APPENDIX 3: BIODIVERSITY AND MARINE PROTECTED AREAS

PIRINGA 3: RERENGA RAUROPI ME NGĀ ROHE RĀHUI MOANA

Biodiversity is a broad term which at its simplest can be viewed in terms of the Hauraki Gulf Marine Park as ‘the variety of plant and animal life in the Hauraki Gulf Marine Park’.

THE HAURAKI GULF SYSTEM

The Gulf extends from shallow tidal creeks and estuaries, out to the edge of the continental shelf. Geomorphically, this includes a relatively large estuary (the Waitematā Harbour) as well as many smaller ones, numerous beaches and rocky headlands, peninsulas, shallow embayments, the large Firth of Thames, and inshore and offshore islands. This relatively complex topography, combined with currents and marine climate (especially the prevailing wind directions), creates a diverse range of environments and habitats, which in turn support a wide range of plant and animals species. Seafloor sediments are predominantly terrigenous (i.e. derived from the land) muds and sands, although there are localised areas of calcareous sediments (formed from the shells and skeletons of marine organisms) in shallow bays and areas of high tidal flow. Extensive shallow rocky reefs occur around much of the coastline, except in the Firth of Thames which is dominated by soft sediments, particularly muds. Deep rocky reefs are located on the outer shelf northeast of Mokohinau Islands, east of Great Barrier Island and the Coromandel Peninsula and west of Little Barrier Island.

Pelagic component

Pelagic biological productivity throughout the Hauraki Gulf Marine Park is strongly influenced by seasonal and interannual variation in the East Auckland Current (EAUC) (Stanton & Sutton 2003), which originates in the Tasman Sea, northeast of North Cape, and flows south-east along the upper continental slope. Offshore of the EAUC is a large-scale permanent warm core eddy (the North Cape Eddy), which extends down to 1500m water depth. This eddy re-circulates about 50% of the EAUC flow, and probably serves as a larval retention mechanism (Roemmich & Sutton 1998). The EAUC-North Cape Eddy system is highly variable, driven largely by variation in the position, configuration and magnitude of the North Cape Eddy core (Stanton & Sutton 2003). Temperature variability in the surface mixed layer of the EAUC is dominated by the annual cycle, with differences between years highly correlated with the Southern Oscillation Index (SOI, a measure of the strength of the El Niño-Southern Oscillation) and wind speed and direction (Sutton & Roemmich 2001).

The EAUC is forced up towards the surface over the upper continental slope by along-shelf winds, resulting in upwelling’s that are nutrient rich (particularly nitrates), making this one of New Zealand’s most productive shelf regions (Sharple & Greig 1998, Zeldis et al. 2001, 2004, Zeldis 2004, Bradford-Grieve et al. 2006). Circulation over the inner continental shelf is dominated by tides, local winds, and the southeast flow of the EAUC (Sharple & Greig 1998; Stephens 2003). Episodic upwelling of slope water onto the shelf and into the Hauraki Gulf during autumn and winter is driven by along-shelf southeast winds. The relative strength of up-welling or down-welling over time varies with wind speed and direction. The El Niño phase of the Southern Oscillation favours upwelling and associated high productivity; whereas the La Niña phase favours down-welling that suppresses phytoplankton production (Zeldis et al. 2001, 2004, 2005; Chang et al. 2003; Zeldis 2004; Bradford-Grieve et al. 2006; Hall et al. 2006). During spring and summer, water column stratification de-couples the surface layer from the rest of the water column, which shuts down upwelling. This results in nutrient depletion of the upper water column by phytoplankton, but an internal tide present in summer has the capacity to mix nutrients across the pycnocline (the horizontal
boundary between different density water masses), and drive sub-surface production (Sharples & Greig 1998; Hall et al. 2006).

In contrast to the outer Hauraki Gulf, circulation and productivity in the Firth of Thames are strongly catchment driven. Freshwater inflow, tides and local winds exert a strong influence on the flow in the Firth of Thames (Stephens 2003; Oldman et al. 2007; Hadfield et al. 2014). The Waikou, Piako and Kaueranga rivers input significant amounts of freshwater, sediments and nutrients into the Firth, resulting in strong vertical and horizontal gradients in salinity, suspended sediments, and nutrients (Hadfield et al. 2014). Phytoplankton blooms in spring and early summer support a relatively high biomass of large zooplankton (particularly euphausiids, hyperid amphipods, salps, siphonophores, and pteropods).

High concentrations of fish eggs and larvae have been recorded over the shelf in a number of places consistent with the observed high primary productivity (Crossland 1981; Bailey 1983; Zeldis et al. 2005). Crossland (1981) recognized three spatial patterns of fish spawning in the Hauraki Gulf: those species where spawning was concentrated in the Firth of Thames (e.g. ahuru, flatfish), those that spawned in the inner (‘central’) Gulf (e.g. anchovy, sprat, jack mackerel, yellow eyed mullet, snapper) and those with spawning grounds located in the outer Gulf (e.g. pilchards, red gurnard, blue mackerel). For snapper, the inner Hauraki Gulf is an important spawning area, with seasonal spawning aggregations concentrated in the Whangaparaoa Bay, between Rangitoto Island and the Whangaparaoa Peninsula, and between Waiheke Island and the Coromandel Peninsula. Snapper spawning also occurs southwest of Great Barrier Island (Zeldis & Francis 1998; Zeldis et al. 2005).

**Benthic component**

Despite the intensive use of the Hauraki Gulf Marine Park by humans, there is a fundamental lack of baseline knowledge for most of the Park. While there have been a number of small-scale benthic surveys, either for geology or for species-habitat purposes, there has never been any large-scale systematic survey/series of surveys made of the Hauraki Gulf Marine Park to quantify ‘what is out there’ (i.e. provide a fundamental resource inventory and classification of habitats), beyond the species that we value economically (e.g. fish), or socially (e.g. sea-birds). The old adage of ‘you can’t manage what you don’t measure’ holds strongly here, both in terms of what is present, and monitoring it over time to detect any significant changes, natural or anthropogenic. Some representative smaller area seafloor assemblage’s reports are briefly summarised below.

Subtidal benthic communities of the Waitematā Harbour and inner Hauraki Gulf were first examined and characterised by Powell (1937), using a small dredge. Hayward et al. (1997) resurveyed Powell’s dredge stations to examine faunal changes between the 1930s and 1990s. In both studies, samples were dredged and associations were intuitively deduced largely on the basis of molluscs and echinoderms, following Powell’s 1930s methods. Hayward et al. found that, away from the wharves and marinas, the soft-bottom fauna was still remarkably rich, and retained a similar gross pattern to the 1930s, with the urchin (Echinocardium) dominated community type still being widespread, and the bivalve (Tawera + Venericardia (now Purpurocardia)) dominated community remaining more localised. However, fourteen mollusc species (mainly carnivorous gastropods) were considered to have disappeared or suffered major reductions in abundance within the harbour by 1997. This resulted in two of Powell’s associations (Tawera-Tucetona (morning star & dog cockle), Amalda (olive shell) disappearing from the outer harbour. There was also a reduction in the abundance and range of the turret shell Maoricolpus roseus (a filter feeding gastropod) and a number of associated species from the shelly channel sediments in the centre of the harbour. Hayward et al. also noted that since the 1930s, at least nine New Zealand mollusc species (mostly deposit- and suspension-feeders) and one crab species appeared to have colonised the harbour, and nine others had increased in abundance within the harbour sites. The establishment of extensive horse mussel beds north-east of North Head was the most significant change. Three invasive bivalve species (Limaria orientalis, Theora lubrica, Musculista senhousia) introduced in the 1960s and 1970s had become so abundant in the harbour that they had become co-dominant, characterising species of six of the eight faunal (invertebrate animal) associations recognised in the 1990s (Hayward et al. 1997).

Chiaroni et al. (2008) described the habitats and species found in Kawau Bay. This area comprised of bays and estuaries of various sizes, sheltered coastal environments,
and more exposed rocky and soft sediment habitats. The species assemblages supported by these diverse habitats varied from rocky reefs dominated by large macrofauna, to soft-sediments supporting diverse infauna (living in the seafloor) and sometimes dense epifauna (living on the seafloor), with many of these taxa being long-lived. Many areas displayed high taxonomic diversity at both a species and order level, with an estimated 400 infaunal species being present in the system. A number of ecological functions and services from the assemblages of Kawau Bay were identified: including species contributing to benthic productivity, nutrient fluxes and water column productivity (i.e., bioturbating, suspension feeding, macroalgal and deposit feeding communities); affecting sediment stability and water clarity (e.g. suspension feeding and tube worm communities); providing refugia for juvenile and small fishes (habitat structuring communities such as Atrina (horse mussels), sponges and macroalgae); providing food for predatory and herbivorous fishes (most communities); and proving food and recreational values for humans (e.g., cockles, pipis, scallops, sponge gardens, kelp and turfing gardens (Chiaroni et al. 2008)

Taylor & Morrison (2008) sampled the benthic fauna (<4mm) of Greater Omaha Bay, in the north-western Hauraki Gulf. One hundred and thirty eight subtidal (1–41m) stations were sampled using suction sampler, grab, and dredge. Omaha Bay stations were mostly comprised of sand and gravelly-sand. Two-hundred-and-thirty-six taxa representing 13 phyla were recorded, with molluscs, arthropods and annelids being the most speciose. The annelids (worms) were identified to Family level only, and the true species number may be considerably higher. Seven discrete animal assemblages were identified, each represented by 6 to 40 stations, and clearly differing from one another according to one or more of the physical variables of sediment type and depth, and/or the presence of high densities of the bivalves Tawera spissa (morning star shell) and Atrina zelandica (horse mussels).

The horse mussel cluster was the most distinct of the seven assemblages, in that it shared the lowest number of common taxa with other clusters. The Tawera spissa-dominated assemblage was less distinct from the others in terms of taxonomic composition, but was remarkable for very high densities of T. spissa, averaging 907 individual's m⁻², and reaching 3476 individuals m⁻² at one station. Omaha Bay's single T. spissa-dominated patch/bed of c. 1.5 km² contained c. 1.4 billion individuals.

Several notable taxa were encountered. A single specimen of the congrid eel Scalanaogo lateralis was caught, the first recorded from outside Australia (P. Castle pers. comm.). Several secretive species whose ecological roles may have been under-appreciated were also quantified. For instance, the rarely encountered worm-eel Scolecenchelys australis (Fam. Ophichthidae) occurred at an average density of 0.09 individual’s m⁻², equivalent to c. 4 million individuals in the bay, and was suggested to be one of the more abundant fish in coastal New Zealand if such a density is typical. Night-time towed-video surveys have since identified high densities of this species (or very similar) in both East Northland (Jones et al. 2010), and from other locations within the Hauraki Gulf (Morrison et al. 2016).

The value of more complex habitat types


Biogenic habitats are habitats formed by living (or once living) species that create emergent three-dimensional structure (e.g. large erect sponges and kelp forests) or provide physical structure for other animals (e.g. shell debris). Biogenic habitats that provide three-dimensional structure have been shown to be especially important to many fish and other associated invertebrate 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, Grattike & Speight 2005, Abokkire et al. 2007, Pérez-Matus & Shima 2010, Rabaut et al. 2010, Humphries et al. 2011, Bailey et al. 2012, Laman et al. 2015). Similarly, remnant shell debris can provide an essential substratum...
for many sessile species (e.g. bryozoans, and encrusting sponges and algae) (Beaumont et al. 2013), where it may substantial increase local biodiversity and may provide the only available hard substrata in otherwise expansive soft-sediment areas (Hewitt et al. 2005, Beaumont et al. 2013; Lomovasky 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).

### Seagrass as a biogenic habitat example

Seagrass meadows are considered to be one of the most productive ecosystems in the world, ranked ahead of coral reefs (Constanza et al. 1997, Grech et al. 2012, Matheson & Wadhwa 2012), yet they are relatively unknown and often under appreciated by the general public. Whilst prior research has shown that seagrasses provide a variety of ecosystem services encompassing both economic and ecological functions, the relative importance of these functions can vary appreciably between different estuarine and coastal systems (Beck et al. 2001, Orth et al. 2002, Heck Jr et al. 2003).

Seagrasses commonly occur in sheltered areas, away from strong currents and wave action, where they can grow on a variety of substrata ranging from mud through to sand and bedrock (Hemminga & Duarte 2000, Green & Short 2003). However, the most extensive meadows are found on soft substrata, often forming continuous expanses over several square kilometres. Alternatively, they can form mosaics of discrete patches (often in areas with more wind-generated wave exposure) (Inglis 2003, M.L. & M.M., NIWA, pers. obs.). Seagrasses are typically found in intertidal (to mid-tide level) and shallow subtidal waters at depths between 2 and 12 m, but can occur down to 50–60 m, depending on water clarity (Turner & Schwarz 2004). Seagrasses require some of the highest light levels of any plant group (about 25% incident radiation compared to up to 1% for other angiosperms; Dennison et al., 1993). Seagrasses are thus acutely responsive to environmental changes, especially those altering water clarity and are considered ‘sentinels’ for these types of environmental changes.

New Zealand has one species of seagrass, Zostera capricorni, which grows mainly in the intertidal zone; with limited populations growing within sheltered subtidal areas in clear water (the maximum depth recorded is 7 m). Morrison et al. (2014a) surveyed seagrass around New Zealand, assessing small fish (including the juveniles of economically valuable species) and invertebrate associations, seagrass genetics, and seagrass secondary (animal) productivity. Unfortunately seagrass beds in the Hauraki Gulf Marine Park were not included in that research, effectively because very few seagrass areas (especially subtidal) remain in the Hauraki Gulf Marine Park (Powell 1937; Morrison et al. 2014a, d, M.M. pers. obs.). Seagrass extent in the Hauraki Gulf Marine Park, while poorly documented from the past, has fundamentally reduced in extent over time, especially its subtidal component. This includes the loss of extensive seagrass meadows from the Waitematā Harbour and out through the Tamaki area (Powell 1937), and probably much more widely (Morrison et al 2014d).

Limited historical evidence suggests that New Zealand has experienced extensive declines in seagrass habitats nation-wide since the late nineteenth and early twentieth centuries (Inglis 2003). These analyses/observations have largely been restricted to the past 40 to 50 year period, due to the limited availability of qualitative survey or photographic data (Inglis 2003, Turner & Schwarz 2006). The loss of the subtidal component in particular has almost certainly resulted in the associated loss of significant levels of juvenile fish production (see the Fish Stocks Appendix), invertebrate biodiversity, as well as the many other ecological functions seagrass provides (Schwarz & Turner 2006, Morrison et al. 2014a). Encouragingly, recently there has been some limited recovery and expansion of seagrass areas within the inner Gulf, including from Meola Reef to the harbour bridge, at Kohimarama, and at Snell’s Beach (MM, pers. obs.). Although the Meola Reef area includes some limited subtidal seagrass, exploratory fish sampling in 2014 found only a few juvenile fish in this habitat (Morrison, pers. obs.), suggesting that greater amounts of seagrass and/or time may be required to support the return of abundant juvenile fishes. Outside the inner Hauraki Gulf region, limited subtidal seagrass meadows still persist at Great Mercury Island, and around the south side of Slipper Island, where they collectively support diverse invertebrate assemblages and abundant juvenile fishes (Schwarz et al. 2006).
Seagrasses are a unique group of flowering plants that exist fully submerged in the sea. Seagrasses are distributed globally, but unlike terrestrial angiosperms exhibit low taxonomic diversity (approximately 60 species worldwide), with 12 genera. All species share similar architecture and physiology, and perform similar ecosystem functions. Seagrasses are a characteristic component of many coastal areas ranging from subarctic to temperate and equatorial regions, reaching their most southerly global distribution at Stewart Island, New Zealand (Hemminga & Duarte 2000, Turner & Schwarz 2006).

Loss of seagrass from intertidal and subtidal areas can have profound effects on ecosystem health and services (Costanza et al. 1997, Hemminga & Duarte 2000). Ecosystem services provided by seagrasses include high primary productivity to both detrital and grazing food webs (Keough & Jenkins 1995, Turner & Schwarz 2004, 2006, Connolly et al. 2005), nutrient recycling (see review Turner & Schwarz 2006), attenuating water flow (Eckman 1987, Fonseca & Koehl 2006, Widdows et al. 2008), trapping and stabilisation of bottom sediments (Fonseca et al. 1983, Gacia & Duarte 2001), providing refuge from predation (Attrill et al. 2000, Hindell et al. 2000, 2001), increasing biodiversity and providing crucial nursery habitat (including feeding/foraging) for a variety of taxonomic and functionally-important groups, including the juveniles of important recreational and commercial fisheries species (Orth et al. 2006, Grech et al. 2012).

Other important services performed by seagrasses include being a significant repository for what is termed “blue carbon” (i.e. as a marine primary producer) (Matheson & Wadhwa 2012), the release of oxygen, and the trapping of nutrients.

Seagrasses in New Zealand have been shown to have an effect on macrofaunal communities, which differ from surrounding unvegetated sediments (van Houte-Howes et al. 2004). Studies of the communities associated with seagrasses have described both meiofauna (e.g. Hicks 1986, 1989, Bell & Hicks 1991) and macrofauna (e.g. Henriques 1980, Woods & Schiel 1997, Turner et al. 1999).

The role of seagrass meadows as nursery areas for fishery species has only recently been acknowledged and investigated within New Zealand. New Zealand wide estuarine fish surveys undertaken by Francis et al. (2005, 2011) first identified the association of small fishes (e.g. snapper, trevally, parore, spotties) with subtidal seagrass, followed by further work on subtidal meadows from Slipper and Mercury Islands, off the Coromandel Peninsula (Schwarz et al. 2006). These studies showed that subtidal seagrass (i.e., that permanently submerged) was the important seagrass component, with a much less pronounced effect (if any, in some circumstances) when only intertidal seagrass was present. Beyond the simple division of intertidal and subtidal seagrass, international studies have shown that other seagrass related factors including landscape metrics (e.g. patch size, perimeter to area ratios) (Boström et al. 2006), and within patch metrics of seagrass condition (e.g. blade density & height) (Horinouchi 2007) also influence the use of seagrass by juvenile and adult fishes. However, in comparison with other countries, fine scale observational and experimental work in New Zealand is limited. Morrison et al. (unpubl. data) used artificial seagrass units (ASU) in Whangapoua Harbour, Coromandel, and found that increasing blade densities resulted in increasing fish densities (although the patterns of response varied depending on the fish species) and species diversity (see summary in Morrison et al. 2014b). Further research by Parsons et al. (2013) confirmed the effect of blade density, and also found that the position of the ASU’s within the harbour (i.e. upper/lower) affected the abundance of juvenile fish (notably snapper and spotties), with greater fish densities found towards the mouth of the Whangapoua harbour. The body condition of juvenile snapper was also found to be greatest in ASU units with the highest blade densities. Given that one of the initial responses of seagrass meadows to environmental degradation (prior to complete loss) is a reduction in blade density, this habitat quality effect (i.e. seagrass blade density) is an important component to consider in assessing the health and functional role of seagrass meadows as fish nurseries (Morrison et al. 2014a–c).

Recent experimental research on factors affecting settlement dynamics and olfactory cues within seagrass and other habitats for larval snapper has also been undertaken (Radford et al. 2012, Sim-Smith et al. 2012, 2013). Tank experiments revealed that larvae preferentially swam towards water taken from over seagrass beds, rather than water that had been taken from the harbour entrance, or from artificial seawater (chemically created ‘pure’ saltwater without prior biological influence) in which seagrass had been soaked.
These results strongly suggest that biological chemical cues from sources other than seagrass, such as from prey or conspecifics present in the seagrass habitat, may also be involved as a pre-requisite for juvenile fishes.

There have been several small scale seagrass restoration studies undertaken within New Zealand. Attempts within the Manukau Harbour had limited success (Turner 1995), but subsequent seagrass restoration in Whangarei Harbour has been more successful with recent anecdotal reports of the reestablishment and expansion of large seagrass meadows (Reed et al. 2004, Matheson et al., in prep.). However, this significant seagrass expansion, including an extensive 3.5 km² area of patchy subtidal seagrass, although starting around the same time period (2008) as the small-scale transplants, is likely to be too widespread to have been generated by transplants alone.

A widely recognised function of seagrass beds is the provision of sheltered habitats and elevated food supplies for fish and macrofaunal communities. Seagrasses in New Zealand have been shown to have an effect on macrofaunal communities which differs from surrounding unvegetated sediments (e.g. van Houte-Howes et al. 2004). Henriques (1980), showed that seagrass habitats in the Manukau Harbour had a higher species diversity and abundance of macrofauna than comparable non-vegetated habitat. Other studies of the animal communities associated with seagrasses include meiofauna (e.g. Hicks 1986, 1989; Bell & Hicks, 1991) and macrofauna (e.g. Henriques 1980, Alderson 1997, Woods & Schiel 1997, Turner et al. 1999; Schwarz et al. 2006). Higher macrofaunal density, biomass and productivity, has also been observed for subtidal seagrass areas, relative to intertidal seagrass in northern (Ellis et al. 2004; van Houte-Howes et al. 2004; Alfaro 2006; Schwarz et al. 2006) and southern New Zealand (e.g. Mills & Berkenbusch 2009). This may be a result of the large fluctuations in environmental conditions (i.e. periodic desiccation and fluctuating temperatures), experienced by intertidal habitats, resulting in stunted growth (shorter blade lengths), and lower overall diversity and productivity (Schwarz et al. 2006). In contrast, subtidal habitats are more environmentally benign and stable, and are characterized by more complex structure, with higher density and longer stems providing up to 20 times more surface area for epifaunal animals to graze (Schwarz et al., 2006).

Rapid large scale seagrass losses reported in both tropical and temperate regions of the world have increased almost tenfold over the past 40 years (Orth et al. 2006). Worldwide, seagrass meadows declined at a rate of 110 km² yr⁻¹ between 1980 and 2006, with 15% of seagrass species now considered threatened (Waycott et al. 2009, Short et al. 2011, cited in Grech et al. 2012). Biological, environmental, and extreme weather events have been identified as causes of seagrass losses which can interact at varying temporal and spatial scales (Orth et al. 2006). Nonetheless, a recent global review of the 6 seagrass bioregions acknowledged that anthropogenic activities including urban/industrial runoff, urban/port infrastructure development, agricultural runoff, and dredging had the greatest impact on seagrasses (Grech et al. 2012). These terrestrially and coastal based activities highlight the growing need for land-based coastal management to be incorporated into conservation and protection of seagrass habitat.

THE PAST

Today’s marine environment may be far removed from what original marine ecosystems were like; both in terms of the spatial extent and configuration of habitats, and of the associated plant and animal populations they supported (e.g., Dayton et al. 1998, Jackson 2001, Jackson et al. 2001). Past human impacts have been profound, but have often gone unnoticed – as each succeeding human generation has a different view of what ‘natural’ is, based on their own observations. This results in diminishing expectations of what is ‘natural’ in the oceans, termed “sliding environmental baselines” by Dayton et al. (1998), and so the magnitude of change is usually seriously underestimated. At present, there seems to be limited public, political, and even scientific awareness of the extent, importance, and consequences of such a long history of coastal habitat loss and ecosystem decline (Lotze 2004).

For instance, Airoldi & Beck (2007) found that the coastal biogenic marine habitats of Europe, including wetlands, seagrass meadows, shellfish beds and biogenic reefs, had been virtually eliminated over the last several hundred years, with less than 15% of the European coastline considered to remain in ‘good’ condition. They also noted that historical loss estimates were conservative as these assessments were based on recent distributions “with little recognition of the compounding impact of centuries and millennia of habitat loss”. Similarly, Lotze et al. (2006) assessed impacts in North America and European ecosystems, and found human impacts to have depleted more than 90% of formerly important species,
destroyed 65% of seagrass and wetland habitat, degraded water quality, and accelerated species invasions. They concluded that “the structure and functioning of estuarine and coastal habitats has been fundamentally changed by the loss of large predators and herbivores, spawning and nursery habitat, and filtering capacity that sustains water quality”. They offered some hope for restoration, noting that as overexploitation and habitat destruction were responsible for most historical changes, their reduction should be a major management priority; and that despite some extinctions, most species and functional groups still persisted, albeit in greatly reduced numbers, and so recovery potential remained. Where human efforts focussed on protection and restoration, recovery had occurred, although usually with significant time lags (see also Lotze et al. 2011).

New Zealand, including the Hauraki Gulf Marine Park, has not escaped such impacts, despite its short history of human settlement. Morrison et al. (2009) concluded that the impacts of past human land use have been significant for coastal systems and species, especially through sedimentation. Parsons et al. (2009) found evidence of large reductions in the abundance and size of snapper from estuarine and very near-shore habitats where once they were commonly caught in the Hauraki Gulf Marine Park, and the probable loss of some behavioural groups. Taylor et al. (2011) used long-term diver recollections of the Poor Knights Islands Marine Reserve to show large and steady long term declines in abundances of black corals, tube sponges, packhorse lobster, and large predatory fishes. Shears (2010) highlighted changes on the intertidal part of Meola Reef, Waitematā Harbour (Figure A3.1), from clean rocks with tube-worm colonies, to a muddier seafloor cover, with a dominance of Pacific oysters (an invasive species). Given the existence of sliding environmental baselines, marine resource management (including fisheries) should be viewed not only in the context of managing what currently exists (at an arbitrary point in time), but also in the context of what was historically present, and what the system might look like in the future, given pragmatic and realistic mitigation and/or restoration research and management strategies.

Figure A3.1 Example of a sliding baseline.

Western side of Meola Reef; top, 1920s with tubeworm mounds and rock with little sediment and no Pacific oysters (Oliver 1923); middle, 1982 with Pacific oysters and little sediment (Dromgoole & Foster 1983); bottom, 2010 with Pacific oysters and large patches of consolidated sediment. Mangroves can also be seen to appear in the background (Source: figure 16 of Shears 2010).
A large multi-focused research programme on the historical reconstruction for the Hauraki Gulf and the Catlins Coast, Otago has been undertaken to "determine the effects of climate variation and human impact on the structure and functioning of New Zealand marine shelf ecosystems over the timescale of human occupation in New Zealand from about AD 1250 to the present day" (nearing completion). Some 18 separate reports are included in this programme; including an overall findings and synthesis report (MacDiarmid et al 2016), and another including oral histories of the Hauraki Gulf (Maxwell & MacDiarmid 2016).

CURRENT THREATS AND STRESSORS TO BIODIVERSITY

The Hauraki Gulf faces a range of threats and stressors that are impacting on its benthic and pelagic marine biodiversity. It is important to emphasise that these do not act in isolation from each other. For example, impacts on benthic habitats from fishing interact with sedimentation derived from the land, and populations stressed by one factor are generally more susceptible to additional stresses caused by other factors (Buchbaum et al. 2005).

Fishing impacts on seafloor assemblages

The first documented concerns about the use of towed fishing gear on benthic habitats were from UK fishermen in the fourteenth century (Lokkeborg 2005). These concerns related to the capture of juvenile fish and the detrimental effects on food sources for harvestable fish. Despite this long history of concern, it is really only since the 1990s that international research has focused on the effects of fishing on benthic communities, biodiversity, and production. The rapid expansion of studies in this area, and the controversy associated with the effects of fishing has led to numerous reviews, summarizing this research and identifying overall patterns (Gislason 1994, Dayton et al. 1995, Jennings and Kaiser 1998, Lindeboom and de Groot 1998, Hall 1999, Collie et al. 2000, Gislason et al. 2000, Kaiser and de Groot 2000, Dayton et al. 2002, Thrush and Dayton 2002, Lokkeborg 2005, Department of Fisheries and Oceans 2006, Kaiser et al. 2006, Rice 2006, Watling et al. 2014).

These reviews are in general agreement, concluding that benthic disturbance from mobile fishing varies in relation to the habitat, fishing gear, and environment, and is likely to have predictable and potentially substantial effects on benthic community structure and function. These effects can lead to regional-scale reductions in biodiversity, reduce benthic community productivity (Jennings et al. 2001, Hiddink et al. 2006), alter natural sediment fluxes and reduce organic carbon turnover (Pusceddu et al. 2014), and modify the shape of the upper continental slope (Puig et al. 2012), reducing morphological complexity and benthic habitat heterogeneity. The effects of fishing on the seabed can be divided into geotechnical (the physical contact of the gear on the seabed) and hydrodynamic (the suspension of sediment into the water column) components, and vary with both fishing gear and benthic habitat (Ivanovic et al. 2011, O’Neill et al. 2011). Heavier fishing gears tend to penetrate deeper into the seabed (Ivanovic et al. 2011), while larger gears towed at faster speeds generate more drag, suspending greater quantities of seabed material, particularly in softer muddier sediments (O’Neill et al. 2011). The likely effects and dispersal of these sediments will vary locally, depending on oceanographic conditions.

Within coastal regions, scallop dredges are generally considered to have a greater impact on benthic communities (per area fished) than trawls or Danish seines, as the gear is heavier and penetrates further into the seabed (Kaiser et al 2006). Habitats with relatively low natural levels of disturbance are generally considered to be more sensitive to fishing impacts than habitats in areas of frequent natural disturbance (Lokkeborg 2005). However, biogenic habitats (created by animals and plants) may occur in such areas (e.g., Spirits Bay), and are particularly sensitive to fishing impacts (e.g., Tuck and Hewitt 2013). Typically, species that are larger, longer lived, slow growing, fragile, erect, and/or sedentary species (e.g., sponges, sea pens, corals, horse mussels) tend to be more sensitive to the physical impacts of fishing gear than smaller, faster growing, less fragile species living below the sediment surface (Tuck and Hewitt 2013). Species sensitivity to re-suspended sediment is likely to be related to different life history characteristics, with species that photosynthesise (e.g. rhodolith beds), filter feed (e.g. gorgonians, bryozoans and infaunal bivalves), or are vulnerable to smothering (e.g., sponges) are most at risk.
Three studies on the impacts of fishing have been completed in the Hauraki Gulf Marine Park. Thrush et al. (1995) conducted a small scale, short term (up to three months) experiment looking at scallop dredging effects, at the individual dredge track scale. Two shallow (24 m) sites were assessed; with one site regularly commercially fished and the other not. Community composition differed between the sites, but both were dominated by small and short-lived species. The experiment assessed the density of common infaunal species, total abundance and species richness between the two sites, and found that both density and species richness decreased following dredging, with some species still significantly different after three months. Significant differences in community assemblage structure between the dredge and control plots were also recorded over the experiment, with stronger effects at the site previously commercially fished. The bivalve Nucula nitidula (a ‘nut-shell’) and tube building polychaetes were consistently sensitive to the effects of fishing, showing significant reductions in abundance at both sites following dredging.

Thrush et al. (1998) examined benthic communities from 18 locations within the Hauraki Gulf Marine Park using video (for epifauna) and grab, suction dredge and core (for infauna) approaches. The benthic communities were examined relative to both gradients of fishing pressure and environmental variables, based on rankings of potential habitat disturbance by commercial demersal trawling and dredging - estimated from fisheries legislation and anecdotal information from fishery managers and scallop fishers. The fishing-pressure gradient accounted for 15–20% of benthic community structure, and also had a significant effect on species richness and benthic community diversity. Increases in fishing pressure significantly reduced the density of large (and long lived) epifauna and echinoderms, and significantly increased the density of small opportunist species, with the effect on deposit feeders varying with the sampling approach. No effect on scavengers was observed. While scavenger attraction to disturbed areas to feed on damaged fauna has commonly been observed in manipulative studies (e.g., Kaiser & Spencer 1994, Ramsay et al. 1996), such effects are likely to be very transient in space and time, and unlikely to be observed in broad scale studies.

In another localised spatial study, Morrison et al. (2016) used video transects to examine the distribution and abundance of benthic epifauna and fish species in five areas inside and outside (up to 2.5 km) the Hauraki Gulf Cable Protection Zone - considered to have been an effective closed area to fishing and anchoring since 1999. Cable Protection Zone status (inside or outside) had a significant effect on common species abundances and univariate community diversity measures, in the main drivers of community composition and species abundance appeared to be location and depth, with Cable Protection Zone status only explaining 1.4% of total variance. There was no discernible effect of the Cable Protection Zone on fish assemblages.

Tuck et al. (in press) provides a comprehensive analysis and review of the impacts of fishing on soft sediment systems in New Zealand, including the Hauraki Gulf. They concluded that:

“The magnitude of the effects of fishing (% variability explained) varied between studies, and as would be expected, greater effects were detected over stronger effort gradients. The levels of effect detected were reasonably consistent between dedicated sampling approaches (within study), while opportunistic data sets were less effective at detecting effects. When effects were detected, fishing was associated with reductions in the number of taxa, diversity and evenness of both epifaunal and infaunal communities, but more consistently for epifauna. Fishing appears to have reduced epifaunal biomass and productivity (whole community and fish prey) by up to 50% in some of the study sites, but effects on infauna were less consistent (increasing by up to 20% in the one area an effect was detected). The species that were most consistently identified as being negatively correlated with fishing pressure were those that either stand erect out of the seabed (e.g., horse mussels, sponges, bryozoans, hydroids, sea pens, tube building polychaetes), or live on the sediment surface, and thus are particularly sensitive to physical disturbance through either direct physical impact (e.g., Echinocardium), smothering (e.g., small bivalves) or increased vulnerability to predation following disturbance (e.g., brittle stars). Where examined, even relatively modest levels of fishing effort (i.e., fishing an area between once and twice per year, estimated at the 5 km * 5 km scale) reduced the density of the combined group of long lived sedentary habitat forming species and individual species group densities of holothurians, crinoids, cnidarians and bryozoans by at least 50%”
Sedimentation

Sedimentation has arguably been of the most significant impacts on the estuaries and coastal fringes of the Hauraki Gulf Marine Park, and may also have impacted in areas further from the coast. In estuarine environments, sedimentation effects over longer time scales are often captured in stratified sediment layers, and can be used to calculate Sediment Accumulation Rates (SAR). Core sampling from numerous estuaries around New Zealand all show the same trend towards significantly increased sedimentation rates following large-scale deforestation. Coromandel estuary examples include Wharekawa Estuary, with pre-Polynesian SAR of 0.09–0.12 mm yr\(^{-1}\), rising to 3.0–7.2 mm yr\(^{-1}\) during catchment deforestation (1880–1945), and 5.0–8.0 mm yr\(^{-1}\) more recently (1945–1999) (an exotic pine production forest was established during this time) (Swales & Hume 1995); Whangamata Estuary, with pre-Polynesian (about 700 BP) SAR rates of about 0.01 mm yr\(^{-1}\) increasing to 11 mm yr\(^{-1}\) after 1880 (Sheffield et al. 1995) due to clearance of relatively steep catchment and commercial forestry development, and estimated to be around 5 mm since the 1940s (Swales & Hume 1984); Whangapoua Estuary, with pre-Polynesian SAR rates of 0.03–0.08 mm yr\(^{-1}\), increasing to 0.12–0.13 mm yr\(^{-1}\) following Māori occupation, and to 0.89–1.5 mm yr\(^{-1}\) following European forest clearances.

Within the Hauraki Gulf, around Auckland city, work in the Tamaki Estuary found early to late Holocene (the last 10,000 years) SAR to be about 0.11–1.6 mm yr\(^{-1}\), when the surrounding catchments were vegetated in podocarp hardwood forests. Following Māori settlement and associated forest clearance, SAR rates increased to 2.4 mm yr\(^{-1}\), and following European land clearances from about 1840 onwards, SAR increased to 6.25 mm yr\(^{-1}\), with significant increases of heavy metals (Cd, Cu, Pb, and Zn) in the most recent layers (Abrahim 2005). In the Papukura Estuary, pre-human SAR rates ranged from 0.2–0.5 mm yr\(^{-1}\); these rates increased three-fold to 0.8–1.6 mm yr\(^{-1}\) following European forest clearance and subsequent agriculture in the mid-1800s, and at the top of the estuary have averaged 32.6 mm yr\(^{-1}\) since 1960 (Swales et al. 2002).

In the Mahurangi Harbour, following catchment deforestation (1850–1900), 3 metres of sediment has accumulated at the head of the harbour, 70% of this since 1900 (Swales et al. 1997). Infrequent floods were found to drive much of the erosion, with one-third of the total catchment erosion being generated from nine floods from 1953 to 1995. In Lucas Creek, in the upper Waitematā Harbour, rates increased from less than 1.5 mm yr\(^{-1}\) before human arrival, to 2.5 mm yr\(^{-1}\) during Polynesian forest clearance (700–110 BP), and then to 3 mm yr\(^{-1}\) after Europeans arrived, associated with the advent of logging, gum digging and land clearance (AD 1841 to the present (Hume & McGlone 1986)).

An extensive review of land-based effects on coastal fisheries and associated biodiversity is provided by Morrison et al. (2009). In New Zealand, arguably the most important land-based stressor is sedimentation, including both suspended sediment and deposition effects, and associated decreases in water clarity (which may also be driven by nutrient effects). Ongoing re-suspension and deposition events (e.g., by storms, currents, and fishing gears) may shift sediments between these two states (suspension; seafloor deposits). Suspended sediments can directly impact on species by clogging the gills of filter feeders and decreasing filtering efficiencies as loads increase (e.g., cockles, pipi, scallops, horse mussels) (Ellis et al. 2001, Nichols et al. 2003, Hewitt & Pilditch 2004), reducing settlement success and survival of larval and juvenile phases (e.g., paua, kina) (Phillips & Shima 2006), and by reducing the visual foraging abilities of finfish (e.g., juvenile snapper, Lowe et al. 2016). Species may also be indirectly effected via the modification or loss of important nursery habitats, especially those composed of habitat-forming (biogenic) species (e.g. green-lipped and horse mussel beds, seagrass meadows, bryozoan and tubeworm mounds, sponge gardens, kelps/seaweeds, and a range of other ‘structurally complex’ species) (Morrison et al. 2009, 2014a-c). These effects do not act in isolation from each other, and may produce additive or multiplicative outcomes.

Eutrophication

International work has shown that eutrophication has the potential to initially increase primary productivity (phytoplankton and macrophytes), and then to create profound cascades of effects into marine ecosystems. These include loss of seagrasses, and eventually macrophytes, increases in phytoplankton blooms that reduce light levels reaching the sea-floor, subsequent oxygen depletions as blooms die and increase detrital levels on the seafloor, and large-scale losses of benthic prey assemblages that support finfish fisheries (Cloern...
Factors that moderate the influence of these processes include tidal streams, the degree of water transport across different areas, and the presence of large numbers of filter-feeding bivalves (e.g. oysters). Loss of such bivalve populations, e.g., from over-harvesting or sediment impacts, may exacerbate other land-based stressors, such as eutrophication, by reducing the underlying resilience of local systems (Cloern 2001). Little research has been done on the potential impact of eutrophication in New Zealand’s coastal systems, though it may be modest due to our lower population size relative to other areas of the world. The Water Quality chapter and appendix discuss nutrients in some detail.

Infrastructure

The development of the city of Auckland has resulted in fundamental changes to the coastal fringe: including extensive reclamation of the approaches to the harbour bridge and the area from the Wynyard Quarter to the Ports of Auckland; along with the creation of motorways, the ‘enclosure’ of Hobson Bay by Tamaki Drive, and the creation of marinas, wharves, breakwaters, and swing mooring areas. Smaller but similar developments have occurred through the mainland fringes of the Hauraki Gulf Marine Park, especially where human settlements have been created, along with the roads and other infrastructure required to service them. Generational memory means that a number of past activities around this may have now being largely forgotten, such as the quarrying of gravel from many island’s beaches around the Hauraki Gulf Marine Park as building materials for Auckland, and the demolition by dynamite of the small ‘tor’ island that once existed in the sea off Bastion Point, to make way for the road, and to provide road building material. Collectively, such actions have probably significantly affected the ecology and biodiversity of the coastal fringe, both through direct removal of areas of marine habitat, and the effects on the adjacent environments. Such impacts are hinted at through an observation by a marine scientist around 80 years ago. Powell (1937) wrote that “Unfortunately there is no prior account of the bottom conditions in the harbour... the Zostera (sea-grass), once abundant in the bay, has now almost entirely disappeared... Tide-deflectors and reclamation works elsewhere have considerably reduced the areas of Zostera... marked effect on the frequency of carnivorous fishes... may be a more important factor than either over fishing or assumed harbour pollution.”

As Auckland continues to develop and expand, new infrastructure will be required, yet even seven decades’ later we are still lacking a formal baseline or ‘prior account’ of the benthic ecosystems for the broader Hauraki Gulf.

Invasive species

Introduced marine species pose a serious threat to marine ecosystems throughout the Hauraki Gulf. At least six Non-Indigenous Species with the potential to cause serious harm to the marine environment have already become established in the Hauraki Gulf, with five of these arriving in the past 15 years. Another four new species have been reported since 2011, one of which (the Mediterranean fan worm Sabella spallanzani) is a high risk species capable of causing serious problems. The Port of Auckland is a key entry point for invasive species and the large amount of boating and other marine-based activities centred on it serve as vectors for the rapid spread of exotic species throughout the Marine Park and to other regions. Controlling the spread and growth of established marine pests is extremely difficult and to date no successful programmes have been implemented. Management is therefore focussed on preventing their arrival and early detection. Little is known about the potential long-term impacts of non-native species on the indigenous biodiversity of the Hauraki Gulf Marine Park.

Climate change and ocean acidification

Global climate change represents a chronic, long-term disturbance to marine ecosystems. Environmental changes associated with climate change include increasing sea surface temperatures, changes in the frequency and intensity of storms and climate phenomena such as the Southern Oscillation (the El Nino-La Nina cycle), and changes in ocean circulation and ocean acidification. The latter is likely to adversely affect organisms with calcium carbonate exoskeletons such as some types of phytoplankton, corals, bryozoans and shell fishes, and will be exaggerated by acidification of coastal waters caused by nutrient inputs from terrestrial run-off. Sea-level rise will also create challenges for the conservation of coastal biodiversity through impacts on intertidal habitats and the composition of coastal vegetation types (in response to changes in immersion-emersion and salinity regimes).
Negative effects of global sea-level rise on marine biodiversity will be greatest in estuarine and coastal ecosystems. The most obvious effect will be the loss of existing coastal lagoons and wetlands; shorebird nesting, roosting and foraging areas; and intertidal habitats unless the ecological effects of coastal inundation are anticipated and planned for. Currently much of the advice around planning for sea-level rise is focussed on coastal infrastructure and property damage. Increased coastal erosion may also result in increased amounts of terrestrial sediment entering the coastal zone.

MARINE DEBRIS

Marine debris includes litter (which comes in many forms, including plastic, glass bottles, and aluminium cans) as well as discarded or lost fishing gear, aquaculture equipment, and abandoned vessels and structures. Plastic litter is the biggest problem.

Litter, especially plastic litter, is a global concern due to its environmental persistence, large volume and widespread dispersal. Litter injures and kills marine life, interferes with navigation safety, poses a threat to human health, and reduces the amenity of beaches and the coastline. Plastics photo biodegrade in UV light but do not biodegrade, so they persist in the environment. Plastics weaken and kill seabirds through starvation and false feelings of satiation, irritation of the stomach lining, and failure to put on fat stores necessary for migration and reproduction. Seabirds that feed on small prey near the surface can mistakenly ingest plastic pellets floating on the water.

Of principal concern to the community regarding plastic litter in the Hauraki Gulf is contamination of the marine food chain. Plastics are consumed by fish and the chemical components are absorbed into the flesh of the fish, which can end up affecting human health through exposure to carcinogens (cancer causing chemicals) and endocrine disrupters (which negatively affect human development).

The majority of the litter entering the coastal and marine environment comes from stormwater drains; litter also comes from the shoreline and recreational activities such as picnicking and beach-going. Abandoned and discarded fishing gear is also a major problem, since it can entangle, injure, maim, and drown marine wildlife, and damage property.

Since 2002 the Watercare Harbour Clean-up Trust (WHCT – previously called the Waitematā Clean-up Trust) and Sea Cleaners, with the help of Sustainable Coastlines and other dedicated volunteer groups, have removed over four million litres of rubbish from the shore, estuaries and mangroves of Waitematā Harbour, Tamaki Strait, and islands in the Auckland region. This equates to more than 140 shipping containers filled with loose litter and over 100,114 volunteer hours.

The amount of effort put into rubbish collection has been fairly steady since 2006 (with the exception of 2011, where Rugby World Cup games were being played in Auckland) whereas the annual volume of rubbish collected has declined since 2008 and the focus of clean-up actions has changed. This has been due, in part, to the sheer quantity of rubbish removed and upgrades to stormwater catchpits retaining large pieces of debris. Anecdotal evidence however suggests that the amount of rubbish discarded on beaches and coastal reserves by recreational fishers and picnickers is increasing.

The distribution of litter and debris on the seafloor is far less clear. Old dumping sites still hold material, including off the Rangitoto Lighthouse and on the north-western side of Kawau Bay (large steel frames, cables and other metal items, M.M. pers. obs.), along with old ammunition dump sites further out in the Hauraki Gulf Marine Park, as marked on charts. Popular recreational anchorages such as Bon Accord Harbour, Kawau Bay, have significant volumes of old brown beer bottles and other items distributed across the seafloor, which may last indefinitely in such environments. Lost fishing gear, including monofilament lines and lead sinkers, are common at rocky reef sites fished from the shore. The lead sinkers are usually un-colonised by marine organisms, probably due to their toxic nature.
MARINE PROTECTED AREAS

Marine Protected Area is an umbrella term used to describe a wide range of areas protected for marine conservation. The Convention on Biological Diversity (CBD) defines marine and coastal protected areas as “an area within or adjacent to the marine environment, together with its overlying waters and associated flora, fauna, and historical and cultural features, which has been reserved by legislation or other effective means, including custom, with the effect that its marine and/or coastal biodiversity enjoys a higher level of protection than its surroundings”.

The New Zealand Marine Protected Areas Policy and Implementation Plan (MPA Policy) reflects the commitment by the Government through its ratification of the CBD and development of the New Zealand Biodiversity Strategy (NZBS) to help stem the global loss of biodiversity. The MPA Policy is intended to assist government achieve Objective 3.6 of the NZBS which is to protect a full range of natural marine habitats and ecosystems to effectively conserve marine biodiversity, using a range of appropriate mechanisms, including legal protection. The MPA Policy recognises that a range of management tools, including marine reserves and Fisheries Act 1996 tools, can be used to protect marine biodiversity. The MPA Policy Protection Standard provides an outcomes-based definition of an MPA. To satisfy the protection standard a management tool must enable the maintenance or recovery of a site’s biological diversity at the habitat and ecosystem level to a healthy functioning state. In order to do this the management regime must provide for the maintenance and recovery of:

a) Physical features and biogenic structures that support biodiversity;

b) Ecological systems, natural species composition (including all life-history stages), and trophic linkages; and

c) Potential for the biodiversity to adapt and recover in response to perturbation. Management tools recognised as meeting these requirements are marine reserves established under the Marine Reserves Act 1971 (Type I MPAs) and Fisheries Act 1996 prohibitions on dredging, trawling, Danish seining, purse seining, gillnetting and potting (when on sensitive biogenic habitats) (Type II MPAs).

Other tools that may meet the requirements of a Type II MPA include cable protection zones, marine mammal sanctuaries, Resource Management Act, possibly in combination with tools available under other acts (pp. 12–13, Marine Protected Areas Classification, Protection Standard and Implementation Guidelines 2008). The 2012 International Union for the Conservation of Nature (IUCN) definition of an MPA is “a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values”.

In general the purpose of all MPAs is the conservation of biodiversity, or in some cases cultural heritage, whereby they provide a higher level of protection than surrounding areas.

There are differences between the Marine Reserve Act 1971 and Fisheries Act 1996 tools. The most important difference between marine reserves established under the Marine Reserves Act 1971, and the Fisheries Act 1996 tools, is that marine reserves are able to protect the habitat from disturbances unrelated to fishing such as discharges, dumping, mining and structures. Fisheries Act tools can offer more flexibility to a variety of fishery uses that may be compatible with varying degrees of marine protection.

Existing marine protection within the Hauraki Gulf Marine Park

There are six marine reserves (Type I MPAs) within the Marine Park, they are: Cape Rodney-Okakari Point Marine Reserve (529.8 ha), Tawharanui Marine Reserve (394.2 ha), Long Bay-Okura Marine Reserve (962.7 ha), Motu Manawa-Pollen Island Marine Reserve (500.5 ha), Te Matuku Marine Reserve (687 ha) and Te Whanganui-A-Hei (Cathedral Cove) Marine Reserve (886.7 ha). Collectively they cover 0.28% of the total area of the Marine Park. In addition there are three cable protection zones that are recognised as Type II MPAs. The largest of these is the Hauraki Gulf Submarine Cable Closure (HGSCC) which covers a total area of 74,342 ha. At its narrowest point off Takapuna the HGSCC is 1.6 km across. At its widest in the outer Gulf it is over 10 km across. The combined coverage of Type II MPAs is 5.46% of the Marine Park, of which 96.7% is the HGSCC. The biological assemblages in all of the marine reserves have been documented.
in some way, either in the original application or in monitoring programmes and research projects since their establishment. In contrast, very little is known of the biology of any of the Type II MPAs, aside from some limited soft sediment work in the cableway by Morrison et al. (2016). The total area covered by existing Type I and II MPAs is 80,827 ha, or 5.74% of the Marine Park.

Jackson (2014) developed a habitat classification based upon substrate information developed for the Hauraki Gulf Marine Spatial Plan and the New Zealand Coastal Classification (MPA Policy Guidelines 2008) and used this to assess the representativeness of the existing MPA network in the Marine Park. This classification identified 46 coastal and marine habitat types within the Marine Park, of which only two (sheltered coarse and mixed sediments below 30 m depth) have 10% or more of their extent protected within Type I or Type II MPAs. In both cases this is attributable to the amount of these habitats occurring within the HGSCC. In contrast, half of the identified Gulf habitats were not protected within any MPA (Jackson 2014). The most extensive habitats within the Marine Park are muddy and sandy mud substrata occurring between 30–200 m depth. Currently very few habitats occurring deeper than 30 m are protected within no-take marine reserves as only a small proportion of marine reserves exceed 30 m maximum depth (Jackson 2014).

Two comprehensive reviews of the use of MPAs in the New Zealand context have recently been published (Thomas & Shears 2013, Willis 2013).

Marine Protected Area network design principles

New Zealand’s marine reserves were established individually and independently to protect local-scale marine wildlife, rather than systematically as a coherent network designed to protect national-scale biodiversity and ecosystem services (Thomas & Shears 2013). The New Zealand Marine Protected Areas Policy and Implementation Plan (MPA Policy) and the Marine Protected Areas Classification, Protection Standard and Implementation Guidelines (MPA Policy Guidelines) were developed to address the NZBDS objectives, particularly the development of network of MPAs that is comprehensive and representative of New Zealand’s marine habitats and ecosystems (pg. 10, para. 13). In this context comprehensive means capturing as much as possible of the full range of biodiversity present within New Zealand’s marine environment, and representative means containing a representative selection of habitats and ecosystems.

There is a large scientific literature on the design of MPA networks, much of it relating to the use of MPAs as fishery management tools (e.g. Martell et al. 2000; Bentley et al. 2004; Pelletier & Mahévas 2005; White et al. 2010). However, using spatial tools to manage or eliminate human activities that adversely affect the marine environment is also an effective way of contributing to the long-term ecological viability of marine ecosystems (Marine Parks Authority 2008). Guidance on ecological principles for the design of MPAs and MPA networks is contained in the MPA Policy (2005) and MPA Policy Guidelines (2008), and reviews such as IUCN (2008), Gaines et al. (2010), Fernandes et al. (2012) and Thomas & Shears (2013).

Design principles emphasised in these documents are:

4. Inclusion of the full range of biodiversity present in a biogeographic region through:
   - representation of all habitats and ecosystems.
   - replication of protection for each habitat and/or ecosystem within the network.
   - protection of habitats that exhibit resilience or resistance to long-term environmental change.
   - increasing resilience to other stressors (e.g. sedimentation, raised temperatures).

5. Ensure ecologically significant areas are incorporated by:
   - protecting unique or vulnerable habitats (e.g. biogenic habitats).
   - protecting critical habitats such as foraging or breeding grounds.
   - protecting source populations, i.e. those that export larvae, juveniles and adults to other areas.
6. Maximise the contribution of individual MPAs to the network through careful consideration of their:

- Size – in general larger MPAs will protect a greater variety of habitats and biodiversity, as well as providing a buffer against edge effects of fishing; some studies recommend large numbers of smaller MPAs for fisheries management objectives – to enhance spill-over; although many reef fishes are physically capable of swimming long distances, some of these are home ranging or territorial (e.g. McCormick 1989; Cole et al. 2000; Parsons et al. 2010) making spill-over effects less likely (Moffitt et al. 2009).

- Spacing – optimal spacing will vary depending on the objectives of MPA management and the species involved; while many marine species have long-lived pelagic larvae capable of dispersing hundreds to thousands of kilometres, many species, including habitat-forming species, such as seaweeds, sponges and bryozoans, have short-lived larvae that may stay in the plankton for less than an hour to just a few days, while other species brood their young. As a result, larval dispersal distances of these species may vary from a few metres to a few kilometres. Although other dispersal factors, such as rafting, may significantly increase dispersal potential (Grantham et al. 2003).

- Shape – boundaries should reflect natural ecological boundaries and be simple (to facilitate compliance and enforcement); the design of individual reserves should aim to minimize the area to boundary length ratio in order to minimize edge effects.

7. Consider hydrographic and ecological linkages between the land and sea – it is particularly important to consider potential land-based impacts on the marine environment when thinking about establishing MPAs in enclosed coastal waters or estuaries, MPAs are unable to directly influence activities occurring in adjoining catchments.

8. Minimise adverse economic and social impacts on existing users.

The Convention of Biological Diversity (CBD) and New Zealand Biodiversity Strategy establish a target of 10% of the marine environment protected within MPAs. However more recent research predicts that maximum benefits for biodiversity conservation and fisheries are likely to occur between 30–50% coverage by MPAs. In most cases extension of MPA coverage to more than 50% coverage of a fishery is predicted to adversely impact fishery yields due to the displacement of fishing effort into the remaining unprotected areas (Gaines et al. 2010). In this context, it is important to note that geographic coverage of a specific area such as the Hauraki Gulf Marine Park is unlikely to equate to the spatial coverage of a fishery. For example rocky reefs represent only a relatively small proportion of the total area of the marine park (actual area unknown). As a result the spatial extent of fisheries for reef-associated species such as kina and rock lobster will be much smaller than the area of the park, and usually much less than the total area of reef due to the habitat requirements of the species involved.

The use of conservation planning software or spatially explicit fishery models allows objective assessment of the cost-benefits (and therefore trade-offs) between conservation goals and exploitation of marine resources (e.g. Bentley et al. 2004; Pelletier & Mahévas 2005; Leathwick et al. 2008). Leathwick et al. (2008) demonstrated the use of conservation planning software (Zonation) to design MPA networks in New Zealand’s Exclusive Economic Zone. Using predicted distributions of 96 demersal fishes sampled by research trawls and information on the location of commercial bottom trawling, they demonstrated that protecting 10% of the habitat based solely on estimated conservation value, without regard for the impact on fishing, would on average protect 27.4% of the geographic range of each fish species and reduce fishing opportunity by 22%. Using the algorithm to select high conservation value sites but avoiding important fishing areas, produced a solution that on average protected 23.4% of the range of each species (marginally lower than the solution that ignored fishing effort) but had no impact on fishing. Increasing the level of spatial protection to 20% but still avoiding heavily fished areas produced a solution that would increase average species protection by 50% with minimal cost to the fishing industry (Leathwick et al. 2008, fig. 5). This solution had greater predicted conservation benefits and less impact on fishing opportunity than the Benthic Protected Areas, which were developed using expert opinion and a physical classification of the marine environment (Helson et al. 2010; Reiser et al. 2013).
Map A3.1  Overview/location maps for proposed MPA network and alternative scenarios.
DESCRIPTION OF EACH PROPOSED MARINE PROTECTED AREA

Fifteen MPA sites have been identified across the Hauraki Gulf Marine Park. All of these were identified for their habitat and ecological values, and were based on the information provided by our science advisors. Nine Type 1 marine reserves and ten Type 2 benthic protection areas were agreed and recommended by the Stakeholder Working Group.

Five areas - Mokohinau Islands, Tiritiri Matangi, Kawau, Motutapu / Rangitoto, and the Alderman Islands - were also agreed and recommended by the SWG as areas that would benefit from protection, but a decision was not reached on a single size, location, or shape for the Type 1 MPAs and which other type of protection would be applied. The Stakeholder Working Group (SWG) members arrived at two options for each of these areas, which include both Type 1 MPAs as well as Type 2 protection. A different option, at the Alderman Islands, is Scenario 2, which provides for a Special Management Area (SMA) (no commercial fishing with restricted recreational fishing) bordering a Type 1 MPA. As well, the Whangateau Harbour has two options for co-management between Mana Whenua and the local community. In order to gain consensus or sufficient support to select and progress one of the options, discussions with mana whenua and local communities will be required for all these areas.

There are four types of Marine Protected Area:

- Type 1: no take marine reserves (other than for customary purposes).
- Type 2: benthic protection – restrict all commercial and recreational fishing methods that impact with the benthic habitat.
- Special Management Areas (no commercial fishing allowed and restricted recreational fishing allowed).
- Ahu Moana (Mana Whenua and community co-management areas) covering the entire coastline from mean high water to 1km, with buffer zones around some Type 1 areas

1. Mokohinau Islands

The Mokohinau Islands, the northernmost islands in the HGMP, include good examples of shallow to deep-water outer shelf reef systems and abundant and diverse marine wildlife. Like the Poor Knights Islands the Mokohinaus are also influenced by the subtropical waters of the East Auckland current and high biological productivity driven by seasonal upwelling along the continental shelf edge. As a consequence, the rocky reefs surrounding the islands are characterised by diverse, colourful benthic assemblages, with deeper reefs supporting populations of vulnerable species such as large sponges, gorgonian and black corals; large schools of planktivorous fish; and species once abundant throughout the Gulf such as hapuku. Clear, oceanic water supports kelp forest growth down to a depth of 40 m. The marine assemblages found around the archipelago show little evidence of degradation by land-based pressures (e.g. sedimentation) observed elsewhere in the HGMP. The pest-free Mokohinau Islands are also known for their importance to seabirds, with a high density and diversity of species breeding on them.
SCENARIO 1

Map A3.2  Mokohinua Islands MPA Scenario 1

Plan elements

a) Type 1: no take marine reserve centered around Burgess Island (Pokohinu), Atihau, Hokoromea and spanning to the Cable Protection Zone in the west, including examples of deep reefs in the north.

b) Type 2: designed to protect benthic habitats associated with the shallow to deep reef system of the archipelago. Excludes all benthic impacting fishing methods, including trawling.
SCENARIO 2

Plan elements
a) Type 1: no take marine reserve centered around Hokoromea and Atihau Islands
b) Type 2: Special Management Area (SMA) – no commercial fishing and restricted recreational fishing

2. Little Barrier Island and Craddock Channel - Hauturu

LBI/Hauturu is surrounded by a variety of intertidal and subtidal habitats ranging from the predominantly rocky shoreline to mid-shelf-depth soft sediments and reefs. The island is encircled by an extensive system of sheltered shallow rocky reefs up to about 30m depth. These reefs support a diverse array on seaweeds, invertebrates and fishes typical of the northeast North Island.

Commercially exploited scallop beds are found around the western and southern side of the island, and the area is an important part of the commercial rock lobster fishery. Anecdotal evidence provided by SWG members indicates that the sea floor between the deep reefs north of LBI/Hauturu and the island once supported dense sponge assemblages, which were progressively removed to allow bottom trawlers to fish the area.
Remnants of these sponge dominated assemblages persist on Northwest Reef (within the cable protection zone and included within the T1) and three small patch reefs found north of the island. The largest of the latter is known as the ‘Coral Patch’ (also within the T1). Juvenile hammerhead sharks can be abundant over summer months, particularly off the northwestern end of the island. LBI/Hauturu is pest free, covered in native vegetation and of international importance for seabirds.

Craddock Channel covers a submarine saddle extending between LBI and GBI and is an area of high tidal current whilst still being relatively sheltered. The area was identified for its rich benthic environments including shallow and deep rocky reefs, holding diverse and productive inshore reef assemblages, high primary production (kelp forests), and biogenic habitats (e.g. sponges). The channel area is important for Bryde’s whale and provides critical habitat for the nationally endangered bottlenose dolphin.

Map A3.4  Little Barrier – Hauturu MPAs

Plan elements

a) Type 1: no take marine reserve extending from the northwest corner of the island west to include the cable protection zone and north to take in several deep reefs.

b) Type 2: protection of diverse benthic habitat associated with Craddock Channel. Excludes all benthic impacting fishing methods, including trawling.
3. Cape Colville - Moehau

The strong currents associated with Colville Channel create a current-swept benthic habitat with high biodiversity associated with a mixture of coarse sand and muddy sediments, as well as numerous deep rocky reefs. Extensive dense dog cockle beds with epifaunal sponges and ascidians occur in soft sediments between the reefs. The reefs are dominated by massive sponges, hydroids and anemones. They support large schools of planktivorous fishes, (predominantly pink maomao, two-spot demoiselles and sweeps) as well as a representative range of reef species such as snapper, wrasses, moki, blue cod and goatfish. SWG members report that benthic habitats in the area have been adversely affected by bottom trawling. The reefs are commercially fished for rock lobster, and are an important part of commercial longline and set net fisheries.

The area is popular with land-based fishers who access the area from Port Jackson. Hapuku historically occurred on rocky reefs in the channel.

Plan elements:

a) Type 1: no take marine reserve reaching out to the channel whilst providing easy access to swimmers, kayakers etc.

b) Type 2: protection of benthic habitats associated with the deep Colville Channel. Excludes all benthic impacting fishing methods, including trawling.
4. Alderman Islands – Te Ruamaahua

The Alderman Islands are surrounded by an extensive and complex system of rocky reefs extending from the shoreline to about 100 m depth. Clear, oceanic waters derived from the subtropical East Auckland Current, and seasonal upwelling along the shelf edge, exert a strong influence on the marine biodiversity of the archipelago. The area supports diverse shallow reef assemblages typical of offshore islands off the northeast North Island. Hapuku, large kingfish and snapper occur on the deep reefs. Seasonal aggregation of short-tail stingrays (possibly related to breeding) has been observed around Ruamahuaiti Island. Sediment transport models suggest that reefs deeper than 90m may be adversely impacted by land-derived sediments. The islands are pest free and of high importance to nesting seabirds. The area is a popular recreational fishing destination and important part of the commercial rock lobster fishery. Mana whenua have guaranteed access to customary fisheries and other taonga in the archipelago.

SCENARIO 1

Map A3.6  Alderman Islands – Te Ruamaahua MPAs
Scenario 1

Plan elements

a) Type 1: no take marine reserve centered around Ruamahuaiti Island to Nga Horo in the north, including complex reef system to the south and spanning east towards the 200 m depth contour.

b) Type 2: rest of the archipelago and reef system extending northward. Excludes all benthic impacting fishing methods, including trawling

c) Ahu Moana Mana Whenua community co-management area extending 1 km around Islands.
SCENARIO 2

Map A3.7  Alderman Islands – Te Ruamaahua MPAs
Scenario 2

Plan elements

a) Type 1: no take marine reserve centered around Ruamahuaiti Island to Nga Horo in the north, including complex reef system to the south and spanning east towards the 200 m depth contour.

b) Type 2: special management areas

c) Ahu Moana Mana Whenua community co-management area extending 1 km around Islands.
5. Mercury Islands – Ahuahu / Whakau

This area represents a relatively uncommon sequence from shallow-coastal to deep outer shelf habitats. The complex bathymetry and varying shelter provided by the islands and adjacent mainland make this an area of high habitat diversity, which is reflected in the diversity of species found in the surrounding waters. The influence of the subtropical East Auckland Current and high water clarity result in diverse algal and encrusting invertebrate assemblages. Shallow rocky reefs are dominated by large brown seaweeds, mainly Ecklonia radiata, to 30-40 m depth. Rhodolith beds occur on coarse sands between the islands and between the islands and the mainland. Below 40 m depth rocky reefs are dominated by diverse sponge assemblages. These also support protected black and gorgonian corals. Video sled observations of reefs deeper than 80 m suggest that although these are still dominated by sponges, including several rarely seen species, they are being adversely affected by terrestrially derived sediments (as predicted by NIWA sediment transport and deposition models). The islands are pest free and of high importance to nesting seabirds.

Map A3.8  Mercury Islands – Ahuahu / Qhakau MPAs

Plan elements
a) Type 2 MPA spanning from Te Koru to Rocky Bay and including Coralie Bay.
b) Excludes all benthic impacting fishing methods - trawling, dredging etc.
c) Excludes all ring netting (set netting).
d) Excludes all cray potting.
e) Excludes all commercial fishing.
f) Ahu Moana Mana Whenua community co-management area 1 km around islands.
6. Hahei

The proposal is to extend the boundary of the marine reserve offshore 1.5 km to account for offshore rock lobster movements, the same reason for the proposed extension to the Cape Rodney to Okakari Point (Goat Island) Marine Reserve. The proposed boundary extension includes South Sunk Rock, all of the coastline of Mahurangi and Te Tio Islands (and associated reefs), and part of Hahei Beach.

Plan elements

a) Type 1: Hahei marine reserve extension. Designed to provide easy access to the reserve from Hahei beach whilst providing for shore fishing from beach.

Sites for launching boats from the beach to be decided at the time of implementation.
7. Slipper Island – Whakahau

Slipper Island includes one of the only known examples of subtidal seagrass within the Hauraki Gulf Marine Park. High water quality combined with a mosaic of rocky reefs, coarse sand and subtidal seagrass habitats results in an area of high biodiversity (i.e. elevated species richness and abundance). The islands are important seabird nesting habitat. Rocky reef assemblages are typical of those found at similar exposures along the northeast North Island.

**Plan elements**

a) Type 1: no take marine reserve over half of Slipper Island, spanning examples of reef systems and associated biodiversity and subtidal seagrass habitats.

b) Ahu Moana Mana Whenua community co-management area around Type 1. This area was initially envisioned as a Type 2 to provide a level of benthic habitat protection around the type 1. Proposed to exclude all benthic impacting fishing.
methods, including trawling.

8. Pakiri Leigh

This proposal extends Leigh Marine Reserve 3 km offshore to cover most of the movement range of rock lobster in order to better protect the integrity and functionality of the marine reserve ecosystem as a whole. The proposed extension covers an offshore reef and area of shallow sand habitat used by foraging rock lobster located seaward of the existing outer boundary of marine reserve.

Map A3.11  Pakiri Leigh MPAs

Plan elements
a) Type 1 – Leigh marine reserve extension.
9. Whangateau Harbour

Whangateau Harbour is notable for the range of relatively intact estuarine habitats contained within a relatively small area. These include a variety of reef types, sandy intertidal and subtidal seabed, muddy habitats, mangrove forests, a variety of algal and seagrass beds, and saltmarsh. The variety of and quality of marine and coastal habitats are reflected in the harbour’s ecological diversity and productivity. The harbour represents the best remaining example in Auckland of a coastal vegetation sequence running from kahikatea swamp forest to saltmarsh and estuarine flats. The harbour is of importance for juvenile fish, including parore and trevally. It is also a shorebird area of importance. The harbour supports dense shellfish beds.

SCENARIO 1

Plan elements

a) Ahu Moana Mana Whenua community co-management area around Horseshoe Island. Previously proposed as a mātaitai with a shellfish removal restriction.

b) Type 2: benthic protection throughout the harbour surrounding the Co-management area, including entrance to harbour and the southern arm of the harbour (Waikokopu Creek).

Map A3.12  Whangateau Harbour MPAs Scenario 1
SCENARIO 2

Plan elements
a) Co-management area throughout entire harbour, with benthic restrictions and restrictions on harvesting shellfish.

Map A3.13  Whangateau Harbour MPAs Scenario 2
10. Kawau Bay

Kawau Bay is an area of high habitat diversity, encompassing bays and estuaries of various sizes, sheltered coastal environments and more exposed rocky and soft-sediment areas. Research indicates that the area is a highly diverse coastal ecosystem. The types of species found are those commonly associated with relatively pristine environments (e.g. sponge, rhodolith and horse mussel beds, kelp forests, scallops and pipi). The bay includes nursery habitats and areas important for juvenile fish including snapper. It was historically a nursery area for sharks, notably rig (spotted dogfish) and school shark. Kawau Bay is extensively used for recreational pursuits. Threats to the area identified are largely related to existing and expected urbanisation of the catchments, and the cumulative impact of increasing recreational use (e.g. trampling of intertidal habitats, anchoring, fishing, scallop dredging, chronic noise pollution and disturbance, etc.).

SCENARIO 1

Plan elements

a) Type 1: no-take marine reserve spanning the cable protection zone in the north and Beehive, Motuketekete and Moturekareka islands in the south.

b) Type 2: protection of benthic habitats. Excludes all benthic impacting fishing methods, including scallop dredging.
**SCENARIO 2**

Map A3.15  Kawau Bay MPAs Scenario 2

**Plan elements**

a) Type 1: no take marine reserve centered around Moturekareka and Motutara Island.

b) Type 2: protection of benthic habitats (same as scenario 1) Excludes all benthic impacting fishing methods, including scallop dredging.
11. Tiritiri Matangi

The Tiritiri Matangi and Whangaparaoa area includes a range of habitats including sheltered and exposed reefs to a high current channel. Strong water flow in the channel is associated with extensive biogenic habitats, particularly rhodolith beds. Sheltered shallow rocky reefs have large brown algae, coralline algae and large sponges. Deeper reefs are dominated by kelp and sponges. Species found in the area include dog cockles, green-lipped mussel, juvenile snapper, eagle rays, and pelagic species (e.g. kahawai, kingfish, and various shark species). Due to heavy recreational use and land-based impacts (i.e. sedimentation), the health of the area is considered degraded. Kina barrens are observed and once abundant species such as crayfish and Hapuku are rarely seen or absent. Tiritiri Matangi Wildlife Sanctuary is a highly popular tourist destination within the Hauraki Gulf Marine Park.

SCENARIO 1

Plan elements
a) Type 1: no take marine reserve around Tiritiri Island, including Shearer Rock.
b) Type 2: protection of benthic habitats extends north from Army Bay and East and South to join the cable zone. Excludes all benthic impacting fishing methods.
SCENARIO 2

Map A3.17  Tiritiri Matangi MPAs Scenario 2

Plan elements

a) Type 1: no take marine reserve extending south from Northwest Point to southern point on Tiritiri Island.

b) Type 2: protection of benthic habitats extends north from Army Bay and East and South to join the cable zone. Excludes all benthic impacting fishing methods.
12. The Noises - Otata Motuhoropapa

The Noises are a collection of small islands surrounded by very sheltered and shallow rocky reefs, with muddy/sandy substrates found in deeper areas. Common inshore reef species are found, and biogenic habitats (particularly dog cockles and rhodoliths) growing on soft sediments provide nursery habitat for juvenile snapper and scallops. Kina barrens however appear to be prominent in the area. This area is heavily used recreationally.

Plan elements

a. Type 1 no take marine reserve centered around Otata and Motuhoropapa islands.

b. Ahu Moana Mana Whenua community co-management area around the islands. Area previously envisioned as Type 2 to protect benthic habitats and provide a level of protection around the high-level protection Type 1 area. Excludes all
benthic impacting fishing methods.

13. Rangitoto & Motutapu

Shallow patch reefs provide nursery habitat for juvenile snapper and kahawai. Shallow reefs are dominated by large brown algae, crustose coralline algae and sponges. Common northeast North Island coastal reef fishes are present. The area appears to be degraded and prominent kina barrens on reefs have been observed.

SCENARIO 1

Plan elements

a) Type 1: no take marine reserve on northern side of Motutapu

b) Ahu Moana Mana Whenua community co-management area around Rangitoto and Motutapu
SCENARIO 2

Map A3.20  Rangitoto and Motutapu MPAs Scenario 2

Plan elements
a) Type 1: no take marine reserve on northern side of Motutapu.

b) Ahu Moana Mana Whenua community co-management area around Rangitoto and Motutapu.
14. Firth of Thames

As a whole and within the New Zealand context, this large embayment and the extensive mussel beds once found in the area would have been quite unique. A near collapse of all hard, biogenic reefs composed of green-lipped mussels, sponges, ascidians and cnidarians brought on by heavy dredging was observed by the 1960s. There are ongoing water quality issues. The Firth of Thames is considered important for juvenile snapper and spotted dogfish (rig), and is a nationally important nursery area for smooth hammerhead shark. The southern end of the Firth is of international significance for migratory birds.

Plan elements

a) Type 1: no take marine reserve around Rotoroa Island.

b) Type 2: protection of Firth of Thames benthic environments to support regeneration efforts of historic mussel beds in the area. Excludes all benthic impacting fishing methods.
15. Motukawao Group

The Motukawao Group is formed by several islands roughly running in parallel to the western Coromandel Coast. Relatively high tidal currents and a diverse underwater topography have resulted in high biodiversity including big sponges and hydroid trees; and kelp in exposed locations. Spawning of snapper has also been recorded in the area. Historically as in most parts of the southern inner Gulf, the area would have held extensive green-lipped mussel beds. From time to time there are occasional observations of subtropical fish species, and Bryde’s whales have been sighted in the area.

![Proposed Marine Protected Area (MPA)](Map A3.22 Motukawao Group MPAs)

**Plan elements**

a) Type 1: no take marine reserve extending offshore to include Motuwhakukewa Island and half of Motukahaua (Happy Jack) Island but excludes Motumakareta Island along west coast of the Coromandel coast.

b) Ahu Moana Mana Whenua community co-management area – 1km.