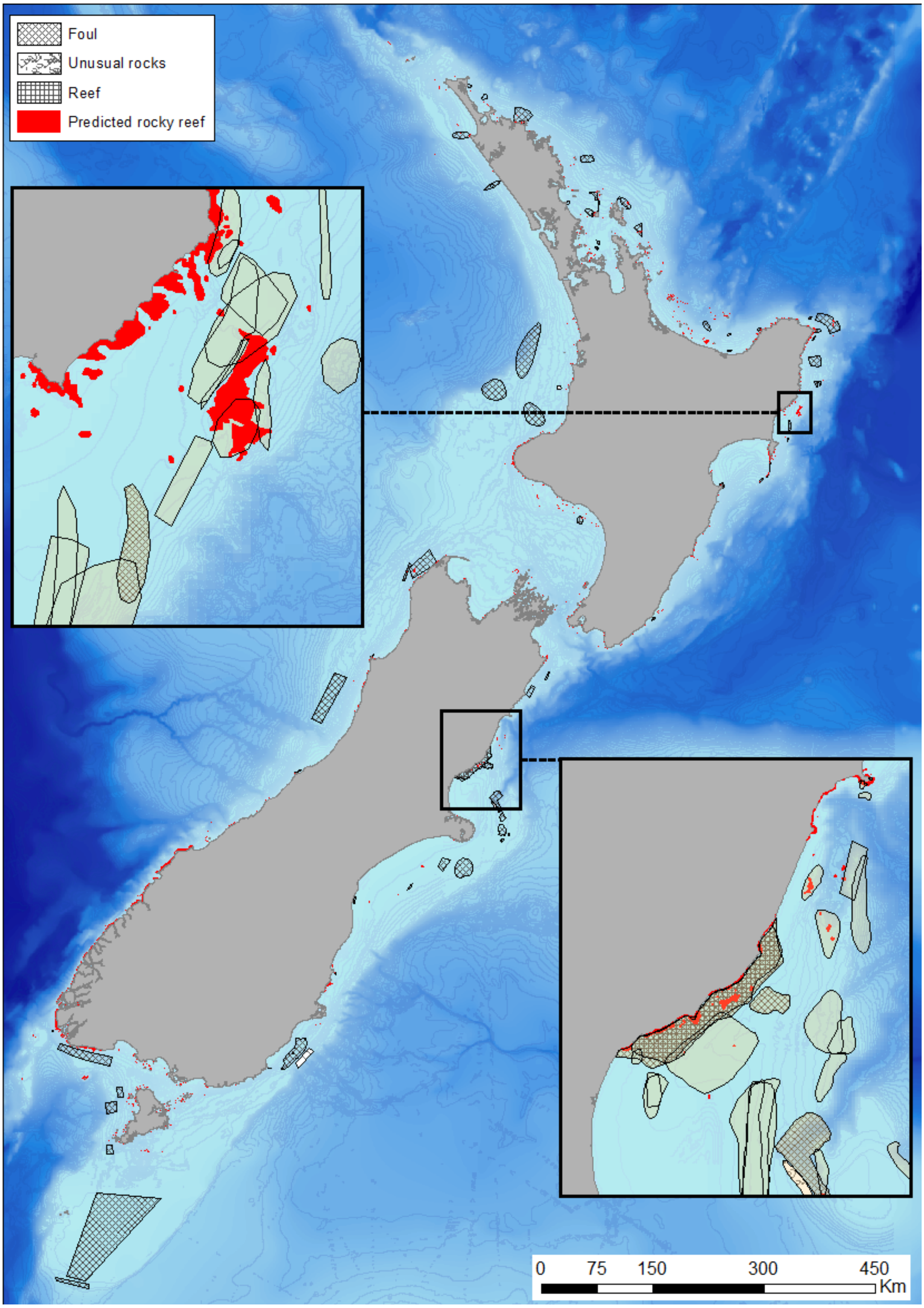


Figure 28: LEK map at the national scale for foul, reef, and unusual rock polygons. Note that the Chatham Rise shallower areas (e.g. Mernoo Bank) were not included in the LEK interviews. Areas of subtidal reefs in less than 50 m water depth, predicted from interpretation of hydrographic faring sheets and expert knowledge are also shows (DOC, unpublished).

6. CONCLUSIONS

A total of 588 observations were recorded from the 50 fishers interviewed, with 496 of those accompanied by areas drawn on nautical charts. Around 66% of the observations were classified as potential biogenic habitat, with a further 15% described as "Foul" or "Reef". The most commonly mentioned biogenic habitats were corals (likely to include bryozoans), sponges, bryozoans, kelp and horse mussels. When combined and overlaid together, these data could be summarized into 109 locations or groups of habitat types, which have been summarized in the regional tables of this report. A total of 65 of these locations were identified by multiple fishers, (i.e. more than one individual), with up to nine individuals (The Rolling grounds, South Taranaki Bight) describing the same or similar habitats that overlapped, or were in close proximity. Of these, 47 were suggested as "Key Sites", as defined in Section 2.4, for consideration for empirical sampling as part of Specific Objective 2, and these are listed in Table 20. There were noticeable clusters of biogenic habitat in certain areas: Cape Reinga/North Cape/Three Kings; East Cape, offshore North and South Taranaki Bight; Stewart Island / Foveaux Strait / Fiordland and the Oamaru to Dunedin continental shelf. In many areas (34 sites overall, 19 key sites), dramatic temporal and spatial reduction in some habitats/species were mentioned, usually attributed to fishing activity (see Table 20): the "*wire-weed*" fields (chaetopterid tubeworms) off the North Canterbury Bight; the "*wire-weed*" / sponge assemblage of the "*Hay Paddock*" off Oamaru; large area/s of big sea-pens off the west coast South Island; and '*sponge-weed'* (a term thought to potentially include sponge, catenicellid bryozoan and /or algal species/s, variously reported under the same generic name) off the South Taranaki Bight.

The inherent uncertainty and bias in these data is acknowledged. Increased confidence in our certainty of the observations was sought by consulting the available scientific literature. In over half of the key sites (30), some scientific information was found (see Table 20). The level of detail available was highly variable; in some places targeted surveys have been published, e.g. studies documenting the extensive dog cockle beds of the South Taranaki Bight (Gillespie & Nelson 1996), the bryozoan assemblages of the Otago Shelf (Wood & Probert 2013) and Foveaux Strait (Michael et al. 2007), the sponge gardens of North Cape and Spirits Bay (Cryer et al. 2000, Bowden et al. 2010). In other places, single station observations or trawl survey bycatch records provided less substantial, but corroborative information, e.g the single station bryozoan sample from west of D'Urville Island (Bradstock & Gordon, 1983), and the comments on presence of chaetopterid worms on the Canterbury shelf (Fenaughty & Bagley, 1981, Carter & Carter 1985, Probert & Anderson 1986). For the remaining areas, minimal, or no scientific information was readily available; e.g. sponge and coral areas off Cape Reinga, and the canyons off the west coast of the North Island, Ariel Bank and the "*Cabbage Patch*" off the Gisborne coast, and "*The Coral Patch"* in Hauraki Gulf. In several regions, scientific information was more readily found for shallow depths (less than 30 m), and / or in deep water beyond the continental slope, than for the shelf itself, e.g. the Bay of Plenty and east coast of the North Island.

Biases in the data collected, due to the interviewee pool sampled are likely. Our sample represented a small (under 5%) proportion of the estimated current number of inshore vessel skippers (estimated at about 1300 in 2007) and an unknown proportion of retired fishers. The process by which LEK was gathered in this study undoubtedly falls foul of many of the issues raised by Drescher et al. (2013) and others in their discussion of the potential pitfalls and bias in using "expert knowledge" (see Section 2.1 of this report). Our interviewee selection technique is likely to have been biased by the non-random methods used to make contact with prominent individuals, and industry organizations, and we did not undertake a formal process of ranking participants beyond the initial phone call, where individuals that did not appear to be able, or willing to offer useful information were noted, and not contacted further. However, using multiple independent starting points should have alleviated bias to some extent, and the process of requesting geo-located information inevitably discouraged individuals from providing information for sites they were less familiar with. Despite its potential drawbacks, this non-random approach was felt to be the best way to overcome the difficulties of engaging an expert group (commercial fishers), where a significant number were unsurprisingly wary, or unwilling to divulge the very localized and specific knowledge being sought, and maximize the chances of collecting information within the constraints of the resources available. In many areas, a substantial amount of information, covering a large area of the shelf was recorded, e.g. South Taranaki Bight and Otago Shelf. In other areas, the number of fishers found with knowledge was fewer, and the information was less extensive. Gaps in coverage of the shelf in these areas may reflect a lack of interviewees with appropriate knowledge instead of a lack of biogenic habitat, e.g. east Northland, Fiordland and Bay of Plenty.

Table 20: List of “Key” sites identified from fisher’s surveys of potential biogenic habitat around New Zealand, summarizing the habitat categories allocated, the number of fishers who made observations, whether fishing impacts were commented on, and listing known scientific data where overlapping or close by.

Key Sites	Fishing Impacts observed?	Frequency of ID by fishers	Habitats	Science info	References
“*The Rock Garden*”, North Cape	●	5	Sponge / Coral	●	Rowden et al. 2004, Cryer et al. 2000
offshore Cape Reinga		3	Sponge / Coral		
Pandora’s Bank, Cape Reinga		4	Sponge / Coral / Kelp		
“*Coral Patch*”, Great Exhibition Bay		3	Sponge / Coral	●	Bowden et al. 2010
Cavalli Islands, East Northland	●	5	Foul / Sponge / Coral	●	Bowden et al. 2010
East of Poor Knights Islands		2	Sponge / Foul	●	Ayling & Shiel 2003, Taylor et al. 2011- from Poor Knights Islands
Ocean Beach, Hauraki Gulf		2	Sponge		
“*The Coral Patch*” (south of Mokohinau Islands, Simpson Rock and north of Little Barrier.)		3	Coral / Black coral / Foul		
Deep reefs, Great Barrier Island		3	Foul	●	Morrison et al. 2001a, Sivaguru & Grace 2002, Lee et al. 2015
"*North-west Reef*", west of Little Barrier Island.		3	Coral / Foul	●	Shears & Usmar 2003
“*The Puddle*”, Mercury Islands		2	Horse mussels / Dog cockles		
The “Knolls”, south-east of Mayor Island, Bay of Plenty		2	Sponge / Coral		
Offshore drop-offs: “The Crater”, Bay of Plenty		4	"Cauliflowers"		
Ranfurly Bank, East Cape	●	4	Coral / Black coral / sponge / Foul	●	Phillips 2002
Ariel Bank, Gisborne coast	●	4	Coral / Kelp	●	DOC predicted reef layer (unpublished), Smith et al. 20013
The “*Cabbage Patch*”, Gisborne coast		4	Coral / Sponge / Bryozoans / Foul	●	DOC unpublished reef layer (unpublished), Smith et al. 20013
Lachlan Ridge, outer Hawke Bay		2	Coral		

Key Sites	Fishing Impacts observed?	Frequency of ID by fishers	Habitats	Science info	References
Wairoa Hard, Hawke Bay	●	5	Kelp / Greenlip mussels	●	Thrush et al. 1997
Clive Hard and Cape Kidnappers, Hawke Bay	●	4	Kelp / Greenlip mussels	●	Thrush et al. 1997
Flat Point Reef, Wairarapa coast	●	3	Sponges / Kelp / Foul	●	DOC unpublished predicted reef layer
The "*Petrified Forest*", West coast, North Island		5	Petrified wood		
"*The Canyons*" / "*The Trenches*", West coast, North Island		3	Sponges / coral		
Shelf edge canyons, North Taranaki Bight		5	Sponges / coral / Foul		
"White Cliffs" and other subtidal reefs, North Taranaki Bight	●	2	Foul / Coral		
Patea Shoals/ The "*Rolling grounds*", South Taranaki Bight	●	9	Dog cockles / Foul / coral / sponges	●	Gillespie & Nelson 1996, Rowden et al. 2004, Beaumont et al. 2013
North and South Traps and Graham Bank, South Taranaki Bight		3	Sponges / sponge weed / lace coral / shell hash	●	DOC unpublished data
Offshore sponge and coral, South Taranaki Bight		3	Sponges		
Cook Strait Canyon		2	Coral / Sponge	●	Lamarche et al. 2012
Cape Campbell and east coast South Island		1	Foul / kelp	●	Davidson et al. 2011
"*Wireweed"* tubeworm beds, Pegasus Bay and North Canterbury shelf	●	3	Tubeworms	●	Fenaughty & Bagley, 1981, Carter & Carter 1985, Probert & Anderson 1986
Sea Tulip (kāeo) beds, South Canterbury Bight		3	Sea tulips	●	occurrence in TRAWL database
Oamaru and Dunedin kāeo beds		3	Sea tulips	●	Graham 1962
"*The Hay Paddock*", Oamaru	●	4	Tubeworms / sponges	●	Graham 1962
Otago Shelf canyons		2	Foul / sponges / bryozoans	●	Probert et al. 1979
The "*Cornflakes*"; Otago shelf bryozoan thickets		5	Bryozoans	●	Probert et al. 1979, Batson, 2000, Batson & Probert 2000 etc.
Kāeo patches, Foveaux Strait		3	Sea tulips	●	occurrence in TRAWL database

Key Sites	Fishing Impacts observed?	Frequency of ID by fishers	Habitats	Science info	References
Bryozoans and oyster beds, Foveaux Strait	●	2	Bryozoans / shell hash / sponges	●	Fleming 1952, Stead, 1971, Carbines & McKenzie 2004, Carbines & Cole 2009, Cranfield et al. 1999, 2001, 2003, 2004, Jiang & Carbines 2002, Michael 2007
Mutton-bird Islands (southern chain), Stewart Island		2	Foul / coral	●	Otago Uni (unpublished)
West of Codfish Island; Mason Canyon	●	3	Bryozoans / coral /Foul		
Offshore of Chalky Inlet, Fiordland	●	3	Bryozoans / coral /Foul	●	Otago Uni unpublished
Kahurangi Shoals and “*Heaphy Valleys”*, West coast, South Island		1	Foul / Coral		
“Tarakihi weed” / sea pen patches of Hokitika and Cooks Canyon	●	2	Sea pens / boulders		
Bryozoan reefs of Separation Point, Tasman / Golden Bay	●	2	Bryozoans	●	Saxton 1980a, b, Bradstock & Gordon 1983, Grange et al. 2003
Bryozoan reefs off D’Urville Island, Tasman Bay	●	4	Bryozoans / sponges	●	Bradstock & Gordon 1983
East coast D’Urville Island, Malborough Sounds	●	3	Bryozoans	●	Davidson et al. 2010
French Pass, Malborough Sounds	●	3	Bryozoans / sponges	●	Davidson et al. 2011
Inner Pelorus Sound - Popoure Reach, Malborough Sounds		1	Sponges		
Other Sites where science information was found					
Middlesex Bank	●	1	Coral	●	bryozoan samples, Rowden et al. 2004, sediment composition, Nelson & Hancock 1984
Table Cape, Mahia Penninsula		1	Sponge / Coral	●	NIWA unpublished, Shears & Babcock, 2007, Smith et al. 20013
Inshore reefs, North Taranaki Bight		1	Sponges / kelp / Reef	●	Battershill & Page, 1996 - Parininihi Marine Reserve. Miller et al. 2005 - the Sugarloaf Islands Marine Protected Area

Key Sites	Fishing Impacts observed?	Frequency of ID by fishers	Habitats	Science info	References
Kapiti Island Reefs		2	Reef / Kelp	●	Shears & Babcock 2007, Battershill et al. 1993
Paterson Inlet, Stewart Island		1	Mixed shellfish	●	Otago Uni (unpublished)
George & Caswell Sound, Fiordland	●	1	Coral / Black coral	●	Grange & Singleton 1981, Grange 1985, Nelson et al. 2002, Willis et al. 2010
Doubtful Sound, Fiordland	●	2	Coral / Black coral	●	Grange & Singleton 1981, Grange 1985, Nelson et al. 2002, Willis et al. 2010

Maurstad (2002) has highlighted the intellectual property rights and confidentiality of information provided by fishers; it is of paramount importance that thoughtful decisions are made about how and what to present to protect individuals and the collective group, to ensure continued cooperation/collaboration in the future. A theme running through almost all interviews was a general mistrust and concern for how the data would eventually be used, with fishers naturally concerned about future restrictions accessing fishing grounds. Although protection of vulnerable biogenic habitat sites is likely to be a key target, where such habitats are identified and mapped, it is possible to involve the fishing industry in such a process to ensure the outcome is workable for all parties. As an example, recent cooperation between scientists and the fishing industry in Europe led to careful area closures to protect areas where cold water corals remained undamaged, minimize impacts on the industry, whilst making sure that any changes in fleet fishing patterns did not impact elsewhere on the environment (Hall-Spencer et al. 2009). A similar engagement and collaboration process would be beneficial in New Zealand, so that fishers are informed and empowered along with other groups in any decision-making process, with the objectives being to ensure protection of key habitats, balanced with minimizing impacts on the fishing industry, and potentially even increasing fisheries production. Working closely with the fishing industry into the future would also be of particular benefit given the amount of undocumented habitat knowledge that undoubtedly still exists for some areas. In addition, fishers unsurprisingly revealed extensive knowledge of fish movements and behaviours on occasion (not reported here), and we suggest further research targeting the capture of knowledge on fish population dynamics, spatial and temporal habitat use patterns, and how the associated fisheries operate would be a valuable exercise.

With the above caveats in mind, the maps and site descriptions presented here represent a valuable, but in many places, unverified indication of where biogenic habitats might exist on the New Zealand continental shelf, and as such are intended only as a starting point to inform the design of future field sampling (consistent with the Specific Objective) and are not analysed further. Many fisher-drawn areas were drawn on maps at a relatively coarse resolution, and in some instances may include a large proportion of non-biogenic habitat. Alternatively, the biogenic habitat may well extend beyond the boundaries of the area indicated by an individual, or may no longer be present due to historical changes. The true identity of species, and extent of the habitats described, in most cases can only be guessed at until samples can be collected and identified, and the habitats properly mapped.

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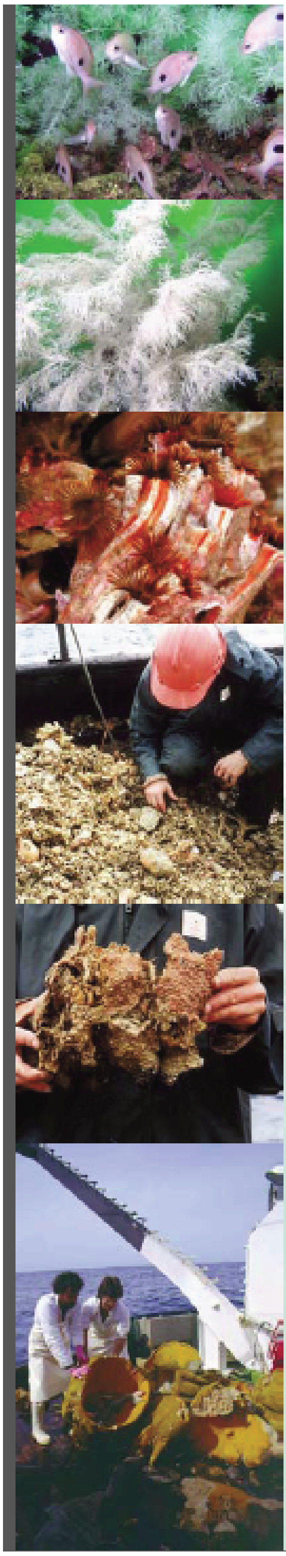
9. APPENDIX 1



NIWA
Taihoro Nukurangi

Biogenic habitats and their value to New Zealand fisheries

Fishermen have a long-term and deep understanding of the marine systems that they have fished over the years, the result of spending more time and effort on the water than scientists are able to. This experience includes seeing many things that may be quite uncommon, such as areas of unusual habitat, or species doing things that are unexpected.

We would like to learn from such knowledge, so that we can better understand how marine systems work. One of the things that we are especially interested in is the distribution and ecological role of biogenic habitats on the continental shelf – from the shore to 200 metres water depth, including their potential function as fish nurseries.

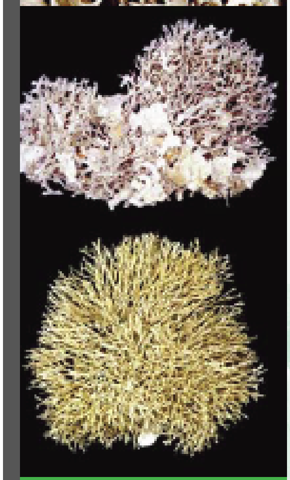
What are biogenic habitats?

Biogenic habitats are 'living' habitats created by the physical structure of the plants or animals themselves. Examples include sponge gardens, corals, bryozoans, tube-worm mounds, and seaweeds. Fish depend on healthy habitats to survive, feed and reproduce. Different species are supported by different habitats and for any one species, certain habitats may be more important at different stages in their life. For example a recent study has demonstrated the critical importance of seagrass beds and other habitats in the Kaipara Harbour as a nursery for snapper from the entire west coast of the North Island (see attached article). These studies show that productive commercial and recreational fisheries are inextricably linked to healthy marine habitats which help support fishing communities both now, and for generations to come.

Can you help us?

To identify the most important sites, we want to learn from the extensive and long-term knowledge of fishermen. Such local knowledge is hugely valuable, built up from years of fishing experience, effectively sampling a much wider area of the seabed far more frequently than scientists are ever able to.

We would like to interview experienced fishermen from different areas who would be willing to help us identify locations where they have observed benthic organisms (such as sponges and corals), at abundances high enough to form 'biogenic reefs'. These may be places you know by nicknames that relate to the unusual things you catch there (e.g. "The Coral Patch", or "The Hay Paddock"). They could also be places where you once fished and found unusual things, or places you think are important for juvenile fish because of certain features. These will not necessarily be places where the most adult fish are caught.



Can we interview you?

We would like to conduct face-to-face interviews that will last around an hour, using nautical charts, and a variety of pictures and specimens, to help identify where such places occur, and what is found in them. You can remain anonymous if you wish.

We are especially interested in the role biogenic reefs and habitats may play as juvenile fish nurseries. As a result of our interviews, we hope to be able to identify sites around New Zealand that support different types of biogenic reefs/habitat, from which we will select a sub-sample for scientific study. This will involve mapping sites with high resolution multi-beam sonar, and the use of night-time flown video cameras to count and measure fish sleeping on the seafloor and quantify their associations with the biogenic habitats themselves. We will also collect biological samples and information on the environmental conditions in these places, to help us understand why biogenic habitats are found in certain places and not others. Ultimately, we want to know what their role is in ecosystem functioning, including as juvenile fish nurseries, and which habitats are the most valuable in terms of supporting ongoing fisheries production.

Please ring or email any one of the following if you are prepared to be interviewed or want to know more:

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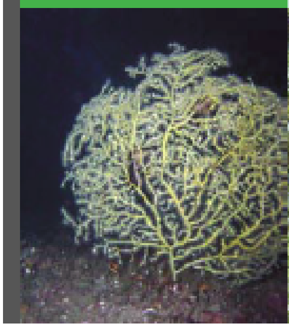

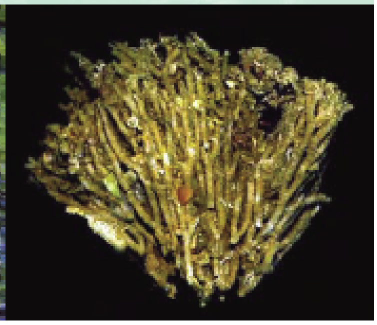

10. APPENDIX 2 - Narrative summary by area of fisher recollections

The content of this Appendix has been removed to protect informant confidentiality. A version of this AEBR with Appendix 2 in its complete form is stored by MPI Wellington (contact Science.Officer@mpi.govt.nz).