JDB: 8 March 2020

Subtidal soft-bottom biodiversity of the Bay of Islands and its vulnerability to the physical impacts of fishing

A report prepared for *Bay of Islands Maritime Park Inc.*

John Booth

Summary Subtidal soft-bottom biodiversity of the Bay of Islands is appraised, with focus on areas/communities prone to physical damage from fishing. Some of these seafloor communities are of national (even international) significance, most risks from fishing deriving from commercial bottom trawling in waters >50 m depth and recreational scallop dredging in waters <20 m. It may be that relatively little physical damage by fishing has been sustained in these areas over the past few decades (the greater impact having been brought about by terrestrially-derived sedimentation), and it is important to ensure that key areas remain secure from the physical impacts of fishing. This contribution helps inform Bay of Islands Maritime Park Inc.'s appeal to the Environment Court to uphold the decision of the Court of Appeal that the Bay of Plenty Regional Council can and should control fishing where it negatively affects physically to a significant extent the native biodiversity. Although the Bay of Islands is the main focus, much of the korero applies to other inshore waters of Northland. Recommendations from this study are that 1) recreational dredging of any form be banned from all waters of the Bay of Islands; 2) any other similar harvesting technique developed in the future involving gear being dragged along seafloor be outlawed; and 3) bottom trawling be discouraged, or banned altogether, from all waters of the Bay of Islands.

1. Introduction

In the recent Appeal Court decision (ATTORNEY-GENERAL v THE TRUSTEES OF THE MOTITI ROHE MOANA TRUST & ORS [2019] NZCA 532 [4 November 2019]), the court ruled that regional councils may not only control fishing practices in their rohe, but may be obliged to do so, where these practices impact physically to a significant extent on native biodiversity. This authority that now lies with regional councils potentially changes radically the previous situation, where the Ministry for Primary Industries alone was required, by the Fisheries Act (1996), to 'avoid, remedy, or mitigate any adverse effects of fishing on the aquatic environment'.

This development emerges at a time when essentially all maritime countries world-wide are realising the necessity and urgency of protecting seafloor biodiversity from the harmful physical impacts of fishing – not simply for altruistic reasons, but also because biodiversity is key to the productivity of many fisheries.

> Regional councils have specific management responsibilities over coastal waters and habitats which lie within New Zealand's territorial seas out to 12 nm offshore. In the face of increasing use of coastal resources, regional councils must recognise and provide for the matters of national importance listed in Section 6 of the Resource Management Act 1991 (RMA). In particular regional councils must provide for the preservation of natural character (which includes an ecological element) (Section 6a) and protection of indigenous vegetation and fauna (Section 6c). They also must give effect to the policies on natural character in the New Zealand Coastal Policy Statement 2010 (NZCPS). Additionally regional councils need to

take into consideration the New Zealand Biodiversity Strategy 2000 (NZBS) to halt the decline in New Zealand's indigenous biodiversity, maintain and restore a full range of remaining natural habitats and ecosystems to a healthy functioning state, enhance critically scarce habitats, and sustain the more modified ecosystems in production and urban environments; and do what else is necessary to protect a full range of natural marine habitats and ecosystems to effectively conserve marine biodiversity. These are statutory obligations, not just a commitment (MacDiarmid et al. 2012a: 7).

This contribution is undertaken to help inform Bay of Islands Maritime Park Inc.'s appeal to the Environment Court for the decision of the Court of Appeal in the case of the Bay of Plenty Regional Council mentioned above to be applicable too in the rohe of Northland Regional Council, with the Bay of Islands the candidate area for scrutiny. It considers negative physical impacts of fishing on subtidal soft-bottom biodiversity known to be, or considered likely to be, taking place in the area inshore of a line from Tikitiki to Motukokako (Figure 1), with particular focus on fragile and/or uncommon habitats. Soft-bottom habitats are those of mud, sand and gravel, but also include biogenic substrates such as seagrass and shellhash, as well as those occurring with or on top of mud, sand or gravel, as well as soft-sediment veneers over rocky reef. Although the biodiversity of *intertidal* soft-bottom habitats can also be impacted by fishing, the only harvesting undertaken intertidally in the Bay of Islands is the hand gathering of shellfish, and the final procedures associated with seining, drag-netting and handlining from the shore; these activities are thought to have relatively little physical impact on seabed biodiversity and are not considered. In order to understand the vulnerability of the subtidal soft-bottom biodiversity in the Bay of Islands, we need to know 1) the nature and distribution of that biodiversity, and 2) the fishing methods that may impact on it.

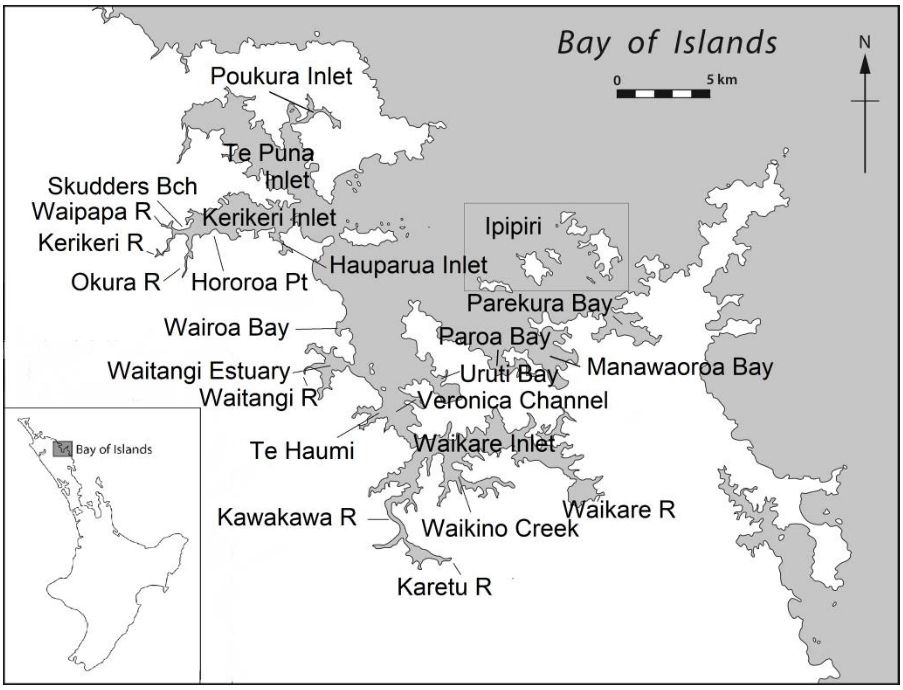

Figure 1. Bay of Islands and locations mentioned in the text. The main body of the Bay of Islands is between 30 m (thin red contour) and 50 m (inner heavy blue contour) deep. The exposed shores (wide red lines) exist in counterpoint to the relative seclusion of the estuaries (green). The large estuaries lie to the west and south, but there are also smaller estuaries in the east. Inner BOI_contour ov – estuaries Needs Ipipiri, Otehei Bay, Te Miko, Kahuwera, Waewae, Urupuk, Maunga, Wairoa, Poroporo Channel, Motukiekie passages

2. Physical and biological setting

Bay of Islands (Figure 1) is a coastal inlet of about 180 km^2 surface area (Heath 1976) on the east coast of Northland, many of its numerous islands marking the summits of what once were hills. The underlying geology is predominantly greywacke, the resultant soils and clays being prone to erosion and aquatic leaching. Bay of Islands lies in a warm-temperate zone with strong subtropical and tropical influences, particularly during summer, with surface waters reaching 20–22° C in late summer and dropping to 13–16° C in late winter (Booth 1974). Extensive estuarine and tidal reaches flow into the mainly 30-50-m deep main basin of the Bay, where depths reach 80 m near the entrance. The semi-diurnal tides have amplitudes of 2.0 m and 1.5 m for spring and neap highs respectively, and the Bay is reasonably well-mixed, one estimate of the residence time for waters being 19 tidal periods (Heath 1976). Tidal streams are generally weak except at the restricted mouths of estuaries and between islands, where speeds can reach 0.5-1.25 $m.sec^{-1}$ (MacDiarmid 2009: 173).

Except for central parts where there is extensive rocky reef, soft sediments dominate the seafloor of the Bay of Islands: fine sediments are widespread in the estuaries and in the deeper parts of the main-basin (>30 m), with more-sandy sediments being most widespread in intermediate areas (Figure 2; also Bostock et al. 2010).

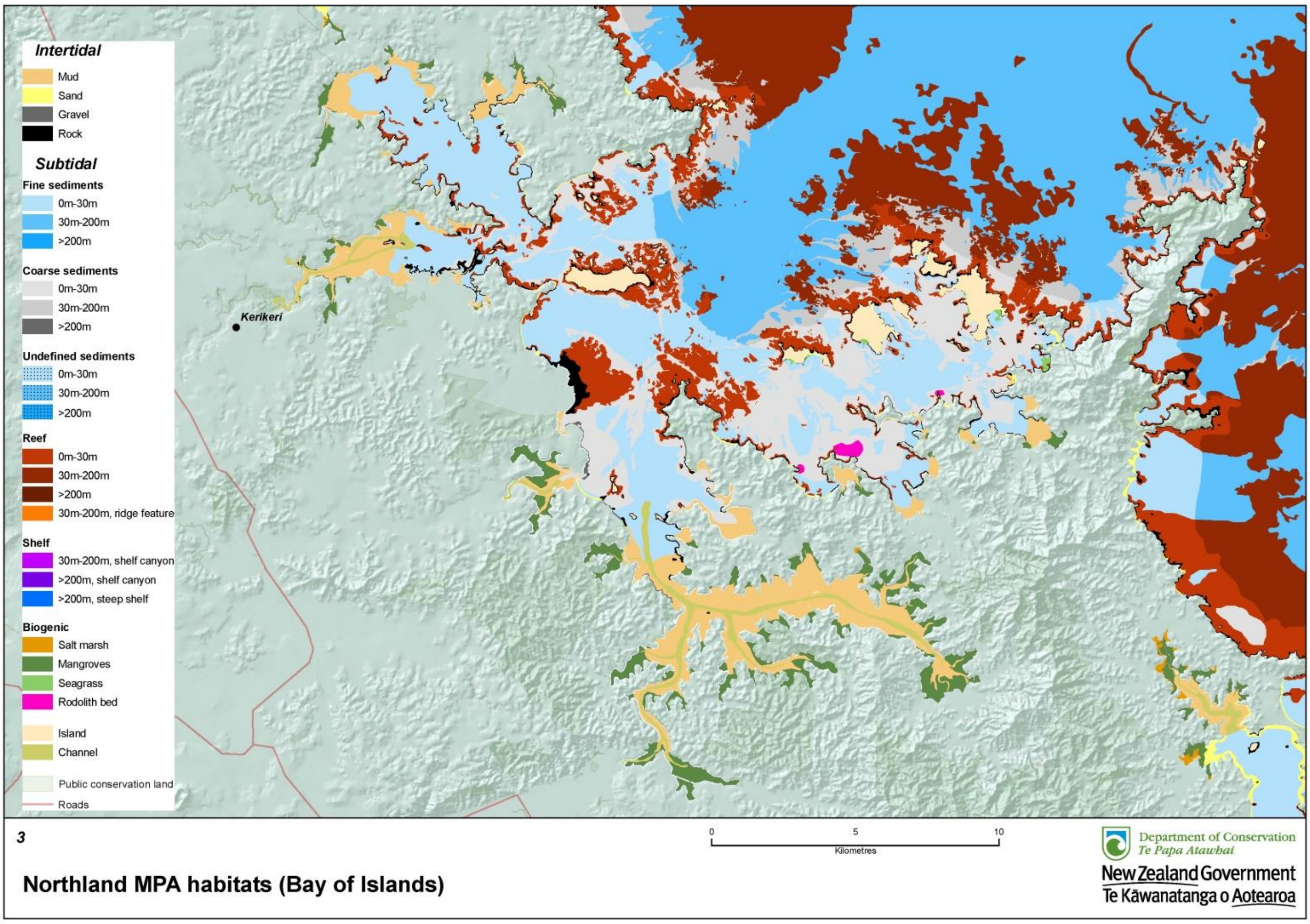

Figure 2. Habitat map of the seafloor of the Bay of Islands (Kerr 2009).
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Certain parts of the Bay of Islands have been the focus of studies of community structure more detailed than can be illustrated in Figure 2, the first having been the south end of Urupukapuka Island (Hayward et al. 1981; Figure 3).

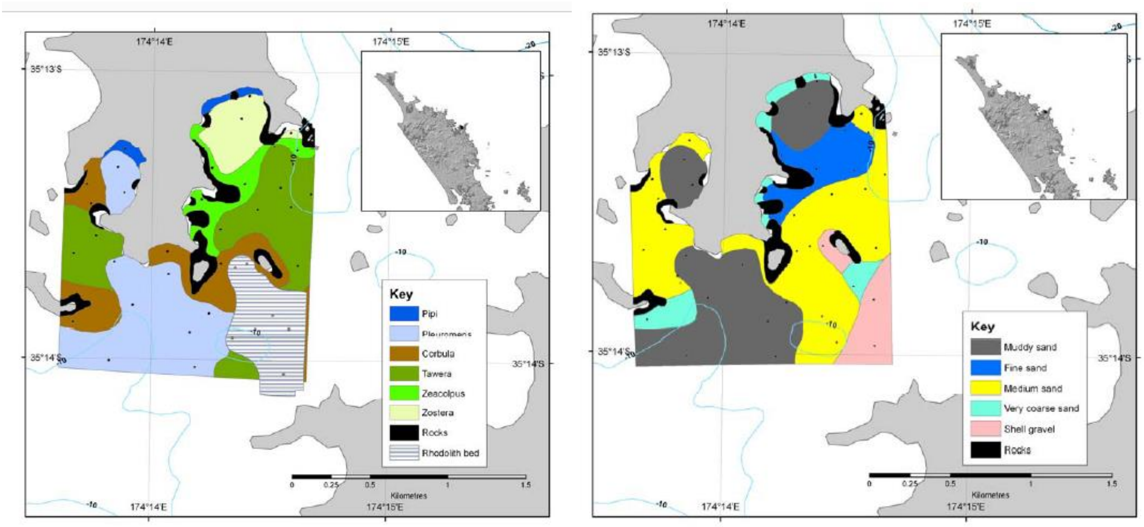


Figure 3. Dominant benthic species (upper) and benthic habitats (lower) of the south end of Urupukapuka Island (Hayward et al. 1981, as recast by MacDiarmid et al. (2009).

The extent of the rhodolith (calcareous red algae, examined in more detail below) beds near Kahuwera Point and Te Miko (Nelson et al. 2012) (Figure 5), and biodiversity within the areas of the proposed Waewaetorea and Maunganui Bay Marine Reserves (Kerr & Grace 2015; Kerr 2016) (Figure 6), have also been studied and reported.

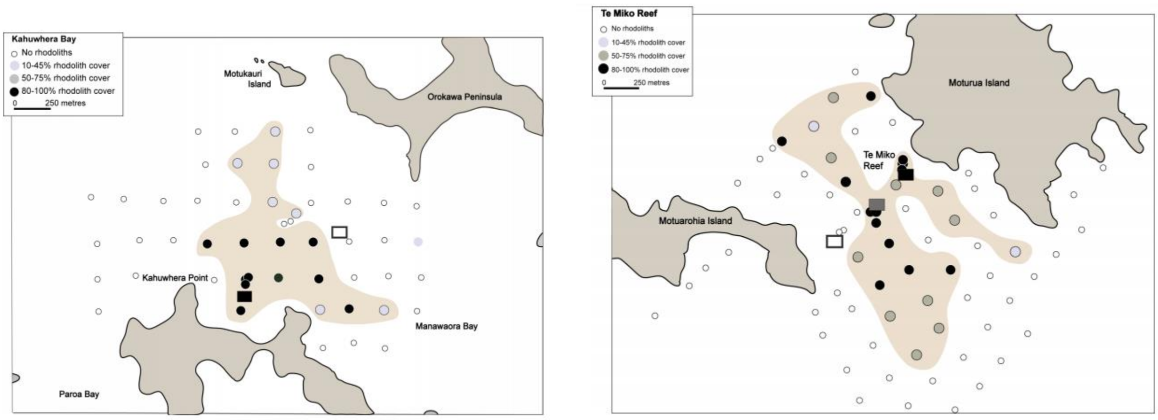
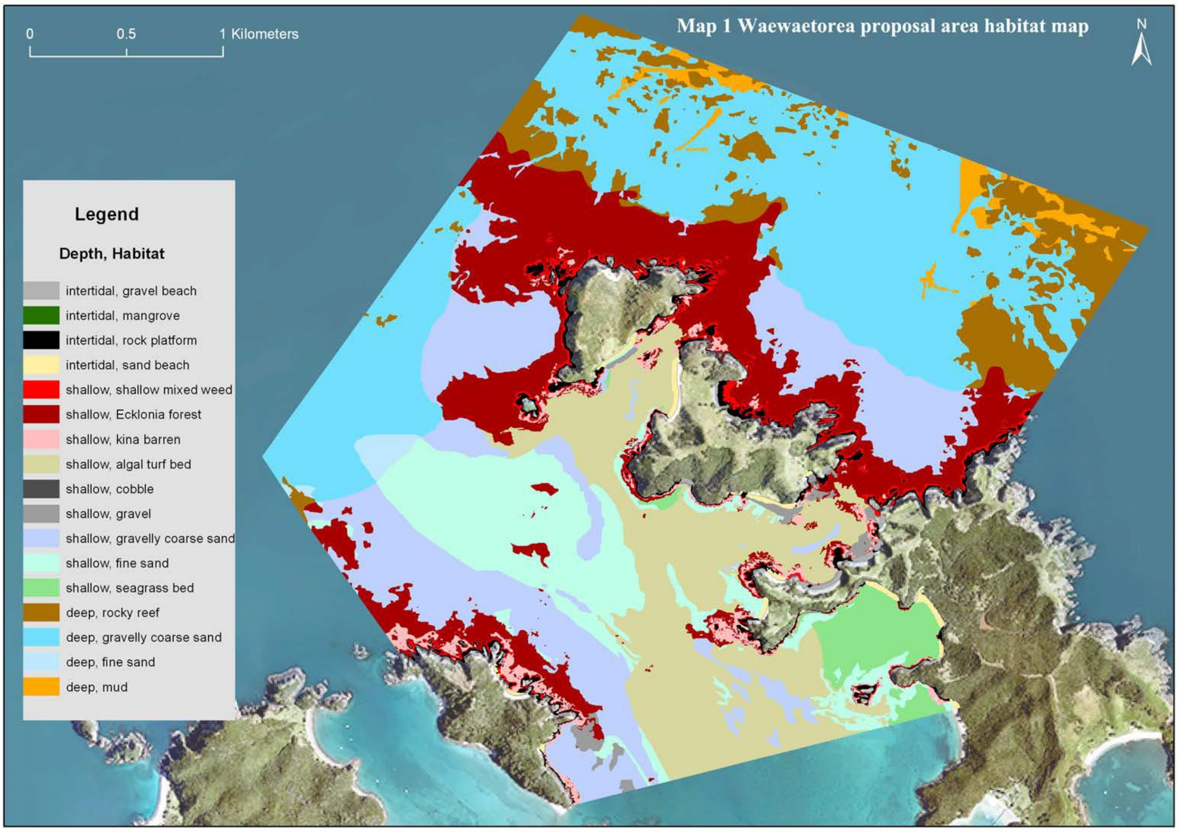


Figure 4. Distribution of rhodolith beds near Kahuwera Point (upper) and at Te Miko (lower) (Nelson et al. 2012).



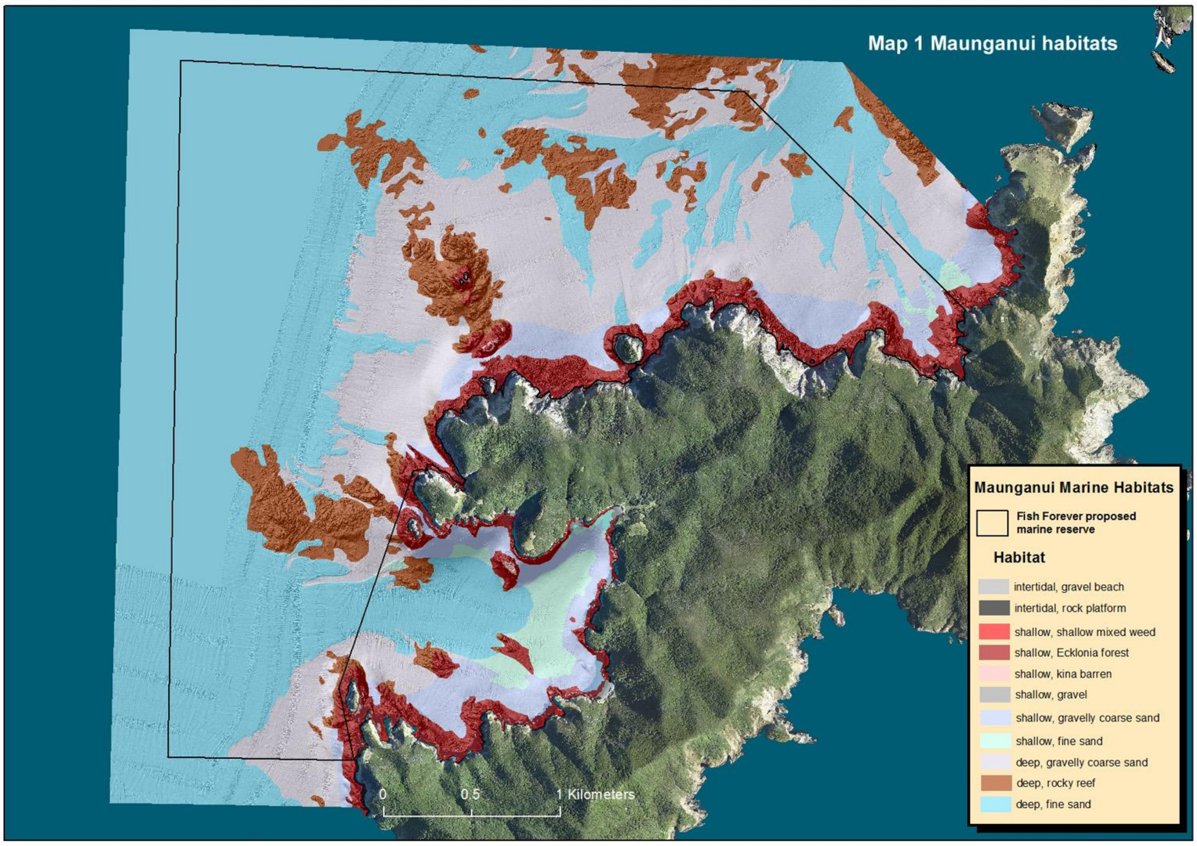


Figure 5. Habitat maps for the region of Waewaetorea (upper) and Maunganui Bay (lower) (Kerr & Grace 2015; Kerr 2016).

In addition to these overviews, dedicated surveys of particular taxa provide insight into the distribution and nature of the soft-sediment communities of the Bay of Islands. Morley & Hayward (1999), in the 1990s (but also incorporating Hayward et al. [1981] above), undertook extensive dredge sampling (330 samples, in 0-60 m depths, sieved to 1 mm) – but only molluscs have been reported so far (Figure 6).

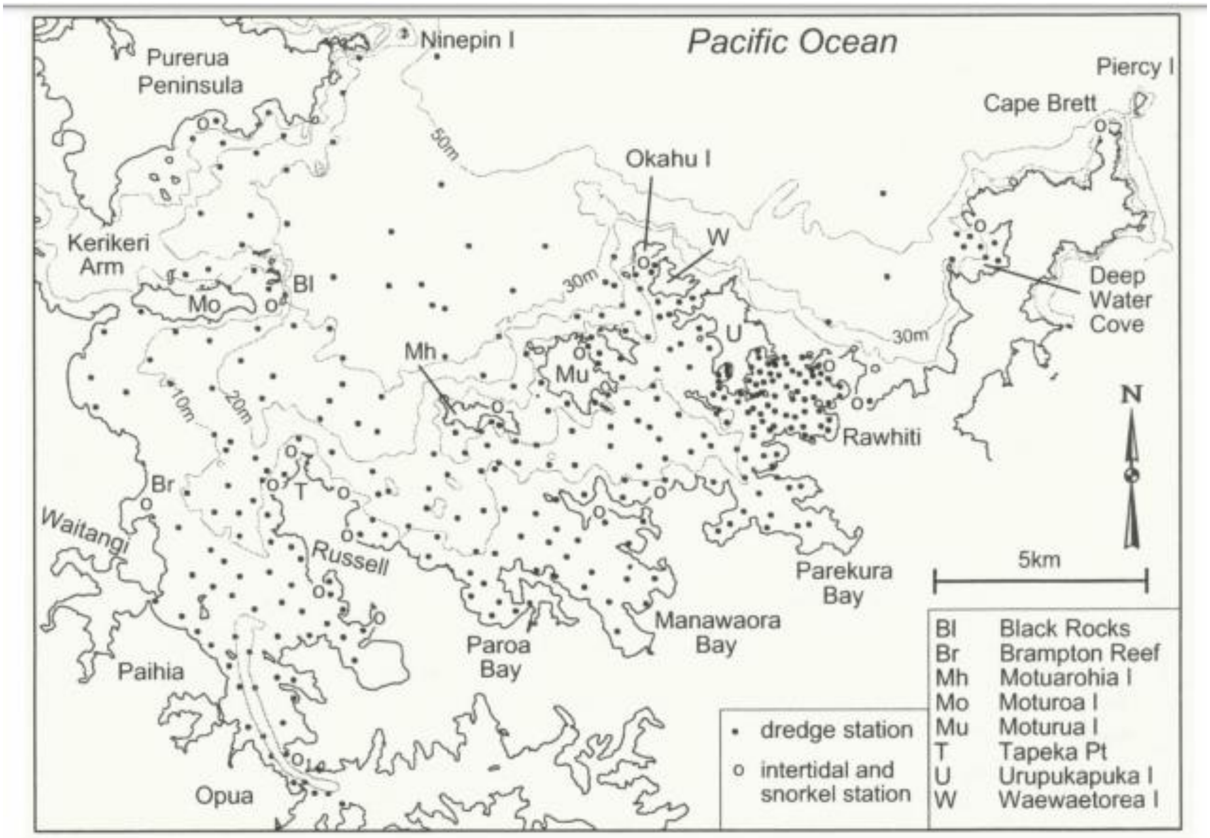


Figure 6. Distribution of the 330 dredge stations and numerous intertidal and shallow tidal snorkel surveys of Morley & Hayward (1999).

The other outstanding threat to biodiversity has been sedimentation, which in the Bay of Islands has impinged most noticeably on the margins of the estuaries (Booth 2020), but also with high accretion rates in various parts of the deeper Bay (Swales et al. 2010). Sedimentation is probably a far-greater overall threat to the biodiversity of the Bay of Islands than are the physical impacts of fishing.

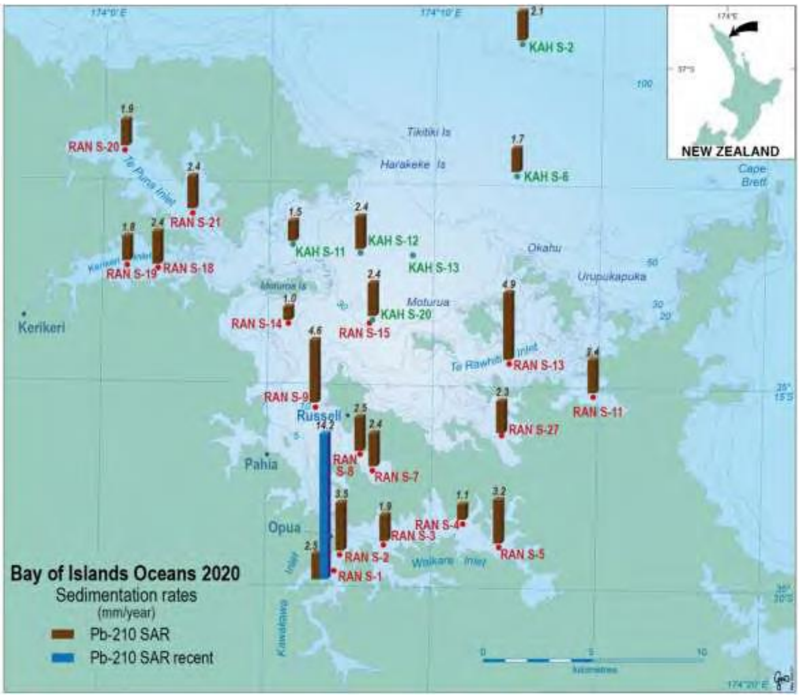


Figure 7. Time-averaged sediment accumulation rates in the Bay of Islands estimated from excess ^{210}Pb profiles measured in sediment cores (Swales et al. 2010: 47).

3. Fishing in the Bay of Islands

A variety of fish and shellfish are harvested within the Bay of Islands by commercial, recreational and customary fishers, the fishing methods used currently - and in the past - over soft seafloors being lining, handlining, seining, trawling, dredging and diving (Booth 2017). Although harvesting impacts are by no means confined to physical alteration of the seabed, such things as species abundance, size structure and genetic diversity also being affected, there are two main fishing methods impacting (actually and potentially) to a significant extent on the integrity of soft subtidal seafloors - commercial bottom trawling for finfish and recreational dredging (there is no commercial dredging) for scallops. This risk categorisation is in line with the recent high-level assessment of anthropogenic threats to New Zealand marine habitats (MacDiarmid et al. 2012: 58).

The level to which the subtidal soft-bottom biodiversity of an area has already been impacted by ground-contact fishing such as trawling and dredging depends on the history of fishing, particularly its type, duration and intensity. During the 1920s and 1930s, a total of 30–60 vessels commercially fished the Bay of Islands and its immediate environs (Figure 8). Set-netters and liners dominated this early fleet - just as they do today. For Northland generally, sail and row boats were overtaken by a progression of more-efficient commercial methods: beam trawlers from about 1899; long liners from about 1912; steam trawlers from about 1915 (although not, it seems, within the Bay of Islands); Danish seiners from about 1923; and pair trawlers during the 1970s to 1980s (Parsons et al. 2009). And soon after the war, rock lobster vessels joined the fishing fleet, the only fishery to be almost entirely reef-focussed.

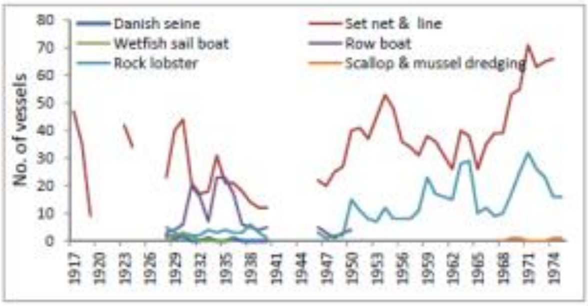


Figure 8: Indicative numbers of commercial fishing vessels for Bay of Islands (Russell), 1917–75 (from Booth 2017), much of this fishing taking place over soft seabeds.

Bottom trawling is one of the least selective fishing methods, having severely modified benthic ecosystems and fish populations around much of New Zealand (eg, Thrush et al. 1998; Beentjes & Baird 2004; Tuck et al. 2017). Commercial only, it involves towing a cone-shaped mesh bag behind a vessel along the bottom (Figure 9), all fish, invertebrates, and debris entering the net and not passing through the mesh being caught and landed.

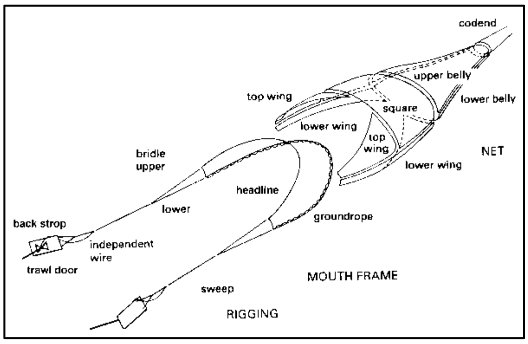


Figure 9. Diagram of a typical bottom trawl used in New Zealand waters (based on Sainsbury 1996). For clarity, the mouth frame (headline plus groundrope) is shown separately from the net to which it is attached.

Commercial bottom trawling in the Bay is spatially restricted, being permitted only in outer parts (Figure 10), and then, by its very nature, cannot take place over heavily-reefed areas (ie, central parts; Figure 2). It can, however, still take place over 'coral' (usually bryozoan-dominated) and similar such typically highly bio-diverse, biogenic features on soft bottoms (eg, Bradstock & Gordon 1983; Grange et al. 2003).

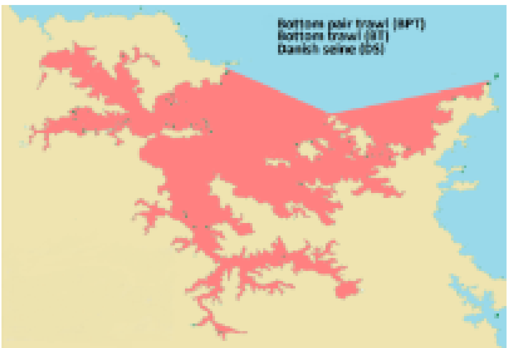


Figure 10: Commercial bottom trawling for finfish is prohibited altogether (red) but for outer parts of the Bay of Islands. Bottom pair trawling involves one trawl-net being towed by two vessels; Danish seining is a relatively benign harvesting bottom-netting method with little physical impact on seabed communities (https://www.afma.gov.au/fisheries-management/methods-and-gear/danish-seine)

The major physical impact of trawling comes from seabed contact and penetration by the gear, particularly the groundrope and doors. Trawling typically changes community species composition and diversity, reduces cover and habitat complexity, and brings about community shift (eg, Bradstock & Gordon 1983; Sainsbury et al. 1997). The level of disturbance to and modification of the benthic environment depends on the timing, severity, and frequency of trawling (Watling & Norse 1998), although low-energy zones tend to be more-severely disturbed than less-tranquil areas because they are less-frequently modified by natural forces, such that evidence of trawl tracks may last more than a year and recovery of the benthic faunal communities may take many years or even decades (eg, Tegner & Dayton 1999, Jennings et al. 2001 a,b). Even relatively modest levels of fishing effort (an area fished only once and twice per year) can reduce the density of long-lived sedentary habitat forming species as well as individual species-group densities of holothurians, crinoids, cnidarians and bryozoans by 50% (Tuck et al. 2017).

Today, only a small handful of commercial fishers routinely operate within the Bay of Islands, using mainly small (<7-m long) vessels with set nets and beach seines (Booth 2017). However, from time to time, visiting vessels line, net and trawl within the Bay of Islands for such fish as snapper, trevally, flatfish and grey mullet, and, near the entrance to the Bay, purse seine pelagic species like skipjack tuna, pilchards and mackerels.

In the Bay of Islands, the main species trawled are John dory; tarakihi; and kahawai. General spatial overviews of fine-scale trawl catch and effort in Statistical Area 003 (the broader finfish management area in which the Bay of Islands is located), and within the Bay itself, for the 2007–08 to 2012–13 fishing years (the most-recent data routinely available) show an average of fewer than a dozen individual shots each year of (a 'standard' bottom trawl typically lasts xx hours and covers around x km of seafloor) (Figure 10; Booth 2017: 35) - low levels of effort when compared with other parts of Northland and further south (see Booth 2017). There seems little reason to think that this situation has changed much since 2012–13.

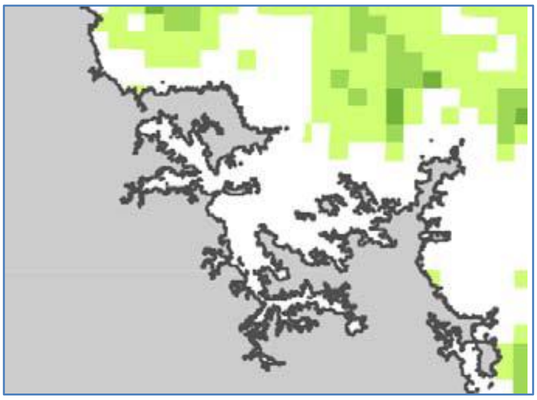


Figure 11. Spatial pattern of average annual number of trawl events starting in each 1 nautical mile grid for 1 October fishing years 2007–08 to 2012–13 in and near the Bay of Islands (from Booth 2017). The five categories, from lightest green, are 0–1 event, 1–2 events, 2–3 events, 3–5 events and >5 events. The level of trawl-effort being applied in this area is low when compared with other parts of Northland and further south (see Booth 2017: 36).

In summary, the impression is that trawling within the Bay of Islands is not particularly intensive (large areas are closed to trawlers; reef negates trawling in many places; and fishing-events take place at relatively low frequencies - up to about one per year); and it appears neither of the towed video sampling systems used in the 2009 Oceans 2020 surveys (http://www.os2020.org.nz/) of the

Bay (DTIS and Dropped Underwater Video [DUW] - discussed below) identified trawl tracks or other damage to the seabed (Jones et al. 2010 and Bowden et al. 2010, searched using the terms 'trawl' and 'damage'), although apparently few observations were made in potentially-trawled areas (Bowden et al. 2010: 25). Further, it seems doubtful that bottom trawling has ever been particularly intensive within the Bay of Islands - and certainly not for at least the past 30 years – meaning that much of the soft-bottom seafloor *may* be little modified from its pristine condition. Unsurprisingly then, although a crude measure, the patterns and nature of demersal fish communities of the Bay of Islands area in 2009 were similar to the two historical (1990s) trawl surveys (Jones et al. 2010: 29).

In contrast, **recreational dredging** is spatially and temporally unrestricted, and - although it is thought to be presently undertaken almost entirely in the southeast among the islands of Ipipiri and near adjacent shores – it can potentially take place over large tracts of soft, inner seafloor of the Bay of Islands.

Dredging involves towing a mesh-backed frame (Figure 12) across the ocean floor to sift out target species and is typically more-invasive and less-selective than most trawling operations (Beentjes & Baird 2004: 4-5). Although there has been no commercial dredging of any sort for years in the Bay of Islands (and then, apparently, at low levels; Figure 8) - scallops have been, and still are, dredged recreationally.

Figure 12. A typical recreational scallop dredge, weighing ~10 kg; the scale is 50 cm.

The level of damage depends on the nature of the substrate, the type of dredge, and the extent to which the dredge bites into the substrate, dredging for the surface-living scallop being less invasive than dredging that targets buried animals such as surf clams. Impacts are particularly pronounced when the frequency of disturbance occurs at intervals less than the time for recovery and in places where growth tends to be slow and where recovery from a single fishing event can take years (Watling & Norse 1998, Collie et al. 2000a).

The effects of commercial scallop dredging on the benthos are relatively well studied, including on the northern-New Zealand scallop grounds (Thrush et al. 1995, Thrush et al. 1998, Cryer et al. 2000, Ministry of Fisheries 2007: 66; Tuck et al. 2009, Tuck & Hewitt 2012; MPI 2019: 413). Mechanical contact with the seafloor can remove three-dimensional habitat structure, interfere with sediment biogeochemical functions, cause resuspension of fine sediments, and remove and kill many non-target species (Morrison et al. chapter 14 2010: 10). Generally, with increasing fishing intensity there are decreases in the density and diversity of benthic communities and, especially, the density of emergent, often-fragile epifauna that provide structured habitat for other fauna. Further, habitat complexity is reduced as sediment is blended to become similar over large areas, rather than there being pockets of different sediment types.

The impacts are believed to be essentially the same for *recreational* scallop dredging, even though the dredge is much smaller and lighter (Figure 12) than the commercial ones. In the mid-1990s, NIWA's study of the impact of recreational scallop dredging in the Hauraki Gulf concluded that "experimental dredging using standard northern "box" type recreational dredges failed to demonstrate any adverse effects on scallop incidental mortality, growth rates, or fecundity…. Average dredge retention efficiency for a 100 millimetre scallop was 11%." (Ministry of Fisheries 2007), but –remarkably - the study did not consider the *impacts* of recreational dredging on the seafloor environment. Although the bycatch of epibenthic species such as sponges, ascidians, and starfish was noted, and there was extensive raking of the seafloor, the report simply speculated that the potential loss of habitat structure and non-target species might be significant in areas heavily dredged by recreationalists. Such impacts are likely to have been ongoing for several decades or more, and the animal and plant assemblages present now may not be representative of what used to be there (Morrison et al. chapter 14 (2010: 10). Since then, however, more definitive statements have been forthcoming: 'There is no doubt that [recreational dredges] damage seafloor assemblages – some heavily fished gravel areas in Kawau Bay look like bare zen gardens from all the dredge passes' (Mark Morrison NIWA, pers. comm. January 2020).

The proportions of recreational scallop fishing prosecuted using dredges, compared with diving, appears to vary considerably regionally. In the early 2000s, although dredging accounted for only ~12% of the recreational scallop catch in the Coromandel scallop fishery, it provided the bulk of the recreational catch in other areas (e.g. Manukau and Kaipara Harbours, Tasman/Golden Bay and Kaipara Harbour) (Ministry of Fisheries 2007; Walshe & Holdsworth 2007).

Korero with Bay of Islands-local scallop fishers and with members of *Fish Forever* (a local community group focussed on conservation of marine biodiversity in the Bay; https://www.fishforever.org.nz/) suggest that free diving and scuba diving are by far the most-used methods to harvest scallops in the Bay of Islands. No physical indications of dredging were noted in the DTIS survey (Bowden et al. 2010), and none was apparent in the October 2009 Oceans 2020 aerial imagery, but other aerial imagery points to dredging potentially having significant impact on the nature of the seafloor in parts of the eastern Bay, defined paths through seafloor assemblages suggested in several places where scallop dredging was likely to have taken place (Figure 13). These paths take the form of single (although at one place, multiple parallel) lines that are visible only where they pass through dark-coloured seafloor features. The time required for the damage to reverse is unknown, but the nature of the seafloor biota (discussed later) suggests it is likely to be many months, if not years.

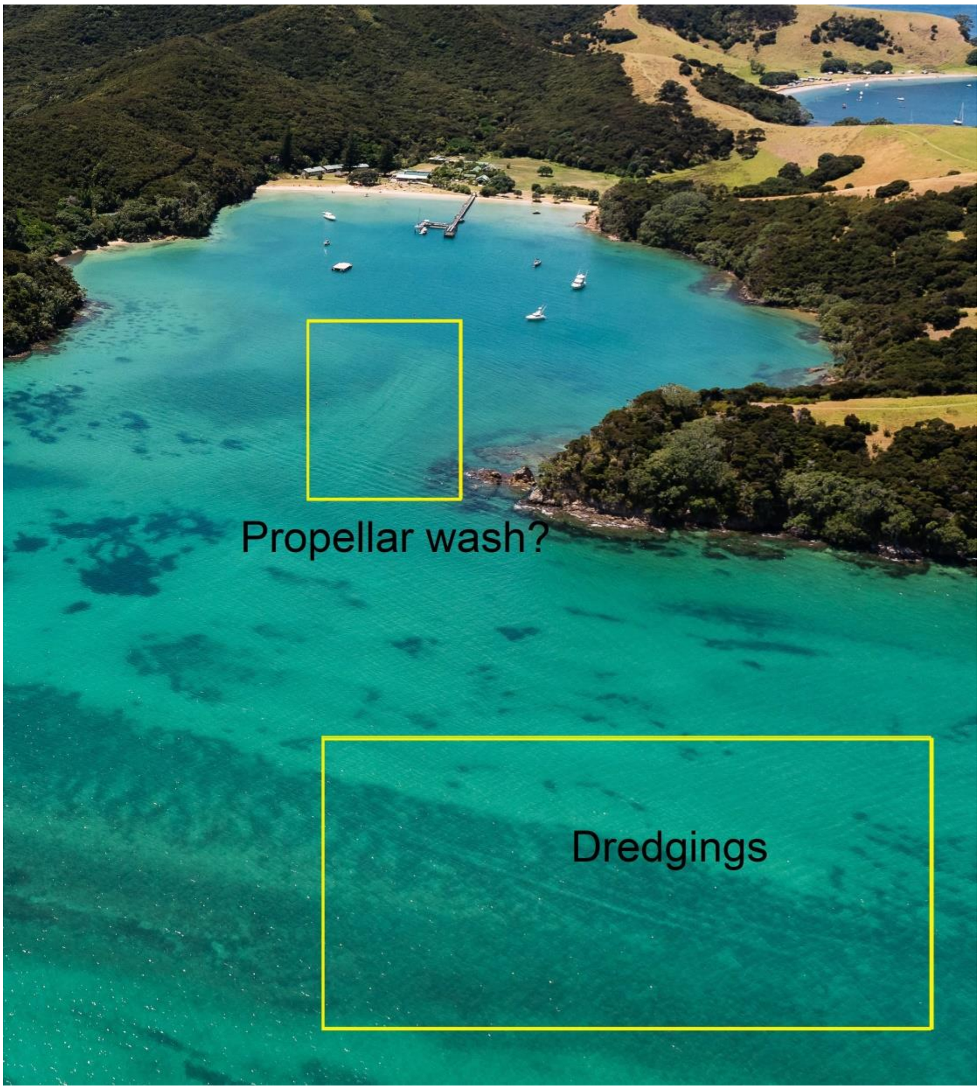

Propellar wash?
Dredgings


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Figure 13. Examples of likely recreational scallop-dredge tracks in Poroporo Channel, more pronounced and defined than what is presumed to be propeller wash in the upper part of the image (upper images) and in Motukiekie Channel (lower pair).

4. Biodiversity of subtidal soft seafloors of the Bay of Islands

Much of the subtidal soft seafloor of the Bay of Islands appears to be of apparently 'featureless' mud, sand and/or shellhash (Hewitt et al. 2010:?), where the biodiversity tends to be located mainly *within* the substrate, but - in places where the hydrodynamics and substrate material are suitable - rich biodiversity near the substrate surface and above it can develop. In this section, what are typically rare and special subtidal soft-seafloor communities at and on the seafloor prone to physical damage by trawling and dredging are characterised in some detail.

Particular focus is the waters of Ipipiri. Although high levels of biodiversity near the substrate surface and above it are likely to also occur elsewhere in the Bay of Islands, Ipipiri probably contains the greatest variety and concentration of biogenic features because of its relatively clear waters and – in places – strong tidal currents, several such communities having been identified and described. It is conceded, however, that the clear waters and the often extensive shallows make this area particularly conducive to examination.

4.1 Case-study: the shallow waters of Ipipiri

Many shallow (<20 m, but with focus on waters <8 m) areas of subtidal soft substrate among and near the islands of Ipipiri and the adjacent mainland in the southeast of the Bay of Islands (Figure 14) are relatively flat, being characterised and dominated by 1) various mixes of unattached (including rhodoliths) and attached algae, 2) dog cockles (*Tucetona laticostata*), 3) scallops (*Pecten novaezealandiae*) and 4) morning star shells (*Tawera spissa*). Certain previous studies (Booth 1972; Hayward et al. 1981) assigned particular combinations of co-occurring taxa within the Bay to specific community assemblages, or signalled it (Kerr & Grace 201x; Morley too?), but in all instances, these assignations were based on small areas (usually a few hectares at most) and may or may not have applied in the same combinations of taxa across the entire Bay. Accordingly, in this section, after a pilot assessment of the stability over time of an exemplar shallow soft seafloor interpreted from aerial imagery, the distribution of each characterising taxon as we understand them to be today is investigated individually. (Biogenic seafloors particularly significant in other parts of New Zealand, but not, apparently, in the Bay of Islands, are summarised in the appendix.) There is evidence that similar biogenic seafloors exist in other parts of the Bay of Islands, but they will not be as concentrated nor extensive.

Figure 14. The islands and adjacent mainland in the southeast of the Bay of Islands commonly referred to as Ipipiri.

Stability of shallow soft bottoms of Ipipiri. Comparison of aerial photographs over time can provide insight into how much the shallow-water communities of Ipipiri vary over time. Two shallow (2-6 m at low water) areas are examined, Poroporo and Motukiekie channels, with comparisons made over the long term (1980 versus 2009), and, for Poroporo Channel, over more frequent recent times (2009 versus 2011, 2017 and 2020). The aerial images allow insight into changes in the nature and extent of firm substrates (as confirmed by ground-truthing in February 2020); subtidal seagrass; and (mainly) brown algae cover. Both passages are protected from swell and waves and so one might expect less evidence of change over time here than in more-exposed places.

The comparisons point to both stability and a certain level of dynamism in the communities. Unsurprisingly, firm seafloor features identified in 2020 appeared similar in form and extent to earlier years, back to 1980 (Figures 15-17). On the other hand, the cover of subtidal seagrass has varied, being much more abundant in 1980 than in 2009, as has shallow-reef kelp (visible under magnification), with significant recovery of the seagrass by 2020.

Figure 15. Seafloor features of Poroporo Channel visible in January 1980 (Crown_5651_J_6_part_4 Jan 1980) (upper) compared with November 2009 (http://www.os2020.org.nz/) (lower).

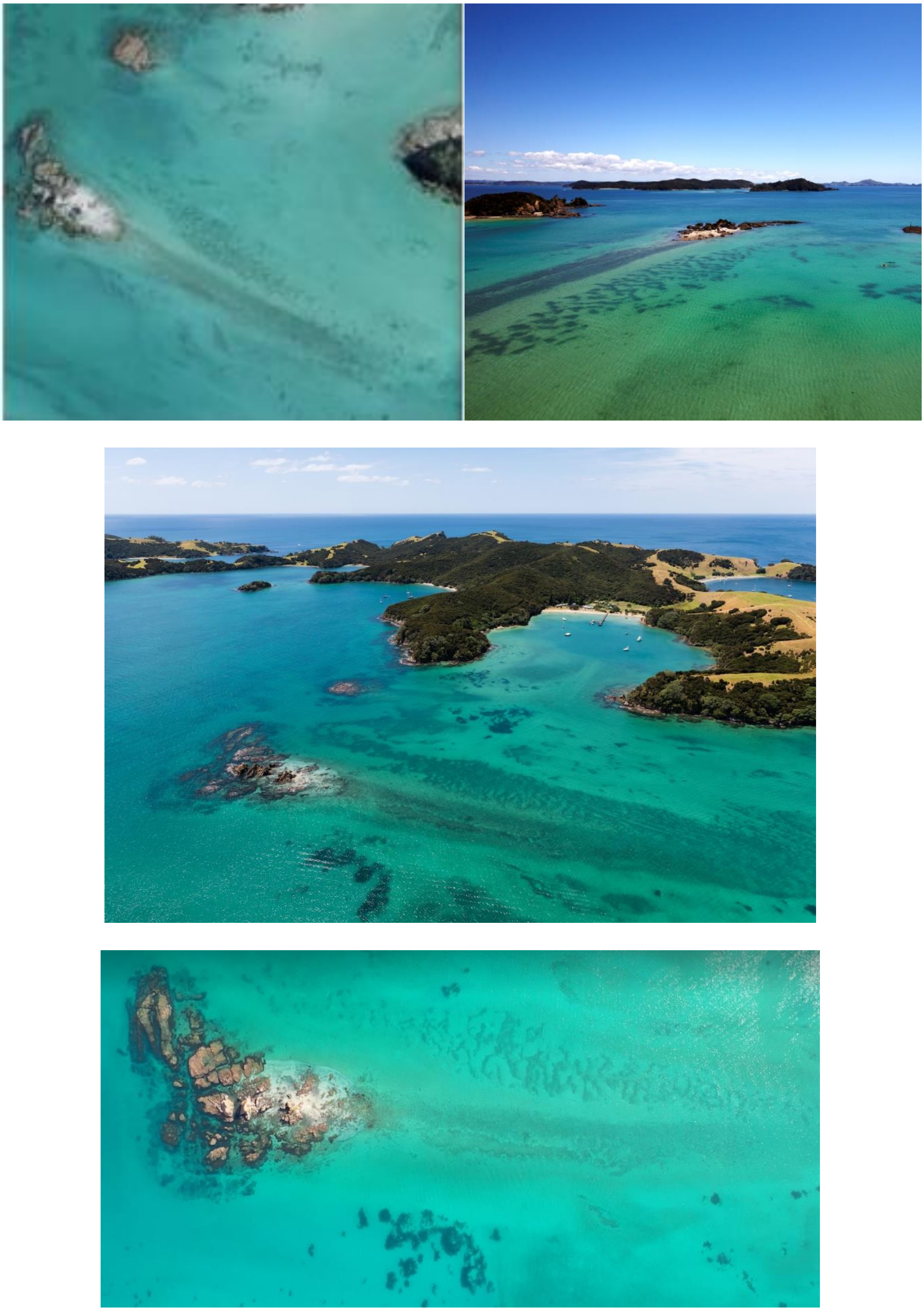

Figure 16. Seafloor features of the central part of Poroporo Channel visible in 2009 (http://www.os2020.org.nz/) (upper) compared with November 2011 (Salt Air Ltd), January 2017 (Dean Wright Photography) and February 2020 (Jay Howell).

The second area examined was Motukiekie Channel, the seafloor of which, again, seemed to be remarkably stable over time (Figure 17).

Figure 17. Seafloor features of Motukiekie Channel visible in January 1980 (Crown_5651_J_4_part_Jan 1980) (upper) compared with November 2009 (http://www.os2020.org.nz/) (lower).

Of particular interest was the biological composition of the seafloor in areas exhibiting high levels of fragmentation – a feature of many parts of Ipipiri. The area of Poroporo Channel examined (2-3 m at low tide; Figure 18) indicated patchy distribution of seafloor life dominated by algal turf comprised of various calcareous species (most being firmly attached) amidst worm fields and shell hash. Mainly in shallower areas were the only potentially mobile alga, *Hydroclathrus* (probably *clatharus*; Nelson et al. 2012) 'balls', which of were widely distributed in the area examined, but concentrated in depressions in waters 1-2 m deep (Figure 19).

Figure 18. Poroporo Channel survey area (yellow box), with boulder ridge at bottom of the box and algal turf patches at the top.

The study site progressed from a rocky ridge (LT depth 1.4 m) with depressions containing up to hundred or more *Hydroclathrus clathratus* (Figure 18); a scatter of *Codium fragile*; and, among the rock numbers of *Evechinus chloroticus* (and even a couple of *Centrostephanus rodgersii*). An occasional, small *Ecklonia* were the only macroalgae of note (until you reach the rocky reefs of the shore of Poroporo Island itself).

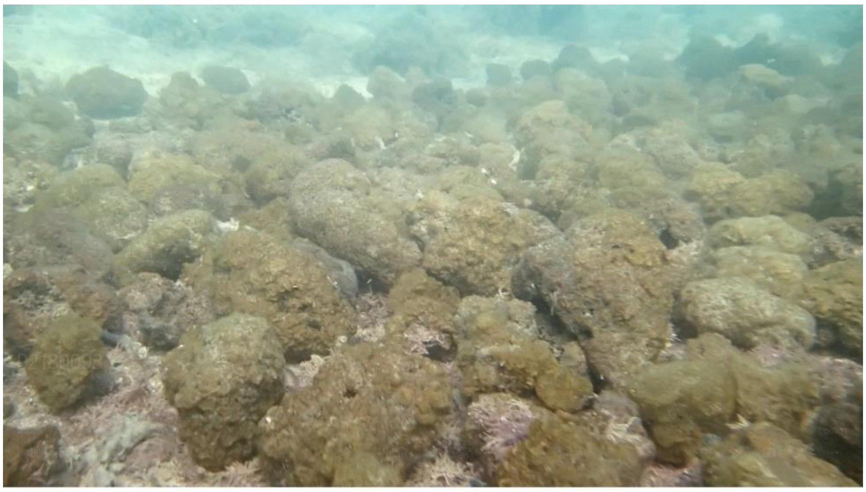

Figure 19. A concentration of *Hydroclathrus clathratus* (each ball about 10 cm in diameter); the indigenous status of this species is being discussed.

Northward, the study area is a more even-bottomed (around 2-5-3.0 m), algal-turf dominated zone (Figure 20), large patches being interspersed with coarse sand/small rhodoliths, as well as patches of dead *Tawera spissa* and a scatter of dead *Tucetona laticostata*, and living *H. clathratus*. (No subsurface sampling was undertaken but Hayward et al. [1981] had classified this area as dominated by the [living] *Tawera spissa* community.) The algal turf has all manner of smaller associates, including tubeworms, and also dead *Chaetoceros* leather-tubes.

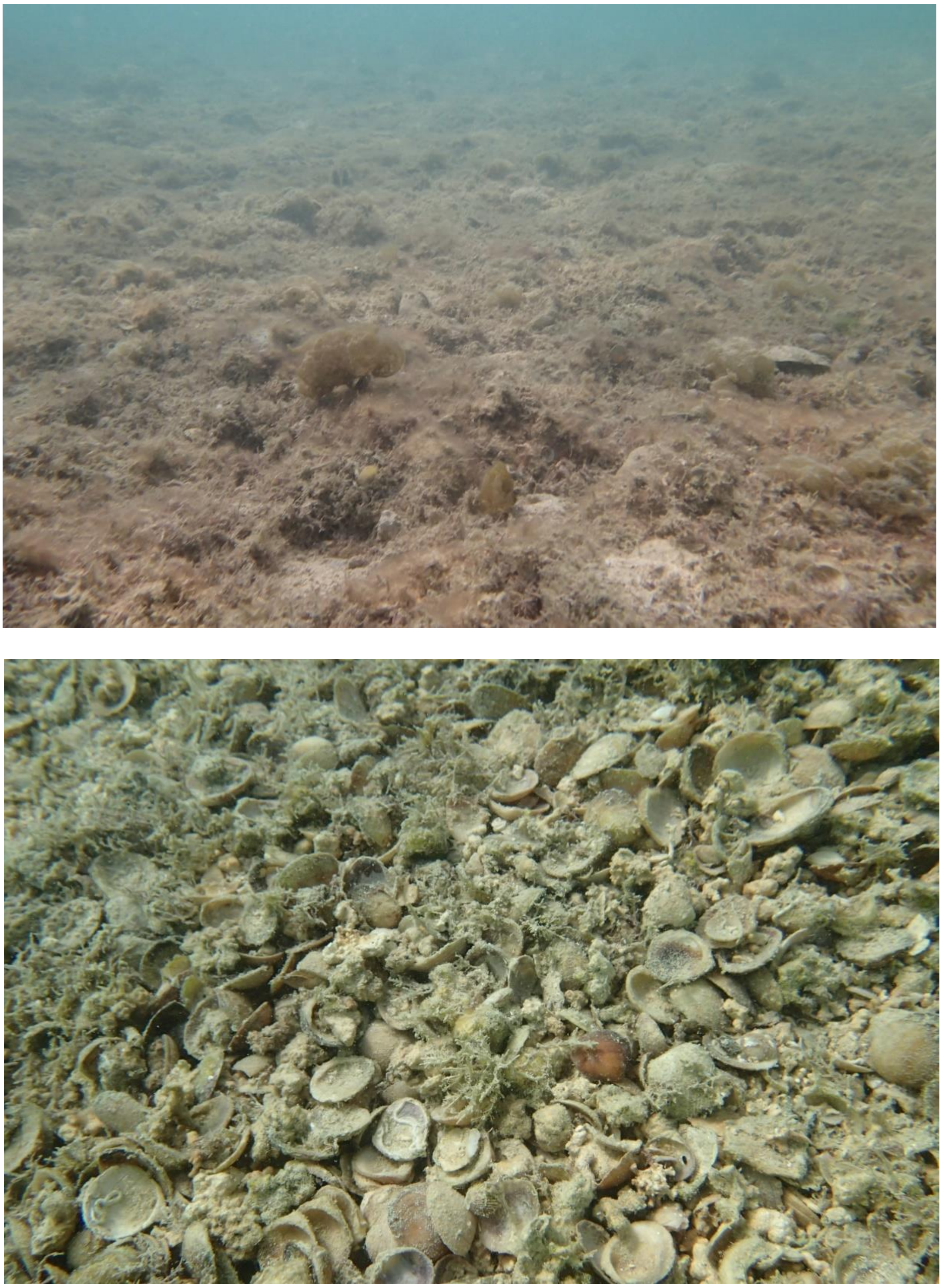

Figure 20. Algal-turf-dominated flats that characterise the northern parts of the survey area shown in Figure 18 (upper). Rhodoliths associated with shell hash within this habitat (lower).

4.2 Biogenic communities of Ipipiri

Unattached algae

The unattached algae of note are 1) living and dead rhodoliths; 2) small quantities of detached calcareous algal fragments; 3) accumulations of free-floating *Hydroclathrus clathratus*; and 4) fronds and remnants of mainly green and brown algae on soft seafloors well beyond where you would expect to find certain species (eg, *Hormosira* at depth) (Hewitt et al. 2010; DTIS observations, and epibenthic sledge collections (Chapter 12: 20). Of these, only rhodoliths are considered further.

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Rhodoliths (maerl) are free-living non-geniculate (lacking uncalcified joints) coralline algae (Farr et al. 2009). Rhodolith beds are found subtidally in areas where coarse sand, gravel or shell debris dominate, often in areas with strong currents. They are not attached to any fixed surface but rather can be rolled on the seafloor by the action of water motion. Individual rhodoliths form around shell, rock, or other material, or be may be comprised entirely of coralline algal material; an individual rhodolith may contain more than one coralline species.

Rhodoliths are long-lived and slow-growing, with individuals likely living ≥100 y (Nelson et al. 2012: 6). They are ecosystem engineers, modifying the physical characteristics of their environment through providing greater sediment stability and structure, producing a habitat that can support diverse associated fauna, and protecting infauna from surface dwellers (Neill et al. 2015). Their beds provide three dimensional structures which are a complex, intricate and often stable habitat for invertebrates, fishes and other algae, and are typically biodiversity hotspots, harbouring rare and unusual species, as well as serving as nursery areas for commercially important fishes and also scallops. Accordingly, internationally rhodolith beds have been identified as critically-important biodiversity hotspots, harbouring high diversity and abundance of marine animals and algae in comparison with surrounding habitats (MacDiarmid et al. 2013: 44: Steller et al. 2003). Associated fauna may include a wide diversity of small invertebrates and algae (including rare species), and particularly sponges, sea-stars, gastropods, and blue cod (Morrison et al. 2014: 35). Dense bivalve-maerl bed associations also occur, the most common being dense beds of the dog cockle *Tucetona laticostata* buried below the surface of shallow water maerl beds (Morrison et al. 2009, Dewas & O'Shea 2011). Further, they may be essential seedbanks for many macro- and micro-algae (Fredericq et al. 2019).

The rhodolith beds at Kahuwera Bay and Te Miko Reef (Figure 4) are characterised by two species, *Lithothamnion crispatum* (previously *L. indicum*) and *Sporolithon durum* (Nelson et al. (2012: 1, 5; Neill et al. 2015): associated biodiversity is high, including, for example, algal species new to Northland and to science (p 63; Neill et al. 2015: 74; also Dewas & O'Shea (2012: 47).

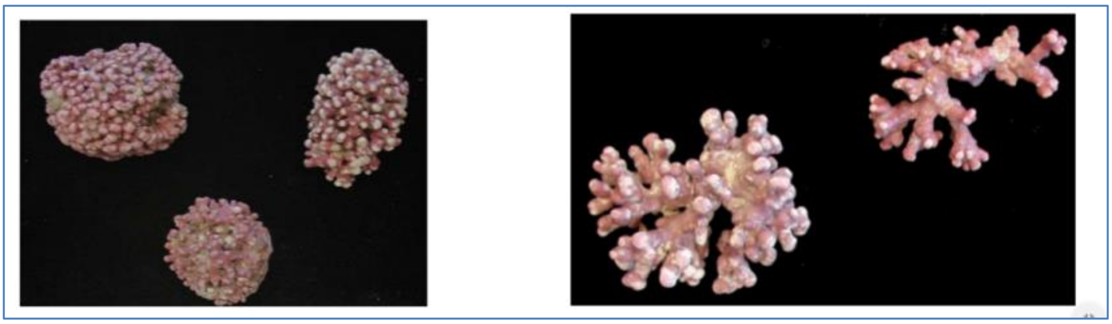


Figure 21. *Lithothamnion crispatum* (left, 4 cm) and *Sporolithon durum* (right, 7 cm) (Nelson et al. (2012).

Figure 22. ***Sporolithon durum*** **rhodolith beds (left), with algae (right) (Oc 2020).**

Rhodolith beds are likely to extend over significant amounts of Te Rawhiti Inlet (Figure 23, based on Morley & Hayward 1999); Kerr & Grace (2015: 33-34) identified scattered individual rhodoliths amongst algal turf near Waewaetorea Island; Chris Richmond and Victoria Froude (pers. comm. in Kerr & Grace 2015) reported small patches of rhodolith beds in the channel between Motukiekie and Urupukapuka; and field observations in February 2020 showed them in association with *Tucetona* shells in Poroporo Channel (Figure 20). Almost certainly they will also be present in other parts of the Bay. For example, specimens were found washed up on the shore at Wairoa (near Hohi) and at Whakapirau (Chris pers. comm.).

Figure 23. Stations in the Bay of Islands with rhodoliths (live or dead) reported by Morley & Hayward (1999) (*see* Figure 6 for distribution of stations).

The greatest physical threat to rhodolith beds comes from dredging, which disrupts the three dimensional structure of the beds (Nelson et al 2012: 66-67, although damage caused by anchoring of vessels can also be significant), and because they are long-lived and slow-growing they have limited ability to respond to or recover from damage or burial (Neill et al. 2015: 63). The risk status of both *L. crispatum* and *S. durum* is 'data deficient' (Nelson et al. 2019), but at least the beds in the Bay of Islands at Kahuwera Bay and Te Miko Reef appear not, so far, to have been unduly impacted by trawling/dredging (Nelson et al. 2012).

Attached algae

Attached algae living on soft substrates has been widely reported for the Bay of Islands and makes up characteristic biomes. Hewitt et al. 2010 were to conclude that, unlike many of other parts of New Zealand, many subtidal soft sediments locations were algal dominated, meaning that fewer habitats defined by beds of suspension-feeding bivalves and sponges. (However, coarse shell habitats with patchy tube worm mats were common, and these habitats have high infaunal diversity here and elsewhere (Chapter 11: 6, 42)). Such algal beds are obviously prone to dredge damage.

Areas of stable cobbles, stones and shell fragments can contain quite diverse algal assemblages, 40 species being found in the Bay, with six found nowhere else. Two of the most common algal species in the rhodolith beds are the red alga *Chondracanthus chapmanii* and the green alga *Caulerpa flexilis*, which appear to play a role in stabilising the rhodoliths and nearby sediments (Nelson et al 2012: 63; Neill et al. 2015). "In soft sediment habitats it [*Caulerpa flexilis*] stabilises the substrate as it has a stolon, or prostrate stem system, that anchors the alga to the substrate and produces upright branches which provide three dimensional structure for invertebrates and fishes. It can form dense mats in water depths of 3–12 m, usually at the rock-sand interface, in north-eastern New Zealand (Morrison et al. 2014: 37: Shears et al. 2004), including in the Bay of Islands (Parsons et al. 2010; Bowden et al. 2010). Other species very common in assemblages found in soft sediment sites included *Cladhymenia oblongifolia*, *Gigartina atropurpurea*, and *Sarcodia montagneana*" (Nelson & D'Archino 2010).

Figure 24. *Ecklonia radiata* growing on rhodolith beds (left), and *Chondracanthus chapmanii* growing on rhodoliths and shell debris (middle) *(*Nelson & D'Archino 2010?). *Caulerpa flexilis* in Poroporo Passage (right).

Algal turfs dominated by small foliose red algae species are widespread on soft bottoms in Ipipiri, including in the Waeweatorea area (Figure 25; Kerr & Grace 2015: 32) and in Poroporo Channel (Figure 20), and almost certainly make up the majority of the areas exhibiting high levels of fragmentation in the aerial imagery (eg, top part of boxed area in Figure 18).

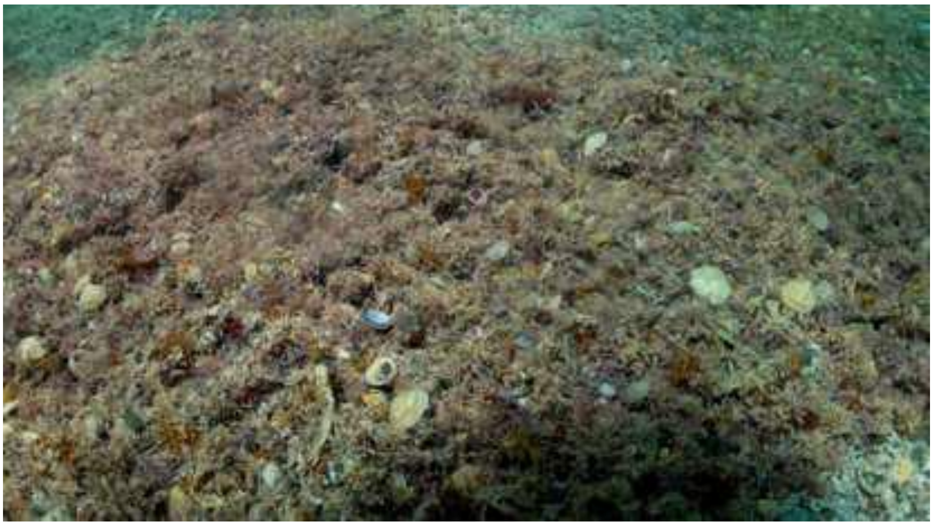


Figure 25. Algal turf habitat growing on a coarse sand, shell, and gravel substrate typical of Okahu Channel (Kerr & Grace 2015: 32).

Scallops

Scallops are important biogenic components of subtidal soft bottoms, and provide structural habitat for other epifauna (e.g., sponges, ascidians and algae) (MPI 2019: 411), and are well-known for their high interannual variability in population size (MPI 2019: 410). Overall, Bay of Islands scallops are heavily fished, and appear to occupy in any significant quantities a much-reduced geographic distribution compared with 20–30 years ago.

The principal beds in the Bay of Islands over the past 10 years have been in the east (Ipipiri), with other beds seemingly now small and diffuse. Yet scallops were once common in the northwest off Rangihoua and Onewhero, off the western side of Motuarohia, and in Maunganui Bay (Nevin 1984; Mountain Harte et al. 2007; MPI 2020 in Te Puna Mataitai), and in the 1990s, Morley & Hayward (1999) found live scallops at six sites (Figure 25), most of them well beyond the islands of Ipipiri. Scallops still persist in the northwest, with MPI (2020: 6) reporting how high levels of silt and mud had led to losses in Te Puna area, and other small pockets are occasionally reported by divers – but these are probably minor populations.

Figure 25. Stations where live scallops were reported by Morley & Hayward (1999) (*see* Figure 6 for distribution of stations).

In Ipipiri today, the main beds are 1) Albert Channel between Urupukapuka Island and the Rawhiti mainland (including Urupukapuka Bay); 2) the area between Paramena Reef, Poroporo Island and Ngatokaparangi Islands/reefs to the south of Motukiekie; and 3) Motukiekie Channel between Urupukapuka and Motukiekie Islands (Pacific Eco-logic Ltd. 2016) (Figure 26). Although population surveys of the beds have been made in this area, the sampling added little to our understanding around their *distribution* (Williams et al. 2008:7; 2009). The size-frequency histograms from the 2006 and 2007 pre-season surveys exemplified the high interannual and spatial variability in abundance characteristic of scallop populations.

Figure 26. Main scallop beds of Ipipiri.

Dredging has wide impacts on scallop and their associated biodiversity (MPI 2019: 409-10). Scallop recruitment is dependent on maintenance of structure on seafloor: 'Scallop veliger larvae spend about three weeks in the plankton. They then attach to algae or some other filamentous material with fine byssus threads. When the spat reach about 5 mm they detach and take up the free-living habit of adults, usually lying in depressions on the seabed and often covered by a layer of silt' (MPI 2019: 410). Dredging is literally killing the golden-egg laying goose; it was the primary reason for the demise of a multimillion dollar enhancement project in the Nelson region (Peart 2019). And there continues to be loss of scallop beds in a domino-like fashion around the country: the area most recently to be closed to scallop harvesting (all of which had been recreational) is Kaipara Harbour [Williams et al. 2018].

Horse mussels

The large pinnid mussel *Atrina zelandica*, the horse mussel, occurs from extreme low tide areas, down to depths of at least 45–70 m (Morrison et al. 2014: 53). They grow to >40 cm in length, anchoring the lower part of their shell in soft sediments using subsurface byssal threads. Densities range from occasional scattered individuals through to very densely packed 'beds', extending over hundreds to thousands of metres. They are relatively long lived (>10 y), and recruitment appears to be highly variable between years, meaning that beds may appear and disappear over decadal scales (e.g. Hayward et al. 1997). Usually individuals within a bed are all of similar size, suggesting discrete mass recruitment events.

Horse mussel beds often support diverse species assemblages of sponges, macro-algae, bryozoans, filter feeding bivalves, and soft corals, and mobile species such as sea cucumbers, hermit crabs, and small benthic fishes, depending on environmental setting (Morrison et al. 2014: 55). Both living and dead horse mussels are also often a component of other diverse biogenic seafloors, along with contributions from dog cockles, scallops, maerl, bryozoans, sponges, hydroids and macro-algae.

Stations that Morley & Hayward (1999) recorded horse mussels in the 1990s were mainly confined to the southeast. Hewitt et al. (2009: 35-37) recorded them at MIS off Onewhero Bay, near Motuarohia, and at PKI (south Moturua); Nelson et al (2012: 22) found scattered individuals among the Kahuwera rhodoliths. But the largest and most-dense populations appear to be in the region of Te Rawhiti Inlet (Figure 27).

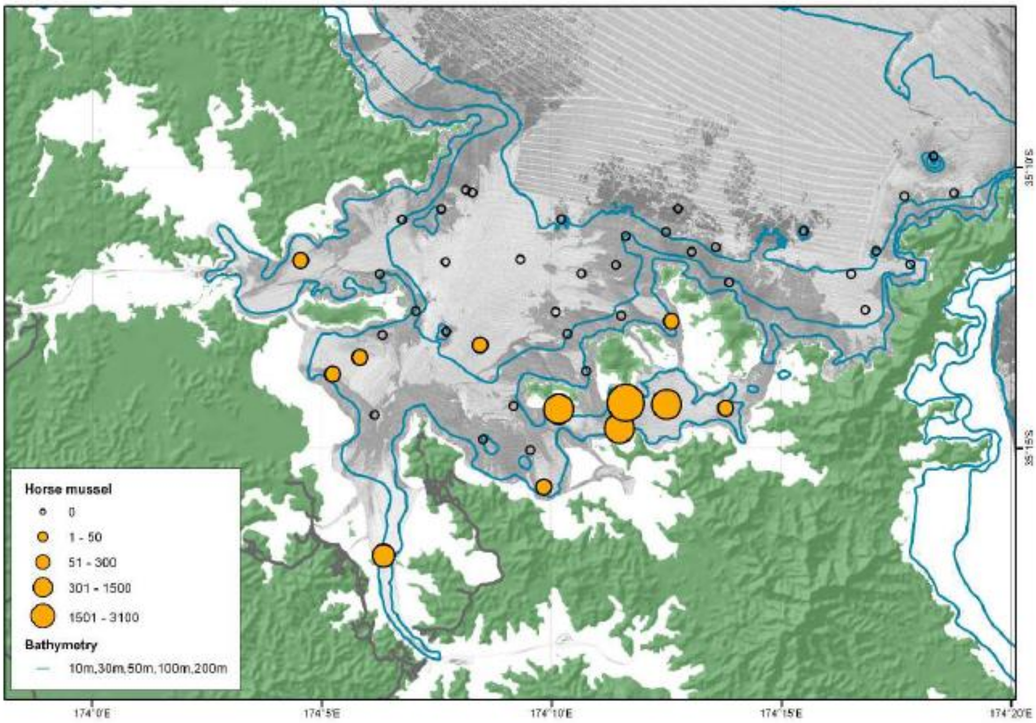


Figure 27. Distribution of horse mussels in video transects within the Bay of Islands: highest densities were in Te Rawhiti Inlet and were associated with sediments consisting of accumulations of shell hash and rhodoliths (Bowden et al. 2010)

Horse mussels are not only prone to anchoring damage (Backhurst & Cole 2000), but are also broken and destroyed by trawling and dredging and are susceptible to suspended sediments (Morrison et al.

2014: 56). Damaged mussels are not likely to survive, because even minor damage makes them vulnerable to predation.

Dog cockles

The large dog cockle *Tucetona laticostata* is often associated with rhodoliths (Hayward et al. 1985-86: 90-92; Hayward et al. 1986; Dewas & O'Shea (2012) Nelson et al. 2012; Morrison et al. 2014: 59; Neill et al. 2015). Their shells may collect in large post-mortem deposits (Dewas & O'Shea (2012), which in turn become important biogenic features of the seafloor.

Dog cockles may live for 100 years, but their valves can persist for thousands of years on the seabed (Dewas & O'Shea 2012: 49). It is quite possible that the shells of dead dog cockles persist on the sea-bed surface in an *articulated* state for decades, if not hundreds of years once encrusting communities have established upon and within the valves; mounds of these dead shells can carry unique faunas. Dog cockles can be associated with *Tawera* (Powell 1937: 366; Grace & Hayward 1980); Grace & Grace (1976); Hayward et al. 1985-86; Hayward et al. 2012: 85), as at Te Miko/Kahuwera (Neill et al. 2015: 72-73). The February 2020 observations in Poroporo Passage showed the widespread (if occasional) distribution of dead shells, and live specimens have been sampled in other parts of Ipipiri by the author.

Tucetona rubble provides long-lasting and well-used settlement for algae and other taxa (eg, Nelson et al. 2014: pages marked but not available). Dredges – while not necessarily breaking shells – certainly break-up the communities associated with them.

*Morning star shells (***Tawera***)*

The morning star shell *Tawera spissa* is a defining species in certain northern waters, forming beds up to >1.5 km^2 and reaching densities of at least 3500 m^{-2} (Taylor & Morrison 2008; Morrison et al. 2014: 58). It is also a species that can exhibit large population changes over time (Hayward et al. 1997: 11). Beds of abundant *Tawera*, typically associated with rhodoliths, occur in strong-current-swept channel situations in several parts of Northland including Great Mercury Island and the Cavalli Islands – and also in the eastern Bay of Islands (Grace & Grace 1976; Grace & Hayward 1980; Hayward et al. 1981; Hayward et al. 1985-86: 98; Kerr & Grace 2015: 32). *Tawera* was also reported near the mouth of Kerikeri Inlet (Booth 1972), and was particularly widespread off southern Urupukapuka Island (Hayward et al. 1981) (Figure 3).

Because they are subsurface, *Tawera* are unlikely to be particularly affected by light recreational dredges.

Subtidal seagrass beds

Seagrass beds/meadows are well-known for the breadth and complexity of their ecological roles (e.g. Morrison et al. 2014), yet seagrass is among the most-threatened and most-rapidly shrinking of all marine habitats (Waycott et al. 2009). Seagrass beds occur mainly subtidally in the Bay of Islands (Hewitt et al. 2009: 6, 31, 33; Kerr & Grace 2015: 34; Booth 2019, 2020) and are unlikely to be significantly affected by dredging.

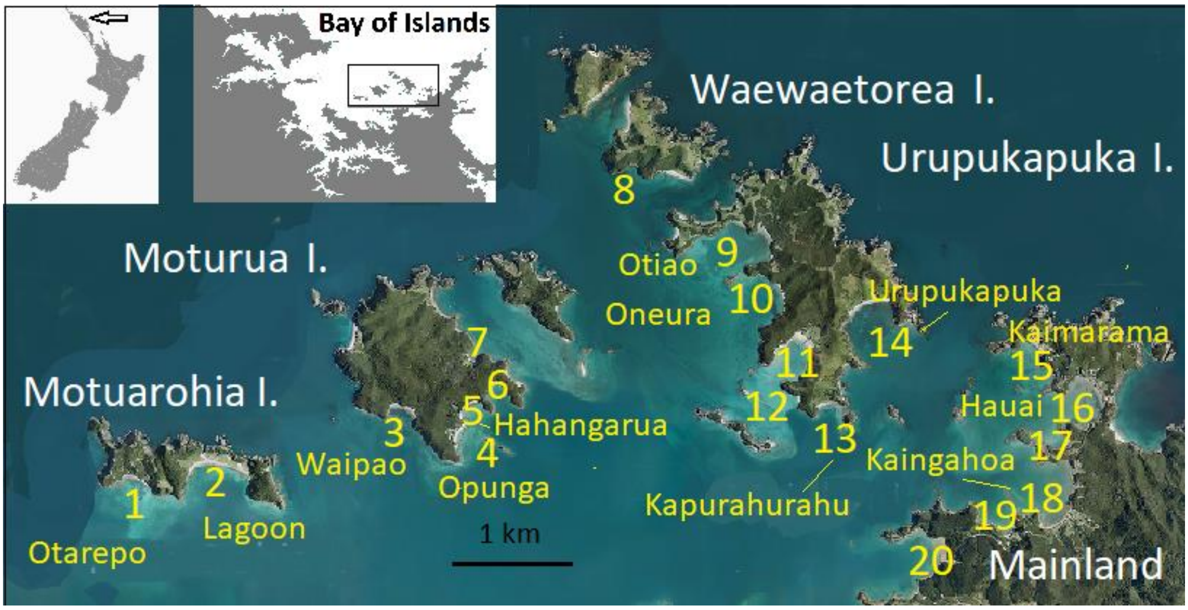
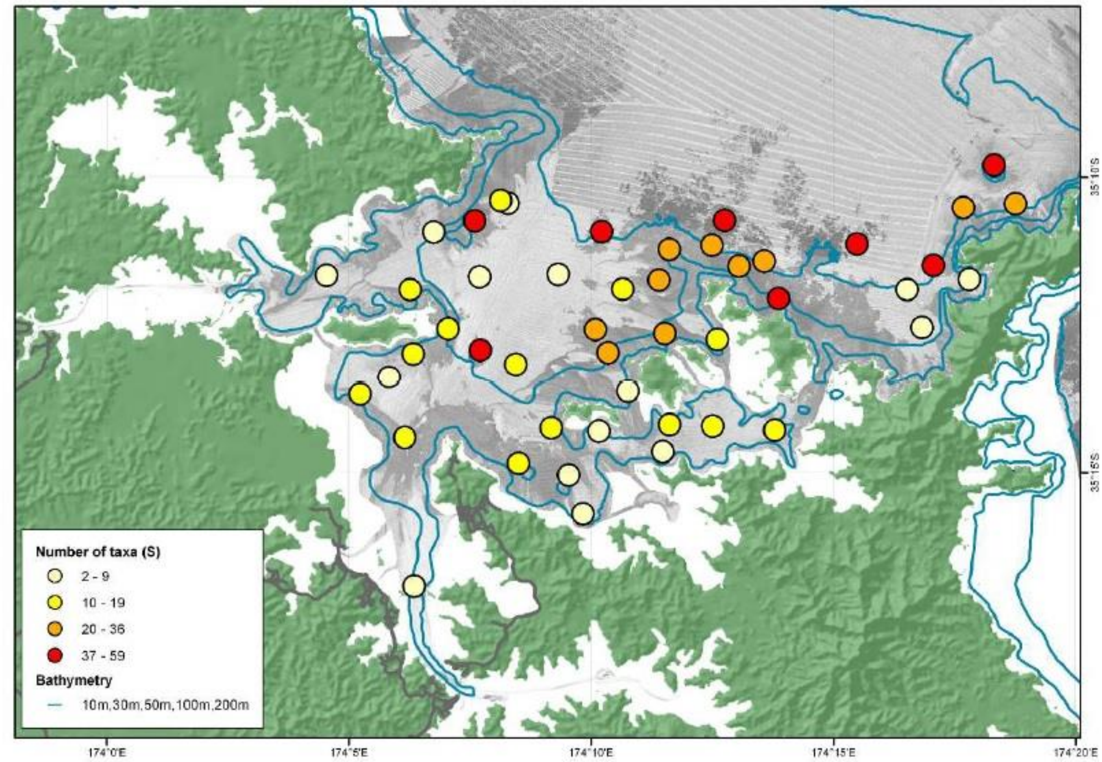


Figure 29. Seagrass beds of the islands and adjacent mainland shores in eastern Bay of Islands (from Booth 2019). Major beds are 1, Otarepo; 3, Waipao; 9, Otiao; 14, Urupukapuka; 15, Kaimarama; 16, Hauai; and 18, Kaingahoa. Other smaller, but nevertheless enduring, beds are 2, Lagoon; 4, Opunga; 5, Hahangarua; 10, Oneura; and 13, Kapurarahurahu. More ephemeral/smaller beds include 6, Awaawaroa; 7, Otupoho; 8, Otawake; 11, Otehei; 12, Sunset; 17, Oruruhoa; 19, Taiharuru; and 20, Omakiwi.

The extensive seagrass beds of the eastern Bay of Islands are probably not under threat from dredging, the greater threat being sedimentation. Thick meadows would quickly foul dredges, and – anyway – scallops are too scarce among seagrass meadows these days to be worth dredging for. However, regenerating tufts and patches adjacent to the main beds are probably prone to dredge damage.

4.3 Indices of subtidal invertebrate faunal diversity of the Bay of Islands

The synoptic overviews provided by the DTIS surveys, in particular, point to the areas of greatest biodiversity (Figure 30). Based on the visible macrofauna, invertebrate faunal diversity was highest at sites dominated by rock, mainly at the mouth of the Bay, but highest individual densities were on soft seafloors in Te Rawhiti Inlet where there were dense horse mussel beds (Figure 27).


Number of taxa (S)
2 - 9
10 - 19
20 - 36
37 - 59
Bathymetry
10m,30m,50m,100m,200m
174°0'E
174°5'E
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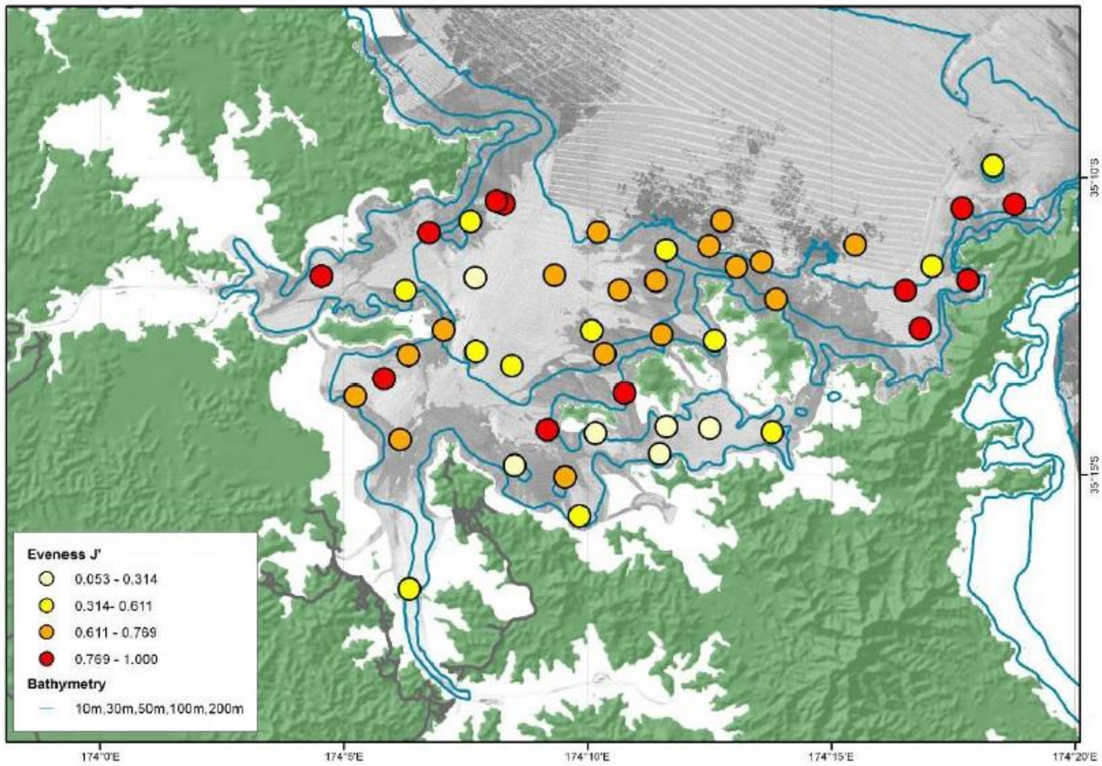
35°10'S
35°15'S


Eveness J'
0.053 - 0.314
0.314- 0.611
0.611 - 0.769
0.769 - 1.000
Bathymetry
10m,30m,50m,100m,200m
174°0'E
174°5'E
174°10'E
174°15'E
174°20'E
35°10'S
35°15'S

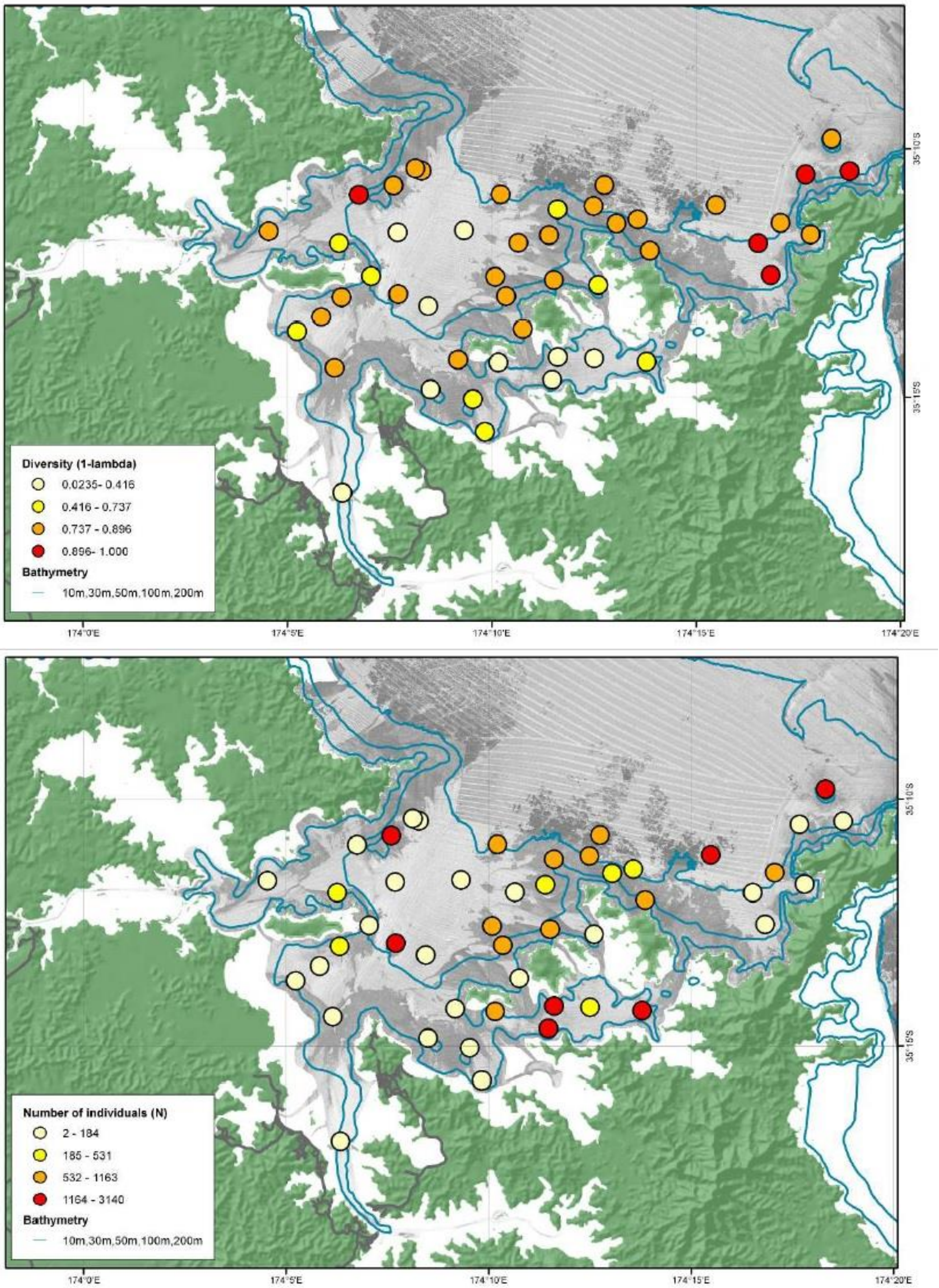


Figure 30. Benthic invertebrate fauna of the Bay of Islands (Bowden et al. 2010). A. Total number of taxa recorded in each DTIS video transect. B. Total number of individual organisms recorded in each transect. C. Simpson's index of diversity. D. Pielou's evenness index.

5. Fish communities in trawled waters >30 m depth

Snapper, leatherjacket, red mullet, yellow eyed mullet and jack mackerel were the most abundant fishes, with inner bay areas being species poor and dominated by spotty and parore (Jones et al.

2010: 8). Trawl catches (soft bottom on central parts of Bay) characterised by snapper, gurnard, leatherjacket, and jack mackerel (Jones et al. 2010: 50) (because DUV and DTIS were used over a wide range of habitats, their results are less useful).

Of note is that a previously unrecognised biome prevails over much of the soft bottom of the Bay of Islands; in soft areas, silver conger eels (*Gnathophis habenatus*) and red bandfish (*Cepola aotea*) were abundant, the first time for these species to be recognised as significant components of a seafloor fish assemblage. But it is unknown if this is a residual effect from previous harvesting, but this is doubtful because, apparently, damaging fishing methods have never been widely or intensively used in the Bay of Islands (Figure 8).

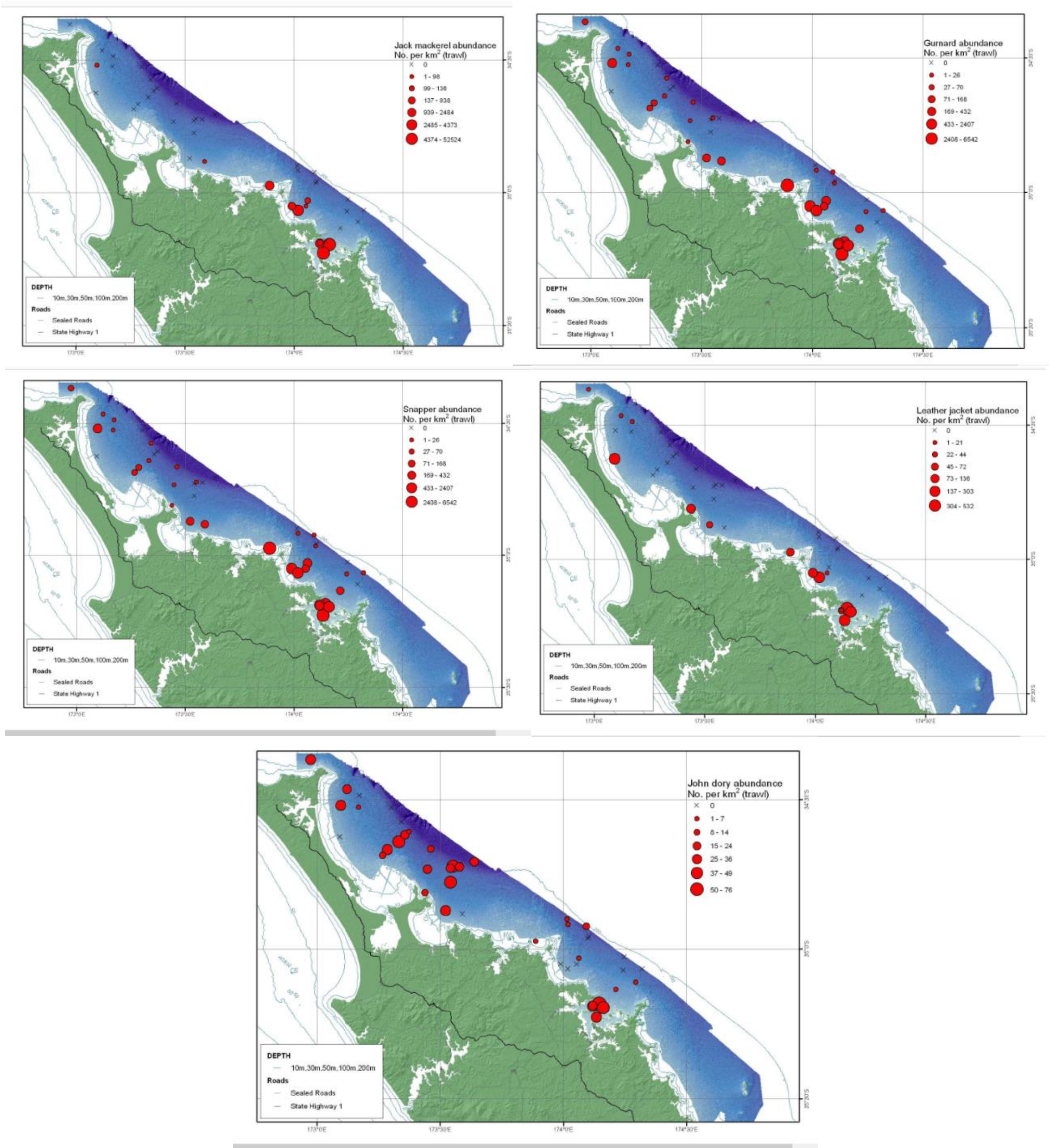


Figure 31. Bubble plots illustrating abundance and spatial distribution of selected species sampled by trawl (App 2 Chpt 9: 81)

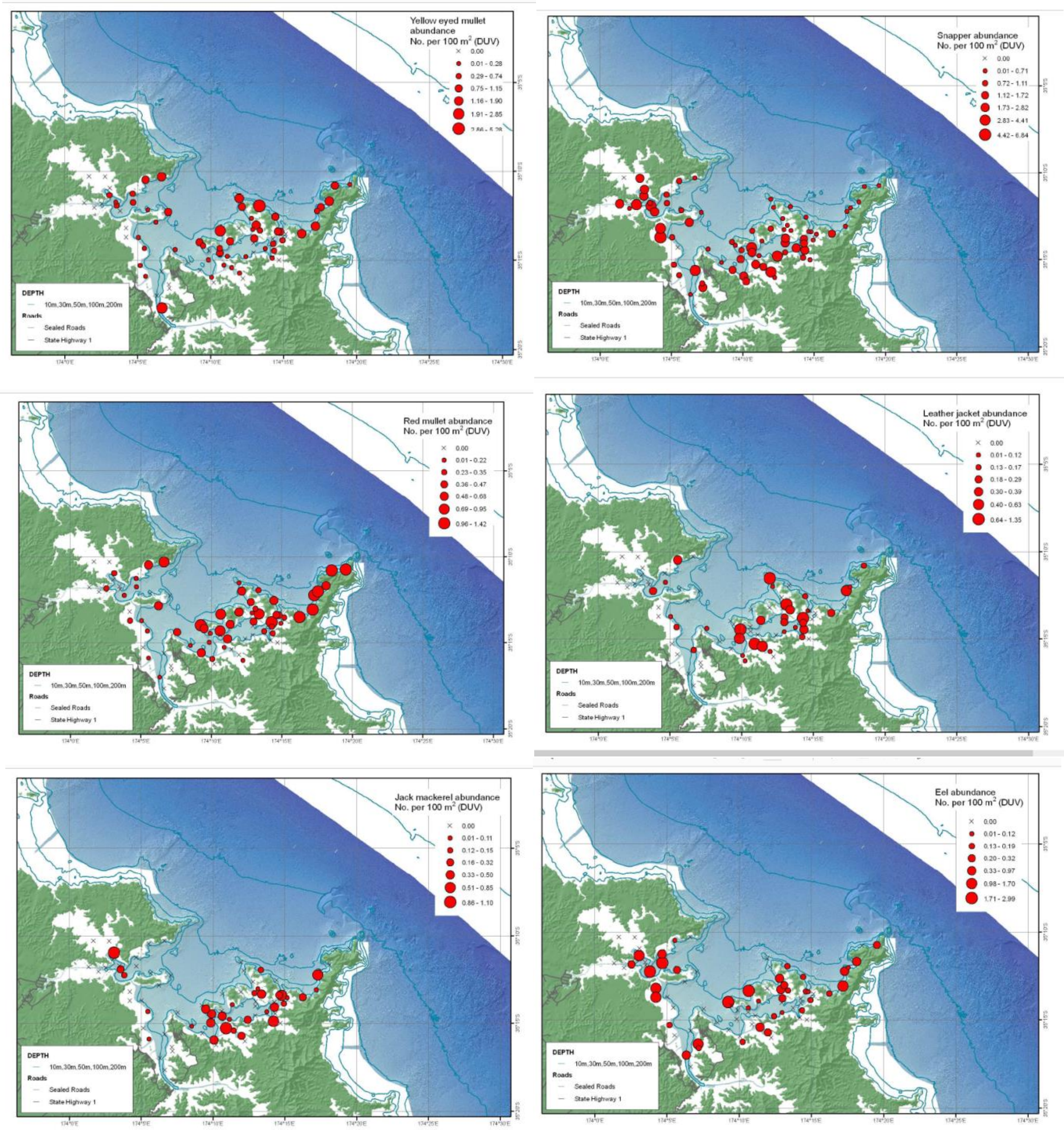


Figure 32. Bubble plots illustrating abundance and spatial distribution of selected species sampled by DUV (App 2 Chpt 9: 81)

But of note is that a previously unrecognised biome prevails over much of the soft bottom of the Bay of Islands; in soft areas, silver conger eels (*Gnathophis habenatus*) and red bandfish (*Cepola aotea*) were abundant, the first time for these species to be recognised as significant components of a seafloor fish assemblage. But it is unknown if this is a residual effect from previous harvesting, but doubtful because apparently harmful fishing methods have never been widely or intensively used in the Bay of Islands (Figure 3).

6. Risk assessment and risk management

This study has addressed the vulnerability of subtidal soft-bottom biodiversity of the Bay of Islands to damaging physical effects of fishing. Most of the detailed analysis has considered shallow (<8 m) waters – waters that show best in aerial imagery – and it may be that the less-well examined, deeper waters hold greater biodiversity than this report recognises. Nevertheless, this is the information available, and it is considered that because the risks of physical impact on biodiversity are not seen as being particularly oppressive (being essentially confined to almost-certainly-limited recreational dredging in shallow waters, and low-intensity trawling in waters >50 m), the risks for the deeper waters may be small.

Marine ecosystems all have inherent dynamism that may lead to significant changes over short time intervals, through to little change over the scale of decades. The information for the Ipipiri area suggests that many of the seafloor features have remained much the same for decades, although the expressions of growth of plants like seagrass may change over shorter scales. Superimposed on this are the effects of overfishing of key taxa that have led to explosions in the numbers of sea urchins (including the long-spined urchin *Centrostephanus rodgersii*) and, in turn, loss of shallow-reef kelp (Froude 2016; Booth 2017).

Essentially all of the rare and special subtidal soft-bottom biodiversity identified for the Bay of Islands in this report appears to be comprised of relatively stable communities, rather than being transient or ephemeral – and so what has been described here has probably applied for many years of recent geological times.

This contribution has identified two current potential sources of physical damage to seafloor caused by fishing – with scallop dredging the only one for which photographic evidence exists. Given the nature of the communities dredged, these impacts are likely to be long-lived (many months, if not years), but specific fishing disturbance events need to be followed over time to be sure. Because disturbance of structures such as biogenic reefs can – in turn - affect the abundance of, for example, juvenile snapper (Thrush et al. 2002: 273), the flow-on effects and risks to fisheries and other diversity can be enormous.

The biogenic reefs of the Bay of Islands are diverse and nationally significant. Even though most habitats may not appear to be overly affected, there is probably a cumulative effect since all those special soft substrates have an importance to biodiversity greater than their actual size may suggest (Ken Grange, pers. comm.). It is essential that they are protected from physical impacts of fishing; accordingly, it is recommended that

1. Recreational dredging of any form be banned from all of the Bay of Islands (as in Fiordland and Paterson's Inlet);
2. Any other similar fishing technique developed in the future where gear is dragged along the seafloor be outlawed;
3. Bottom trawling be discouraged (or banned) from all parts of the Bay of Islands, with a convenient boundary being the line Tikitiki to Motukokako.

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Appendix

Other biogenic habitats

> "Biogenic habitats encompass both a) those living species that form emergent three-dimensional structure, that separate areas in which it occurs from surrounding lower vertical dimension seafloor habitats and b) non-living structure generated by living organisms, such as infaunal tubes and burrows" (Morrison et al. 2014: 8).

With this definition in mind, brief reference is made to biogenic habitats otherwise well-known in other parts of the country but which are apparently rare in the Bay of Islands. **Bryozoan-dominated** epifaunal reefs are conspicuous elsewhere in New Zealand, perhaps the best-known bryozoan reefs (both dramatically and seemingly irreparably affected by dredging and trawling respectively) are 1) (*Cinctipora elegans*) are the ones that support the dredge oyster *Tiostrea chilensis* in Foveaux Strait; and 2) trawling of bryozoan beds near Nelson, these having been critical juvenile-fish habitat (Bradstock & Gordon 1983; Grange et al. 2003). Yet bryozoans have received little if any mention in the above surveys of soft sediments in the Bay of Islands – suggesting they are not important here.

Huge reefs of **green-lipped mussels** overlying soft subtidal seafloors were once characteristic of several harbours in Northland - and particularly of the Hauraki Gulf (Morrison et al. (2014: 45). Their overfishing by dredge – without recovery - in the Firth of Thames (McLeod et al. 2011) may be a core reason for decline in several fish stocks in the Gulf, the fish having been robbed of critical juvenile habitat. But only small quantities of dredged mussels have been reported from the Bay of Islands (Booth 2017). If dense beds of green-lipped mussels ever did exist on soft seafloors of the Bay of Islands, it is unlikely that they were extensive.

Sponge gardens occur around New Zealand not only on rocky reef assemblages, especially below depths at which large algae are able to grow, but also across a range of soft sediment systems, where sufficient hard surfaces are available for initial attachment (Morrison et al. 2014: 61). However, although present in the Bay of Islands, sponges appear not to be prominent: using search terms 'sponge' not in xxxx or Morley & Hayward (1999). And not reported in DTIS; Kerr etc. Because sponges may be particularly affected by sediment, and at the Leigh Marine Reserve, sponge gardens seem to have declined in favour of more silt tolerant tufting red algae (Morrison et al. (2014: 63) – sponges may once have been more widespread in the Bay of Islands.

A range of **tubeworms** species create tubes, with some reaching sufficient sizes and/or densities to provide biogenic habitat for fisheries species, and occurring in shallow waters (Morrison et al. 2014: 76). For example, *Phyllochaetopterus socialis* ('wire-weed' or 'tarakihi weed') lives in a thin wiry tube some 8–10 cm in length forms extensive dense mono-specific meadows at the tens of kilometres scale usually on muddy seafloors in the Marlborough Sounds. There are a number of invasive/non-indigenous species of tubeworm species that may also provide habitat for fisheries species. For example, the parchment worm *Chaetopterus* sp. (Figure 32a) has at times occurred widely across the Hauraki Gulf, causing problems for scallop dredge fishers, and there are concerns about the exclusion by them of other benthic species (Tricklebank et al. 2001). However, it has also been reported by fishers as being a favoured dietary item for adult snapper, and the tubes themselves might conceivably provide shelter for small fish. Tubeworms – including *Chaetopterus* – are found in the Bay of Islands, but overall tubeworms do not seem a dominant taxon.

Brachiopods (lamp shells) are small (adult shells are typically 5-50 mm in length), filter feeders superficially resembling bivalve molluscs (MacDiarmid et al. (2013: 15). They are generally anchored to a hard substrate such as rock, gravel, or shell debris by a muscular stalk. Some species are gregarious forming dense beds sometimes 2 or 3 layers deep and up to 1000 individuals per m^2 (Lee and Smith 2007). In some areas dead brachiopod shells contribute to habitat complexity and provide abundant interstices for small invertebrates and fish (Helen Neil, NIWA, unpublished data) – but apparently not in the Bay of Islands.