5. Subtidal zonation

5.1 Subtidal habitats

Schiel (1984) constructed the first habitat map of the Poor Knights Islands Marine Reserve (Fig. 7), which described five main subtidal habitat types for depths of less than 30 m; 1) vertical reef walls and caves, 2) macroalgal reef habitats, 3) coralline rock flats & echinoids, 4) broken rock, and 5) sand. The majority of the subtidal region consists of steep rock walls, caves, and archways that are covered with an abundance of sessile invertebrates and macroalgae. These rock wall regions are not represented on Schiel's two-dimensional map. The second major habitat type is gently sloping rocky reefs covered in laminarian macroalgae. Large areas of macroalgae reefs that extend down to 50+ m in some places are present at Frasers Bay, Bartle's Bay, Nursery Cove, Cleanerfish Bay, Te Paki Point, Lighthouse Cove, and the channel between the two main islands. Coralline-encrusted rock flats associated with large numbers of echinoids are present at Bartle's and Frasers Bays. Large areas of broken rock are present on the west side of Aorangi Island (The Gardens), around Ngaio Rock, and at the southern point of Tawhiti Rahi Island (Fig. 7).

Over the years the majority of habitats around the Poor Knights Islands have been stable, but there have been some changes. For example, prior to 1980 Nursery Cove Reef was covered in large brown macroalgae but by 1984 it was devoid of large macroalgae and instead dominated by the sea urchin, *Evechinus chloroticus*. This change in habitat was associated with an increase in abundance of the black angelfish, *Parma alboscapularis,* which builds nests on prominent boulders that are devoid of large brown macroalgae (Schiel, 1984). Between 1999 and 2006 the habitat at Bartle's Bay changed from turfing red algae to coralline flats/echinoid-dominated reefs. Areas of *Ecklonia radiata* forest at 10–12 m depth at Frasers Bay and Cleanerfish Bay were also replaced with coralline flats/echinoid-dominated reefs, but these areas were associated with the black sea urchin, *Centrostephanus rodgersii*, rather than *E. chloroticus* (Shears, 2007).

The first two habitat types have been well studied and more detailed descriptions of these habitats are given below. Very little information is available about the other habitat types.

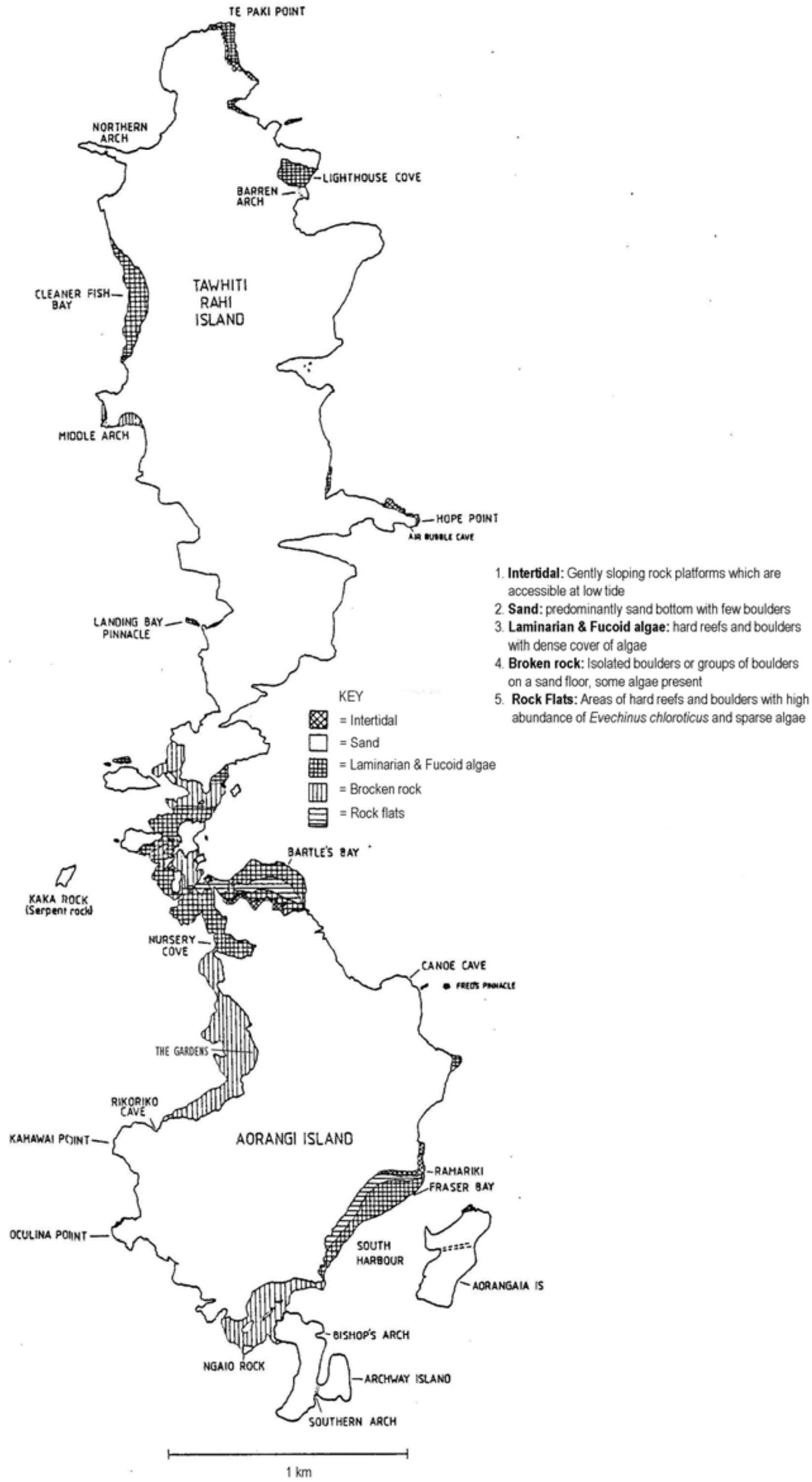

Figure 7 **Schiel's (1984) habitat map of the Poor Knights Islands (reproduced with permission).**

5.1.1 Vertical reef walls and caves

The Poor Knights Islands Marine Reserve is most renowned for its vertical reef walls and caves that are covered with an amazing diversity of flora and fauna including sponges, bryozoans, ascidians, anemones, and encrusting algae. The species diversity on these rock walls is much higher than the diversity at the Cape Rodney–Okakari Point Marine Reserve, with more than 140 sponges, 131 molluscs, 58 cnidarians, 43 echinoderms, and 36 bryozoans recorded from the Poor Knights Islands (Battershill, 1986). Notable components of deep reef communities include the rare black coral (*Antipathes lillei*), giant tube sponges (*Calyx imperialis*)[23], and organ pipe sponges (*Iophon laevistylus*).

Light and wave action are the major factors that determine the community composition on the rock surfaces, and a general pattern of change can be seen in the community composition with increasing depth. Near the sea surface the rock wall is covered by macroalgae, predominantly *Carpophyllum* sp. and red foliose algae, which are succeeded by *E. radiata* at depths between 5–30 m. Under the canopy of *E. radiata* the rock surface is covered by numerous sponges (e.g. species of *Tethya, Polymastia, Cliona, Tedania, Callyspongia*), bryozoans (*Bugula dentata, Emma triangula, Marginella hirsute*), anemones (*Corynactis australis, Corynactus haddoni*), hydroids (*Symplectosycphus* sp., *Thecocarpus* sp., *Aglaophenia* sp.), and encrusting algae. As depth increases beyond 30 m the community composition becomes dominated by sponges (*I. minor, Siphonochalina* sp., *C. imperialis*), hydroids, bryozoans, and gorgonians (e.g. *Primnoides* sp.), that thrive in the low light and calm water conditions. This pattern of change in community composition is also evident in caves but along a horizontal plane towards the back of the cave. Near the cave entrance the community is similar to that near surface overhangs, but growth is less profuse as water movement in the caves is limited. Further into the cave large finger sponges (*Callyspongia ramosa*) are absent and gorgonian fans are stunted. This community is dominated by encrusting sponges, compound ascidians, hydroids, and polyzoans. In the near dark depths of the cave the flora and fauna are sparse, predominantly simple ascidians and the solitary cup corals such as *Monomyces rubrum*[24] and *Tethocyathus cylindraceus*[25] (Doak, 1971; Ayling, 1974a; 1974b; Battershill, 1986; Ayling & Schiel, 2003).

Although the community composition of the rock walls varied greatly with location and depth Battershill (1986) observed some general trends:

[23] Previously *Haliclona imperialis*
[24] Previously *Flabellum rubrum*
[25] Has been referred to as *Paracyathus conceptus*

1. The most abundant groups of organisms in terms of percentage cover were thin encrusting sponges, thin encrusting algae, turfing hydroids, and turfing bryozoans.

2. Sites on the more exposed eastern side of the island had a higher percentage of ascidians (mainly *Cystodites* sp., *Leptoclinides* sp., and *Aplidium* sp.) and massive sponges (mainly *Stelletta* sp. and *Ancorina* sp.).

3. In shallow, turbulent areas thin encrusting sponges, ascidians, and algal species dominated, while in sheltered shallow waters bryozoans and turfing branching hydroids dominated.

4. Reef fish and urchins were found in low numbers on vertical walls.

5. The composition and distribution of the vertical reef community is stable over time.

5.1.2 Macroalgal reef habitats

A variety of macroalgal habitats are present in shallow waters (< 5m) including *Carpophyllum*, mixed algal, red foliose algal, and turfing algal habitat depending on location and wave exposure. Between 5 and 30 m *Ecklonia radiata* is the dominant algal species accounting for more than half of the total algal biomass (Shears, 2007) (See Section 4.2 for more detail). Sponges, bryozoans, hydroids, and ascidians are important substrate covers underneath the *E. radiata* canopy. The common sea urchin, *Evechinus chloroticus*, is the most common mobile macroinvertebrate on the reefs, accounting for approximately 90% of the total counts of all macroinvertebrates. Densities of herbivorous gastropods at the Poor Knights Islands are much lower than on similar coastal reefs, possibly because of recruitment limitation or the high abundance of predators (Shears & Babcock, 2004). The macroalgal habitats support a large numbers of small fish, primarily labrids (Choat & Ayling, 1987).

Shears and Babcock (2004) and Shears (2007) conducted surveys of nine reef sites[26] in 1999 just after all fishing was prohibited at the Poor Knights Islands, and again in 2006. The results showed that subtidal reef communities at the Poor Knights Islands were relatively stable over the eight year period, although there was a significant increase in the total macroalgal biomass. This increase was primarily because of a doubling in *E. radiata* biomass. There were no major changes in the species

[26] Lighthouse Bay, Rocklily Inlet, Nursery Cove, Cleanerfish Bay, Skull Bay, Bartle's Bay, Matt's Crack, Frasers Bay, and Labrid Channel (see Fig. 2 for locations).

composition or extent of the reef areas between the two surveys. There was a reduction in turfing algal habitat, and an increase in the coralline flats/echinoid-dominated reefs between 1999 and 2006. The increase in coralline flats/echinoid-dominated reefs was most apparent at Bartle's Bay. Surprisingly, the abundance of *E. chloroticus* was similar between the two sampling periods despite a significant increase in snapper numbers between 1998 and 2001 (Denny *et al.*, 2004). Generally, sea urchin numbers are negatively correlated to the numbers of large predators.

5.1.3 Coralline flats/echinoid-dominated reefs

The coralline flats/echninoid-dominated reef habitat (sometimes referred to as 'urchin barrens') was first described by Ayling (1981). This habitat is characterised by coralline covered rocks that are generally devoid of any large macroalgae, but with a high abundance of sea urchins (*E. chloroticus*). This habitat typically occurs at depths of between 5–10 m where *E. chloroticus* is most abundant (Choat & Schiel, 1982; Schiel, 1984). Coralline flats/echninoid-dominated reefs are uncommon at the Poor Knights Islands and large areas are only present at Bartle's Bay. Small patches of coralline flats/echninoid-dominated reefs are also present at Rocklily Inlet, Matt's Crack, Frasers Bay, Cleanerfish Bay, and Labrid Channel (Shears, 2007). Abundance of labrids around the coralline flats/echninoid-dominated reefs is lower than within macroalgal reef habitats, but higher numbers of large benthic carnivores such as snapper are present (Choat & Ayling, 1987).

5.2 Subtidal habitat mapping (by Jarrod Walker)

The National Institute of Water and Atmospheric Research Ltd (NIWA) are currently undertaking a research programme at the Poor Knights Islands Marine Reserve, entitled 'Marine Recreation' which is funded by the Foundation of Research, Science, and Technology (Contract no: C01X0506). This project sets out to determine whether the current levels of recreational diving has a detectable impact on the benthic flora and fauna associated with near-shore, shallow rocky reefs (0–50 m depth). NIWA are using a number of methods to determine what effect current diving intensities have at the Poor Knights Islands. The overall aim of this project is to move towards an ecosystem management framework that will allow managers, Iwi, and interested stakeholders to manage and sustainably progress the tourist industry while protecting the resources that are the foundation of the tourist industry at the Poor Knights Islands. One of the main outputs is to overlay, in GIS, biological and habitat information that has been collected onto a bathymetric map to produce habitat maps for public and managerial end users.

5.2.1 Methods

Bathymetric surveys of the Poor Knights Islands, using multi-beam sonar, were completed in 2006. Multi-beam technology is an advanced depth sounding and hydrographic mapping system which allows acoustic mapping of the topographic features of the seafloor. It provides detailed information about the rugosity (roughness) of the terrain and bathymetry (water depth), and can produce high resolution images and maps of the seafloor. It also collects information that can be used to predict the geology, and potential habitats available to marine life. This mapping exercise provided a detailed and accurate description of the major physical components of both the rocky reef and sandy areas of the sea floor in depths from approximately 2 to 100+ m (Fig. 4, Section 2.1).

In addition to this work, large scale biological surveys have been undertaken using both a dropped underwater video camera and diver operated video cameras (detailed below). From the images captured by video, counts and estimates of the percentage coverage of various organisms found inhabiting the reef were collected. A range of habitats were also recorded from the video footage along with the depth that they were found and GPS locations. The types of habitat classifications used in this study were those described by Ayling (1978) and more recently by Shears *et al*. (2004). This information, in particular the habitat data, will be compiled with the multi-beam maps to produce high resolution physical and biological maps of the Poor Knights Islands underwater seascape, due to be published in 2009.

Dropped underwater video surveys

To survey the subtidal rocky reef biota of the Poor Knights Islands a dropped underwater video system was employed. At 80 sites evenly distributed around the Island chain (Fig. 8) cameras were lowered along a series of transects to capture the biological communities residing on the reef. Transects were run from the shallow intertidal (~2 m depth) out to 50+ m, with the length of transects dictated by the slope of the reef (i.e. steep reefs = short transects, while gently sloping reefs = longer transects). A downward facing underwater camera was lowered to the rocky substrate 3–5 times in each of 9 depth strata (0–5, 5–10, 10–15, 15–20, 20–25, 25–30, 30–35, 40–50, and 50+ m), with each camera drop treated as a 0.5 m^2 sampling unit. From each quadrat, the benthic habitat was classified (e.g. kelp forest or mixed algae), and counts and estimates of the reef coverage of all major categories of invertebrates and macroalgae were recorded. Each camera drop was GPS, time, date, and depth stamped to enable the integration of these data with the multi-beam data.

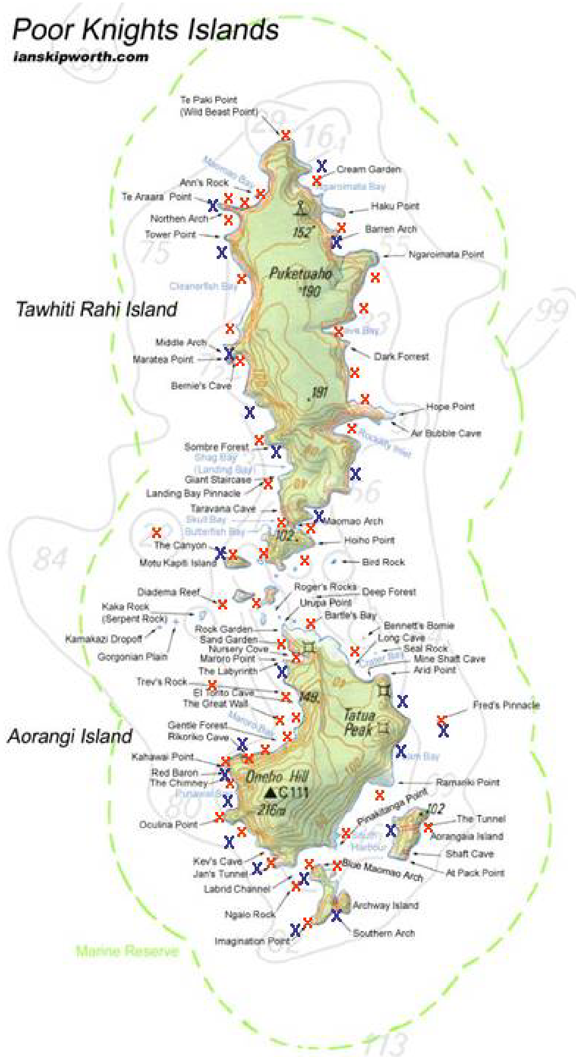

Figure 8 **Map of the Poor Knights Islands displaying sites where the dropped camera system (red x) and diver operated camera systems (blue x) were used to survey benthic biological communities. Not shown on the map are two sites at the Sugar Loaf Rock and four sites at the High Peak Rocks (Pinnacles) (Map courtesy of IanSkipworth.com).**

Diver operated underwater video and still photography

In places where the drop camera could not access, e.g. caves, archways and against vertical cliffs, a team of divers using video/still cameras sampled the biota using similar methodologies as to the dropped underwater camera surveys. Transects ran from shallow intertidal to 30 m depth and were typically vertical. Video footage was taken of the entire transect to obtain information on habitat variations down a depth gradient. Along each transect six still photos were taken within each of 6 depth strata (0–5, 5–10, 10–15, 15–20, 20–25, 25–30 m) with each photograph treated as a 0.5 m^2

sampling unit (Fig. 9). From each quadrat, the benthic habitat was classified (e.g. kelp forest or mixed algae), and counts and estimates of the reef coverage of all major categories of invertebrates and macroalgae were recorded. Each photo contained time, date, and depth information while the transect start point was GPS-ed enabling these data to be combined with the dropped camera data and integrated with the multi-beam maps.

Figure 9 Still photo from the diver operated underwater camera showing an orange massive sponge (*Stelletta* sp.) and a rich assemblage of encrusting ascidians and bryozoans at 23.2 m depth.

5.2.2 New habitat types

The first habitat maps constructed by Schiel (1984) were detailed and well-constructed and displayed a range of habitat configurations and the depths at which these habitats altered. The current work undertaken by NIWA at the Poor Knight Islands covers a larger spatial scale (80 sites spread across the entire island chain, including the Sugar Loaf Rock and High Peak Rocks (Pinnacles), and down to depths greater than 40 m), than previous research at the Poor Knights Islands (Ayling, 1974b; 1974a; Schiel, 1984; Battershill, 1986; Shears & Babcock, 2004; Shears, 2007), and has lead to the development of two new habitat types.

The first habitat was predominantly found at depths greater than 40 m where divers have a very limited duration of safe dive times. Accordingly, very little scientific work has been undertaken at these depths. This habitat mainly consisted of encrusting coralline algae that formed leaf like plates and occupied the majority of the reef. As such this habitat has been name "encrusting corallines" and was recorded at a number of sites from around the two main islands.

A second habitat, equivalent to the urchin barrens habitat described in Shears *et al.* (2004) was also observed. Called "Centro barrens", this habitat consisted of moderate densities of the Australian sea urchin, *Centrostephenus rodgersii.* The Centro barrens habitat was found deeper (~20–25 m) than the previously described urchin barrens habitat (~4–10 m), which is formed by the New Zealand sea urchin *Evechinus chloroticus* (Choat & Schiel, 1982; Schiel, 1984; Shears, 2007).

This current survey has shed light on the ranges and breadth of subtidal habitats over a number of spatial scales (metres to kilometres) and at depths where few scientific divers are able to access. Accurate mapping of deep subtidal habitats will allow the identification of benthic communities that are vulnerable to damage, and allow management practices to be put in place to protect them.

6. Human use

6.1 Biosecurity

The Poor Knights Islands Marine Reserve is a high value area of national significance and the unique marine assemblages present in the reserve need to be protected from modification by invasive organisms. Vessel movement in the vicinity of the Poor Knights Islands is the most likely method for the introduction of invasive organisms to the islands via hull fouling, ballast water, and sea chests (water-intake recesses in hull). International and local shipping traffic to and from the port of Whangarei pass near the Poor Knights Islands and may discharge ballast water containing the larvae or spores of invasive species in the vicinity of the islands (Dodgshun *et al.*, 2007), which are then distributed at a local scale by water currents. Pleasure crafts visiting the Poor Knights Islands are also a significant biosecurity risk as many of these vessels remain inactive for long periods of time in sheltered marinas where invasive organisms are prevalent.