Hawke's Bay Marine Information: Review and Research Strategy

Call to let fish stock recover

A report prepared for HBRC by

Tim Haggitt

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Executive Summary

This report summarises available information on marine habitats within the Hawke's Bay Coastal Marine Area (CMA). A synopsis of this type was required by Hawke's Bay Regional Council (HBRC) due to a general lack of knowledge across the range of coastal habitats of which it has the task of managing under the Resource Management Act (1991). Additional objectives of the collation exercise were to: understand how various pressures resulting from land-based activities within the region may have changed these habitats; identify gaps in the information base; and, develop a strategy that could be applied to the CMA to bridge those gaps alongside other agencies (MPI, Iwi, DoC) and various stakeholder groups into the future. A GIS database collating available information on the different habitat types and their spatial extents within the CMA was also produced as part of the project. Main findings of the investigation are summarised below.

Coastal Habitats

The Hawke's Bay region is comprised of numerous coastal environments and habitat types. Some of the more recognisable being gravel beaches, dune systems, lagoon-type estuaries, expansive intertidal rocky reefs and patchily distributed subtidal rocky reef habitat. Muddy subtidal soft sediment is the most expansive subtidal habitat within the CMA. The coastal domain is typified by two distinct areas, that of Hawke Bay which extends from Mahia in the north to Cape Kidnappers in the south, and the more-exposed coastline south of Cape Kidnappers to Porangahau. Land cover in adjacent catchments to the CMA reflects a highly modified landscape the result of large-scale clearance of native vegetation since the mid-1800s for sheep and beef farming.

During the data collation phase of the project it was evident that much of the habitat-related information for coastal environments was limited to isolated or *ad hoc* studies, which are summarised accordingly. The exception to this being State of the Environment (SoE) Monitoring undertaken by HBRC, which has increased in scope and intensity from 2006 onwards. Interviews undertaken with a range of stakeholder groups identified, albeit anecdotally, a reasonably rapid history of degradation to various habitats and coastal species. Unfortunately, for the majority of habitats there are very little baseline data on which to gauge the rate and scale of any change. Interestingly, there were a range of consistent themes emanating from the interview process some of which included:

- Variation in the oceanographic climate – especially a decline in the intensity of spring equinox offshore (NW) winds;
- Significant decline in water quality – predominantly underwater visibility (region-wide) since the mid-1970s;
- Reduction of inshore and estuarine bivalve beds, particularly pipi and tuatua; and,
- General perception of increased sediment loading and sedimentation throughout rivers and estuarine systems.

Results from SoE monitoring have confirmed an increase in muddiness of the majority of estuaries.

Iwi

Iwi of Hawke's Bay have a strong and extensive affinity with the moana (sea) and awa (rivers) that constitute the Hawke's Bay region. They too are deeply concerned over the present day state of the coastal environment including fisheries. Many feel disenfranchised with respect to the management of the CMA, but several hapu are being extremely proactive in terms of their restoration and monitoring of key (taonga) species.

Fisheries

The Hawke's Bay region is well known as supporting a mixed-species fishery with the predominant commercial fishing method being demersal trawling. Even since the early 1900s there was evidence of boom and bust phases associated with climatic variation and over-fishing and today there is widespread concern over the current state of the fishery across all sectors (commercial, customary, and recreational). Some of the more prominent changes emanating from the interview process were:

- Absence of historically abundant species in trawl deployments, particularly hoki (based on fishers personal log books);
- Inability for Tangata Whenua to collect enough kaimoana to feed marae, as was done in the past (common theme);
- Mixed fishery status is becoming less prominent compared to 1970s-1990s period;
- Reduction in gurnard numbers in the nearshore regions (0-50 m) over the last 5 years, coupled with an increase in spiny dogfish;
- Absence of baitfish and kahawai feeding fronts;
- Reduction in paddle-crab numbers;
- Change in the faunal composition of the inshore benthos surrounding Napier.

Gaps

There were a range of gaps in the information-base identified with respect to marine habitats, fisheries, Tangata Whenua values, and effects of land- and sea-based pressures on the CMA. Some of the more prominent were:

Habitats

- Lack of quantitative information on the spatial extent of habitats within estuaries, intertidal environments and water quality pre-2006.
- Large vacuum of information on subtidal habitats (rocky reef, soft sediment etc) across Hawke's Bay.
- Lack of knowledge on the effects of multiple stressors – sedimentation, nutrients harvesting, etc on marine habitats.

Iwi

- Cultural practices, beliefs and tikanga (custom, tradition, protocols);
- Key areas for harvesting kai moana;
- Environmental condition of kai moana areas.

Fisheries

- Climatic variability and its role in driving the Hawke's Bay fishery;
- Change in species distributions across Hawke's Bay through space and time; including movement patterns of various fished species;
- The importance of various habitat types in supporting fishery production and different life history stages of fished species;
- Effect of land-based stressors on fisheries;
- Effectiveness of various fisheries closures within Hawke Bay.

Strategy

A total of 8 key strategy/research components were identified as being of importance for the variety of agencies (HBRC, MPI, Iwi, DoC) and additional stakeholders (community groups, recreational fishing groups) to consider and implement into the future. These 8 components, albeit at varying levels of precedence have been recommended in an effort to achieve improved integrated management of the Hawke's Bay coastal environment so that the effects of various land-based activities can be minimised/better regulated. While many of the strategies are aimed at building and enhancing current SoE monitoring, the recommendations were made with the intention that there would be collaboration across agencies and stakeholder groups.

Strategy 1 – Formalisation of inter-agency and stakeholder collaboration to work through and prioritise strategies

Strategy 1 is centred on formalising the collaboration of key agencies (HBRC, MPI, DoC, Iwi) including additional stakeholder entities (Area 2 Inshore Finfish Stakeholder Management Ltd, LegaSea, NZ Sport fishing Council, Napier Sport fishing Club, conservation groups) within Hawke's Bay with an impetus placed on working through and prioritising the remaining strategies.

Strategy 2 – Maintenance of exiting SoE monitoring and explore ways to amalgamate and develop customary (Matauranga Maori) monitoring linkages based on cultural knowledge

The second strategy is focused on maintaining the SoE monitoring effort within the CMA as data of this nature are imperative to evaluate trends (stability, deterioration, and improvements) in relation to land-based stressors. In addition to this it is recommended that effort is placed into empowering and valuing cultural monitoring through development of a mauri-model specific to the Hawke's Bay coastal environment. This model will be built on the knowledge of various Kaitiaki in an effort to weave Matauranga Maori with western science and increase the knowledge base within the CMA.

Strategy 3 – Develop integrated management plans for major estuarine systems

To better manage the range of estuarine environments throughout the Hawke's Bay region some of which are under severe stress from sedimentation, Strategy 3 is focused on the development of estuary-specific strategic integrated management plans for these systems. The over-arching aim of management plans would be that through understanding these ecosystems in greater detail i.e., from all avenues (values, land-use, catchment type, hydrological and environmental), agencies can have a much better chance of reducing the effects of various land-based stressors. In addition, novel catchment- and estuarine-specific restoration measures can be explored and established.

Strategy 4 – Incorporate subtidal monitoring into the SoE framework and undertake larger-scale surveys of important fisheries habitat

A clear outcome from undertaking the information collation exercise was the distinct lack of information concerning how subtidal physical and biological habitats may have changed through space and time across the Hawke's Bay region. Other than one-off spatially-limited studies and those associated with impact assessments, there are presently no consistent/relevant baselines for Hawke Bay subtidal habitats, which is of concern. Recommendations are given to establish rocky reef and soft sediment monitoring in order to develop these baselines and be able to make inter-regional comparisons. Included in the wider strategy is to undertake a habitat survey of the Wairoa Hard given its significance to the Hawke Bay fishery.

Strategy 5 – Development of a hydrodynamic model

Given the extensive modifications to the various catchments within the Hawke's Bay region and effects associated with river plumes (sedimentation, nutrient enrichment, increased turbidity), together with the range of point-source discharges (wastewater, storm water), and dredging activities - all of which have the potential to impact the CMA to varying degrees - development of an "in-house" 3-D hydrodynamic model would be of immense value. Such a tool would be instrumental in enabling a whole gambit of investigations to be undertaken, particularly evaluating the effects of land-use changes and climate change on the wider CMA. Data collected by the HBRC's water quality buoy HAWQi can be used to help build/validate the model.

Strategy 6 – Evaluate effectiveness of fisheries spatial management areas

The Hawke's Bay region has had a long history of establishing spatial fisheries management areas that restrict either certain fishing sectors, fishing methods, and/or vessel sizes. Presently it is not overtly clear how the various closures (based on area and time) are, or are not, functioning within Hawke Bay, nor the habitat types associated with them. As such, Strategy 6 recommends establishing a working group and undertaking workshops with relevant scientists, stakeholders and agencies to evaluate the strategies underpinning these management areas, and the sampling protocols required to evaluate their effectiveness.

Strategy 7 – Determine fisheries habitats-linkages within Hawke's Bay

While the role that various habitat types play in fisheries production within New Zealand is gaining increasing attention, many gaps in the knowledge-base still exist particularly around habitat linkages; many of these gaps are pertinent to the Hawke's Bay region. Strategy 7 advocates for identification and prioritisation of research that addresses key knowledge gaps surrounding fisheries habitat linkages, in tandem with establishing protection/enhancement methods for important fisheries habitats identified.

Strategy 8– Continue to develop the GIS database developed for this project

The GIS database developed as part of this project contains information and data regarding the range of physical and biological habitats that constitutes the Hawke's Bay CMA. Data underpinning the database varies considerably in nature and age and there is a real deficiency in finer-scale details of habitat composition. It is anticipated that as new data comes to hand the various components will be updated accordingly and the knowledge base across Hawke's Bay will continue to build. As it presently stands there are a range of possible analyses that could be done within the GIS module. An obvious starting point would be to integrate fisheries trawl data, recreational fishing data, various biological datasets *etc* and evaluate where the most impacted areas within Hawke's Bay are likely to be. These types of analysis could drive and support supplementary investigations going forward.

Acknowledgements

Over the course of this project interviews and discussions were held with a range of individuals representing a variety of organisations. Many freely gave up their time to discuss their views on the current state of the Hawke's Bay CMA and wider fishery and share many years of knowledge and providing valuable insight. The authors would like to thank: Allen Smith, Christine Smith (Te Tira Whakaemi o te Wairoa); Johnathon Dick (Ngati Kahungunu); Dave Wakefield, Jim Hutchenson, Allen Hutchenson, Paul Sciascai (Ngati Kere); Gordon Paku (Ngati Hawea); Te Kohu Hawaikirangi (*Nga Hapu o Tutaekuri);* Jenny Mauger (Te Matau a maui committee); Alicia McKinnon (MPI); Rod Hansen, Hans Rook, Debbie Freeman (Department of Conservation); Kerry Hewitt, Rob Yarrell (National Aquarium of New Zealand); Rick Burch, Kahl Warr, Matt Douglas, Dave Patton (Commercial fishers); Wayne Bicknell, Brian Firman, Collin Murray (LegaSea Hawke's Bay); Hayden Moffit, Shane Gilmer (recreational fishers); Shade Smith (Triplefin Consulting), Anna Madarasz-Smith, Kathleen Kozyniak, Hellen Munro (HBRC).

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1.0 Introduction

1.1 Preamble

This report reviews the current knowledge base and understanding surrounding main ecosystems and habitats that comprise the Hawke's Bay Coastal Marine Area (CMA). Knowledge of the type and spatial distribution of habitats is imperative in order to appropriately comprehend and manage various pressures/threats to these resulting from land-based activities. This is especial true for those habitats of high ecological function and value, yet information is often greatly lacking (Peart 2007) Presently, marine science information within the Hawke's Bay CMA from Hawke's Bay Regional Council's (HBRC) perspective, is difficult to access and is data deficient. Furthermore, other than what HBRC monitors as part of its State of the Environment (SoE) monitoring, a high level of ambiguity exists as to where the major information gaps lie across the region.

Hawke's Bay Regional Council is statutorily required through the Resource Management Act (RMA, 1991) to manage both catchment activities in tandem with activities occurring within the coastal domain. Further governance obligations within the Regional Coastal Environmental Plan (RCEP 2014) extend to ensuring that marine habitats are not adversely affected by those activities. The Hawke's Bay coast is extensive in nature encompassing 353 km of shoreline from Mahanga Beach in the north to just south of Porangahau at its southern limit. The coastal marine area, from mean high water springs (MHWS) out to 12 nm is approximately 770,000 ha in spatial extent and is comprised of myriad ecosystem types (estuarine, marine, intertidal, deep reef *etc*) and falls within the eastern North Island coastal biogeographic classification – from East Cape down to Cape Turnagain (DoC/MPI 2008). Within the RCEP (2014), HBRC defines the coastal environment as including:

(a) the coastal marine area;
(b) any areas identified as being affected by, or potentially affected by, coastal flooding or coastal erosion; and,
(c) any of the following:
   i) tidal waters and the foreshore above mean high water springs
   ii) dunes
   iii) beaches
   iv) areas of coastal vegetation and coastal associated fauna
   v) coastal cliffs
   vi) salt marshes
   vii) coastal wetlands, including estuaries and
   viii) Areas where activities occur or may occur which have a direct physical connection with, or impact on, the coast.

Other key stakeholders with statutory obligations that extend across the CMA are the Ministry of Primary Industries (MPI), Department of Conservation (DoC), Iwi and hapu and territorial authorities. These entities tend to have different mandates and values for the coastal environment, yet management of resources often overlap, which can lead to conflicts over certain issues, or ambiguity over core responsibilities. Of these, DoC has an extensive directive concerning the conservation of natural and historic resources, whilst advocating for conservation and is governed by the Conservation Act 1987; Marine Reserves Act 1971; Reserves Act 1977; Wildlife Act 1952; Marine Mammals Protection Act 1978; Resource Management Act 1991; and Coastal Policy Statement 2011. MPI has a more defined focus concerned with managing fisheries (Fisheries Act 1986) and invasive non-indigenous species incursions (Biosecurity Act 1993). Iwi and hapu have a holistic kaitiakitanga focus across all areas of the coastal environment, and recognition of this to a certain degree is apparent within the Fisheries Act 1996 and Resource Management Act 1991 (see Peart 2007). More recently the Marine and Coastal Area (Takutai Moana) Act 2011 has helped give iwi a stronger directive within the coastal space. Territorial authorities are governed by the Resource Management Act 1991 and Local Government Act 2002 and while their focus is essentially land-based, activities under their authority can impact on the CMA, e.g., storm water.

1.2 Project Objectives

Three main objectives were identified by HBRC for this project - these were to:

1) Collate the existing/available information on the Hawke's Bay CMA into a useable GIS format;
2) Utilise this information to help develop an in-depth understanding of the Hawke's Bay CMA, the habitats that exist there, the species that rely on them, and the pressures they are under – primarily from land- and water-based activities; and,
3) Develop a strategy for Hawke's Bay refined into what type of work should occur and develop a prioritised set of research programmes or investigations for the future.

This report is divided into eight main chapters:

Excluding the introduction:

- Chapter 2.0 outlines the methodological approach used for the project.
- Chapters 3.0 and 4.0 review the physical and biological elements contained within the various coastal and estuarine systems across Hawke's Bay.
- Chapter 5.0 summaries fisheries-related information within Hawke's Bay for key species based on available information and stakeholder interviews.
- Chapter 6.0 summarises Iwi-related information.
- Chapter 7.0 draws on both measured and anecdotally observed effects to coastal habitats stemming from main land- and water-based activities within Hawke's Bay
- Chapter 8 0 summarises key gaps in our knowledge concerning these habitats (Chapter 7.0).
- The sixth and final section (Chapter 9.0) outlines a strategy for Hawke's Bay refined into a set of research programmes/and or investigations moving into the future.

2.0 Methodology

To assess and classify the dominant physical and biological habitat types across the Hawke's Bay region, a range of datasets were compiled – these ranged from existing spatial datasets held by HRBC such as shapefiles of estuarine habitats, spatial maps of soft sediment habitat types, side scan sonar, and environmental information contained within technical reports and monitoring databases. All available spatial information that was not in digital format were digitised and amalgamated into a GIS database (geodatabase) using ArcGIS 10.1. Details of the database development are contained in Appendix 1.0.

To obtain historical information on key habitats or main species that may have changed within the Hawke's Bay CMA through time – that was not readily discernible from available literature – a range of stakeholder interviews were undertaken. This included HBRC staff, MPI staff, National Aquarium staff, representatives from Ngāti Kahungunu, Ngāti Kere (Porangahau), Ngāti Hawea, Kohupatiki marae, Te Matau a Maui, Department of Conservation staff, environmental consultants, and recreational and commercial fishers. MPI provided catch data on main fished species for 2009/10 – 2014/15 for statistical areas 13 and 14 located within Fisheries Management Area 2 (FMA 2).

For the majority of stakeholder interviews maps of the coastal marine area were provided. These served as a means to obtain relevant spatial information (albeit anecdotal) on focal fishing "hot-spots", main species targeted, and observed changes in fishes and habitats that interviewees were aware of. Information contained on maps were then digitised and incorporated into the GIS database (Fig. 2.1).

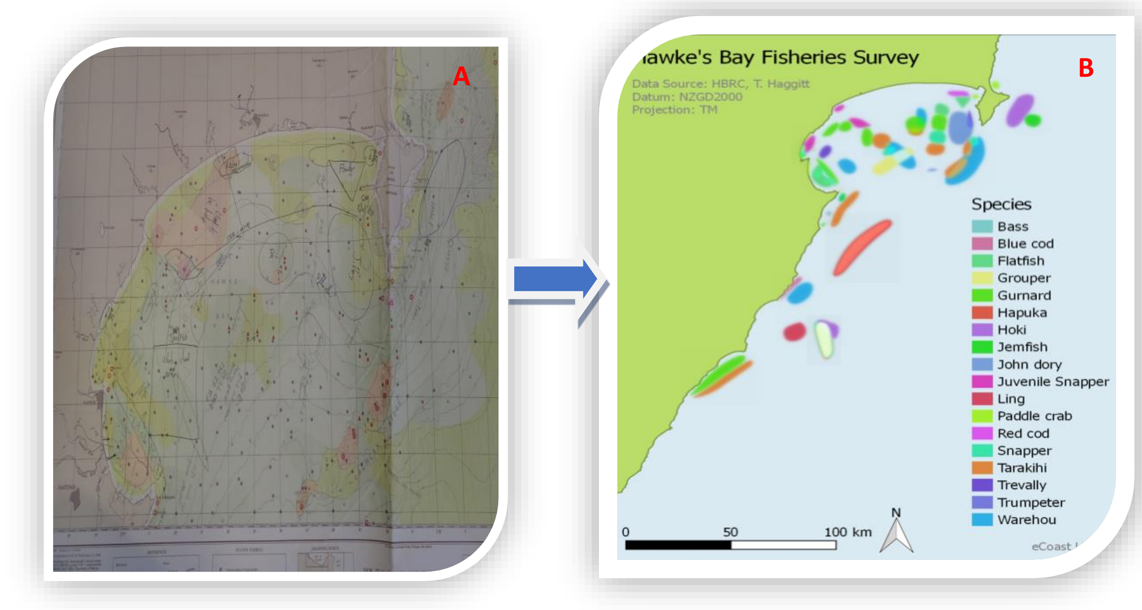


Figure 2.1. Example of digitising process for fisheries data- A: raw data from stakeholder interviews; and, B: final digitised shapefiles within a GIS database.

To further glean additional information site visits were made to Mahia, Wairoa, Aramoana/ Te Angiangi Marine Reserve, Porangahau, and throughout coastal Napier (Ahuriri and Waitangi Estuaries) in April 2016. Due to the limited timeframes for this project unfortunately discussions with Iwi were not as comprehensive as the authors' would have liked. Much of the information relating to iwi within this report has been derived from various Iwi management plans. We are however indebted to the time that Tom and Anni McGuire, Allen and Christine Smith, Jim and Allen Hutcheson, Paul Sciascai and Te Kaha Hawaikirangi gave in showing us around their rohe and sharing their stories with us. Rod Hansen from the Department of Conservation was equally generous with his time.

3.0 Hawke's Bay Region

3.1 Main catchments

Prior to human arrival within Hawke's Bay, the landscape was heavily forested dominated by beech trees (*Northofagus* sp), together with an assortment of subalpine plants that grew both on the mountain ranges and lower foothills and southern coastal hills. Conifer–broadleaf forest and pockets of grassland also covered the lower hills and plains. Smaller species like manuka and kanuka grew throughout the coast, and pingao (native sedge) and spinifex colonised the beaches and large active dune systems. The Ruataniwha and Heretaunga plains were covered with native grasses. European pioneers replaced these plants with exotic pasture (grasses) for farming. Forests in southern Hawke's Bay, and on the hill country and ranges, were later burned and felled by saw-millers and farmers.

Based on pollen percentages in soil cores widespread destruction of lowland podocarp/hardwood forests in Hawke's Bay followed permanent Maori settlement in the region in the 1600s (Whilmhurst *et al*. 1997). Podocarp species were largely replaced by bracken (*Pteridium esculentum*) and various shrub taxa that included *Coriaria arborea* (tutu), *Aristotelias spp* (makomako*)*, and various species of *Coprosma.* Shrub taxa dominated for around 200 years before the arrival of Europeans who cleared it for pasture production in and around 1870. Removal of soil stabilising vegetation and its replacement with pasture, ultimately left soft-rock hill country soils vulnerable to erosion and landslides (see Wilmshurst 1997). Today there remains a number of threatened coastal plants in the Hawke's Bay region (Walls 1998a).

The Hawke's Bay region spans a range of catchments summarised from northern to southern and by land use in Fig. 3.1. For management purposes these are collated by HBRC into 6 broader catchments –Wairoa-Northern Coastal, Mohaka, Waikari-Esk- Aropaoanui, TANK, Tukituki and Porangahau-Southern Coastal (Fig. 3.2). Present-day land use varies moderately across catchments although there is a high percentage of land in high to moderate production within all catchments. Native plant cover in the northern catchments is highest in the Wairoa > 40 % and uniformly low throughout the Waikari-Esk- Aropaoanui catchment< 10 %. This is also true for Ruataniwha and Porangahau catchments, the exception being the upper Ngaruroro, where > 80% of the land remains in native cover.

In terms of geology, the northern coastal, Waihua, Ngaruroro, Papanui and Porangahau catchments are predominantly comprised of soft sedimentary rock (sandstone and mudstone) and prone to erosion. Hard sedimentary rock is the dominant geological type in the Ruataniwha, and Lower Tukituki catchments with the Esk, Aropaoanui, Waikari, Ahuriri and upper Ngaruroro described as having diverse mixed (miscellaneous) geologies. Volcanic acidic soils are only prominent in the upper Tutaekuri (> 40 %), Esk and Wairoa catchments, being variable and negligible elsewhere (Fig. 3.3).

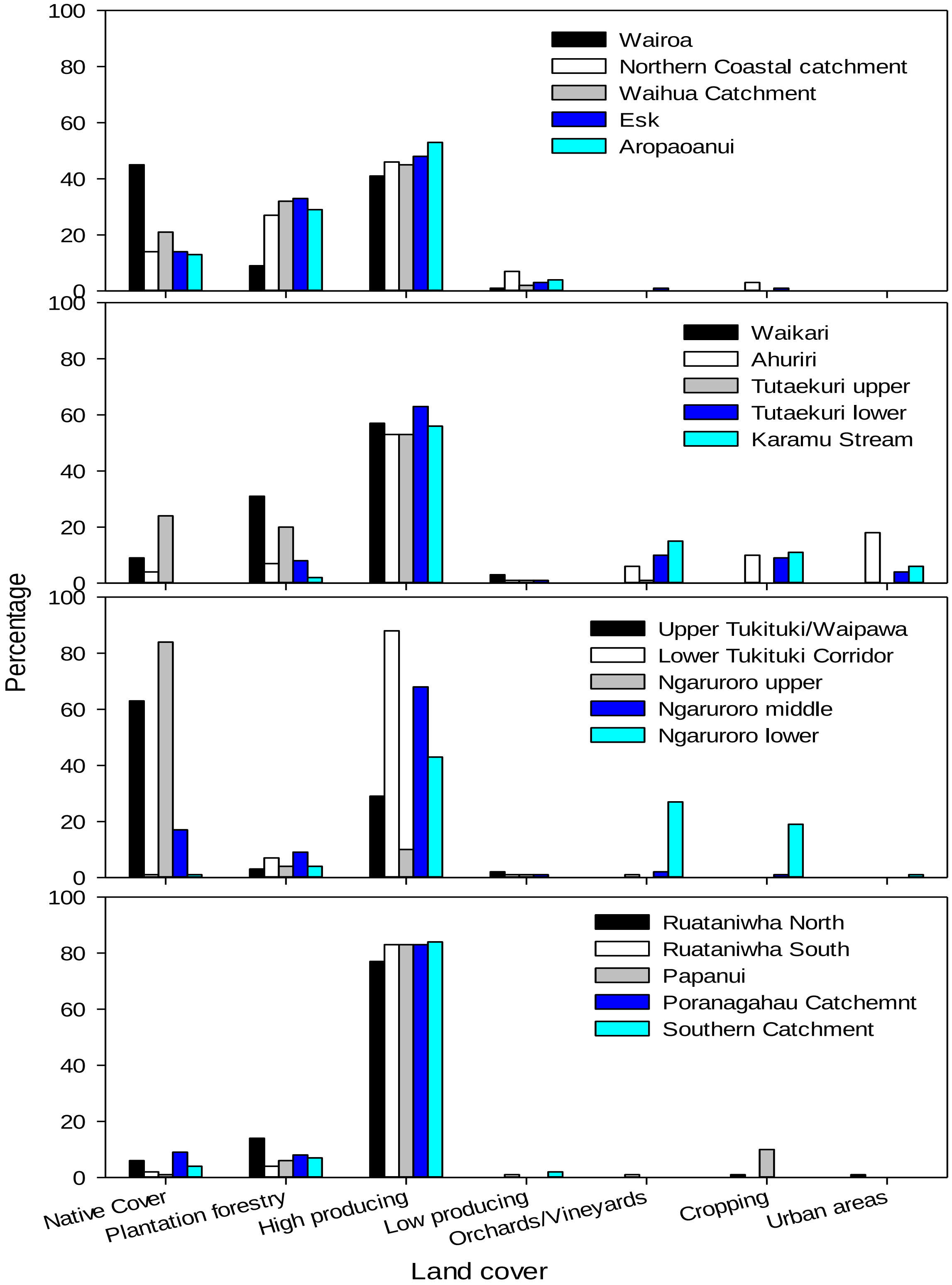


Figure 3.1. Land use categories for predominant catchments that comprise the Hawke's Bay region. (Unpublished data HBRC, 2016).

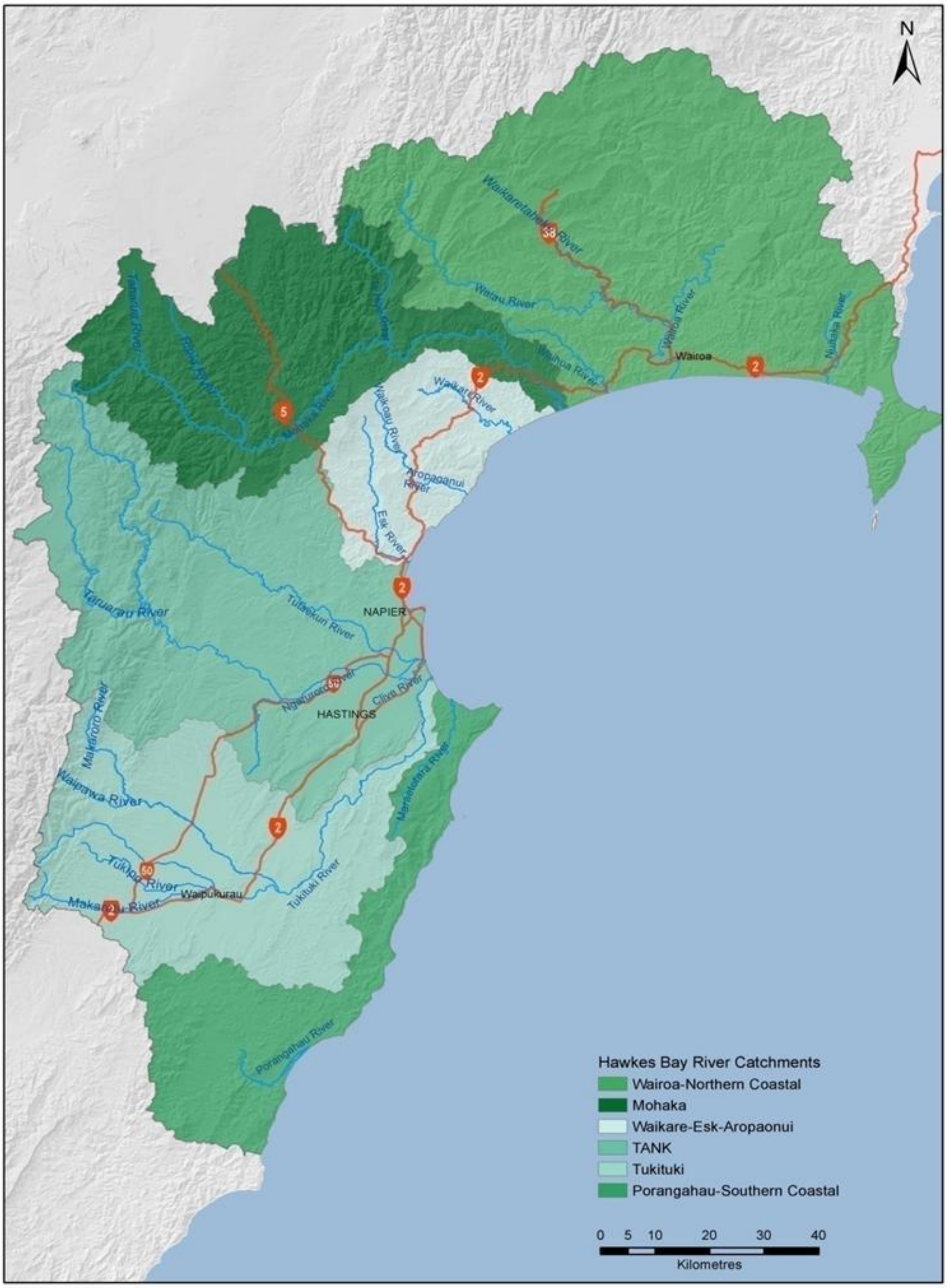


Figure 3.2. Combined Hawke's Bay river catchments (unpublished data HBRC, 2016).

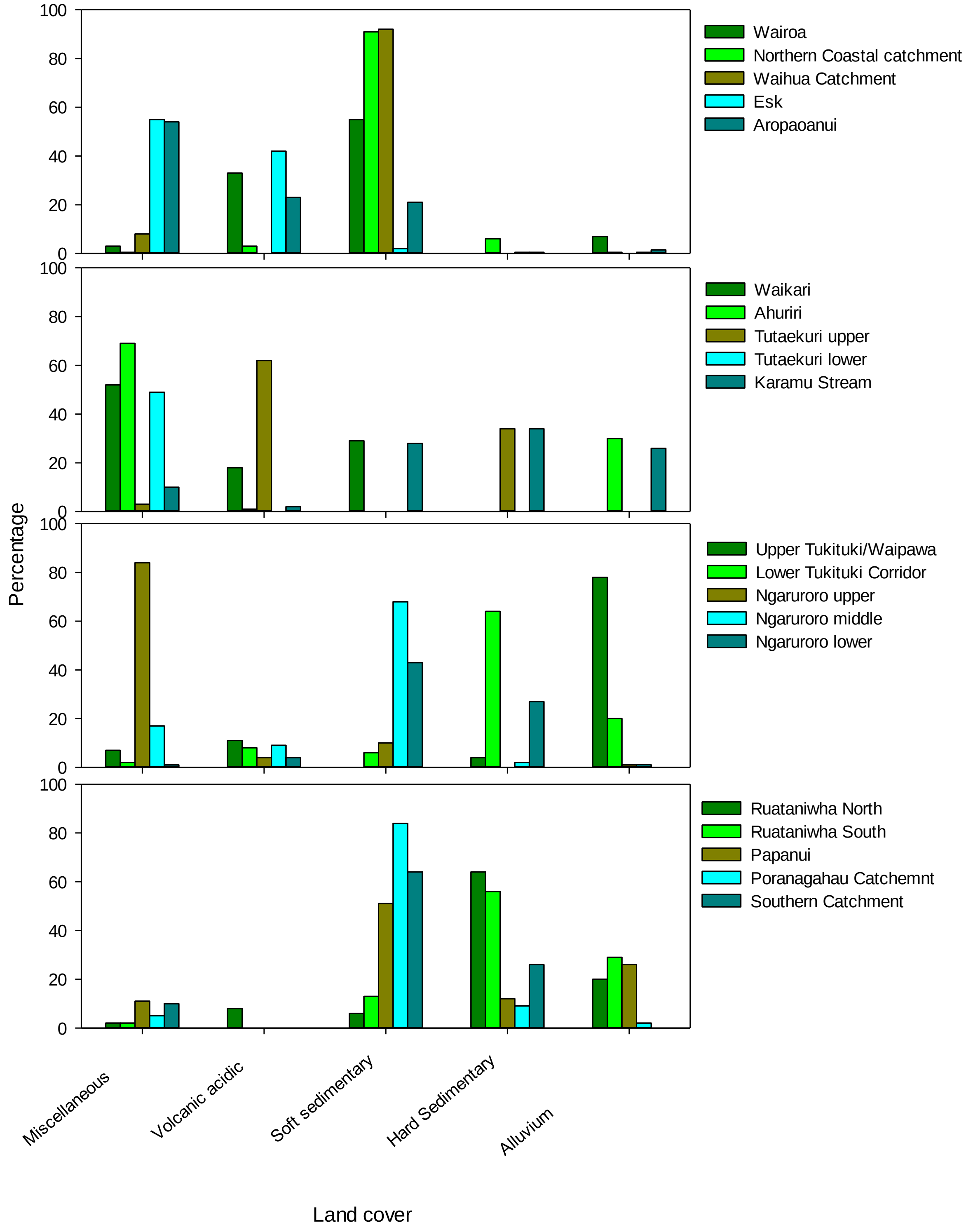


Figure 3.3. Geological categories for predominant catchments that comprise the Hawke's Bay region. (Unpublished data HBRC, 2016).

3.2 Physical oceanography

Bathymetry

At a broad-scale level the Hawke's Bay CMA is made up of two distinct areas, that of Hawke Bay itself (spanning 2,950 km^2; Heath 1976) and the region of coastline south of Cape Kidnappers to Porangahau. The separation of the two areas is apparent with respect to the coastline and bathymetry with Hawke Bay gradually sloping with the 50 m depth contour typically > 15 km from shore. South of Cape Kidnappers, the bathymetry becomes somewhat steeper with the 50m depth contour often < 5 km from the coast, the exception being the area of coastline between Blackhead Point and Porangahau Estuary in the south, where the seabed returns to a more gradual gradient. The coast of Hawke's Bay is located on the tectonically active Hikurangi Margin, whereby the oceanic Pacific plate collides with and is being sub ducted beneath the continental Australian plate. Historic earthquakes have been associated with this subduction boundary, summarised in Komar and Harris (2014).

Oceanographic Climate

Coastal currents

The oceanographic climate of the Hawke's Bay region is influenced by the interplay of a range of physical phenomena. Collectively, river discharges and associated plumes, several dominant alongshore surface currents and semi-permanent eddies, together with variation in wind and waves all influence Hawke Bay and the southern coastline south of Cape Kidnappers; albeit at varying degrees. Different components of the oceanographic makeup of the Hawke's Bay region have been studied since the early 1960s (Ridgway 1960; Gibb 1962). Heath (1976) evaluated the physical makeup of Hawke Bay against other tidal inlets suggesting that Hawke Bay fell into a group where circulation was not tidally dominated, but due to other factors, e.g., vertical and horizontal wind-induced circulation. Of all areas evaluated in that study a distinguishing feature of Hawke Bay was that it was calculated to experience the highest annual runoff at 435 $m^3 s^{-1}$ being more pronounced in winter – 618 $m^3 s^{-1}$ relative to summer – 154 $m^3 s^{-1}$.

At a basic level, it has been demonstrated that two main oceanographic currents influence the Hawke's Bay region. These are the warmer East Cape Current[1]originating from the north and the southern Wairarapa Coastal Current[2] (WCC) originating from the south with the longshore extent and position of these varying through space and time (Ridgeway 1960; Heath 1976; Francis 1985b; Chiswell 2000). The East Cape Current is generally the major current penetrating the centre (mid-line) of Hawke Bay, which thereby splits in two travelling along the southern and northern coastline and leaving the bay at the respective northern and southern

[1]The East Cape Current is warmer and more saline than the Wairarapa Coastal Current

[2] The Wairarapa Coastal advects relatively cool and fresh water northwards along the coast inshore of the relatively warmer and more saline East Cape Current (ECC). Chiswell (2000) suggests the WCC contains a mix of water from the Southland and D'Urville currents, and that the current has the highest transport off Cape Palliser, but becomes progressively more entrained into the ECC further north.

ends. Francis (1985b) highlights the importance of both the Wairoa and Mohaka River discharges and extension of the Wairarapa Coastal Current in causing variation in the direction of surface current inflows and outflows within Hawke Bay. Based on the presence of juvenile angel fish (*Parma alboscapularis*) a northern fish collected in the southern Hawke's Bay rock pools (Rob Yarrell *personal communication* in 2016) provides biological evidence that the East Cape Current, (the only feasible source of the fish), can penetrate well beyond Cape Kidnappers.

Heterogeneity in the Wairarapa Coastal Current based on numerical modelling suggests that variations are wind-driven, and that alongshore advection accounts for most of the temperature change at Napier. The WCC is more important in influencing short-term temperature variability than upwelling. The role of El Niño and La Nina cycles in influencing these coastal currents are, perhaps less well understood. MetOcean and Cawthron (2013) suggest that El Niño conditions tend to impose a west-southwest anomaly on the 'normal' wind conditions with increase upwelling, while during La Niña events there is usually an east-north-easterly wind field anomaly associated with minimal upwelling. This is supported by historical climatic data (Kathleen Kozyniak personal communication in 2016).

The hydrodynamic properties of the inshore region between Westshore and Napier Port and East Clive Wastewater Outfall, located northeast of the City of Hastings and have both been studied in relation to examining the effects of dredge disposal (Mead and Black 2001) and wastewater dispersion (MetOcean and Cawthron 2013) respectively. In the former study, it was found that in addition to the normal northern transport of fine sediment around the Napier Port (see Komar 2007) there is a recirculating loop immediately south of the port and Westshore Beach that is responsible for the formation of the Westshore Sand Fillet.

A basic hydrodynamic model was recently established for Hawke Bay, with a focus of evaluating the East Clive wastewater outfall. Current measurements as part of the wastewater monitoring indicated that currents in and around the diffuser were predominantly SE in that 77% of all instances the measured currents were flowing to the S and SE octants. All high flow current speeds were associated with these directions and the greatest depth-averaged current speed was > 0.26 m s^{-1}. Current profiles were found to exhibit shear with the upper water column different to the near bed current directions. This was driven by changing winds, rising southerly winds, and to a lesser degree diurnal cycles associated with land and sea breezes. The plume dynamics varied in accordance with modelled climatic phases being more pronounced in El Niño conditions where it pushes south beyond Cape Kidnappers. A permanent eddy and strong near bed currents > 3.5 m s^{-1} is characteristic of the Cape Kidnappers region (MetOcean and Cawthron 2013).

Waves

The effect of wave refraction patterns were initially described for Hawke Bay, the Clifton-Awatoto section of coastline, and Napier Port in 1960. It was noted that refraction is most noticeable near Cape Kidnappers for waves approaching from the south and Mahia Peninsula and Portland Island for waves approaching from the north (refer to Figures within Gibbs 1960). Further offshore, the Lachlan Banks and Lachlan Ridge (which rise to 40 m depth) are reported to affect waves with periods between 15-20 seconds.

Additionally, the wave climate of the Hawke Bay area is evaluated in Gorman *et al*. (2003), Komar (2005; 2007), and Komar and Harris (2014), the latter summarising results from 10 years of wave measurements taken from the Port of Napier's wave buoy deployed in 16 m water depth offshore and to the north of its breakwater in 2000. Summary results based on available datasets indicated the mode of most frequent occurrence in the distribution of deep-water significant wave heights was 1.2 m, with a maximum significant wave height of about 10 m. This data has been recently used to evaluate the effects of climate change on Hawke Bay's coastal processes.

Productivity

Coastal productivity, expressed by phytoplankton growth, within Hawke's Bay is driven and influenced primarily by nutrient levels, light availability, and stratification. These all vary considerably through space and time. Rivers and streams in the Hawke Bay catchments collectively deliver an estimated 6,021 tonnes of nitrogen (N) per annum to the Bay and the municipal outfalls of East Clive contribute 1,010 and Napier City off Awatoto 1,271 tonnes of N per annum respectively (Figure 4, in Cornelisen 2013). Chlorophyll *a* (Chl-*a*) concentrations are used as a proxy for phytoplankton growth within the water column. Based on seasonal differences in Chl-*a* Hawke Bay varies from oligotrophic (low nutrients and productivity) to mesotrophic (moderately productive) conditions. From time to time, Chl-*a* concentrations are symptomatic of eutrophic conditions that create extensive phytoplankton blooms (Cornelisen 2013; HBRC unpublished data) (Fig. 3.4).

Figure 3.4. Large-scale 10s km phytoplankton bloom at the mouth of the Ahuriri Estuary – 2012)

Following the phytoplankton bloom depicted in Figure 3.3, low water column dissolved oxygen (hypoxia) was recorded between 30 to 40 % (HBRC unpublished data) a phenomenon that is often associated with intense phytoplankton blooms. Oxygen depletion during large-scale blooms can occur either from increased phytoplankton oxygen respiration at night or as the bloom dies from bacterial consumption which can further reduce dissolved oxygen levels. Dissolved oxygen levels < 30 % are considered lethal to fish and other marine organisms.

In December 2012, Hawke's Bay Regional Council, with the assistance of the Cawthron Institute, deployed the *HAWQi (**HA**wke's Bay* **W**ater **Q**uality **i**nformation) water quality buoy approximately 5km off Tangoio Bluff, Hawke Bay. HAWQi collects continuous temperature, conductivity, turbidity and Chl-*a* data. Knight and Jiang, (2014) used continuous data from HAWQi to develop an algorithm to correct satellite imagery of Chlorophyll *a* concentrations in Hawke's Bay for the elevated turbidity found in these waters. Resultantly, this algorithm has facilitated the use of historical satellite imagery to analyse changes in Chlorophyll *a* concentrations throughout Hawke's Bay over the last decade. Temporal analysis of that data showed clear seasonal signals in Chl-*a* consistent with light and nutrient levels coupled with inter-annual variability. Trend analysis revealed a small, but noteworthy increase in Chlorophyll *a* concentrations of 0.02 mg m^{-3} per year (Knight and Jiang 2014).

Coastal and estuarine water quality

One of the most poignant outcomes of undertaking various stakeholder interviews as part of this project was the perception of declining water quality, especially clarity, over the last 40 years particularly within Hawke Bay. Many describe underwater visibility as being routinely > 15 m in shallow water pre-1980 and at certain times > 20 m between Tangoio Bluff and Cape Kidnappers. This is certainly not the case today.

Prior to undertaking a coastal water quality pilot study in 2006, water quality information was limited to one-off studies e.g., relating to marine sewage outfalls (see Knox 1979a), or to gauge the effects of nutrient enrichment e.g., Ahuriri Estuary and pollution-related effects Knox *(*1979b); Of the estuarine systems within Hawke's Bay the Ahuriri has by far received the most attention with water quality monitoring initiated in 1976.

Formal spatially-detailed coastal water quality monitoring was not established within the Hawke's Bay region until 2006 with initial monitoring identifying that nitrogen concentrations in Hawke's Bay coastal waters were high relative to other open coastal and harbour sites around New Zealand ((Madarasz 2006a). Average nitrate levels were around 0.2 mg/L and many sites above (ANZECC 2000) trigger values for this parameter, which are often used to evaluate the risk of adverse effects of nutrients on coastal (marine and estuarine) ecosystems.

The 2006 pilot study prompted routine monitoring of sentinel coastal sites that were collectively representative of the various coastal environments and adjacent catchment types within Hawke's Bay with routine sampling commencing in November 2006, which continues to the present day. Key sites included in the monitoring are Ocean Beach, Awatoto, Marine Parade, Westshore, Whirinaki, with additional sites at Wairoa, Nuhaka, Mahia and Waikokopu added in 2012 to enhance the geographical spread (Fig. 3.5). Typically, trend analysis is undertaken to evaluate which indicator is changing and the magnitude to which it is changing. In the case of escalating negative change, the site can be identified further with follow up investigations. Median values and associated outliers are used to report and evaluate trends.

Main trends in coastal water quality

As expected for water quality monitoring there is generally high variability in measured parameters both within and among sampling locations through time, reflecting the suite of environmental conditions, periods of high and low freshwater input, storm-events, oceanographic processes, and so on. Despite this natural variability there are subtle patterns in key parameters (turbidity, suspended sediments, nutrients and chlorophyll across the coastline Basic patterns across the sampling area are summarised below.

Turbidity and suspended sediment concentrations were found to be highest at Ahuriri Estuary, Mohaka, and southern Awatoto site for varying reasons. Both Awatoto and Ahuriri median values reflect fluvial (riverine inputs) and subsequent resuspension of fine mud and silt; whereas the Mohaka (high turbidity and SS) and Nuhaka, Mahia and Waikokopu (high SS only) are more representative of sand resuspension.

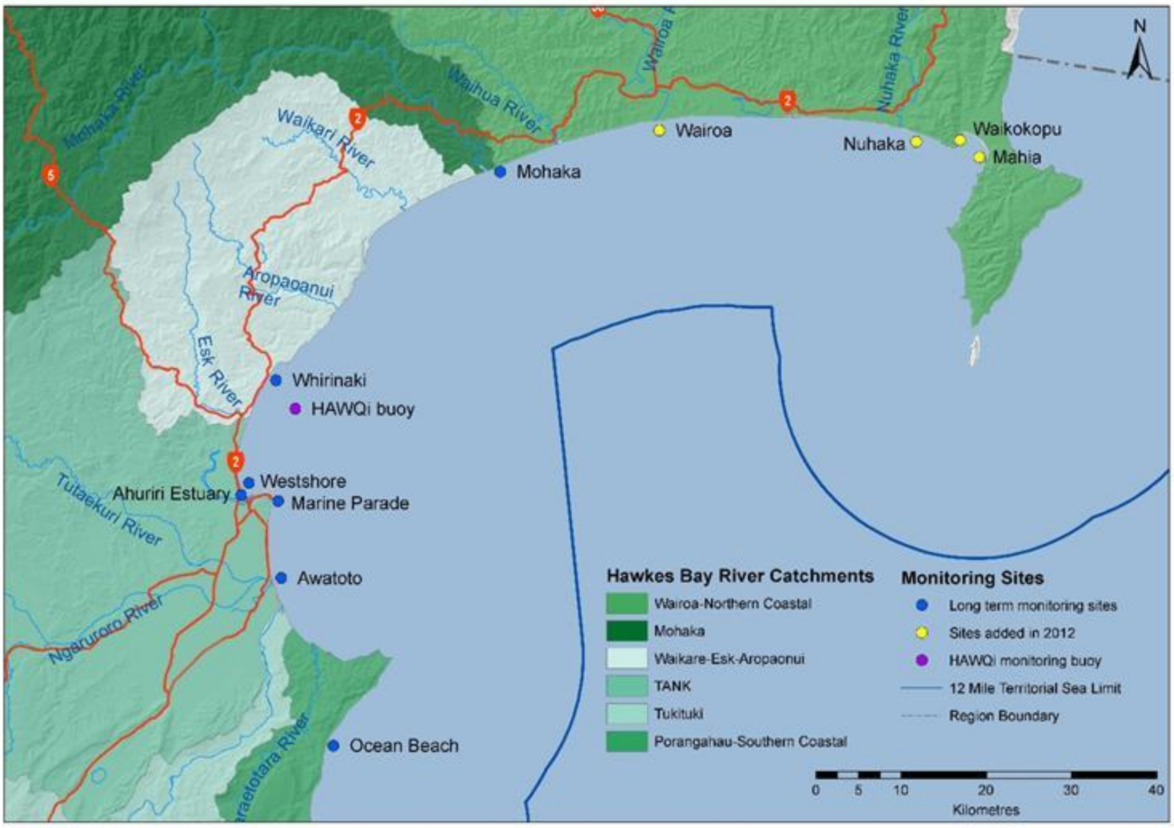


Figure 3.5. Coastal water quality monitoring sites within Hawke Bay routinely measured (every 6 weeks) by Hawke's Bay Regional Council.

Measurements of nutrients such as nitrogen and phosphorus are used to evaluate potential eutrophication, which can lead to phytoplankton blooms and nuisance macro algal growth. Of these both dissolved inorganic nitrogen (NO_2+NO_3+NH_3) and dissolved reactive phosphorus (DRP) are utilised as indicators of the ability of a waterbody to support and sustain such growth.

Total phosphorus measured over the course of the sampling was generally low across all sites typically ≤ 0.002 mg/L and much lower than reference locations elsewhere in New Zealand. The exception to this was Nuhaka in that while the median value was < 0.02 this site exhibited high variability in TP. The Ahuriri also had a median value of around 0.05 mg/L reflecting its estuarine status; however, there was an improving trend (10 % annual reduction).

For DRP there was a trend of decreasing concentrations from Ocean Beach (0.01) to Wairoa followed by a subtle increase from Nuhaka to Mahia Beach, albeit northern locations were lower than the southern location sampled (Ocean Beach to Mohaka). This spatial trend was mirrored for DIN with higher values recorded for Ocean Beach and the southern coastal sites than northern. The higher median value at Ocean Beach may be the result of upwelling as this site is presumably less-affected by fluvial inputs. As for TP, the Ahuriri had much higher DRP (0.03) and DIN (0.038) than coastal water sites.

Measurements of Chl-*a* can exhibit notoriously high variability over both short (days) and longer (seasons) time periods reflecting sudden, short-term pulse events that deliver nutrients into the systems and seasonal changes in nutrients associated with upwelling and grazing by zooplankton (see above). Chlorophyll *a* concentrations as measured exhibited interesting patterns being highest at Awatoto and decreasing to Whirinaki, and thereafter variable but lower than southern sites The Ocean Beach site had the lowest Chl-*a* concentrations of all sites despite the elevated DRP and DIN. This suggests either that the background concentrations of nutrients do not result in increased levels of productivity, or that the phytoplankton is consumed rapidly by zooplankton and other water column grazers. The high Chl-*a* levels at Awatoto are likely to be related to the combined effects of wastewater treatment and riverine inputs.

Water quality in the coastal environment throughout Hawke's Bay is regarded as being of a high standard of compliance, supporting recreational usage and values most if not all of the time. In addition to coastal water quality monitoring HRBC undertakes an annual Recreational Water Quality Monitoring Programme (Gilmer *et al*. 2015) in collaboration with Territorial Local Authorities (TLAs) and the Public Health Unit of the Hawke's Bay District Health Board (PHU) across a range of sites. This involves measuring faecal contamination levels in the water column at contact recreation and shellfish gathering sites.

3.3 Coastal Processes

The main beaches of Hawke Bay and the coastal process resulting in their formation has been well studied and described. Divided into 3 littoral cells (stretches of shore containing a beach that is largely separated from other beaches by rocky headlands) these are the Wairoa Littoral Cell, Bay View Littoral Cell, and the Haumoana Littoral Cell (Figures 1-1 and 1-2; in Komar and Harris 2014). The beaches that make up the Bay View Littoral Cell and the Haumoana Littoral Cell are a mixture of gravel and sand that was derived from the Mesozoic greywacke rocks eroded from the Coastal Front Ranges of Hawke's Bay. As described by Komar and Harris (2014), 100 years ago the four main rivers within southern Hawke Bay (Tukituki, Tutaekuri, Ngaruroro and Esk Rivers) delivered large volume of gravel to the ocean beaches. The 1931 Napier earthquake transformed this process by lifting parts of the Bay View Littoral Cell, and the Haumoana Littoral Cell entrapping the gravel with these rivers that now only delivers sand and silt to the beaches. The exception to this was the Tukituki River, which experienced subsistence during the earthquake and coupled with erosion of Cape Kidnappers to the south are presently the only source of gravel and sand to the system.

Due to the dominance of wave action from the south-east there is a net northward longshore transport of the beach gravel and sand, progressively carrying it to the beaches along the full length of the Haumoana Littoral Cell. Due to abrasion of the pebbles and cobbles into sand and silt this transportation of gravel decreases with increasing distance north with the sand and silt being transported offshore. The progression terminates at Bluff Hill, south of the Napier Port, although it is stressed in Komar (2005, 2007) that the gravel has historically never been carried by the waves and currents past this headland – even prior to the construction of the Port of Napier's breakwater in the late 19th century. Commercial gravel extraction is undertaken at Awatoto mid-way along the Haumoana Littoral Cell's shoreline.

For the Bay View Cell, unlike the Haumoana Littoral Cell, there are no natural sources of gravel to its beaches other than minor contributions of sand from the Esk River. Consequently, gravel from Pacific Beach, the Napier shore south of Bluff Hill, is transported to Westshore to nourish the beach. Komar and Harris (2014) describe the Bay View Cell as "a pocket beach that over the long term has a net zero longshore transport". Periods of erosion and accretion are at times observed at northern (Tangoio) and southern (Westshore) ends of the cell associated with seasonal cycles and climatic events.

Sediment budgets compiled for the Haumoana Littoral Cell (Komar 2005) estimate that both the Tukituki River (source -28,000 m^3 y^{-1}) and the erosion of Cape Kidnappers (source -18,000m^3 y^{-1}) combine to contribute an estimated 46,000 m^3 $y^{-1}$of gravel to this cell while loses amount to a total of-91,000 m^3 y^{-1}. Losses are due to Awatoto gravel extraction (-47,000 m^3 y^{-1}); Pacific Beach extraction (-12,000 m^3 y^{-1}) and natural gravel abrasion (-30,4000 m^3 y^{-1}). Resultantly, erosion of the Haumoana cell has occurred for the most-part south of the Tukituki River estimated at -45,000 m^3 y^{-1}, with accretion of 3,800 m^3 y^{-1} to the north stemming from the northward longshore transport (via south-east wave action) of the beach sediments and Cape Kidnappers erosion.

4.0 Coastal Habitats of Hawke's Bay

The Hawke's Bay region is characterised by a diverse range of coastal habitats and environments. These include both marine and freshwater dominated lagoons and bar-built river mouths and other estuarine systems (McClay 1976; Cameron 2008; Wade 2013a), expansive intertidal rocky reef platforms (Duffy 1992; HBRC 2009), widespread gravel and sand beaches (Komar 2005; Stevens and Robertson 2005); nationally significant dune fields (Walls 1998a,b), patchy distributed subtidal rocky reefs (Duffy 1992; 1998; Shears and Babcock 2007), and subtidal soft sediment benthic habitats; the latter of which is the most widespread coastal habitat (Pantin 1966). Many coastal environments across Hawke's Bay have been substantially modified over the last century to accommodate the expanding cities of Napier and Hastings and to allow for increased farming and horticulture practices. Equally, natural events such as the 7.8 magnitude earthquake that struck on 3 February 1931, landslides within the Esk catchment in 1938, flooding-related effects of Cyclone Bola in 1988 and more-recent landslides/erosion in 2011 (Macpherson 2013) have all impacted the Hawke's Bay coastal environment to varying degrees.

Despite the general perception of a lack of biological inventories for Hawke's Bay (see Madarasz-Smith 2007; Hashiba *et al*. 2014) various descriptions of coastal habitats do exist e.g., Duffy (1992); although, these often lie in isolation merely marking a certain point in time. Some of the main findings of broader-scale descriptions are summarised in the following sections. Owing to the difference in physical makeup of Hawke Bay relative to the central and southern coastlines these descriptions are often delineated by geographic location as a point of reference. A summary of any relevant monitoring that has taken place within these habitats is also noted. Significant estuarine systems including the Ahuriri Estuary, Porangahau Estuary, Waitangi Estuary, and Wairoa Estuary are also described separately, with main trends in various environmental parameters based on monitoring and anecdotal information/observations highlighted.

4.1 Duneland systems

Significant areas of active duneland exist throughout the Hawke's Bay region with exceptional examples between Porangahau and Blackhead Point; Ocean Beach; and, Wairoa to Mahanga Beach (north-east of the Mahia isthmus). Nationally there has been significant loss and deterioration of these systems and Hawke's Bay is of no exception. Hilton (2006) calculated the area of active dunes in New Zealand has declined from 129,000 ha in the early 1900s to about 39,000 ha by 2000; i.e., a reduction of 70 %. For the Hawke's Bay region Hilton (2006) calculated a 48.33 % reduction in active duneland between 1950s-1990s; i.e., from 27,930.4 ha to 1,441.7 ha (2.2 % of the national total).

The duneland systems that comprises a significant proportion of the Ocean Beach backdrop has been described by Walls (1998a,b; 2002) as possibly the most significant dune system on the east coast of the North Island. Equally, the Porangahau dune field has been long recognised for its similar ecological values (Partridge 1992; Walls 2002). Ecosystems of this type are of importance due to the vegetation within, their buffering role between the ocean and terrestrial systems, and provision of habitat for numerous native invertebrates and breeding shorebirds (dotterel and penguin) (summarised in Walls 2002; Hilton *et al*. 2000).

Unfortunately, these active duneland systems have been under threat for decades primarily due to an increase in encroaching pastureland concomitant with significant grazing damage by domesticated livestock (cattle, sheep, horses, goats, possums, rats), invasive weeds (pines, lupin, blackberry, boxthorn, willows, pampas grass, marram grass, and pink ragwort), feral/pest animals (dogs, cats, rats, hedgehogs, possums, and mustelids) and off-road vehicles – summarised in McLennan (2011).

Walls (1998; 2002) has through great effort and passion documented the major changes within the Ocean Beach dune system since 1989, investigating the following aspects: 1) How has the vegetation on the mobile dunes has changed?; 2) What were the agents of change?; 3) What was the impact of browsing mammals and human recreationists?; 4) Was the pingao dying, and if so, why? From that study the following were identified as being the most serious threats: Proliferation of weeds already present; invasion by new weeds; invasion by exotic invertebrates (snails, spiders; browsing by rabbits and other animals); predation by dogs and cats; predation by other feral predators; and, disturbance and damage by vehicles. Stock grazing within the dune systems up until 2002 is thought to have resulted in the present-day absence of sand daphne (*Pimelea arenaria*) and tree daisy (*Olearia solandri*).

Vegetation of note within the Ocean Beach dunefields includes pingao (*Ficinia spiralis)* and silvery spinifex (*Spinifex sericeus*) and the area is widely considered as the last stranglehold of pingao in the region (McLennan 2011). However, marram grass *(Ammophila arenaria)*, a major weed of the more mobile dunes, is a significant threat through direct competition and stabilising the sand, thereby becoming unsuitable for pingao and spinifex. McLennan (2011) summarises a range of plant species absent from the Ocean Beach duneland system such as shrubby tororaro (*Muehlenbeckia sp*), sand daphne (*Pimelea arenaria),* coastal shrub daisy (*Olearia solandri*), sand tussock (*Poa billardierei*), shore milkweed (*Euphorbia glauca)* and matagouri (the wild Irishman - *Discaria toumatou*). Efforts are underway to re-establish these taxa with the dune systems. Rear dunes are also being re-established with native shrubs and trees including flax (*Phormium cookianum),* tauhinu (*Cassinia leptophylla),* cabbage tree (*Cordyline australis*), manuka (*Leptospermum scoparium*), kanuka (*Kunzea ericoides*), ngaio (*Myoprum laetum),* and taupata (*Coprosma repens)*. It is anticipated that Totara (*Podocarpus totara*) will be integrated into the planting scheme once primary colonising species have become better established.

4.2 Coastal vegetation and intertidal habitats

Broad scale mapping of the intertidal coastal habitats from approximately 5km north of Mahanga Beach, including Mahia Peninsula, to approximately 13km south of Porangahau encompassing the coastal area around Napier (total distance 350 km) was undertaken in 2005 (Stevens and Robertson 2005). The purpose of the mapping was to "characterise the type and extent of broad-scale habitat features along the coastline between low tide, and the clearest terrestrial delineation point or landscape feature".

Prominent intertidal habitats in order of maximum cover included: 48 % firm sand; 35 % rock field; 8 % gravel field; 7 % boulder field; and, 2 % a mixture of cliff, cobble field, and man-made boulder fields. Of these, main habitats were reported to match the geomorphology of the region with gravel beaches dominating between Te Awanga and Tangoio Bluff; cliffs common between Cape Kidnappers and Cape Turnagain, Mahia Peninsula, and immediately north of Mahanga Beach; and, sand and duneland common to Porangahau, Waimarama, Mohaka, and

Wairoa. Vegetation was not a dominant cover in intertidal areas but was classified according to structural class where mapped. Of particular note was the paucity of native forest estimated at only 2.6 ha. Specific vegetative features of the coastal stretches were:

4.2.1 Southern coastline between Cape Turnagain and Te Awanga

Extensive areas of unvegetated steep cliff lines. These are dominated by grassland (pastoral farming), patches of flax and toitoi, and small pockets of exotic forest. Native vegetation is very rare and is represented by small fragmented patches of karaka forest (*Corynocarpus laevigatus*) and/or regenerating scrub (e.g., manuka). Where steep cliffs are absent, dune fields are the dominant ecosystem that buffer the ocean beaches. They are extensive in places (extending 100s of meters inland) particularly between Porangahau and Blackhead and are dominated by marram grass and spinifex. Steven and Robertson (2005) echo the sentiments of Walls (1998) that many of the duneland systems have been extensively modified by grazing.

4.2.2 Central coastline between Te Awanga and Tangoio Bluff

North of Napier, herbfields – a nationally significant and threatened terrestrial habitat –are the predominant vegetation type inland from beach systems. These are comprised of the African daisy (*Osterospernum fruticosum*), yellow daisy (*Arctotis stoechadifola)*, marigold (*Tagetes* sp), tree lupin (*Lupinus aboreus*), and boneseed (*Chrysantemoides monilifera*). In some locations grassland and housing are present where herbfields would otherwise naturally exist. The coastline south of Napier to Te Awanga is typified by less-extensive herbfields, but increased wetland habitat located behind the main single dunes where present.

4.2.3 Northern coastline between Tangoio Bluff and Mahia

The northern coastline shares elements of the southern, with steep cliff lines and grassland dominant components. Wide gravel beaches are common south of Wairoa transitioning to sand-dominated beaches further north. Sand dunes are frequent in and around Wairoa with the vegetation comprised of marram, spinifex, pampas grass and introduced weeds. Stevens and Robertson (2005) note that Moeangiangi River is important for the dominance of native scrub around the cliff margins such as manuka, flax, and tauhinu (*Ozothamnus leptophyllus)*.

4.2.4 Mahia Peninsula

Sand dune systems bordering intertidal rock platforms are more-common of the eastern sandy coastline of the Mahia peninsula. Steeper hillsides and cliffs are typically grass and the region has been modified extensively by grazing, although small pockets of native bush are present (particularly tauhinu). The western coastline of Mahia is dominated by steep, largely unvegetated, cliff lines with pasture and grazing also dominant. Larger sand dune systems flank the coastal stretch between Opoutama and Mahia Beach township and Mahanga Beach and Oraka Beach. The Maungawhio Lagoon is an important wetland system.

4.3 Gravel Beaches

Despite their prominence around Napier gravel beaches make up 8 % of the intertidal coastline of Hawke's Bay. There formation and occurrence is summarised in Section 3.4.

4.4 Sandy Beaches

Beaches dominated by sand make up 48 % of the Hawke's Bay coastline (Stevens and Robertson 2005). Prior to 2006 there was no formal monitoring programme in place to describe changes in beach profiles or their composition and temporal variability. These areas of coastline are highly variable in nature being affected by tidal inundation and wave action and have the potential to be threatened by coastal development, especially vehicle use.

Since 2007, faunal communities have been studied periodically (yet in some detail), at Mahanga, Opoutama, Ocean, Blackhead, Waimarama, and Pourerere Beaches. This selection was established following an inventory of beach and intertidal reef systems done in 2007 (Madarasz 2006b; Madarasz-Smith 2007). Beaches range from moderate to moderate/high wave exposure. The initial focus of the beach monitoring was to establish baseline conditions from which changes in faunal communities across tidal heights could be gauged through space and time. Initial sampling revealed low numbers of individuals and exceptionally high variability among tidal zones across the beaches, thus making trend detection impracticable. Accordingly, the aims of the sampling were changed in 2008 to data acquisition for baseline inventories.

Main patterns across monitored beaches to date have included high abundances of the amphipod *Waitangi chelatus* (all locations) the occurrence of tuatua (*Paphies subtriangulata*) at all locations except Blackhead; and high bivalve abundances at Waimarama (tuatua, pipi and cockles). Opoutama Beach was notable for an infaunal community dominated by the polychaete worm *Glycera ovigera*, and nematode worms. This was attributable to its depositional nature whereby large amounts of beach-cast seaweed, wood fragments, and associated material are frequently present on the beach.

4.5 Estuarine environments

In his early inventory of the status and origin of New Zealand estuarine systems, McLay (1976), summarises the estuarine environment as the interface (link) between the freshwater and marine environment. By default these systems experience rapid environmental fluctuations associated with regular tidal cycles, flood events and wave surge, and are thus highly variable and dynamic environments. McLay (1976) describes many estuaries as highly productive systems due to the input of nutrient-rich freshwater (largely human-induced) and noting their physical diversity across New Zealand including lagoons, bar built, drowned river valley and fiord.

Table 4.1 Summary data from McClay (1976) describing key features of Hawke's Bay estuaries and river mouths.

Hawke's Bay	Area(km^2)	Topographic classification	Stratification	Condition	Change in condition since 1965
Maungawhio and Kopuawhara Lagoons	30	BB/L	SW	SP	S
Nuhaka River mouth	10	L	SW	SP	S
Wairoa River mouth and Ngamotu Lagoon	50	BB	SW	MP	W
Waihua River mouth	5	BB		C	S
Aropaoanui River mouth	4	BB	SS	C	S
Esk River mouth	NE	BB	WM	C	S
Ahuriri Estuary	50	L	SW	MP	W
Ngaruroro River and Tutaekuri River (Waitangi Estuary)	15	L	WM	MP	W
Tukituki River mouth	10	L	WM	MP	W
Porangahau River mouth	106	BB	SW	SP	S
Wainui River mouth	NE	BB	-	-	-

Topographic classification: BB: bar-built; DR: drowned river; FD: fiord; L: lagoonal.
Stratification: WM: well mixed; SS: slightly stratified; HS: highly stratified; SW salt wedge; - unknown.
Condition: C: clean; SP: slightly polluted; MP: moderately polluted; GP: grossly polluted; - unknown.
Change in condition: B: better; S: similar; W: worse; - unknown.

It is a well-documented fact that that the northern Hawke's Bay coastal environment is strongly influenced by five main river/estuarine systems (Ridgway 1962; Gillespie 2007). These are the Wairoa River mouth and Ngamotu Lagoon (Wairoa), the Ahuriri Estuary, the Ngaruroro River and Tutaekuri River that forms the Waitangi Estuary mouth, and Tukituki River mouth. The Porangahau River and associated river mouth is the only large estuarine system in the southern Hawke's Bay (Fig. 4.1). Other estuarine lagoons/rivers of note include the Maungawhio and Kopuawhara Lagoons (Mahia), the Nuhaka River mouth, Aropaoanui River mouth, Esk River mouth and Wainui River mouth. Summary data for these systems are provided in McClay (1976) in terms of topographic classification, degree of stratification, condition (environmental), and changes in condition since 1965 (Table 4.1). From that study, it was evident that of those estuaries the Wairoa River mouth and Ngamotu Lagoon, Ahuriri Estuary, Waitangi Estuary and Tukituki river mouth had worsened in condition since 1965-1976.

Due to the obvious value of estuaries resulting from their wide range of functions and services associated with them and diverse habitats that are associated with them the main estuaries within the Hawke's Bay region and are describe in more detail below along with summary data where pertinent.

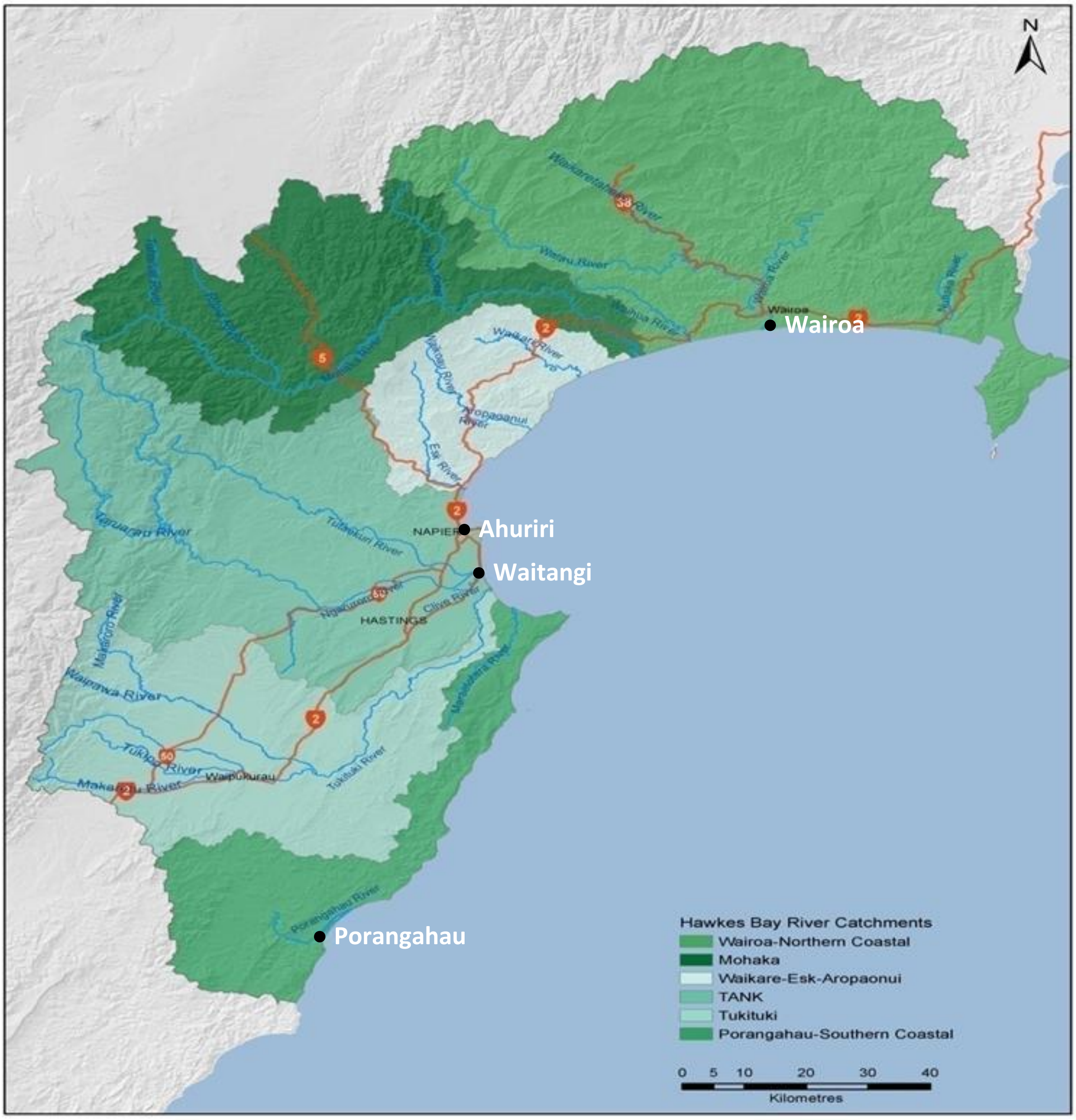


Figure 4.1. Main estuarine systems across the Hawke's Bay region (Wairoa, Ahuriri, Waitangi and Porangahau), also refer to Fig. 3.5.

Salinity intrusion

The intrusion (penetration) of saline water into the main estuaries (Tukituki Estuary, Clive River, Ngaruroro River, Tutaekuri River and Ahuriri River all surrounding Hastings and Napier was investigated by Wade (2013a). The purpose of the study was to provide a benchmark for the extent of saline penetration, so that change driven either by Council managed activities (such as those regulated through the resource consent process), or natural events (e.g. climate change, change in shape and extent of the estuary following an unusual hydrological event) may be detected and better understood. Not surprisingly it was established that all systems had different saltwater regimes, driven largely by their physical characteristics and the magnitude of freshwater inflows. Maximum extent of saltwater influence in these estuaries was approximately:

- 1 km into the Tukituki Estuary;
- 4.1 km into the Clive River arm of the Waitangi Estuary (most saline ;
- 5.1 km into the Ngaruroro River arm of the Waitangi Estuary;
- 2.9 km into the Tutaekuri River arm of the Waitangi Estuary;
- 9.2 km into the Ahuriri Estuary.

Correlations with flow and tide suggested that that the dominant variable(s) driving the extent of saltwater influence was flow in the Tukituki, flow and tidal height in the Waitangi estuary and tidal height within in the Ahuriri estuary. Results from studies help explain changes that have been observed within these systems through time and highlight the importance of physical monitoring within estuarine systems. Similar investigations have been conducted within the more-rural estuaries.

4.5.1 Ahuriri Estuary (Te Whanganui-a-Orotu)

The Ahuriri Estuary has been described as the most significant wetland along the entire coastline between East Cape and Wellington (Henriques *et al*. 1990). This is, in part, due to the presence of 5 adjacent wetlands (175 ha in extent) within reclaimed land surrounding the main body of the estuary, which are otherwise sparse, to non-existent elsewhere. Over the last 80+ years the Ahuriri Estuary has been modified extensively both naturally and anthropogenically.

Prior to Napier's 1931 earthquake, the Ahuriri estuary was a freshwater lagoon known as Te Whanganui A Orotu being approximately 3,840 ha in size (Fig. 4.2). The Tutaekuri River previously flowed into the lagoon, and a small opening to the sea was present in close proximity to Bay View. The 1931 earthquake altered this natural system by way of raising the lagoon bed approximately 2m exposing a third of the seabed creating the Ahuriri Estuary (approx. 2,600 ha)

Physical makeup and hydrology

Ensuing drainage and reclamation of the exposed seabed through time reduced the estuary from its post-earthquake 2,600 ha to its present day size of approximately 470 ha. Remnants of Papapapa and Te Ihooterei Islands can be seen on the grazed pasture today, although much of Papapapa was excavated for roading metal (Stevenson *et al*. 1987). The mouth of the estuary is presently contained by hard structures such as boulder breakwaters, seawalls and berthing structures, with the main channel margins beyond the motorway causeway contained by man-made stop-banks. The western margins of the estuary between Poraiti and the upper reaches are less modified. Unlike other estuarine systems in Hawke's Bay the Ahuriri is not influenced by any large river systems, but is prone to flooding (e.g., 1963). Due to the farming activities occurring below sea level stop banks and pump stations were established to reduce this.

Hydrodynamic and sediment transport modelling done within the estuary in 2008 (Eyre 2009) indicated the estuary is ebb-dominated, resulting in a likely net downstream movement of sediment through the estuary. Differences in flow are apparent between upper, mid, and lower reaches with flow described as highly channelised within the middle to lower estuary, with a much-reduced energy regime in the upper estuary. The lower flow velocities in the upper channel and lack of residual currents in the upper estuary results in a large proportion of sediment introduced during storm runoff settling out of suspension, resulting in net deposition in close proximity to the source. In contrast, sediment introduced into the estuary from the Taipo Stream is hypothesised to be flushed from the estuary providing it reaches the mid-estuary region.

Stevenson *et al*. (1987) describe the salinity profile of the Ahuriri Estuary as decreasing in salinity from seawater at the mouth until almost completely freshwater at the head of the estuary. Storm water can affect the salinity greatly and suggest that after a period of rain a much larger volume of freshwater enters the estuary from pumping stations associated with the adjacent Landcorp farm. The empirical study of Wade (2013a) however suggests that conductivity remains high in the estuary throughout the tidal cycle and that there is limited stratification due to the estuaries shallow depth, meandering nature, and wind mixing.

As, such the extent of saltwater influence is more likely to have an impact on the bankside vegetation than other estuaries, e.g., the Waitangi Estuary. Maximum saltwater penetration into the estuary was described as being of 9.2 km. More recent accounts albeit anecdotal, suggest that the higher saltwater penetration can persist for lengthy periods and that the upper water takes significantly longer to flush, with wind being a dominant driver of this rather than a normal tidal cycle.

Habitats of high ecological value

Unquestionably the wetlands contained within and adjacent to the Ahuriri Estuary are of high ecological importance due to the provision of structure, diversity and associated ecological function and integrity they afford. Early descriptions of the estuary (Stevenson *et al*. 1987) highlighted high faunal diversity, including at least 55 species of birds, 29 species of fish and 33 species of invertebrates. Henriques *et al*. (1990) suggest that the transition in plant communities from saline tolerant in the lower sections through to freshwater communities in the upper sections provides a diversity of habitat types not found elsewhere in Hawke' Bay south of the Wairoa coastal lagoons.

Herb fields dominated by conspicuous monospecific patches of the glasswort *Sarcocornia quinqueflora* occur throughout the estuary immediately adjacent the Pandora causeway to the upper reaches of the estuary proper (HBRC habitat mapping 2007). This species also occurs in mixed patches with the rushes *Juncus krausii*, *Triglochin striata*, *Selliera radicans*, and the marsh flower *Cotula coronopifolia*. The river tulip bulrush *Bolboschoenus fluviatilis* occurs throughout much of the upper reaches of the estuary in tandem with Raupo (*Typha orientalis).* DoC (1990) highlighted the occurrence of remnant ribbon wood *Plagianthus divaricatus* in the lower estuary.

Ahuriri Estuary is an important nursery area for fish. At least 30+ species of fish have been recorded historically the dominant species being short-finned eel (*Anguilla australis*), yellow-bellied flounder (*Rhombosolea leporine*), sand flounder (*Rhombosolea plebeia*), yellow-eyed mullet (*Aldrichetta forsteri*), black flounder (*Rhombosolea retiaria*) and parore (*Girella tricuspidata)* (Kilner and Ackroyd 1978). Grey mullet (*Mugil cephalus*) have become increasingly dominant in recent years, thought to be related to greater salt-water intrusion further up the estuary. Coastal species including kahawai (*Arripis trutta*), kingfish (*Seriola lalandi)*, and seahorses (*Hippocampus* sp) frequent the estuary. Traditional Maori use of the estuary has involved the gathering of an assortment of shellfish, including the cockle *Austrovenus stutchburyi*, pipi *Paphies australis* and tuatua *Paphies subtriangulata*. Common fish species harvested from the estuary were Inanga (*Galaxias maculatus)*, patiki (flounders), tuna (eels), mullet (awa), kahawai, and parore to name a few.

Historical information on the nature and spatial extent of benthic habitats is sparse to non-existent other than *ad hoc* historical accounts of extensive horse mussels beds within the lagoon, that became a casualty of the 1931 earthquake (Hay 1990) and the occurrence of seagrass habitat, also of which in non-existent today (Duffy 1998). The intertidal mudflats and the numerous faunal organisms within serve as significant foraging habitat for numerous bird species.

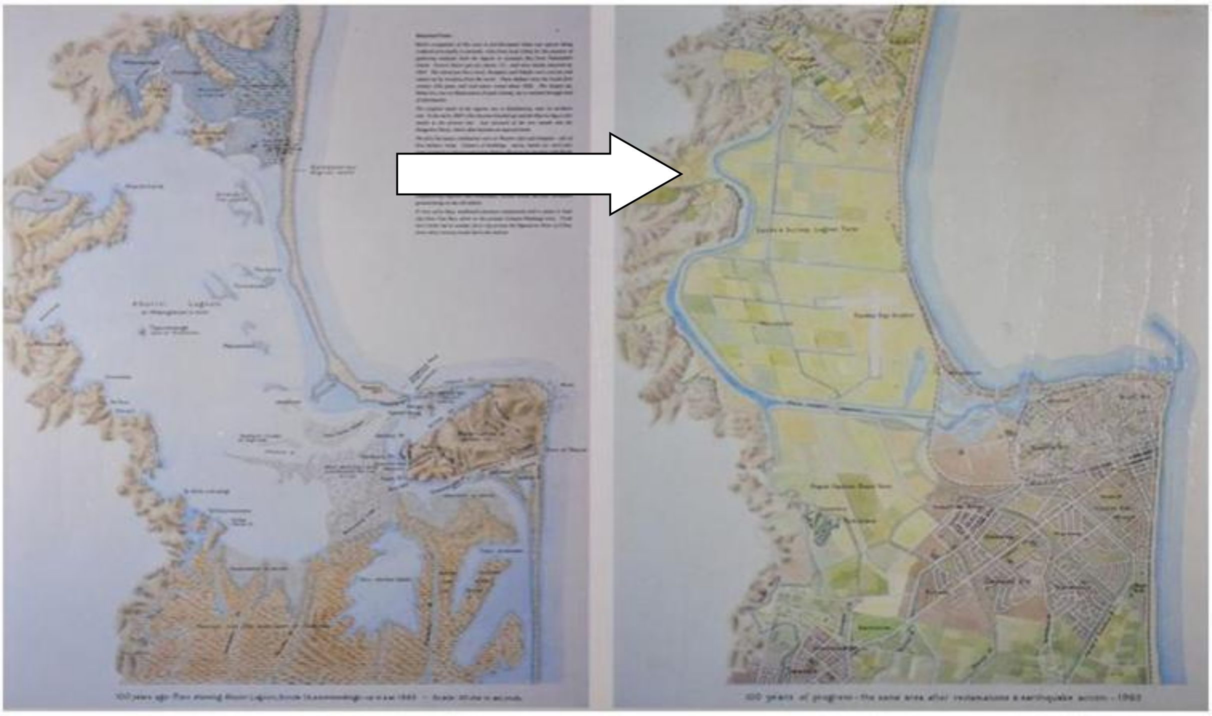


Figure 4.2. Ahuriri Estuary pre (2,600 ha – 1865) and post (470 ha – 1965) Napier's 1931 earthquake. Source: knowledgebank.org.nz

Of these, the estuary is of national importance for numerous wintering bird species such as the royal spoonbill (*Platalea regia)* and white heron (*Egretta alba)* and is of regional importance for Australasian Bittern (*Botaurus poiciloptilus)*, Grey Teal (*Anas gracilis)*, New Zealand shoveler (*Anas rhynchotis variegata)*, marsh crake (*Porzana pusilla affini)s*and black fronted dotterel (*Charadrius melanops)*. Other major species that are more variable within the estuary includes banded dotterel (*Charadrius bicinctus),* Pacific reef egret (*Egretta sacra),* wrybill (*Anarhynchus frontalis)*, far eastern curlew (*Numenius madagascariensis)* (occasional summer visitor), Asiatic whimbrel (*Numenius phaeopus variegates)* (regular summer visitor), American whimbrel (*Numenius phaeopus hudsonicus)* (occasional visitor).

Monitoring

Given its immediate proximity to Napier and the likelihood of numerous threats to its ecological functioning and integrity, the Ahuriri Estuary has undoubtedly been the most well researched/studied estuarine system within the Hawke's Bay. Early studies of Knox (1979b) investigated water quality and Rycroft (2002) identified a number of unauthorised discharges and numerous sources of contaminants including boat slipways discharging into the lower Ahuriri Estuary.

Ecological studies have been undertaken sporadically since the early 1970s, with a formal SoE monitoring programme established as part of a regional Estuarine Ecology Monitoring Programme and sediment quality monitoring in the inner harbour in 2006 (HBRC 2006). As part of this programme, a range of indicators are measured that includes sediment grain-size, organic material, nutrients, trace metals and benthic infauna. These are compared against available guidelines e.g., ANZECC (2000) and other reference estuarine systems elsewhere. Within the Ahuriri estuary four sites (A, B, D and E) are routinely monitored.

Key findings from this monitoring are:

- Moderate sediment stress at middle Ahuriri sites A and B and higher levels of sediment stress at sites D and E;
- Increasing sediment stress at all sites excluding E;
- A point source for phosphorus is evident at Ahuriri D;
- Elevated concentrations of DDT, PAHs *etc.* in Inner Harbour associated with Boat maintenance activities.
- Trace metals well within ANZECC interim sediment quality guidelines apart from Ahuriri D. Site Ahuriri D shows significantly higher levels of zinc, lead, cadmium, chromium and copper. While median levels (represented in the graphs) appear to fall within guideline values, individual samples exceeded concentrations where adverse ecological effects could be expected occasionally.
- Infauna appears to be responding to mud content and mud intolerant species reflected in the absence of species such as the polychaete worm *Aonides oxychepala* and *Macomona liliana* from sampling sites that exceed 25 % mud content.
- A Traits Based Index (TBI) applied to the sites corresponds closely to concentrations of mud (silt/clay) indicting a reduction in the resilience of sites as mud concentration increases.

In addition to SoE monitoring, evaluating effects resulting from potential storm water contaminants entering the estuary have been undertaken every 4-5 years in accordance with resource consent conditions. Both HBRC and Napier City Council hold joint resource consent to discharge storm water into the estuary through the County, Plantation, and Georges Drive drainage network (see Smith 2014). The monitoring undertaken to evaluate effects includes comparing 2 potential impact sites (PUR and GPC) which are located adjacent to the final discharge points 'impact' sites relative to1 reference site (AHU) ((Bennett 2006; Smith 2010,

2014) (Fig. 4.3). The Purimu Stream catchment which abuts this drainage network is described as mixed-rural, residential, and commercial with rural areas located primarily in the upper catchment and comprising the large majority (approximately 53 %) of land area. Storm water effects-based monitoring involves evaluating benthic characteristics including sediment composition and quality and biological community composition.

Figure 4.3. Sites of storm water effects monitoring. PUR and GPC demote potential impact sites, whereas AHU is a control site.

As is common to estuarine systems elsewhere in New Zealand, temporal patterns of sediment quality and benthic community composition were highly variable across surveys reflecting wider catchment effects, for example, all sites were characterised as muddy sand with site PUR muddier and sites AHU and GPC sandier; although there has been a general increase in the percent cover of mud content across all sites. Results were also suggestive of storm-water related effects particularly at one of the impact sites (GPC). At site GPC[3] in 2014, zinc and lead were present at high levels, but were currently below levels at which adverse biological effects would be expected to occur based on ANZECC sediment quality guidelines (ANZECC, 2000). Resultantly, GPC was ranked among the most polluted sites when compared to New Zealand reference estuaries and another Hawke's Bay estuarine site (Wairoa). Both zinc and

[3]*Note: Smith (2014) suggest that to evaluate temporal and spatial trends in sediment contaminants it is standard practice to normalise contaminant concentrations to 100% of the mud/fine component to account for changes in sediment composition. As such it is possible that the high results presented were an artefact of this process and it was recommended that for future surveys direct monitoring of the fine fraction (63µm) is undertaken to provide greater certainty around the results.*

cadmium were described as increasing through time at GPC, whereas sediment nutrient and organic matter, while indicative of nutrient enrichment changed very little across surveys. At impact site PUR there has been a documented decrease in heavy metal contaminants and normalised phosphorus and organic content (AFDW), suggesting improved environmental conditions. This was also true for the control site.

In terms of benthic ecology it was found that there was a slight deterioration in diversity (based on multiple-indices) at 'impact' site GPC and little change at site PUR, whereas diversity at the reference site AHU was improving slightly across surveys. Epifauna were found to track changes in macro algal biomass increasing in diversity or abundance at all sites and Community structure at the control site AHU was significantly different statistically to 'impact' site GPC whereas no difference between 'impact' site PUR and reference site AHU was apparent. Main species responsible for the among-site and across-survey changes were the bivalves *Austrovenus stutchburyi*, and *Macomona liliana*. There was little evidence to infer that silt/clay levels in the sediment were currently at levels driving community composition towards more mud-tolerant species.

Of particular note in the mid to upper reaches of the estuary in recent years has been the spread of the estuarine worm *Ficopomatus enigmaticus* (Fig. 4.4) and large persistent dinoflagellate blooms comprised of *Cryptomonas* sp, *Gymnodinium* sp and diatoms such as *Cylinderotheca* spp. Macrophyte blooms dominated by *Ulva intestinalis* are also common in drainage channels and within the estuary proper again dominated by *Ulva* sp., G*racilaria* sp, and to a lesser degree *Cladophora* sp.

Changes to the physical and biological makeup of the Ahuriri estuary

Following the aftermath of the 1931 earthquake the Ahuriri Estuary has experienced significant changes to its physical and biological composition some of the main effects include:

- Channel dredging to create stop banks and deepen the channel as a flood prevention measure;
- Increased siltation through time, particularly in upper reaches and follow-on variation in hydrodynamics and salinity regime;
- Loss of key habitats such as horse mussel beds, seagrass and more-recently raupo;
- Evidence of stock grazing within the upper reaches of the estuary (Fig. 4.4);
- Catchment development and associated effects (water quality, at some monitoring sites;
- Rapid spread of invasive tube building fan worm *Ficopomatus enigmaticus.*

Key elements of the Ahuriri Estuary and these changes are summarised in Table 4.2.

Table 4.2 *At a glance - Ahuriri Estuary*

Summary component	Description	General comments
Physical makeup	Lagoon Ebb-tide dominated Change in sediment composition	Sediment moves from upper to lower reaches of estuary, flow greater in channel regions Trend for increased muddiness
Habitats/species of significance past and present	Raupo–upper reaches Seagrass Coastal vegetation Sand and mudflats Shellfish – pipi, cockle Mussels prolific at harbour mouth associated with hard structures (piles, rock walls)	In decline from upper parts of estuary Absent from estuary since 1970s– historic accounts (Duffy 1998). Increased muddiness and sediment anoxia in places Cockles prolific, pipi in decline
Ecological significance of estuary	Nursery habitat for fishes Large areas of wetland and associated vegetation – high ecological value Foraging and roosting habitat for international and nationally significant birds	 Unknown
Major changes	Stop banks established 1950's Industrialised Dredging 1960's New motorway – 2002-2003 Pipi Grey mullet Dinoflagellate, diatom and macrophyte blooms Flushing and water exchange (Upper to lower) Change in salinity – increase in salinity in spring affecting ground water Flooding often prominent at Bay View End	Channels dug entire length of estuary – now silty Storm water runoff effects potentially becoming problematic Altered hydrology Large increase in muddiness and possible altered hydrology Declined Large increase in abundance – dominant in upper reaches Present in upper estuary and drainage channels boarding stop banks Major lag in flushing, high salt water intrusion and retention in upper reaches Inability of estuary to cope with flood and storm water events
Threats to habitats of significance	Sedimentation Eutrophication Reclamation Heavy metal contamination and nutrient enrichment of sediments Water quality poor (nutrients and high faecal counts) Spread of fan worm *Ficopomatus enigmaticus* over the last few years Evidence of loss of significant habitats Overall inability for Ahuriri Estuary to function properly Stock grazing within estuary	Increasing in upper and middle estuary Fluctuates Raupo

Figure 4.4. Ahuriri Estuary: A: weirs created by an increase in the tube building fanworm *Ficopomatus enigmaticus* – mid estuary; B: Patches of glasswort *Sarcocornia quinqueflora* – upper estuary *Note:* Raupo was common to this area prior to 2013; and, C: Stock grazing on *Sarcocornia quinqueflora* habitat.

4.5.2 Porangahau Estuary

Porangahau is the largest bar built tidal lagoon estuary within the Hawke's Bay at around 750 ha in size (Fig. 4.5). The entrance to sea is transient in nature and the landward regions of the estuary particularly to south boarder extensive exotic pastureland that primarily supports beef and sheep farming. The landward region to the north becomes progressively framed by sand-dune systems, that transition often abruptly into pastureland with small pockets of exotic forestry also present. There is evidence of historic drainage of wetland areas throughout.

Figure 4.5. Mouth of the Porangahau Estuary (source: Google Earth).

Habitats of ecological significance

Porangahau Estuary is classified as a Significant Conservation Area 2 in HBRC's coastal plan and is of national significance due to the provision of roosting, feeding, and breeding habitat for myriad birds. Caspian terns or taranui (*Hydroprogne caspia*) are of particular note. Its importance as a nursery and foraging habitat for many fish species e.g., whitebait, flounder, mullet and kahawai is also eminent (Davis 1987). Toheroa (*Paphies ventricos*) were once abundant on Porangahau Beach. Dominant estuarine benthic fauna are bivalves cockles, pipi, tuatua, and the wedge shell *Macomona liliana*, (Smith 2009a; Jim Hutcheson *personal communication in* 2016) and various polychaete worm species.

Monitoring

Early summary data from McClay (1976) defined the Porangahau Harbour as moderately polluted. Estuarine monitoring by Smith (2009) found some evidence of a decline in several benthic species noting that an increase in fine sediment had resulted in an increase in the polychaete worms *Edwardsia* sp, *Scolecolepides* sp, and *Nicon aestuariensis* (tolerant of fine sediment). Conversely, this had a negative effect on *Macomona liliana* and the polychaete *Aonides trifida* populations. These trends match those of northern estuaries (e.g., Ahuriri).

Key findings from SoE monitoring undertaken at Porangahau are:

- Evidence of high sediment stress within the estuary with sediment profiles containing approximately 55% mud content;
- Decreasing levels of sediment bound nitrogen and phosphorus;
- Trace metals well within ANZECC interim sediment quality guidelines. Levels of arsenic and copper were slightly elevated above background levels as defined by HBRC. All trace metals exhibited decreasing trends through time;
- Macro fauna were of low abundance and moderate biodiversity;
- Infauna appears to be responding to mud content with Porangahau notable for very high abundances of the mud tolerant spionid polychaete *Scolecolepides spp* compared to other estuaries.
- A Traits Based Index (TBI) applied to the sites corresponds closely to concentrations of mud (silt/clay) indicting a reduction in the resilience of sites as mud concentration increases.

Changes to the physical and biological makeup of the Porangahau estuary

Due to a lack of long-term monitoring within the estuary, changes that have occurred pre-2006 are not available. Discussions held with prominent Kaitiaki Jim and Allen Hutchison and Paul Sciascia (Ngati Kere) brought to light a range of their environmental concerns primarily relating to the upper catchment and those effects synonymous with sedimentation and erosion. A flood event in 2004 that altered the path of the Porangahau River and caused widespread flooding and delivered significant amounts of sediment and silt into the estuary was still a vivid memory, as were the draining of wetlands for grazing pasture in 1996. There was also considerable angst and a sense of grievance over the present-day state of the estuary and an inability to share their customary knowledge and fulfil their roles as Kaitiaki.

During a site visit to Porangahau in April 2016 by the authors', numerous threats to the estuary were observed such as, a severe lack of riparian planting surrounding the estuary proper that also stretched to smaller tributaries and the main branch of the Porangahau river; stock induced erosion of Waikaraka Stream; stock within the Porangahau estuary; and, damage/loss of wetlands converted to pasture for cattle grazing (Fig. 4.6). Areas of the lowland pasture were being extensively irrigated and fertilised at the time of the visit.

Table 4.3 *At a glance - Porangahau Estuary*

Summary component	Description	General comments
Physical makeup	Lagoon system, mouth of estuary fluctuates: Volume - 1,667,332 m3 Catchment surrounding estuary is predominantly exotic pasture for beef and sheep crazing. Small patches of exotic forestry (*Pinus radiata*) evident. Sheep and Beef (79%); Exotic Forest (6.5%)	Largest area of intertidal mudflats within Hawke's Bay.
Habitats/species of significance past and present	Dune systems Wetlands Shellfish – pipi, cockle, tuatua beds. Seahorses Toheroa	Increases on landward side of the estuary north of opening Increases on landward side of the estuary north of opening Historically abundant within lower margins of the estuary Historically common within estuary Historically common - Porangahau Beach
Ecological significance of estuary	Breeding, nursery and foraging habitat for fishes Foraging and roosting habitat for international and nationally significant birds	Flounder, mullet, kahawai, whitebait Caspian Tern
Major changes	Sedimentation Reduction in upper estuarine crab (unknown species) Mullet Kahawai not as common within estuary	Increased muddiness of sampling sites change in faunal composition Decrease in abundance – attributed to reduction in crab numbers
Threats to habitats of significance	Sedimentation Upper catchment erosion River and stream bank erosion Stock in estuary and surrounding streams Damage to existing wetlands	 Evidenced during site visit Evidenced during site visit Evidenced during site visit

Figure 4.6. Porangahau Estuary: A: stock damage to Waikaraka Stream; B: Erosion of Waikaraka Stream; and, C: gazing pasture – northern Porangahau.

4.5.3 Waitangi Estuary

The Waitangi Estuary is approximately 30 ha in spatial extent and is principally the mouth of the combined Clive/Karamu, Tutaekuri and Ngaruroro Rivers. Historically both the Ngaruroro and Tutaekuri have been extensively modified (Parrish 1988) with the Tutaekuri River originally flowing into the Ahuriri Lagoon. Following the 1931 Napier earthquake the river was diverted to discharge at Awatoto. The Ngaruroro was also diverted from its former course (in what is now the Clive/Karamu River) to a more direct route via a stop-banked canal. These two rivers form the Waitangi Estuary. The catchment of the Waitangi, is primarily sheep and beef pasture (42 %), indigenous forest (16 %) and manuka/kanuka scrub (13 %) (HBRC unpublished data 2016).

Figure. 4.7. Mouth of the Waitangi Estuary (Source: Google Earth)

Habitats of ecological significance

The Waitangi estuary (Fig. 4.7) has been described as providing exceptional habitat for wetland birds comprised of several rare and iconic species, e.g., godwit, golden plover, black-billed gull, gannet and kotuku. Brackish swamps at the mouth contain species such as spotless crake and bittern. The gravel beach ridge and bar system at the entrance provides important nesting and roosting habitat for birds (dotterels, stilts, and terns). Significant native vegetation to the estuary includes shore ribbonwood, marsh clubrush and the threatened turf plant *Mimulus repens* (Walls 2005). The salt tolerant aquatic plant *Ruppia* sp forms beds in the Clive/Karamu. Various sections of the Clive/Karamu riverbanks and Tutaekuri blind arm also serve as important Inanga spawning habitat.

Regular fish to the estuary include inanga, mullet, eels, kahawai, warehou, and flatfish. A 790 mm fork length (FL) (6.91 kg) kahawai was netted in Waitangi Estuary in August 1997 which was the new size record for New Zealand at that time (Duffy and Petherick 1999).

Changes to the physical and biological makeup

The Waitangi estuary, like the Ahuriri to the north is reasonably modified particularly the river margins upstream of the lagoon area. The effects of storm water induced erosion of the river banks are very pronounced through the Karamu River and from Awatoto into the blind arm of the Tutaekuri River. All catchments have prolific growth of freshwater algae such as (*Egeria* sp), curly pondweed (*Potamogeton crispus*), hornwart (*Ceratophyllum demersum*), and Canadian pondweed (*Elodea canadensis*). Nuisance growths of these species are managed through mechanical cutting.

Monitoring

SoE monitoring within the Waitangi estuary with the exceptions of the broad descriptions of Walls (2005) is very limited with formal monitoring only instigated on 1 occasion since 2012.

Key findings from SoE monitoring undertaken at Waitangi are:

- Evidence of high sediment stress within the estuary with sediment profiles containing approximately 55% mud content;

- Chl-*a* levels suggest Waitangi Estuary may be indicative of slightly enriched sediments;

- Trace metals well below ANZECC interim sediment quality guidelines;

- Macro fauna were of high abundance for the amphipod *Paracorophium excavatum* and the estuarine snail *Potamopyrgus estuarinus* with moderate to low moderate biodiversity overall;

As for the Porangahau, due to a lack of long-term monitoring within the estuary, changes that have occurred pre-2012 are not available. A site visit in April 2016 revealed cattle grazing extensively along unfenced banks of the lower Ngaruroro River, with stock occasionally observed in the river (Fig. 4.8). Erosion was prolific where cattle were grazing. Erosion of the river banks along the lower Tutaekuri was also apparent.

Encouragingly significant riparian planting has been undertaken along parts of the Clive River by Tom McGuire and whanau in an effort to reduce erosion and create a riparian buffer between the various horticulture and farming endeavours that occur throughout the catchment. Monitoring of eel and flounder populations is also undertaken in an effort to evaluate current status of these (taonga) species. At the time of writing wetland restoration on the northern embankment adjacent the causeway was about to commence.

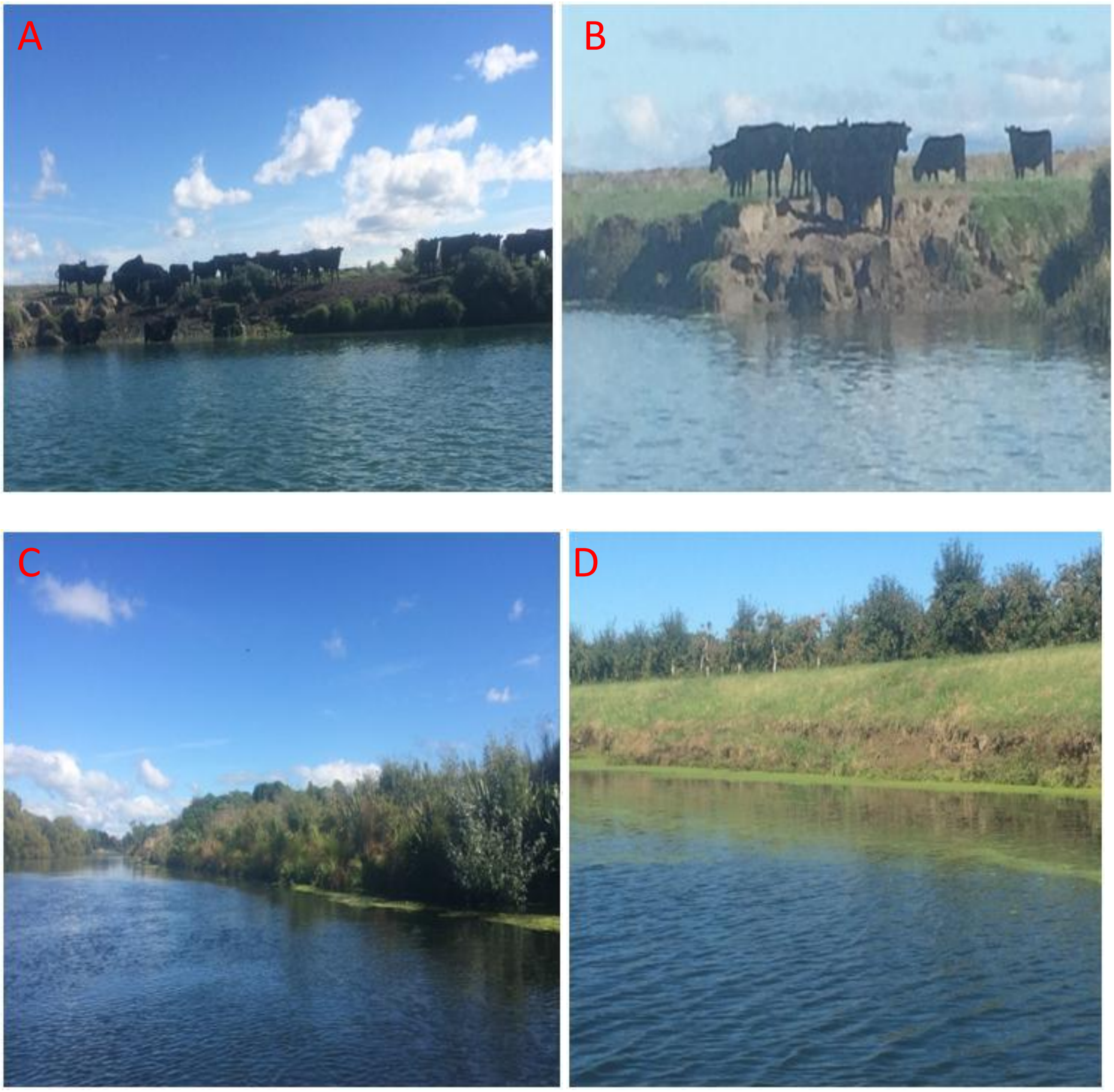


Figure 4.8. Waitangi Estuary and main tributaries: A and B: stock throughout waterways and exacerbating river-bank erosion –Ngaruroro River; C: Results of river bank riparian planting – Clive River; and, D: lack of riparian buffer between horticulture and Clive River

Table 4.4. ***At a glance –Waitangi Estuary***

Summary component	Description	General comments
Physical makeup	Lagoon system, mouth of estuary fluctuates: Volume - 1,667,332 m3 Catchment is primarily sheep and beef pasture (42%), indigenous forest (16 %) and manuka/kanuka scrub (13 %)	Largest area of intertidal mudflats within Hawke's Bay.
Habitats/species of significance past and present	*Ruppia* beds within the Clive/Karamu Brackish swamps at the mouth important for wading birds Native vegetation ribbonwood, marsh clubrush, Manuka/kanuka scrub and the threatened turf plant *Mimulus repens* Shellfish – pipi, cockle, tuatua beds offshore from entrance	Reduction in abundance through time
Ecological significance of estuary	Breeding, nursery and foraging habitat for fishes Foraging and roosting habitat for international and nationally significant birds Inanga spawning sites (numerous)	Flounder, mullet, kahawai, Inanga, eels, warehou Caspian Tern
Major changes	Sedimentation Flounder, mullet, kahawai, flatfish and eels not as common within estuary Warehou very rare Large-scale riparian planting along banks of the Clive River Wetland restoration	Eel and flatfish abundance currently being evaluated – Tom McGuire Initiative to restore mauri to the awa
Threats to habitats of significance	Sedimentation Upper catchment erosion River and stream bank erosion Stock in estuary and surrounding streams Damage to existing wetlands Lack of riparian buffer Nuisance growth of freshwater algae	SoE monitoring Evidenced during site visit Evidenced during site visit Evidenced during site visit Evidenced during site visit Evidenced during site visit- possible nutrient enrichment

4.5.4 Wairoa Estuary

The Wairoa estuary is a river mouth dominated estuary with two bar-built lagoons the Whakamahi and Ngamotu at its mobile entrance. These lagoons form part of a complex lagoon system that would have extended north up the coast to Whakaki Lagoon encompassing Ohuia, Wairau, and Te Paeroa lagoons (Cameron 2008). The estuary marks the end point of the Wairoa River which sits within a catchment area of 356,300 km^2 of which 264,547 km^2 is within the Hawke's Bay regional boundary. This is Hawke's Bay's largest catchment. The river is formed by the confluence of the Hangaroa and the Ruakituri rivers which meet at Te Reinga Falls, and flows 65 km to drain into the sea near Wairoa township. Other rivers of note include the Waiau that meets the Wairoa River adjacent Frasertown approximately 10 km from the mouth. Main uses of the catchment include indigenous forests production (36 %) and sheep and beef farming (34.5%). Smaller horticultural practices are common to the area as well. The Wairoa Township is a dominant feature located on the southern bank near the entrance. Industrial activities associated with the Affco Meat works (Wairoa) and Silver Fern farms meat works (Frasertown) discharge waste into the Wairoa River/Estuary.

Habitats of ecological significance

The Wairoa Estuary comprising the lagoon, sandspit, and mudflats is a Department of Conservation Wildlife management reserve (Cheyne and Addenbrook 2002) and is designated by HBRC as a significant conservation area due to its biodiversity values. Birds of significance associated with the estuary include Australasian Bittern *Botaurus poiciloptilus* Marsh Crake *Porzana pusilla* and Spotless Crake *Porzana tabuensis* and the Royal Spoonbill *Platalea regia*. The Wairoa estuary, as for other estuarine areas within Hawke's Bay serves as a nursery ground for flounder and short and long-finned eel, and inanga. Both cockles and pipi occur within the estuary proper and fresh water mussels (kakahi) were also historically abundant.

Changes to the physical and biological makeup of the Wairoa Estuary

As for the Ahuriri Estuary the summary of McClay (1976) inferred the environmental condition of the Wairoa Estuary had worsened between 1965 and 1976 and in 1976 was classified as moderately polluted. This is still likely the case today. A site visit in April 2016 found the sandflats within the estuary to be strewn with debris and litter, evidence of localised oil contamination, and a distinct lack of any riparian buffers at the entrance or along the river banks (Fig. 4.9). Discussions with Allen and Christine Smith (Te Tira Whakaemi o te Wairoa - Te Wairoa Tapokorau) highlighted that sedimentation and forestry debris emanating from land-use activities in the upper catchment were of a large concern, as was the lack of any wetland habitat at the mouth.

More-recently they have been proactive in water quality monitoring at many river and estuarine sites and transferring eels from the Waiau River to the Wairoa estuary entrance. This is in an effort to ensure successful eel migration between the two systems and they suggest the stretch of water between the Waiau River and estuary mouth has become too polluted from land-based activities for successful eel migration. Additional species that had declined included most bivalves (pipi and freshwater mussels) and several fishes (lamprey and black flounder). Inanga were considered to be in a reasonably healthy state. An increase in salt-water intrusion into the river was also highlighted as being an issue, which has seen mullet occurring further up the river in recent years.

Monitoring

State of the Environment monitoring has recently indicated that of all the estuaries surveyed, the Wairoa Estuary is demonstrating the greatest signs of sediment stress with sediment samples having median mud content of > 60 %, and ranging between 33-88 %. This was reflected in macrofaunal community composition with low overall diversity and general absence of mud-sensitive species, e.g., cockles *Austrovenus stutchburyi*, the wedge shell *Macomona liliana*, and the polychaete *Aonides oxychephala*. Rather, species defining the community composition for Wairoa Estuary were all mud tolerant and included the amphipod *Paracorphium excavatum*, polychaetes *Nicon aestuariensis and Scolecolepides sp* and the mud snail *Potamopyrgus estuarinus*. Sediment heavy metal content and nutrients were all below pre-defined background levels and thus ANZECC (2000) interim sediment quality guidelines.

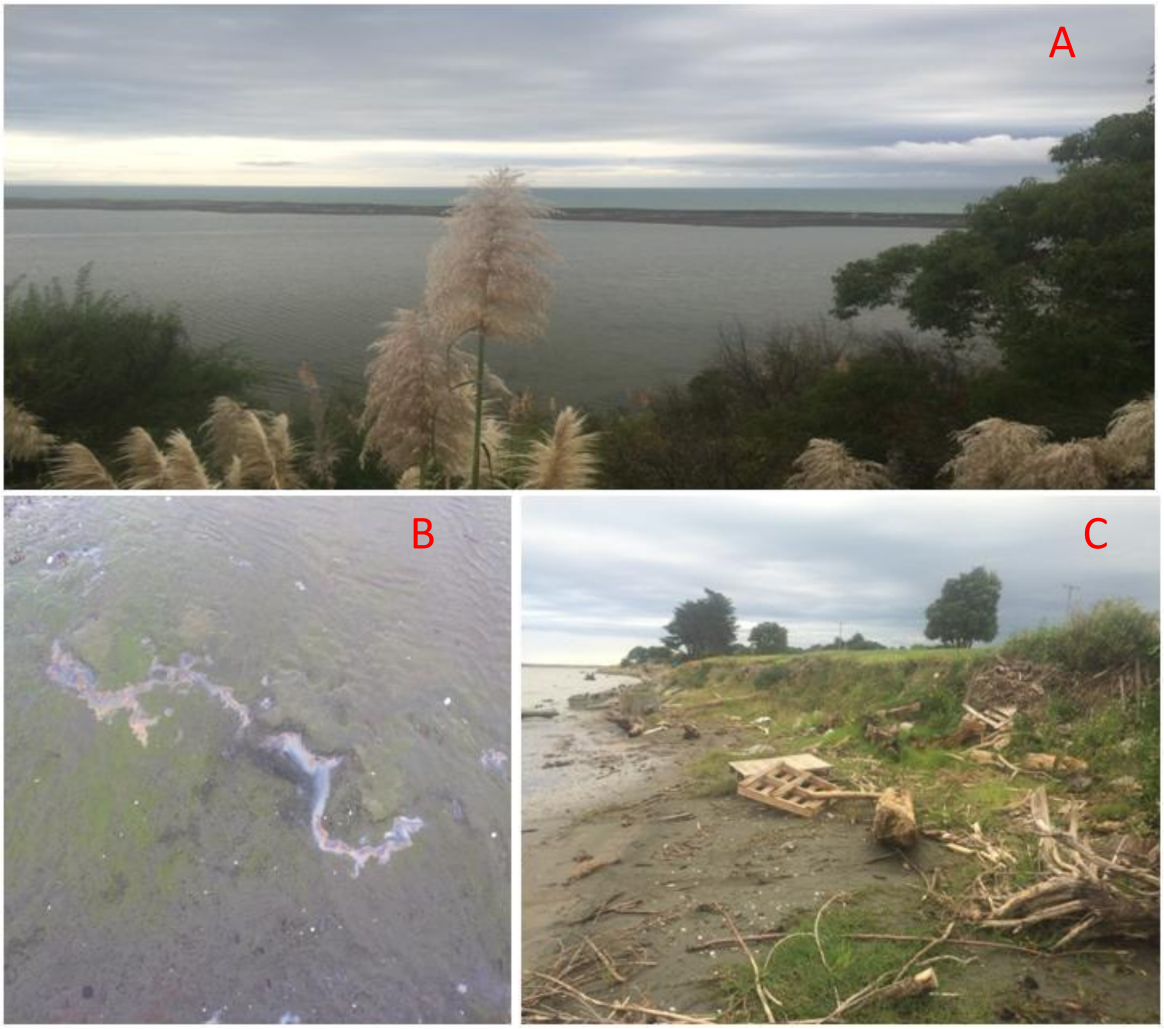


Figure 4.9. A: Wairoa Estuary entrance region; B: localised oil contamination on intertidal sandflats; and, C: Absence of riparian planting on southern estuary bank adjacent Kopu Road.

Table 4.5. ***At a glance - Wairoa Estuary***

Summary component	Description	General Comments
Physical makeup	Rivermouth estuary; Bar-built lagoon systems; mouth of estuary fluctuates; Volume; 9,734,902m^3	Increased muddiness
Habitats/species of significance past and present	Mudflats, sandflats Shellfish – pipi, cockle, fresh water mussel beds Eels Lamprey	 In decline from lower parts of estuary In decline – efforts underway to help migration Historically abundant now absent
Ecological significance of estuary	Nursery habitat for fishes Significant habitat for eels Foraging and roosting habitat for international and nationally significant birds	Flounder, inanga
Major changes	Increase in saltwater intrusion, past Wairoa bridge Increase in muddiness of estuary Pipi	Mullet occur further up estuary Absence of mud-intolerant species *Austrovenus stutchburyi*, *Macomona liliana*, *Aonides oxychephala* In decline
Threats to habitats of significance	Sedimentation from forestry and farming Debris associated with forestry blocking channels Potential pollution from wastewater discharges Litter and localised oil spills on sandflats	Among highest of all estuaries - becoming problematic Evidenced during site visit

4.6 Rocky Reef physical and biological habitats

Mahanga to Cape Kidnappers - physical characteristics

Intertidal and subtidal rocky reef

Intertidal and subtidal rocky reef habitat characteristic of the region between Mahanga Beach (north-eastern Mahia) to Cape Kidnappers (southern Hawke Bay) varies considerably (Duffy 1992) and is somewhat reduced in spatial extent when compared to soft-sediment and intertidal gravel beach habitat (Duffy 1992; 1998; Stevens and Robertson 2005).

Intertidal rocky reef platforms south of Mahanga Beach to Ahuriri Point (Mahia) including Portland Island are predominantly siltstone in nature, with intertidal platforms to the north of Ahuriri Bay (Mahia Peninsula) and Waikokopu Bay typically a combination of boulder reef and siltstone platform reef. Subtidal reefs of the Mahia region are in places extensive, extending down to depths of 30 m which terminate in sandy substrates that eventually transition to more muddy substrates with increasing depth (Stevenson *et al*. 1987; Duffy 1998; Dr. N. Shears *personal communication* in 2016).

The intertidal region between Waipatiki Beach and Tangoio is punctuated by small boulder reefs and the rocky reef habitat surrounding Napier City down to Cape Kidnappers where present is a mix of both platform and boulder reef. Subtidal reef habitats of note include Pania Reef, Town Reef, Te Awanga, and Black Reef. Pania Reef is approximately 4.7 km^2 and extends down to a depth of 15-20 m Town reef is smaller than Pania Reef located immediately east of the Napier Port with a maximum depth of 12m (Duffy 1992; 1998). Black Reef is notable for its size relative to northern reef systems extending approximately 3.5 km offshore and down to a depth of 15m, with various sections of the reef exposed at low tide (Duffy 1992; 1998).

Two additional semi-reefs of note within this region include the Wairoa Hard and Clive (Clifton) Hard. The Wairoa Hard located between the Moeangiangi and Wairoa Rivers in central Hawke Bay covers approximately 303.4 km^2 of seabed and extends 18km offshore. The substratum texture, as described by Tai Perspectives (1996); Duffy (1998); and, Thrush *et al*. (1997), includes low ridges of cobbles/small boulders within the southern region of the Hard; areas of foul comprised of large mounds of boulders towards the Mohaka River; and, cobbles and small boulders reportedly increase in abundance from Tangoio south of the Hard towards the Mohaka River. The north-eastern corner of the hard is referred to as "The Island" and is made up of large 1m diameter boulders which transition into a rubbly or hard-smooth bottom (thought to be papa) within the northern expanse of the hard. Areas of dense foul are common along the shoreward edge of the Hard between 45-7 0m depth Tai Perspectives 1996). In contrast, Thrush *et al*. (1997) describes the Wairoa Hard as being comprised of large areas of featureless, finely rippled sand, interspersed with fingers of mega ripples, coarse rippled sand, fingers of mud, and occasional patches of low rock outcrops. This description differs somewhat from that of Tai Perspectives (1996); however, in summary the Thrush *et al*. (1997) survey sampled a relatively small area of the hard and thus may (as noted in the report) have likely to have under described the full complement of physical and biological habitats within the area.

The Clive Hard located between Clive and Cape Kidnappers in the southern region of Hawke Bay, lies in approximately 15 m depth and is substantially smaller than the Wairoa Hard (Tai

Perspectives 1996). It is principally a matrix of gravel and small boulders and bookended to the north and south by sandy mud and muddy substrates (Duffy 1998; Thrush *et al*. 1997).

A survey employing side scan sonar with associated ground truthing mapped the southern region of Hawke Bay north of Tukituki River entrance and Cape Kidnappers, inshore and across parts of the Clive Hard. The aim of mapping the seafloor in this region was to better-understand the sediment transport dynamics particularly river mouth dynamics and associated gravel movement (MetOcean, 2011). The study identified five types of seabed including Sand; Rock; patches of rock; and, sand; Rock ridges interspersed with sand; and, Sand and gravel. Of these habitats, sand was particularly dominant in the western region of the survey area north-west of Te Awanga, but was also present throughout much of the survey area in accordance with other habitat types. Rock habitat was dominant within the nearshore regions of Te Awanga and Clifton and typically co-occurred with sand across the entire survey area. Rock ridges interspersed with sand was a dominant feature of the eastern part of the survey area between Clifton and Cape Kidnappers; whereas, sand and gravel dominated at the entrance of the Tukituki River off Haumoana.

Mahanga to Cape Kidnappers - biological characteristics

Intertidal rocky reef

The biota of intertidal rocky reef habitats for the Mahanga Beach to Cape Kidnappers stretch of coastline tend to exhibit discreet zonation patterns consistent with exposure and tidal immersion (Duffy 1998; Smith 2009b). The splash zone has been described as commonly species depauperate save for black lichen, which is succeeded by a littorinid zone (*Littorina unifaciata* and *Littorina cincta*) then a limpet (*Cellana radians* and *Cellana flava*)/ barnacle (*Chameosipho columna*) zone.

On boulder dominated shores, the boulders themselves tend to be relatively bare of flora and fauna but do support turfing algae species, encrusting invertebrates, and other small grazing gastropods in the crevices and on the undersides of the boulders. Species common to intertidal rocky reef habitat characterised by medium to large sized mobile sandstone/mudstone 'papa' boulders often typical of the northern and southern Hawke's Bay include the limpet *Cellana radians*, the banded periwinkle *Littorina antipoda* (supralittoral fringe), and *Cellana ornata*. The red alga *Gigartina* sp. is commonly encountered along with the barnacle *Chamaesipho columna* (Smith 2009b).

Lower on the shore coralline crusts and turfs on exposed platform reefs become more widespread as does the bulbous brown alga *Leathesia difformis*, and turfing red algae *Gelidium* sp. Within tidal pools low on the shore a diverse array of algal species is often dominant with algal assemblages being an assortment of brown fucalean algae including *Sargassum sinclarii*, *Cystophora torulosa*, *Carpophyllum maschalocarpum*, *Carpophyllum plumosum*, *Glossophora kunthii*, and *Zonaria* sp (Duffy 1992; 1998). Shears and Babcock (2007) reported the kelp *Durvillaea antarctica* occurring in the shallow intertidal and subtidal at Mahia and the invasive introduced kelp *Undaria pinnatifida* is a regularly encountered on intertidal cobble and boulder habitat at Hardinge Road.

Common invertebrate species as described by Duffy (1992; 1998) include: sponges (*Halichondria* sp); gastropods (*Cominella maculosa*, *Buccinulum colensoi*, *Buccinulum lineum, and Haustrum haustorium)*, small paua (*Haliotis iris)*; echinoderms (*Patriella* *regularis)* and small kina *(Evechinus chloroticus)* and various crustaceans such as the crab *Guinusia charbus* and shrimps (*Alope spinifrons and Palaemon affinis).* The tube-building polychaete *Pomatoceros caeruleus* (*Spirobranchus cariniferus*) is also regularly encountered.

Subtidal rocky reef
Along the Mahia region Shears and Babcock (2007) described subtidal communities at Black Rock and Portland Island comparing these two locations elsewhere in New Zealand, particularly Gisborne. Macroalgal communities were typically dominated by a small number of brown algal species (*Ecklonia radiata*, *Carpophyllum maschalocarpum*, *Carpophyllum flexuosum*). Of these, *Carpophyllum maschalocarpum* was found to proliferate in shallow depths down to approximately 9 m at Mahia followed by *Ecklonia radiata* >10m depth; although biomass of the latter was reasonably low, attributable to high wave exposure. The substratum was dominated by crustose coralline algae (CCA) and the percentage cover of sediment on the reef was found to increase with depth. Foliose red algae were represented by *Osmundaria colensoi*, *Pterocladia lucida*, and *Plocamium* sp. A reasonably low diversity of mobile invertebrates was found to occur at Mahia sites with *Haliotis australis*, *Cantharidus purpureus*, *Cookia sulcata*, *Trochus viridis*, and *Modelia granosa* being present. Of these, *Cookia sulcata* were the most abundant > 4 m depth. *Haliotis iris* was notably absent and the urchin *Evechinus chloroticus* was uncommon at all depths surveyed. Subtle differences in subtidal communities were detected between Mahia and Gisborne sites that were attributed to higher turbidity at Gisborne.

Within the Wairoa Hard, *Ecklonia radiata* was reportedly extremely abundant on cobble habitat in the Ridgemount region and north of the Waikari River pre-1970 (Tai Perspectives 1996). *Ecklonia radiata* abundance was supposedly significantly reduced following heavy trawling across the Hard (refer to Section 5.0) followed by an increase in *Pterocladia* sp. The latter survey of Thrush *et al*. (1997) inferred little *Ecklonia radiata* presence.

Of the reefs surrounding Napier down to Cape Kidnappers the green-lipped mussel *Perna canaliculus* is the dominant habitat forming species. Duffy (1998) reports that across Pania Reef extremely high densities (unit per area unavailable) occur above 10m; although, substantial numbers can occur down to at least 15m depth. Conversely, brown macroalgae where present tends to be sparsely distributed, although a shallow *Carpophyllum* band has been described as typical between 4-5m with juvenile and adult *Ecklonia radiata* patchily distributed > 8 m depth. Other community types present include sponges (*Ancorina alata*, *Raspailia* sp) and associated sessile invertebrates, e.g., hydroids and jewel anemones. The urchin *Evechinus chloroticus* is notoriously patchily distributed and does not form extensive barrens habitat. Similar biological constructs can be found on Town Reef, Te Awanga, and Black Reef. The smooth boulders comprising the Clive Hard are reported to be colonised by barnacles and sporadic patches of *Ecklonia radiata* and *Pterocladia* sp (Tai Perspectives 1996; Thrush *et al*. 1997).

Cape Kidnappers to Porangahau - physical characteristics

Intertidal and subtidal rocky reef
From Cape Kidnappers south to Porangahau intertidal platform reef is sparse between the Cape to Waimarama; thereafter, increasing considerably in spatial extent particularly from Huarau to Blackhead Point south and intermixed with numerous sandy beaches. Reef platforms often terminate at the base of large cliffs, or are framed by narrow bands of sand which extend to

cliff margins e.g., between Blackhead and Aramoana. Intertidal platforms along this stretch of coastline are comprised of siltstone and are often of low elevation with papa boulders a common feature strewn throughout.

Motu O Kura (Bare) Island (3.4 km SE and offshore from Waimarama) is a notable feature of the Cape Kidnappers to Porangahau stretch of coastline and is associated with complex subtidal reef platforms (Duffy 1998). Additional offshore features, albeit of minor size relative to Motu O Kura Island include Karamea Island, Hinemahanga Rocks (Kairakau Beach), and Taikorai Rocks (Porangahau).

Subtidal reef while patchily distributed between Tuingara Point and Blackhead Point often extends continuously down to 20-30m depth. In some areas with patch reef occurs down to 60m. Typically subtidal reefs are a combination of complex platform reef and boulder fields. For this stretch of coastline, Duffy (1992) provides descriptions of reef profiles for Taupunga and Motu O Kura Island (8 sites); Karamea Island; Te Wainohu; Paoanui Point; Pourerere (3 sites); Pourerere-Aramoana; Aramoana/Blackhead (7 sites); and Aramoana (4 sites).

Cape Kidnappers to Porangahau - biological characteristics

Intertidal rocky reef

Intertidal rocky reef communities characteristic of the southern region of the Hawke's Bay at a broad-scale level have been described by various studies (Duffy 1998; Smith 2008; HBRC 2016). Extensive monospecific bands of the fucalean alga *Hormosira banksii* are very common and are generally found highest on the shore, and often interspersed with coralline turf and/or replaced with patches of eelgrass *Zostera muelleri* approaching the mid intertidal zone (Fig. 4.10). *Zostera muelleri* forms large continuous patches at many locations. Larger brown fucalean algae such as *Sargassum sinclairii*, *Cystophora torulosa*, *Cystophora retroflexa*, *Carpophyllum maschalocarpum*, *Carpophyllum flexuosum*, and coralline turf occur in high abundances in the lower intertidal. Of these, *Carpophyllum maschalocarpum and Ecklonia radiata* tend to be the dominant algae of the subtidal fringe with *Durvillea antarctica* often present where limestone or volcanic rock persists, e.g., Motu O Kura, Hinemahanga Rocks, Taikorai Rocks (Duffy 1998).

Common mobile invertebrates within the mid-intertidal include the gastropods *Turbo smaragdus*, *Melagraphia atheops*, *Zeacumantus subcarinatus*, and limpets *Cellana radians* and *Sypharochiton pelliserpentis*. Mobile invertebrates commonly found within the low intertidal include *Turbo smaragdus*, *Diloma bicanaliculata*, *Sypharochiton pelliserpentis*, and the hermit crab *Pagurus* sp (Smith 2008). Intertidal pools are described as being commonly fringed by an assortment of fucalean algae including *Cystophora torulosa*, *Cystophora retroflexa*, *Carpophyllum maschalocarpum*, and *Hormosira banksii*.

Within Hawke's Bay intertidal rocky reef SoE monitoring occurs at three sites – Te Mahia Hardinge Road, and Kairakau and was established in 2013 (Fig. 4.10), with sampling occurring on a quarterly basis. The main focus of the monitoring is to collect data on the abundance and percent cover of major habitat forming species. These sites were selected as they span the diversity of physical and biological habitats found within Hawke's Bay and collectively are vulnerable to a variety of land-based stressors. Due to the short time period that sampling has been occurring, variation in species and habitats are not well understood/documented, other than broad-scale geographic variations described below.

Te Mahia is of particular note due to expansive platform reef, lack of boulders and the presence of the cyanobacteria *Lyngbya* sp and the brown alga *Cladostephus spongiosus* both of which are persistent on the lower shore and not found elsewhere with Hawke's Bay. *Lyngbya* sp is of particular interest as it has been associated with human health and ecological concerns when found in high abundance. Other species of note includes *Zostera* sp common to the mid intertidal and the fucalean algae *Cystophora torulosa* and *Carpophyllum plumosum* in tidal channels. The upper intertidal as for the majority of locations is typified by low biological diversity. The common gastropod *Zeacamantus* sp and crabs *Pagurus* sp and *Notomithrax sp* are common mobile invertebrates.

Hardinge Road located in Napier between Napier Port and the mouth of Ahuriri Estuary is a unique intertidal habitat within Hawke's Bay. It is narrow, relative to southern and northern intertidal reefs, being comprised of small limestone boulders that are the product of disintegrated fill from an old Landing Wharf. Consequently, the reef is dynamic in nature due to higher mobility of these boulders and is of higher complexity compared to platform reefs. As such, a different type of biological community occurs.

Algal species are dominated by turfing and encrusting forms reflecting the mobile nature of the reef with red algae Coralline turf, *Apophlaea sinclairii* and *Gigatina* sp and the brown alga *Ralfsia* sp prominent. Interestingly, *Hormosira banksii* which is a dominant component of intertidal rocky reef co-occurring with *Coralline* turf elsewhere is absent at Hardinge Road, with turfing *Gigartina* sp occupying this zone. Large algae are also absent the exception being the introduced brown algae *Undaria pinnatifida* and *Colpomenia sinuosa* occur within the lower intertidal and sublittoral fringe are seasonally abundant reflecting the proximity to Napier Port Mobile invertebrates are typified by the gastropods *Zeacamantus* sp, *Turbo smaragdus* and *Melagraphia aethiops* cushion star *Patriella regularis* and sea slug *Onchidella negricans.*

The Kairakau reef system is representative of central and southern intertidal reefs, and is identified as an area of Significant Conservation Value due to the occurrence of expansive *Zostera* beds.

Figure 4.10. A: Sampling of intertidal habitat as part of HBRC SoE monitoring. B: Patches of the neptunes necklace (*Hormosira banksii*), coralline turf and eelgrass (*Zostera muelleri*) common to intertidal platform reef in the southern Hawke's Bay.

Subtidal rocky reef

Typical subtidal zonation patterns as described by Duffy (1998) for siltstone reefs south of Cape Kidnappers include a band of *Carpophyllum maschalocarpum* and *Carpophyllum plumosum* comprising the sub-littoral fringe, which transition into mixed algal guilds down to a depth of 5m. Dominant species include *Carpophyllum maschalocarpum*, *Carpophyllum plumosum*, with smaller patches of *Lessonia vareigata*, *Ecklonia radiata*, *Landsburgia quercifolia* and *Cystophora scalaris* intermixed. Sub canopy species are represented by the brown algae *Glossophora kunthii*, *Euptilota formosssisima*, *Haliptilon roseum* and red algae *Pterocladia lucida*, *Cheilosporum sagittatum*. *Lithothamnion* is dominant on rock surfaces across all depth strata.

Ecklonia radiata becomes the prevalent canopy forming alga (cover > 50%) anywhere between 5-12m but often intermixed with discrete patches and isolated plants of large *Carpophyllum flexusosum* sporophytes. Gaps in the canopy are also punctuated by dense patches of the green alga *Caulerpa brownii* and *Caulerpa articulata*. Beyond 12m *Ecklonia radiata* canopies tend to diminish and sessile invertebrate communities compromised of sponges and bryozoans become conspicuous. Colonies of the hydroid *Symplectoscyphus johnstoni* are common between 15-18 m and at 20 m depth *Ecklonia radiata* cover is exceedingly low and is replaced by large sponges such as *Ancorina alata*, *Stelletta* sp, *Callyspongia* sp and *Raspailia* sp together with red foliose algae.

Te Angiangi Marine Reserve

Te Angiangi marine reserve (Fig. 4.11) was established in southern Hawke's Bay in 1997. Management goals associated with it are to give effect to the purposes and principles of the Marine Reserves Act (1971); to contribute to the Department of Conservation's function to conserve and protect the natural character and quality of New Zealand's coastal and marine environments, to establish a nationwide network of marine reserves that is representative of these; and, to provide educational and recreational opportunities for non-extractive users of the Hawke's Bay coast (Freeman 2011). The intertidal and subtidal habitats within the reserve are considered to be representative of the inshore marine environments of southern and central Hawke's Bay and the reserve falls within Ngati Kere rohe moana.

Surveys of the reserve were done prior to and following its establishment, with a range of focal indicator species being evaluated, e.g., rock lobster, paua, kina, and fish community composition (Freeman and Duffy 2008; Freeman 2011), with subtidal habitat mapping also undertaken (Funnell *et al*. 2005), which has been incorporated into the GIS database. Of the monitored species, lobster (*Jasus edwardsii*) have demonstrated a positive response to marine protection significant changes in density occurred after 2, 4.5, 5.5, 8 and 9.5 years of protection. These changes were all increases in total density, with the exception of declines in 2003 and 2004. Interestingly, the declines were due to reductions in sub-legal individuals reflecting recruitment pulses, whereas the density of legal-sized lobster have demonstrated a continual increase in abundance (Freeman *et al.* 2012). For common reef fish (butterfly perch, banded wrasse, blue maomao, scarlet wrasse, spotty, sweep, butterfish and red moki, blue moki and blue cod, abundance patterns between reserve and non-reserve sample areas are less clear.

A large landslide that affected the intertidal region in 2011 (Fig. 4.12; see Macpherson 2011) initially had a significant impact on paua and kina abundances both inside and outside the reserve, but recovery is now occurring and the landslide-derived sediment has moved into the subtidal. The reserve intertidal populations paua (*Haliotis* spp.), kina (*Evechinus chloroticus*) and seagrass (*Zostera capricorni*) were considered to be more-resilient to the events with post-landslide surveys indicating greater abundance and larger size in protected populations relative to non-protected. Effects on subtidal habitats are unknown although potting surveys to evaluate lobster abundances within and outside the reserve are being considered in the near future (Rod Hansen *personal communication* in 2016). Discussions with Dave Patton (commercial lobster fisherman) suggest crayfish abundance within the area was affected by the 2011 event and stock levels are only beginning to recover now.

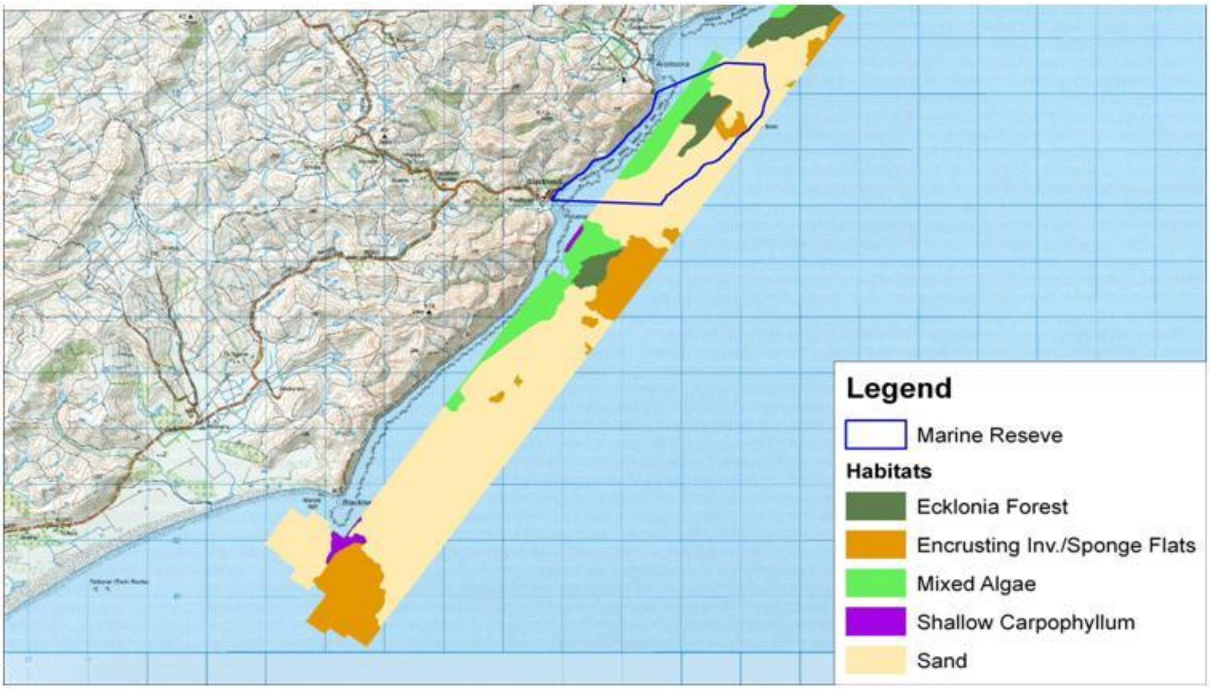


Figure 4.11. Te Angiangi Marine Reserve (blue boundary line) and associated subtidal habitats in southern Hawke's Bay

Figure 4.12. Te Angiangi Marine Reserve - 2011 landslide covering the intertidal rocky reef habitat.

4.7 Subtidal Soft sediment habitats

Physical characteristics

Subtidal soft sediment habitats (sand, coarse sand, and muddy substrates) are by far the most expansive across the Hawke's Bay CMA with subtle variation between northern and southern areas apparent. Much of our understanding is derived from the survey work of Pantin (1966) which described the depth distribution of broad soft-sediment types across the region. Outputs from the GIS database prepared as part of this project equate the habitat extents derived from Pantin (1966) as follows: muddy substrates 7694 km^2; Sand 1,861 km^2: and coarse sediment 484.14 km^2.

Biological characteristics

McKnight (1969) provides some of the earliest descriptions of the benthic fauna within Hawke Bay describing five main community types. Interestingly, of the 13 benthic community types described across the New Zealand continental shelf, the *Amphiura aster–Nucula nitidula* community is touted as being unique to Hawke Bay; being present across a depth range of 9-46 m on substrates ranging from muddy sand to mud throughout the Bay. Most samples containing this community type were obtained from depths between 20-30 m and mainly from a muddy-sand substrate. Characterising echinoderms included the Ophiuroid *Amphiura aster* and *Echinocardium cordatum* with dominant bivalve species including *Nucula nitidula*, *Maorimactra ordinaria*, *Tellinella huttoni*, and *Dosinia lambata* (McKnight 1969).

Of the 4 dominant bivalve communities described a *Nemocardium pulchellum– Plueromeris zelandica* community was also widespread in the bay < 40 m depth and present mainly on substrates of muddy sand or muddy substrates, though ranging from gravelly sand to mud. Characteristic species included *Nemocardium pulchellum, Plueromeris zelandica, Nucula nabellula, Notocallista multistriata, Nucula nabellula,* and *Poroleda lanceolate*. In deeper water > 7 0m depth a *Nemocardium pulchellum –Venericardia purpurata* was recorded from muddy gravels and characteristic species of this community were *Venericardia purpurata*, *Nemocardium pulchellum*, *Notocorbula zealandica*, *Notocallista multistriata*, *Dosinula zealandica*, and *Nucula nabellula.*

Samples obtained from regions the Wairoa and Clive Hards identified *Tawera spissa–Venericardia purpurata* communities defined as an open-coastal community in depths of 10-50 m, sometimes deeper (to 260 m) occurring mainly on gravelly sand or sand substrates, though ranging from gravel to sandy mud. Characteristic species were *Tawera spissa, Venericardia purpurata*, ± *Glycymeris laticostata*, *Glycymeris modesta* or *Gari stangeri*. McKnight (1969). At the south-western end of the Wairoa Hard, a *Glycymeris laticostata - Venericardia purpurata* community was described from one grab sample.

The fauna contains elements of the *Amphiura rosea–Dosinia lambata* community and the *Scalpomactra scalpellum–Mactra ordinaria* community. The substrate is generally coarser than for the former community, but finer than for the latter. It can be distinguished from the former by the replacement of *Amphiura rosea* by *Amphiura aster* and the lesser abundance or absence of species such as *Dosini lambata*, *Tellinella charlottae*, *Neilo australis* and *Nucula hartvigiana*; and it can be separated from the latter community by the abundance of *Amphiura*, the lesser abundance of *Scalpomactra scalpellum* and the presence of *Dosinia lambata*. It may be a compromise development between these two communities in an environment not completely suitable for the typical development of either.

Following this survey there has been negligible other broad scale surveys across the wider Hawke's Bay subtidal to support the existence and the prevalence of these benthic communities. Of those done within Hawke Bay many have been undertaken for the purposes of resource consent studies associated with discharges into the CMA (Knox 19798a,b) or associated with the Port of Napier's dredging and disposal of spoil (Smith 2015). While such studies are often by default limited in spatial scale, they nonetheless provide some insight into the nature of nearshore benthic communities and temporal changes that may have occurred in community structure.

Early studies focused in and around the Napier region (Knox and Fenwick 1978; Roper *et al*. 1989) described a rich benthic fauna dominated by polychaete worms, molluscs largely represented by bivalves, small crustaceans and echinoderms. Studies done in accordance with the Napier City Council Wastewater outfall discharge have routinely demonstrated that the polychaetes worms *Heteromastus filiformis*, *Pectinaria australis*, *Prionospio aucklandica, Sagitta* sp, *Aoindes oxygephala*, and the bivalves from the *Soletellina* genus are both widespread and numerically dominant – these are characteristic of impacted environments. Other bivalves common to the area include *Dosinia anus*, *Nucula nitidula*, and *Mactra ordinaria*. The most recent survey of the outfall (Smith 2011) identified several individuals of a rissoid gastropod, but no other species. Duffy (1998) suggests the gastropods *Struthiolaria papillosa*, *Austrofusus glans*, and *Umbonium zealandicum* are also dominant within the nearshore surrounding Napier. Common echinoderms described by Duffy (1998) include the cushion star *Patriella regularis*, brittle star *Amphiura sp*, and holothurians *Heterothyone ocnoides* and *Paracaudina chilensis*, which are all species encountered in sample cores of Smith (2011). Historically, *Heterothyone ocnoides* is found in particularly high numbers north of Pania Reef (Duffy 1998). Common crustaceans to the region are described as the paddle crab *Ovalipes cantharus*, common crab *Halicarcinus* sp, hermit crabs *Pagurus auratus and Paguristes setous*, shrimps *Pontophilus sp, Ogyrides sp* and mantis shrimps, cumaceans, and amphipods (Duffy 1998; Smith 2011).

Smith (2011) suggests that while there are measurable effects attributable to the Napier outfall within the zone of acceptable mixing (≤ 300m surrounding the outfall) in terms of sediment geo-chemical changes and faunal composition, fluctuations through space and time also reflect the high natural spatiotemporal variability of soft sediment communities in general.

A similar suite of benthic fauna, albeit of higher diversity has been described from nearshore soft sediment environments associated with the Pan Pac timber and pulp outfall north of Napier and offshore from Whirinaki (Smith 2015). Species encountered at this site, not present in southern Napier include the bivalves *Tellinota edgar, Dosinia lambata,* and *Scalpomactra scalpellum* and, in particular, large numbers of juvenile *Echinocadium cordatum.* Holothurians *Heterothyone ocnoides* and *Paracaudina chilensis* were absent from benthic samples.

5.0 Fisheries

5.1 General history

From a national perspective the Hawke's Bay region has traditionally been known as a "mixed species fishery" consisting of at least 7-8 main species that have largely shaped the fishery since the advent of commercial fishing in the late 1800s. Common fishes that were initially targeted by trawlers included flounder/flatfishes, gurnard, snapper, dogfish, small sharks, trevally, terakihi, moki, kahawai and crayfish (Daily Telegraph 1901; Tai Perspectives 1996). These species continue to be fished today; yet, discussions held with Iwi and a range of commercial and recreational fishers suggest that for many species their abundance and distribution have changed within the region, particularly over the last decade. Some species (e.g., hoki) are no longer abundant in trawl catches, and the mixed fishery status is widely regarded as being less prominent.

The diversity and composition of benthic and pelagic fish species within Hawke's Bay is undoubtedly archetypical of the numerous habitat types that occur across the region including offshore deep water formations such as the Madden and Lachlan Banks, nearshore mixed habitats that comprise the Wairoa Hard and Clive Hard, estuarine regions associated with the 5 main river systems and lagoons that would collectively afford important nursery and foraging habitat. The Hawke's Bay region is also recognised as being a migratory pathway for blue moki, terakihi, snapper, and warehou (Morrison *et al.* 2014a).

The Hawke's Bay fishery from its initial beginnings in 1885 to this present day is predominantly a trawl fishery and early experiments at the start of the 20th century evaluating different trawl gear identified the best fishing occurred in 5 to 25 fathoms (approximately 10-50 m). The history of commercial fishing and associated boom and bust period's specific to the Hawke's Bay have been largely summarised by Stevenson *et al*. (1987) and Tai Perspectives (1996) with key phases/periods gleaned from those reviews presented in Table 5.1.

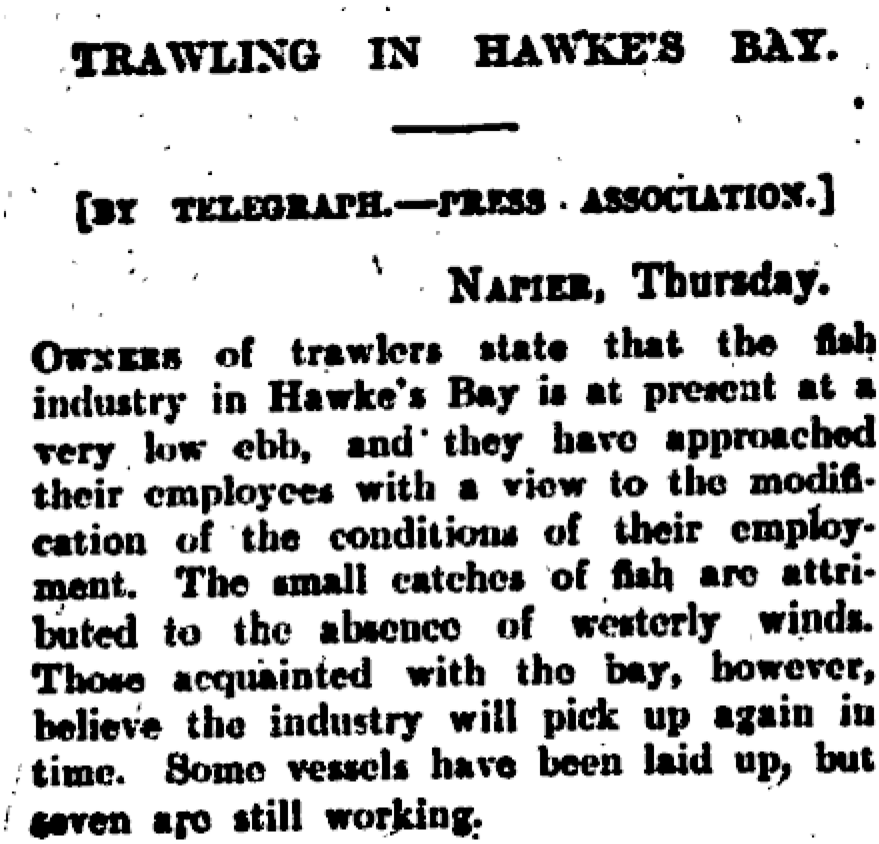
Even at the development stage of the trawl fishery there was evidence of high inter-annual variability in catch rates attributed to potential overfishing coupled with unfavourable oceanographic climatic phases. For example, an article from the New Zealand Herald in 1910 inferred that the absence of westerly winds coincided with poor fish returns that year with a subsequent article highlighting the scarcity of flounder in 1911 that crippled the industry (Fig. 5.1). The easterly wind is commonly known within the region as the "starvation wind" and is associated with very poor fishing. Additional periods of downturn between 1920 and 1945 were associated with volatile markets, wartime scarcity, the 1931 earthquake, and ensuing depression-era. An underlying notion of overfishing within the Bay was, however, always eminent.

Over and above traditional methods of conservation, Maori of Waimarama were the first to drive for formal marine protection in the Hawke's Bay, which stemmed from concerns over trawl fishing. Petitioning the then Minister of Marine, a trawl ban was established within 4.5 km of the coast between Haupouri and Karamea in 1925 (Stevenson *et al*. 1987).

Table 5.1 Summary of Hawke's Bay trawl fishery – synthesised from Stevenson *et al*. (1987) and Tai Perspectives (1996).

Period	Description
Pre-1860	Maori predominant fishers
1860	Start of European fishing operators
1885	Trawl net introduced to Hawke Bay
Early years of power trawling	
1890-1907	Steam trawlers operating in Hawke Bay
1901-1907	Terakihi grounds discovered and fished by steam trawlers (37-55m) Stream trawlers fished flatfish and roundfish in competition with smaller motor launches
1912-1920	Fishery in decline especially flatfish – catches dropped due to wartime shortages
1920-1930	Productive increase in roundfish
1925	Trawl ban established within 4.5 km of the coast between Haupouri and Karamea
1931-1934	Decline in fishery due to earthquake and depression
1934-1938	Flatfish dominant species targeted
1939	Licensing introduced in 1939 restricted vessel numbers
1934-1942	Fishery reasonably constant – fish landed at Napier supported the lower North Island and limited exports to Australia
Gear development after the second world war	
1942-1950	Vessel numbers low
1950-1960	Vessel numbers rose slowly together with a rise in set-net effort for snapper and rig Change in trawl gear to plastic sweeps and bobbins allowed trawlers to fish hard grounds such as the Wairoa Hard
1961	complete commercial fishing ban from Waipuka Stream (Ocean Beach) to just south-west of Karamea Island
1963	Licensing system abolished
1960s	Cutters and bobbins fitted to the groundline of Gourock trawl to mow kelp (*Ecklonia radiata*) ahead of the trawl net so the Wairoa Hard could be fished
1967	Wing trawls introduced used to fish the Wairoa Hard from 1967 to 1974
1960s-1970s	Set net fishery dominant for sharks between Whirinaki and the Wairoa River , 18m depth Sharks were reportedly fished down considerably over this period Set net moki fishery increases between 1964 and 1970 Set net snapper fishery increases between 1968 and 1978
1970s	Wairoa Hard fished extensively by single trawlers due to attaching heavy bobbins, sputniks and floats to the groundropes for protection. These devises raised the net edge approximately 2m above the seabed. Knives were fitted at the gallows to cut kelp from sweep wires as the nets were retrieved
Late 1970s	Protection reduced due to considerably less kelp Protection of nets included covering the groundline in plastic hose, change to orange polypropylene net which was more resistant to abrasion, change to cutaway lower wings resulted in less drag and damage to nets on rough seabed Concern that pair trawling was having significant effect on the snapper fishery in Hawke Bay
1979-1981	Pair trawlers fished the hard. The technique resulted in a higher headline height and as such caught larger mid-water snapper than earlier trawlers
Closure of Wairoa Hard	
1981	Hawke Bay Fisheries Management Area (FMA) defined Purse seining banned within the FMA Wairoa Hard was closed to commercial wetfishing and amateur set netting Pair trawlers restricted to 210 tonne quota for snapper within Hawke Bay
1983	Pair trawling banned on east coast of the North Island south of Cape Runaway to Castlepoint
1986	Introduction of Quota Management System in 1986 invoked catch limits on main commercial species

In 1961, further measures were put in place following additional petitioning from the Waimarama Tribal Committee by establishing a complete commercial fishing ban from Waipuka Stream (Ocean Beach) to just south-west of Karamea Island. This second ban was in relation to concerns regarding sustained heavy fishing pressure on shellfish and seaweed beds in the Waimarama region (Stevenson *et al*. 1987).



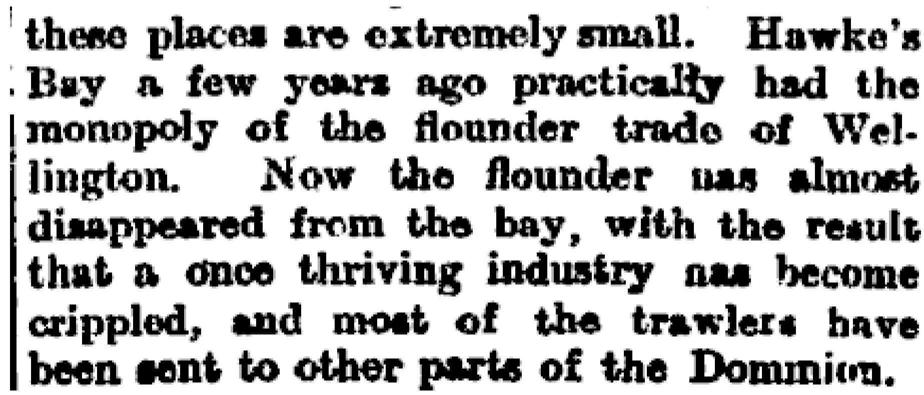
TRAWLING IN HAWKE'S BAY.

[BY TELEGRAPH.—PRESS ASSOCIATION.]

NAPIER, Thursday.

OWNERS of trawlers state that the fish industry in Hawke's Bay is at present at a very low ebb, and they have approached their employees with a view to the modification of the conditions of their employment. The small catches of fish are attributed to the absence of westerly winds. Those acquainted with the bay, however, believe the industry will pick up again in time. Some vessels have been laid up, but seven are still working.

Source: "New Zealand Herald, Volume XLVII, Issue 14351, 22 April 1910, Page 5"



these places are extremely small. Hawke's Bay a few years ago practically had the monopoly of the flounder trade of Wellington. Now the flounder has almost disappeared from the bay, with the result that a once thriving industry has become crippled, and most of the trawlers have been sent to other parts of the Dominion.

Source: New Zealand Herald, Volume XLVIII, Issue 14788, 18 September 1911, Page 5

Figure 5.1. Accounts of variable fish catches within Hawke Bay in the early 1900s.

Both the Hawke's Bay trawl and set net fishery increased in intensity through the 1960s and 1970s. Similarly, blue cod fishing in Hawke Bay had increased in intensity during the late 1960s after deregulation of the fishing industry in 1963 (Voller and McGregor 1985). For the trawl fishery, gear advances by way of cutters, bobbins, floats, and sputniks fastened to groundlines and other modifications to the nets allowed locations like the Wairoa Hard to be fished extensively for snapper. This ultimately led to the destruction of kelp (*Ecklonia radiata*) and to a lesser degree cobble habitat by the late 1970s (Tai Perspectives 1996; Table 5.1).

Fisheries studies undertaken in the late 1970s and early 1980s using acoustic methods supported the findings of early trawl experiments done at the start of the 20th century, in so far as identifying the shallow water regions < 50 m depth of Hawke Bay as continuing to support significant biomasses of fish. Francis (1985a) described large and constant fish aggregations in reasonably shallow water < 40 m depth; conversely, deep water aggregations were considered to be derived from several large schools that were more transient in nature. Resultantly, these inshore stocks have continued to be the foundation of the Hawke's Bay fishery for the last 30 years.

By the early 1980s there was genuine concern from the commercial sector on the effects of pair trawlers on the Wairoa Hard that extended to the wider Hawke Bay region. Succeeding lobbying by the commercial sector in an effort to protect habitats of significance for species like snapper, regulations were established by the Minister of Fisheries which took effect on 12 November 1982. These were:

1. Purse seining banned from the Hawke's Bay Fisheries Management Area;
2. All forms of net fishing banned on the Wairoa Hard; and,
3. A quota of 210 tonne for snapper caught by pair trawl within the Hawke Bay Fisheries Management Area.

Under the introduction of the Fisheries Act in 1983 all pair trawling was banned from Cape Runaway (eastern Bay of Plenty) to Castlepoint (Wairarapa), which made point 3 above null and void. Thereafter, the introduction of the Quota Management System (QMS) in 1986 invoked catch limits on main commercial species e.g., snapper within a designated fisheries management area (FMA 2). Two statistical areas – 13 and 14 – encompass the Hawke's Bay Region (Fig. 5.2).

5.2 Location of fished species within Hawke's Bay

The importance of the Wairoa and Clive Hards' for many species has been summarised in detail by Tai Perspectives (1996) and Stevenson *et al*. (1987). Those associated with Wairoa Hard are both pelagic and benthic in nature and include juveniles of snapper, John Dory, rig, trevally, red moki, blue moki, and warehou. Additional species consistently found within the Wairoa Hard were mackerel, kahawai, kingfish, gurnard, blue shark, hammerhead shark, and white shark. Rock lobster (*Jasus edwardsii*) were also touted as being associated with rocky ridges and flat fish were also fished to the north of the Wairoa Hard off Wairoa.

In contrast, the Clive Hard was considered as having a smaller fishable area relative to the Wairoa Hard. The adjacent fishery to the north and south was generally fished for flat fish with red cod, John Dory, gurnard, snapper and terakihi also targeted. The Clive Hard was also considered an important nursery area for sole, red cod, and yellow-eyed mullet.

Fisheries information summarised by Stevenson *et al*. (1987) further describes key areas within Hawke's Bay for various fished species. The majority remain focal areas for fishing today. In the 1980s common fish targeted by commercial set netters at Mahia were moki, rig, gurnard, snapper, flatfish, warehou, terakihi, and trevally, with trawlers also targeting moki, rig, gurnard, flatfish, and trevally. Deepwater trawling to the east and south-east of Mahia Peninsula took place around 9 km offshore with fishers targeting terakihi, groper, bass, and blue moki with some gurnard and snapper occurring/taken as bycatch (Stevenson *et al*. 1987). The commercial rock lobster fishery was also considered highly productive in and around Mahia at that time.

As for Mahia, nearshore rocky reef habitat surrounding Napier (Tangoio Bluff, Pania Reef, Town Reef, Black Reef *etc*) held significant customary and recreational value for the collection of green-lipped mussels, kina, paua, rock lobster, and various fin-fish species (kahawai, gurnard, hapuka). Tuna (skipjack and albacore) were targeted throughout Hawke Bay during summer months when water temperatures exceed 20° C. All estuarine systems are considered important for the collection of pipi, tuatua, cockles, flat fish, eels, mullet, and whitebait.

In southern Hawke's Bay particularly around Waimarama, trawlers fish for moki and terakihi out to a depth of 90m and beyond that for terakihi, barracoutta, John Dory, and gemfish (Stevenson *et al*. 1987). An area of reef, given the moniker "Post Office Rock" adjacent Ocean Beach which rises to a depth of 20m, is also a popular fishing spot for grouper, hapuka and trumpeter. For locations like Pourerere commercial fishing is predominately for crayfish, kina, and the red alga *Pterocladia* sp. Recreational and customary fishing targets paua, kina and rock lobster. Paua are fished heavily and often illegally at Paonui Point (Rod Hansen *personal communication* in 2016).

In their recent review of habitats and areas of significance for coastal finfish, Morrison *et al*. (2014a) describe the Hawke's Bay region as an important nursery habitat for juveniles of red gurnard (10–20 cm; of 0+ and 1+ modes); barracoutta 0+ mode (15–20 cm) within 50–200 m depths in late summer, smooth skate, and juvenile school shark up to 2 years old (less than 70 cm) (Hurst *et al*. 2000, Blackwell & Francis 2010); terakihi under 20 cm (Vooren 1975; Hurst *et al.* 2000); and snapper 0+ and 1+ modes primarily associated with the Wairoa and Clive Hards. Snapper from within Hawke Bay are considered genetically distinct (Smith *et al*. 1978) and have much faster growth rates than snapper north of Mahia (Walsh *et al*. 2012).

As well as provision of juvenile habitat Hawke's Bay is considered as a potentially important spawning ground for gurnard (September-October); blue warehou (August-September) (Jones 1988; Bagley *et al*. 1998); kahawai (Jones *et al*. 1992); and both snapper and John dory in summer (December-February) (Hurst *et al*. 2000). For snapper and John Dory, it is generally considered that they move into shallower water at certain times of the year and onto hard ground, especially in and around the Clive and Wairoa Hards (see below for snapper). Species that utilise the Hawke's Bay as part of their migration pathway include blue warehou, terakihi, and blue moki (Morrison *et al*. 2014a).

5.3 Current status and trends

Interviews conducted with customary, commercial, and recreational fishers, staff at the National Aquarium, Tangata Whenua and MPI as part of this project have not only described focal areas for fishing across Hawke's Bay, but also various changes to the Hawke's Bay fishery they have observed - particularly over the last decade. These accounts were very consistent, irrespective of stakeholder group and included:

1. Significant decline in water quality - predominantly underwater visibility (region wide) since the mid-1970s;
2. Increase in sedimentation on rocky reef habitat surrounding Napier;
3. Changes in the distribution and catchability of fishes within Hawke Bay for gurnard, snapper, kahawai, trevally, hapuka, hoki, warehou, flounder, and paddle crab (based on log-books and fish diaries provided);
4. Absence of certain species in trawl deployments, particularly hoki (based on log-books);
5. Inability for Tangata Whenua to collect enough kaimoana to feed marae, as was done in the past (common theme);
6. Mixed fishery status is becoming less prominent compared to 1970s-1990s;
7. Increase in spiny dogfish over the last 5 years in nearshore regions of the coast together with a decline in gurnard;
8. Absence of baitfish and kahawai feeding fronts;
9. Reduction of inshore and estuarine bivalve beds, particularly pipi and tuatua;
10. Change in the faunal composition of the inshore benthos surrounding Napier;
11. Variation in the oceanographic climate – especially a decline in equinox offshore (NW) winds;

Also of concern were:

12. Pollution of green-lipped mussel beds surrounding Te Awanga;
13. Fishing methods and associated bycatch;
14. Effects of dredge spoil.

5.4 Changes in key species abundance and distribution

Of those species that are commonly caught within Hawke Bay, red gurnard, snapper, hapuka, kahawai, terakihi and trevally are thought to have declined substantially over the last 5-10 years. The following section describes various aspects of those species as they relate to the fishery within Hawke Bay's. It must be stressed that this is by no means a comprehensive list of all the important fish species within the region. Commercial catch data provided by MPI for statistical areas 13 and 14 are also presented (2009/10 to 2014/15), as are survey data collected by LegaSea Hawke's Bay from the Hawke's Bay Sport Fishing Club ramp. Distributions of commonly targeted fish across Hawke's Bay based on discussions with various stakeholders have been amalgamated into the GIS database.

5.4.1 Red gurnard (*Chelidonichthys kumu)*

Trawl survey data of red gurnard distribution around New Zealand suggests that the Hawke's Bay is not a major spawning ground relative to northern New Zealand (both west and east coasts), however becomes increasingly important for 1+ stages onwards (Hurst *et al*. 2010). Red gurnard are considered a relatively fast growing species maturing at 2 years old and all by

4 years. Females grow faster and bigger than males and mature at 33 cm, whereas males mature at around 26 cm (Francis 1996a,b). Both crabs and shrimp are the main food source of red gurnard, with small fishes and worms also consumed (Ayling and Cox 1987; Francis 1996a,b).

Within Hawke Bay, gurnard have traditionally been commercially caught at North Buoy (adjacent Pania Reef) and along an inshore trawl line between Napier City and Cape Kidnappers commonly between 40-50m depth. Recreational hot-spots also include Pania Reef, and the inshore across Bay View region. Commercial take within statistical area 13 has been consistently larger than for statistical area 14 over the last 5 years (Fig. 5.2). The general feeling among select commercial fishers is that the inshore gurnard fishery (0-50m) has been overfished and they are now targeting gurnard in deeper water (50-100m), i.e., in areas that were previously not traditionally fished.

Similar inshore declines have been reported from customary and recreational sectors, which has seen the abandonment of the recreational "Gurnard Guru" fishing competition run by Napier Sports Fishing Club in recent years. It is unclear whether the shift to deeper water reflects depletion of inshore stocks, or a possible change in physical or biological characteristics of inshore benthic habitats (see below). There is a broad consensus across fishing sectors that many of the areas where gurnard have traditionally been caught (within and outside Hawke Bay), are now dominated by spiny dog fish (*Squalus acanthias*), a species which has become more prevalent over the last five years particularly in winter. Interestingly, a similar phenomenon has been anecdotally reported from central Taranaki (Dan Govier *personal communication* in 2016).

Commercial data on gurnard catches within Hawke Bay provided by MPI illustrate consistently higher catches within statistical area 13 (Fig. 5.2) and a shift in depth-distribution with increased catches derived from deeper water (50-100 m from Cape Kidnappers to Portland Island) since 2012 (Fig. 5.3). Ramp survey data (2006 to 2014) collected by LegaSea, while variable across surveys also infers a general reduction within the Hawke Bay nearshore (< 50m depth) with catches in 2006 around 2.2 gurnard angler^{-1} day^{-1}, compared to 1.2 gurnard angler^{-1} day^{-1} in 2014 (LegaSea/Hawke's Bay Sports Fishing Club ramp survey data).

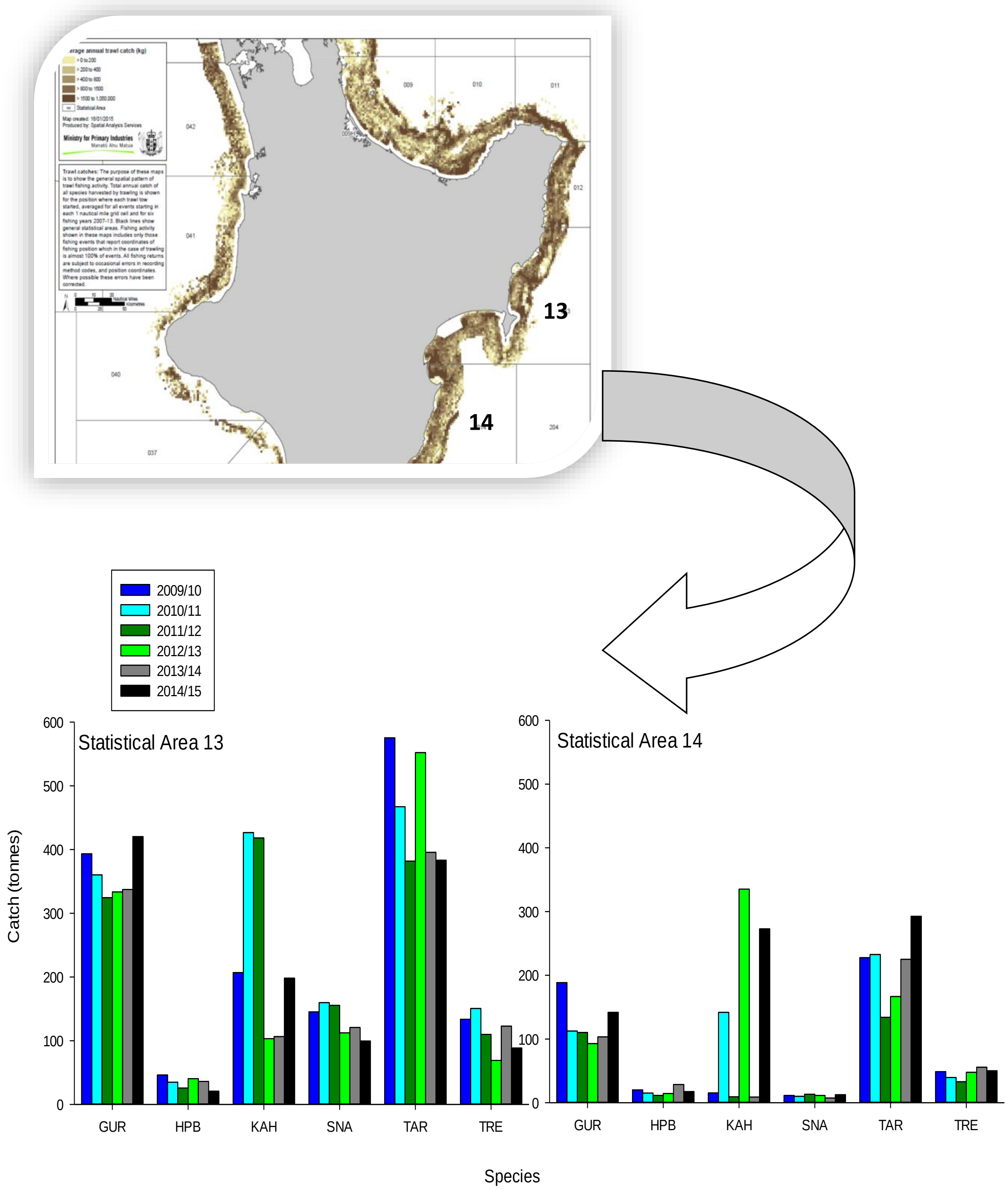


Figure 5.2. Commercial catch data for statistical areas 13 and 14 (all fishing methods) from 2009/10 – 2014/15 fishing years for gurnard (GUR), hapuka (HPB), kahawai (KAH), snapper (SNA), terakihi (TAR), and trevally (TRE). Data source, MPI (2016).

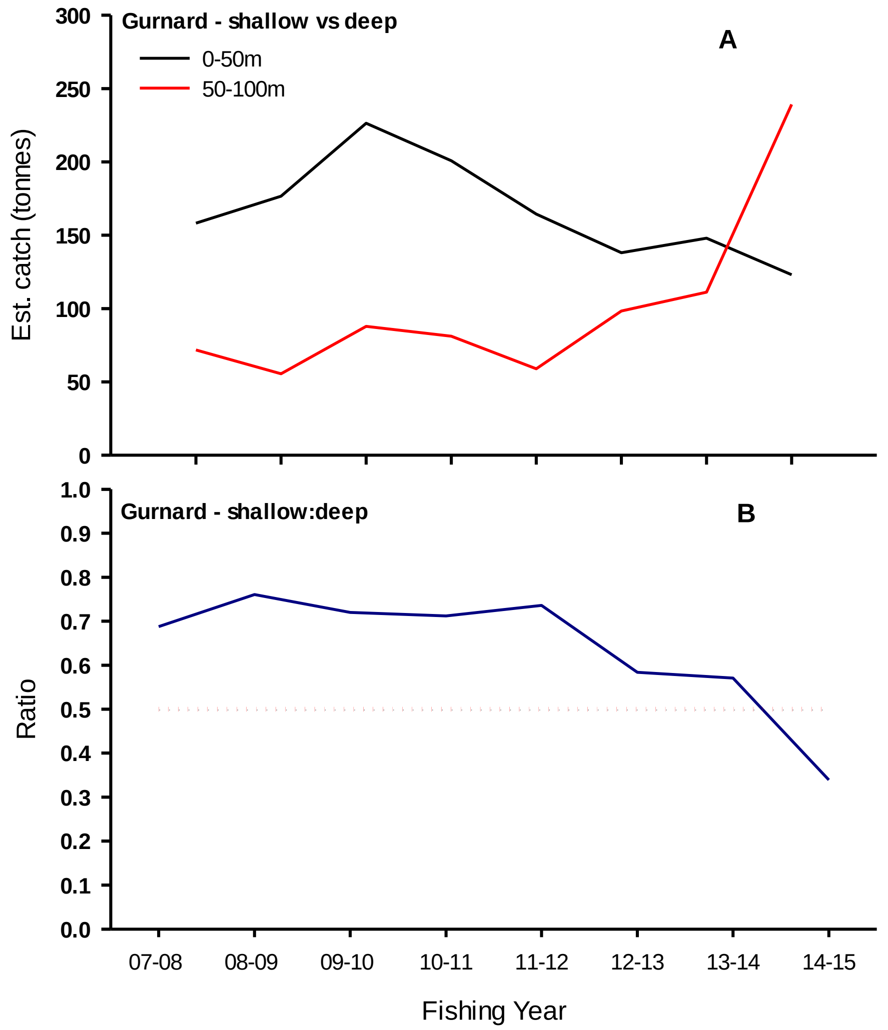


Figure 5.3. A: Estimated commercial catch for red gurnard by trawl method from Cape Kidnappers to Portland Island based on shallow (0-50 m - black line) and deep (50-100 m - red line) depth strata; and, B: gurnard catch expressed as a ratio of gurnard catch between shallow and deep depth strata. Data source, MPI (2016).

Table 5.2. Estimated commercial catch data by trawl method from Cape Kidnappers to Portland Island (0-50 m depth) for commonly caught species for the period 2009-10 to 2013-14.

Year	Gurnard	Trevally	Kahawai	Snapper	Hapuka	Terakihi
2009-10	226.1	58.6	17.57	70.19	2.46	11.69
2010-11	200.76	84.4	27.42	80.13	1.88	9.38
2011-12	164.39	61.26	16.39	68.43	1.31	9.37
2012-13	138.05	35.86	8.8	37.28	0.6	4.86
2013-14	148.02	53.86	13.61	39.99	0.53	3.44

5.4.2 Trevally (*Pseudocaranx dentex*)

Trevally are predominantly a North Island fish and may occupy a range of habitat types. Juvenile trevally occur within harbours and estuaries and are planktonic feeders. Following age 2, individuals enter a demersal phase until sexual maturity at around 32-37 cm after 5 years (Gilbert 1988; Francis 1996a,b). Thereafter, adults fluctuate between demersal and planktonic phases. When in the demersal phase adults eat crabs, brittle stars, heart urchins and bivalves, and planktonic crustaceans when in mid and surface waters. Trevally commonly form very large schools at the surface and adults are routinely associated with edges of rocky reef (foul), headlands, and islands. The Hawke Bay region is utilised by immature and adult stages (Hurst *et al*. 2010).

Within Hawke Bay, trevally are predominantly caught by commercial trawl fishers (offshore from Pania Reef and along the western coast of Mahia) with set net and purse seine comprising the other methods. Parsons (2010) suggests that based on existing and historical fisheries data it is not known whether catches of trevally within FMA 2 are sustainable. More-recent data infer there has been a declining trend in commercial catch within statistical area 13 between 2009/10 and 2012/13, although statistical area 14 has remained stable (Fig. 5.2). Catches of trevally have been highly variable within the shallow (0-50m) inshore region between Cape Kidnappers and Portland Island between 2009 and 2014 (Table 5.2).

5.4.3 Kahawai (*Arripus trutta*)

Kahawai are a commonly fished species within Hawke Bay. Nearshore regions in and around Napier are important for juvenile and immature stages with adult schools occurring throughout Mahia, central Hawke Bay, and southern Hawke's Bay (Hurst *et al*. 2010). Adults traditionally form very large schools and consume smaller schooling fishes (anchovies, mullet, pilchards) and a variety of benthic fauna (crabs, worms and shellfish) when feeding at the seabed. Kahawai mature at 35-40 cm after 4-5 years (Francis 1996 a,b).

Kahawai within Hawke Bay and FMA2 are largely targeted by purse seine, with other methods being trawl, longline, and set net. Parsons (2010) suggests the sustainability of FMA2 stocks are unknown and commercial catch data for kahawai in statistical area 13 have demonstrated a decline over recent years whereas catches in statistical area 14 have fluctuated dramatically between 2009/10 and 2014/15, as have numbers between 0-50 m depth between Cape Kidnappers and Portland Island (Fig. 5.3; Table 5.2). A frequent theme resonating from stakeholders interviewed, has been the observed decline in kahawai feeding fronts at the ocean surface throughout the Bay. These were reportedly a very common sight across nearshore areas of Napier, but are less-so nowadays. Kahawai numbers within many of the estuaries are also perceived to be in decline.

5.4.4 Terakihi (*Nemadactylus macropterus*)

Terakihi are a popular fished species within Hawke Bay generally > 50 m depth. Terakihi tend to aggregate in small groups near deeper reef edges and are especially targeted by commercial fishers following rougher weather where they come off the foul. Terakihi have a complex life history. They spawn in large aggregations (March-June) in a few select areas such as East Cape, Fiordland, and the north-east coast of the South Island. Terakihi have a long planktonic larval phase (7-10 months) with nursery areas in both the northern and eastern coast of the South Island (see Hurst *et al*. 2010). Juveniles eat mainly small crustaceans and remain in the nursery grounds until they mature at around 4-5 years. Males mature at 25-30 cm and females at 28-34 cm, with females growing faster and to a bigger size than males. At around age 6, terakihi migrate to the spawning grounds travelling > 500 km along the east coast of the North and South Islands. Within Hawke Bay, Terakihi have been recorded from trawl surveys for 1+, immature, and mature stages (Hurst *et al*. 2010). Terakihi comprise some of the largest commercial catches of all species within Hawke's Bay, with catches increasing is statistical area 14 between 2009/10 and 2014/15, being variable within statistical area 13 (Fig 5.2). Inshore catches of terakihi between Cape Kidnappers and Portland Island (0-50m depth) have steadily declined between 2009-10 and 2013-14 (Table 5.2).

5.4.5 Snapper (*Pagurus auratus*)

Both commercial and recreational fishers have highlighted a distinct snapper migration pattern within Hawke Bay along the 50m depth contour. Snapper reportedly appear along the west coast of Mahia in early spring. They then run along the 50 m depth contour before diverting to the inshore boulder bank area between Waipatiki Beach and Tangoio Bluff in October-November, thereafter congregating in shallow-water south of Bay View near Napier in November-December. This is followed by offshore migration of adults to the springs in late December through January with larger fish typically oscillating between inshore and offshore habitats throughout the summer period. These migrations may be associated with spawning (see Francis 1996a,b). As previously mentioned both the Wairoa Hard and Clive Hard are reputedly important habitat for juvenile 0+ snapper and are thought to be analogous to larger estuarine systems further north (Morrison *et al*. 2014b).

Hawke's Bay snapper are considered to be a separate stock to northern Mahia snapper and are reported to have some of the fastest growth rates in New Zealand (Walsh *et al*. 2012). Catch estimates for SNA 2 for length and age composition between northern Mahia and Hawke's Bay subpopulations demonstrate variability between the two areas. Walsh *et al*. (2012) suggest that while approximately 90% of bottom trawl data for both areas are comprised of small snapper < 10 years, the point of difference for the Hawke's Bay sample population was that it was comprised of substantially more larger and older fish (some > 50 years) relative to Mahia. These larger individuals are thought to contribute greatly to the overall biomass and long-term sustainability of the FMA2 fishery.

Recent catch history for statistical area 13 shows a decline in snapper since 2012/13, whereas statistical area 14 has remained low < 15 tonnes since 2009/10. Catch estimates from 0-50m water depth between Cape Kidnappers and Portland Island (Table 5.2) illustrate a large and sustained decline from 2010-2011 onwards. While variable across surveys, reductions in the recreational catch have also been reported from within Hawke's Bay between 2006 and 2014, i.e., approximately 0.9 snapper angler^{-1} day^{-1}, to approximately 0.3 snapper angler^{-1} day^{-1} (LegaSea ramp survey data).

5.4.6 Hapuka

Hapuka (*Polyprion oxygeneios*)

Hapuka are a large fish that are associated with rugged rocky reef areas such as caves, arch-ways and pinnacles (Francis 1996a,b). Migration patterns are not well understood, but larger adults demonstrate high site fidelity (Parsons 2010). Hapuka have a history of being heavily fished throughout New Zealand and now are only found > 40 m depth. Historical reports suggest Hapuka were very common throughout the water column down to 400m depth and in nearshore waters. Juvenile stages are pelagic until around 45 cm commonly associated with floating debris (logs, kelp etc). Both male and female stages mature at about 85-90 cm and consume a variety of fishes, squid, and crayfish (Francis 1996b). Deeper regions of the Hawke's Bay including the Lachlan Bank and Ridge, and inshore reefs Pania Reef, Cape Kidnappers and Post Office Rock are all focal areas for targeting Hapuka (recreationally and commercially) (see Hurst *et al*. 2010). Hapuka were initially targeted commercially by longline fishing since the late 1960s and 1970s within Hawke's Bay, with the remainder caught by set net and trawl. The estimated commercial catch of hapuka between Cape Kidnappers and Portland (0-50m depth) has declined since 2009 (Table 5.2).

5.4.7 Flounder and flat fish

Traditionally, inshore regions of Hawke Bay particularly adjacent the Clive Hard, and inshore regions south of Mahia Peninsula and have been principal fishing grounds for flounder and flat fish. Common fishing practices within the Mahia region included waiting until conditions were extremely calm with no swell over a 3-4 day period. Initial catches would be of sole and then mixed flounder species over ensuring days. Stomach contents included very small bivalves (unidentified) and polychaete worms, and declines in flats in the mid-to late 1990s in and around Mahia in particular are thought to coincide with a change in benthic species (Rick Burch *personal communication* in 2016). Interestingly, estimated commercial catch data for FLA within statistical area 13 over this time period supports this reduction.

The nearshore coastal areas off Napier and the Clive Hard are considered to be important spawning habitats for flat fish, whereas and the Ahuriri and Waitangi estuaries are considered vital nursery habitats.

5.5 Habitats and fisheries

It is has becoming increasingly evident over the last 20 years that many of the actively fished species in New Zealand may depend on several habitat types as they transition through different life history stages (otongenetic shifts in behaviour and feeding). These habitats may serve as settlement substrates; afford shelter and protection, e.g., mega-ripples on sandy substrates; provision of food; or, serve multiple functions. As such, fish may use a variety of habitat types coined 'habitat chains' over the course of a lifecycle. Consequently, the quality and integrity of these habitats is paramount in determining survival through to the adult population. Morrison *et al*. (2014a) suggest that there may be 'habitat bottlenecks' where important habitats are limited in spatial extent, or are of such poor quality that they in-turn limit the survival of juvenile fish into the adult population.

Two recent MPI reviews focused on evaluating the role of biogenic habitats and identifying habitats and areas of particular significance for coastal finfish fisheries management in New Zealand (Morrison *et al*. 2014a, b) have shed some light on the importance of particular habitats; but, have equally highlighted the dearth of our knowledge on habitat linkages for many commonly fished species. Of the range of habitats common to coastal regions those biogenic in nature often play a pivotal role in fish survival, (particularly juveniles). Common examples within estuarine and nearshore coastal zones include seagrass meadows, kelp forests, *Caulerpa* beds (green algae), sponge gardens, green-lipped mussel reefs, oyster reefs, horse mussel beds, bryozoan fields, maerl/rhodolith beds (red algae that form nodules of calcium carbonate), tubeworm mounds, and dog cockle beds (Morrison *et al*. 2014b). Key linkages have now emerged of the importance of seagrass, horse mussel beds, and sponge habitat for juvenile snapper survival. Unfortunately, for many other species there remains a paucity of knowledge linking the productivity of fished species to their foundation habitats (see Morrison *et al*. 2014b).

5.5.1 Biogenic habitats within Hawke's Bay

Of the main biogenic habitats listed as being potentially important for fisheries and broader-level ecosystem functioning, green-lipped mussel beds, dog cockle beds, kelp forest, *Caulerpa* habitat, intertidal seagrass beds, *Ruppia* sp beds and sponge habitats are all represented to varying degrees within the Hawke's Bay. With the exception of dog cockle and *Ruppia* sp beds the majority are associated with rocky reef habitat. Seagrass habitat was reported as once eminent within the Ahuriri Estuary, but is now non-existent (Duffy 1998), although forms extensive intertidal beds in southern Hawke's Bay. Subtidal seagrass habitat was also reported as occurring in and around Cape Kidnappers and the Clive Hard but has since disappeared. The horse mussel *Atrina zelandica* has been recorded in discrete patches adjacent the Wairoa Hard (Stevenson 1987; Thrush *et al*. 1997; Tai Perspectives 1996) but are not considered to be a dominant feature. Interestingly, (Hay 1990) suggests that vast beds of horse mussels were exposed when the west shore of the Ahuriri Lagoon was uplifted 0.5–1 m in 1931, indicative of the likely importance this lagoon system held to the wider Hawke Bay snapper fishery.

Due to the fact there has been a significant lack of research and understanding of habitat-fishery linkages and the effects various fishing methods (e.g., trawl gear) on inshore benthic habitats within New Zealand - which can be extended to being a worldwide phenomenon (see Morrison *et al*. 2014a) -determining changes to benthic habitats, benthic communities and species associations within Hawke's Bay is exceeding difficult, bar isolated cases such as the Wairoa Hard. Morrison et al. (2014b) further suggest that historical data on biogenic habitat extents and changes over time are very inadequately documented for New Zealand.

In tandem with a change in the distribution and abundance of select fish species there is also emerging evidence from the commercial trawl sector of a change in the epifaunal composition, particularly of the inshore benthos < 30 m depth within Hawke Bay. Commercial fishers surveyed are reporting a recent transition from a community dominated by brittle stars (ophiuroids), whelks, and certain crab species (entrained in trawl gear) to a large spatial increase in abundance and spatial distribution of the 11 arm starfish *Coscinasterias muricata*, oysters and hermit crabs (Paguroidea), the latter which is touted by fishers to be part of the diet of the spiny dog fish. While these changes are observational, they merit consideration given that brittle stars are considered globally as ecological indicators and synonymous with non-impacted benthic conditions (Thrush *et al*. 1998; Macleod *et al*. 2013), whereas hermit crabs and 11 arm starfish are typically scavengers. Current gear trials (May 2016) are documenting this possible shift in benthic species composition more rigorously.

5.6 Oceanographic climate

While the role of climate and its effect on coastal productivity and fisheries production has not been studied in any great detail within the Hawke's Bay it is clear from both early and more-recent observations that westerly winds continue to be associated with vibrant fisheries and fishing, whereas northerly and north-east winds are not. This contrast is conceivably related to upwelling, which as described by Heath (1973) may result from water rising in a compensatory flow when surface and near-surface water is driven offshore by the wind, or when water passes over an area of decreasing depth or across a headland. The net result of upwelling is often increased nutrients and productivity. This notion is further supported by commercial fishers who note that strong westerly winds (common in spring) are associated with dense plankton blooms, followed by subsequent zooplankton and krill blooms that drive the coastal fishery – Hawke's Bay wide. Wind data from Hawke's Bay show that since 2000 spring wind runs have not averaged over 250 km/h as tended to occur in the 1980s and 1990s. This reduction may be related to the positive phase of Inter-decadal Pacific Oscillation (IPO) from the 1970s to the late 1990s, during which El Niño events were more prevalent. Since the turn of the century there has been a strong negative phase of the IPO which favours La Niña conditions and easterlies (Kathleen Kozyniak *personal communication* in 2016).

5.7 Fisheries restrictions

A clear theme from the various fisheries reviews available for Hawke's Bay is the continual reoccurrence of stock depletions and the need for formal restrictions to be put in place that are still occurring today. Following on from the actions that resulted in establishment of the Waimarama fishing reserve, the closure of the Wairoa Hard to all forms of set net fishing and the abolishment of pair trawling in the early 1980's (described above), a range of other fisheries management areas that either partially or totally ban various forms of fishing were concurrently established. The majority of these are situated between Mahia and Cape Kidnapper's (Fig. 5.4) and include:

- Trawling by vessels > 46 m is prohibited across the entire Hawke's Bay fisheries management area;
- Surrounding the Mahia Peninsula the use of trawl nets and Danish seine nets are prohibited;
- Within the embayment that contains Opoutama and Mahia Beaches and on the east coast between the southern point of Oraka Beach to Table Cape (Kahutara Point), which Auroa Point. All commercial fishing is prohibited;
- Between Waipatiki Beach in the north and Cape Kidnappers in the south the use of trawl net and Danish seine net is prohibited by vessels over 13.5 m .
- Between Bay View and the Napier Port all trawl net and Danish seine net use is prohibited. Similarly, restrictions are in place for the area between south of the port to Te Awanga.

Within Hawke Bay there are five Mataitai Reserves, some of which are encompassed within the above fisheries restriction areas. Mataitai as defined by MPI under the Kaimoana

Customary Fishing Regulations (1998) and derived from the Treaty of Waitangi (Fisheries Claims) Settlement Act (1992) as areas where Tangata Whenua manage all non-commercial fishing by making bylaws. Bylaws must apply equally to all individuals. Reserves can only be applied for over traditional fishing grounds and must be areas of special significance to the Tangata Whenua. Generally there is no commercial fishing within the reserves.

South of Hawke's Bay, Te Angiangi marine reserve established in 1997 and approximately 466 ha in extent is designated as a full no-take marine reserve. The marine reserve was established to protect representative marine habitats and communities for science and education, and to provide a safe haven for marine life to live and breed. Major trends since its establishment are described in Section 4.5.

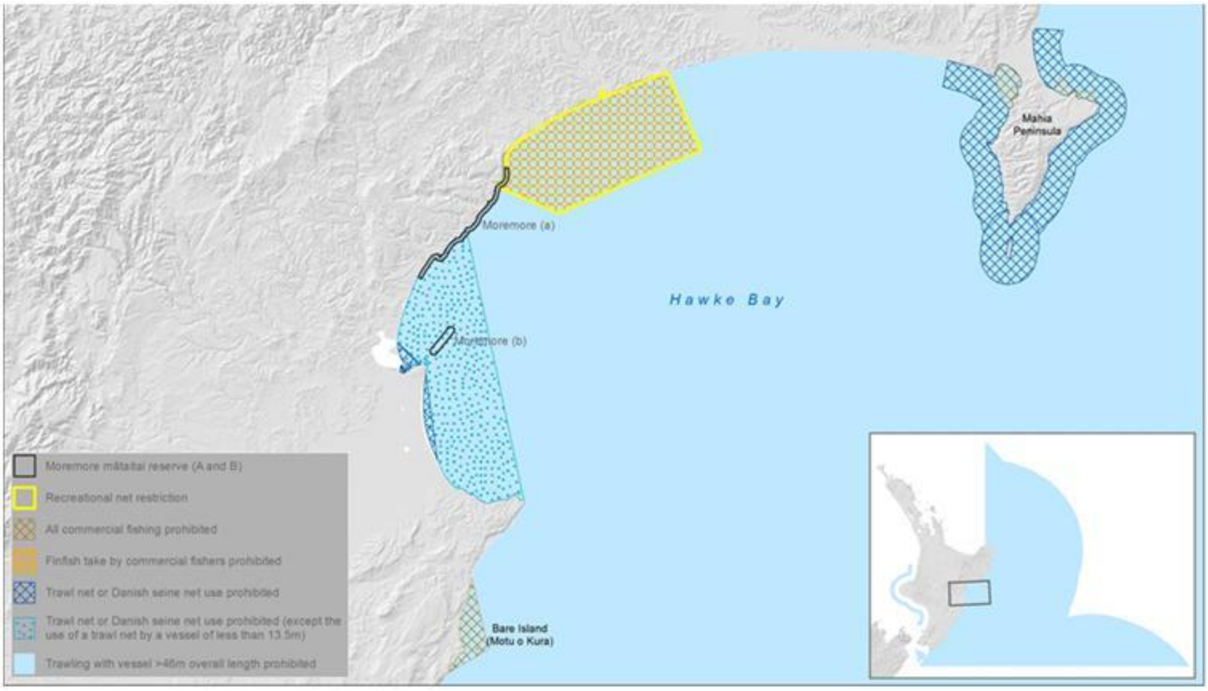


Figure 5.4. Hawke's Bay Fishing Regulations (spatial management areas) in 2014.

5.7 Gear trial research

Experiments on trawl methods to enhance fin-fish catches have been undertaken since the late 1890's. Early trials were to evaluate best locations and target depths, whereas trials in the 1960's and 1970's were largely aimed at increasing the access to areas difficult to trawl such as the Wairoa Hard (Tai Perspectives 1996). Due to increasing awareness of the damaging effects of trawl gear and the omnipresent concern over bycatch, the Hawke's Bay fishery has been at the forefront of experimental trawl gear trials over recent years. The focus of these trials has principally examined how modifications to existing trawl gear and in some instances new approaches can be effectual in releasing undersized or unwanted catch from the trawl before surface landing. Wade (2013) trailed 3 different trawl setups: Trawl 1 (Autumn 2011), was constructed entirely of turned mesh; with T90 through the body and the codend of the trawl and T45 in the lengthener; Trawl 2 (summer 2013) consisted of an attachment to the control trawl with a standard diamond mesh codend but with a 100mm T45 codend and Trawl 3 comprising 100mm T45 lengthener and a 100 mm T90 codend.

While there were positive outcomes for experimental Trawls 1 and 3 by way of releasing large numbers of fish of a 'round' profile, none of the trawls tested were successful in releasing elliptical fish. Table 5.5 depicts the 50+ taxa picked up across the trails and demonstrates not only the range of fish species that occur within the Hawke Bay nearshore but also those vulnerable to trawl fishing.

Table 5.3. Summary of fish species caught in trawl gear, as part of gear trials conducted in 2013 – modified from Wade (2013). Grey cells denote fish caught within the various gear treatments (T) and associated controls (C).

Common name	C1	T1	C2	T2	C3	T3
Anchovy						
Barracouta						
Blue Cod						
Blue Shark						
Blue moki						
Blue Warehou						
Brill						
Bronze whaler						
Carpet Shark						
Conger Eel						
Eagle Ray						
Electric Ray						
English Sole						
Frost fish						
Gurnard						
Gurnard (Streaked)						
Hapuka						
Herring						
Jack Mackerel						
John Dory						
Kahawai						
King Fish						
Leather Jacket						
Lemon Sole						
Ling						
Mackerel						
Octopus						
Pig Fish						
Pilchard						
Porcupine Fish						
Puffer Fish						
Red Cod						
Rig						
Rough Skate						
Sand Flounder						
School Shark						

Silver side						
Skate						
Snapper						
Spiny Dogfish						
Squid						
Stargazer						
Stingray						
Terakihi						
Thresher shark						
Trevally						
Turbot						
Blue Warehou						
Silver Warehou						
Witch Flounder						
Yellow flounder						

At the time of writing, FINZ, Te Ohu Kaimoana and MPI are committed to working with commercial fishers in Hawke Bay on the trials of new trawl gear technology to release 'round' and also elliptical fish. It is proposed that three different vessels will be involved in gear trails during 2016.

6.0 Iwi, the coast and fisheries

The ocean is of particular significance to Maori, as historically it provided a means of navigation, a mechanism by which trade was conducted, and particularly as sustenance by way of food (kaimoana / mātaitai) contained within. As such, the health of the ocean in a cultural/spiritual sense is fundamental to the wellbeing and health of coastal Maori throughout Hawke's Bay. The connection between Maori and the ocean emanates in the variety of marine mammals and marine species occurring in myths and legends (purakau) see (Wehi *et al*. 2013), which originated in Maui fishing up the North Island from the moana. In Maori legend, the North Island - Te Ika a Maui (the fish of Maui) was foul hooked by Maui at a mountain in the North of Hawke's Bay. Furthermore, the giving of kaimoana remains an important mechanism to demonstrate hospitality and generosity (manaakitanga) at hui (meetings), tangi (funerals), and assorted gatherings (Wehi *et al*. 2013). The review of Stevenson *et al*. (1987) provides some information on the history of Maori colonisation and Bay seafood resources used by early Maori within various parts of the Hawke's Bay. The Ahuriri Estuary is highlighted as an especially important source of kaimoana.

For Maori the cultural health of the rivers (awa) and sea (moana) is often evaluated in terms of mauri and kaitiakitanga, which in-turn directly affects the mana (of a hapu or iwi). Activities that diminish these values and/or prevent the act of gathering kaimoana will in turn reduce the cultural perception of a healthy sea (moana). For example, for a given area of coastline where hapu can carry out their customary practices pertaining to kaimoana collection, and other resource management practises would likely equate to a high degree of cultural health/wellbeing. From the interviews that were undertaken with various iwi and hapu there was a high level of concern regarding the depletion of many kaimoana species.

"*Tangaroa a mua tāngata ki muri* – If Tangaroa is abundant, the people will thrive" Ngati Kahungunu (2008)

The above statement introduces a recently developed marine and freshwater fisheries strategy put forward by Ngāti Kahungunu (Kahungunu ki Uta, Kahungunu ki Tai (2008) in effort to better manage the resources within the Kahungunu rohe. This strategy was in direct response to the degradation, depletion and conflict surrounding the lakes, rivers, streams, estuaries, foreshore and sea that has resulted from a perceived lack of management by various government agencies in charge of the awa and wider moana. Specifically the aim of the strategy is to "integrate the management of fisheries, freshwater and coastal resources and to develop management practices which are inclusive, rather than piecemeal and *ad hoc"*.

The strategy outlines a range of concerns relating to: 1) **Fisheries management** (Stock assessment; setting of, and variation in, TACs and TACCs; compliance: rights protection); 2) **Fisheries spatial management** (lack of localised management); 3) **Environmental issues** (pollution, run-off, sedimentation – all reducing the mauri of inland and coastal waterways and impacting fisheries);**4) Customary Fishing (**effects of treaty of Waitangi Settlement Act (1992), separating commercial and non-commercial customary rights resulting in loss of holistic management and undermine the mana and aspirations of hapu**; 5) Commercial Fishing**(responsibility and stewardship of the quota KAHC holds); 6) **Recreational Fishing** (concern over the size of charter boats, recreational take bigger than commercial; lack of robust information on recreational take including management tools); 7) **Compliance** (illegal fishing);

Nga Tangata (lead the restoration and enhancement of iconic/taonga species); 8) **Capacity** (resources required for strategy implementation - Ngati Kahungunu Iwi Incorporated to be point of contact for all fisheries management issues within the rohe); 9) **Information issues** (lack or recreational, commercial and customary data, no historic baselines); 10) **Communication** (engagement and development of a communications strategy).; 11) **Relationships** (foster relationships with MPI; DoC; local and regional councils); 12) **Training and development** (Develop and implement a training and development strategy so that Kahungunu people increase and broaden their skills for fishery management). Core species of customary significance with Hawke's Bay are presented in Table 6.1.

Table 6.1 Species considered being of high cultural importance to Hawke's Bay Iwi and hapu

Māori name	Common name	Scientific (Latin) name
Tuna heke Tuna roe	long-finned eel short-finned eel	*Anguilla dieffenbachia* *Anguilla australis*
Piharau	Lamprey	*Geotria australis*
Paua	Abalone	*Haliotis iris*
Kuku	Green-lipped mussel	*Perna canaliculus*
Kina	Sea urchin	*Evechinus chloroticus*
Kanae	Mullet	*Aldrichetta forsteri*
Koura	Rock lobster	*Jasus edwardsii*
Ngākihi	Limpets	*Cellana ornata* *Cellana radians*
Rori	Shield shell	*Scutus breviculus*
Pupu	Cats-eye	*Turbo smaragdus*
Karikawa	Whelk	*Haustrum haustorium*
Koiri	Neptune's necklace	*Hormosira banksii*
Papaka	Rock crab	*Hemigrapsus edwardsi*
Wheke	Octopus	*Octopus maorum*
Kourea	Snapper	*Pagrus auratus*
Puuwhaiau	Gurnard	*Chelidonichthys kumu*
Kooukauka	Kahawai	*Arripis trutta*
Warehenga	Kingfish	*Seriola lalandi*
Paatikimohoao Paatikitotara Paatiki	Flatfish	*Rhombosolea retiaria (black flounder),* *Rhombosolea leporine (yellowbelly flounder)* *Rhombosolea plebeian (dab/sand flounder),* *Rhombosolea tairina (greenback flounder)* *Peltorhamphus novaezealandiae (NZ sole)*

Over recent years, various hapu within Hawke's Bay have been instrumental in making efforts to understand through monitoring the current status and trends of kaimoana that are taonga within the significant awa of their rohe. Of particular note are Allen and Christine Jones (Wairoa) that are extremely proactive in transplanting eels from various locations within the Wairoa and Waiau awa to the sea. They feel that the Wairoa awa has become so polluted from various land use practises (farming and horticulture) that the downstream eel migrations are now being affected. In addition, they routinely monitor numerous water quality parameters from tributaries that enter the Wairoa to build-up more of a quantitative picture of environmental changes that they have observed. Similarly, Kohupatiki marae are monitoring eel and flounder populations within the Waitangi estuary in tandem with undertaking extensive riparian planting.

6.1 Customary marine titles

At the time of writing four customary marine titles are being sought for the Hawke's Bay by various entities under the Marine and Coastal Area Takutai Moana) Act (2011) (Table 6.1). The Act allows a coastal tribe to gain customary marine title if they can demonstrate they have exclusively occupied and used the foreshore and seabed since 1840. The titles allow tribes to govern and declare areas sacred and evaluate all applications for resource consents and other activities. Coastal areas of significance to Iwi within Hawke's Bay are summarised within the Hawke's Bay Regional Council's RCEP (2014) Part H.

Table 6.2. Customary marine titles sought under the Marine and Coastal Area (Takutai Moana) Act

Entity	Location	Status
Ngati Pahauwera	Common marine and coastal area Ponui Stream and Poututu Stream, Hawke's Bay	Formal engagement
Maungaharuru-Tangitu hapu	Common marine and coastal area between Keteketerau and Ponui Stream, Hawke's Bay (from mean high water springs out to 12 nautical miles)	Formal engagement
Ngati Pahauwera	Common marine and coastal area between Ponui Stream and Esk River, Hawke's Bay	Minister's decision to engage pending
Rongomaiwahine	Common marine and coastal area between Paritu and the mouth of the Nuhaka River including areas surrounding Te Mahia Peninsula.	Minister's decision to engage pending

6.2 IWI/Hapu Management Plans

Iwi/hapu management plans (IHMP) as summarised by HBRC are primarily tools for understanding the concerns of tangata whenua that may relate to resource management and council planning. As a rule IHMP is generally a policy statement that formalises the intent of tangata whenua regarding their social, economic, cultural and environmental development. It puts this intent into a form where, once recognised by the Iwi Authority and lodged with a council, it must be considered in council statutory processes under the Resource Management Act 1991. Management plans are in existence for the entire Ngāti Kahungunu area with hapu-specific plans in place for many locations

While objectives and intents may vary subtly across IHMPs there are a range of common themes central to all such as Matauranga Maori, enhancing mauri, empowering kaitiakitanga, restoring mana and working with HBRC. For example, in their Iwi/hapu management plan Nga Hapu o Tutaekuri (Hawaikirangi *et al.* 2014) have particular concern around the current land management activities that impact upon the Tutaekuri awa and have the following aspirations:

- Enhancement of the mauri of the Tutaekuri awa
- Enhancement of rongoa and native species proliferation
- Enhancement and proliferation of mahinga kai species
- Realisation of kaitiakitanga for Nga Hapu o Tutaekuri

Nga Hapu o Tutaekuri specifically state that they recognise through monitoring, testing, scientific reporting, and from living on the Tutaekuri awa that the mauri of the awa has been degraded by the impact of land development and various land-use practises in the catchment.

The concept of enhancing mauri was particularly strong within the Nga Hapu o Tutaekuri IHMP and divided mauri into four life essences referred to as Te Mana Atua. These were **Papatuanuku** – the earth mother (land); **Tane Mahuta** – the spiritual guardian of the forest and all living things that dwell within; **Tangaroa** – the spiritual guardian of water bodies and all living things that dwell within, and **Tawhirimatea** – the spiritual guardian of wind, incorporating the scientific area of meteorology and climatology. Concerns and aspirations to restore Te Mana Atua and mauri to the Tutaekuri awa are summarised in Table 5.4.

Partly owing to the limited timeframe for this project a range of gaps were evident with respect to Iwi and hapu coastal and marine information. These included understanding:

- Cultural practices, beliefs and tikanga (custom, tradition, protocols);
- Key areas for harvesting kai moana;
- Environmental condition of kai moana areas
- Core management concerns for individual rohe.

Table 5.4 Core concerns and aspirations to restore Te Mana Atua and mauri to the Tutaekuri awa (Hawaikirangi *et al*. 2014).

Ta Mana Atua	Concerns	Aspirations
Papatuanuku	Pastoral grass cover, residential and industrial developments, horticulture. Cropping, and plantation forestry have now replaced native flora and fauna that previously covered Papatuanuku. Catchments are highly erodible, and shed sediment into the Tutaekuri awa under rainfall events	Ensuring that Papatuanuku is able to support diverse ora and ecosystems within the greater Tutaekuri awa catchment Ensuring that the total area of erosion prone and exposed ground coverage decreases each year over the next 10 years (2015-2025), Ensuring that excessive sediment generation sourced from erosional forces are locked into Papatuanuku through native planting initiatives. Ensure that good environmental land management policies and practices, which restore the ecological health and mauri of the Tutaekuri awa are adopted and adhered to by government agencies, businesses and land owners within the Tutaekuri awa catchment.
Tane Mahuta	Lack of native riparian planting, which can be effectual in reducing sediment movement from erosion prone terrain. Areas once used for the collection of rongoa and natural resources along the Tutaekuri awa no longer plentiful and accessible to whanau. Absence of habitat for our native species e.g New Zealand dotterel (tuturiwhatu), crested grebe (puteketeke) and the white heron (kotuku).	Ensuring that Tane Mahuta is able to support diverse ora and ecosystems within the greater Tutaekuri awa catchment, Ensuring that the percentage of native forestry cover increases each year over the next 10 years (2015-2025), Enhanced riparian planting of site specific native plant species that will contribute to improved habitat creation for mahinga kai species, and improve water quality, The protection and restoration of kukuwai (wetlands) located within the Tutaekuri catchment, Ensuring that rare and threatened habitats located throughout the Tutaekuri catchment are identified and protected, To hear the bird song of the tui, the kereru, the piwakawaka, and the korimako around the Tutaekuri awa, To have native species increasing in the Tutaekuri awa catchment across all species over the next 10 years (2015-2025).
Tangaroa	Information upon which to base decisions is not currently supplied to hapu. Cumulative effects of water takes on water volumes and secure drinking water supply for Whanau, Impact on water quality from decreased water quantity, Over allocation of water resources in the Tutaekuri catchment, Drainage, and loss of wetlands	Ensuring that Tangaroa is able to support diverse ora and ecosystems within the greater Tutaekuri awa catchment, Ensuring that water quality and mauri in the awa is enhanced each year over the next 10 years (2015-2025), Ensuring the microbial quality of the awa is suitable for swimming in and gathering mahinga kai from by whanau, Ensuring that issues caused by nutrification and periphyton growth within the awa are remedied, Ensuring that the diffuse discharge of soluble inorganic nitrogen and dissolved reactive phosphorus are controlled so that they're not problematic, Ensuring that the quantity of ground and surface water that flows through the Tutaekuri awa catchment is able to sustain whanau Ensuring that good environmental water management policies and practices are adopted and adhered to by government agencies and owners within the Tutaekuri awa catchment.
Tawhirimatea	The wind dispersal of contaminants in discharge to air activities, primarily (spray drift) on agricultural land, particularly in areas where mahinga kai is collected. The aerial application of agrichemicals and fertilisers to land that may enter the awa.	Ensuring that Tawhirimatea is able to support diverse ora and ecosystems within the greater Tutaekuri awa catchment, Ensuring that airborne contaminants do not create adverse impacts on waterways, mahinga kai and its indigenous biodiversity, Ensuring that the wind dispersal of contaminants in discharge to air activities, (i.e. primarily spray drift on horticultural/agricultural land), does not affect riparian vegetative margins and areas where mahinga kai is collected, Ensuring that agrichemicals and fertilisers applied aerially to land do not enter the awa, and do not make contact with riparian vegetative margins. Ensuring that best environmental air quality management policies and practices are adopted and adhered to by government agencies and landowners within the Tutaekuri awa catchment.

7.0 Threats to marine habitats from land-based activities

There are a wide range of potential direct and indirect threats to the Hawke's Bay estuarine, coastal, and marine habitats stemming from various land-based activities within the region. Logically, these differ in type and magnitude due to their type (pasture farming, forestry, horticulture, industrial, and residential), the physical characteristics of the principal catchments (steepness, soil type, composition, erodibility) they occur within, and the proximity to and sensitivity of the final receiving environment(s). Included in the mix are those activities that are not necessary land-based, but have the potential to directly impact the seabed such as aquaculture, trawl fishing, dredging, disposal of dredge spoil, and various wastewater discharges (industrial and municipal). Land-based effects can further be divided into pulse (sudden, but infrequent) and press (continual) impacts. Moreover, it must be recognised that many of these activities and impacts may not operate in isolation from one another, i.e., are synergistic and therefore impacts can be cumulative in nature.

The following section outlines the main land-based effects likely to be impacting the coastal marine area of Hawke's Bay. These are summarised collectively in Table 7.2 in terms of type, source, nature (direct versus indirect), spatial effect (localised versus far-field) and environment types most likely to be affected.

7.1 Sedimentation

At the forefront of threats to coastal habitats with Hawke's Bay is that derived from terrigeneous sediment which can enter the coastal environment from multiple sources (Airoldi 2003; MacDiarmid *et al*. 2012). The effects of sedimentation are multifaceted and range from direct deposition and smothering of habitats and species, reduced water clarity due to increased suspended sediment loads, to increased nutrient enrichment and contamination (from sediment bound nutrients and contaminants). Due to intensive modification of the coastal landscape for pastoral livestock farming, and exotic plantation forestry (refer to Section 3.1) there are numerous examples of areas of active erosion throughout the Hawke's Bay region. These primarily take the form of cliff-line attrition through to catchment, stream, river, and estuary bank erosion.

Areas of active erosion are the primary source of sediment entering the marine system during heavy rain fall events (Glade 2003; Morrison *et a*l. 2009; Basher 2013). As these events are highly variable on a seasonal, inter-annual, and decadal basis they tend to invoke pulse-type effects, although depending on the severity may transition into press-type effects (see below). Variability in land use is also important with respect to the volumes of sediment generated, which has been the focus of several studies in the Hawke's Bay. Fahey and Marden (2000) investigated sediment loads from a mature forested (exotic) and pasture catchment (between January 1995-May 1997) revealing that total suspended sediment yields from the forested catchment was 32.7 t/km, whereas the catchment in pasture equated to approximately 3 times higher yields at 104 t/km^2. Glade (1983) infers based on sediment cores of several lakes there has been constant landsliding in the Hawke's Bay hillsides since the 1880s, and particularly in 1938, 1945, 1963, 1965 and 1988 with the most active years of landsliding between 1938 and 1988. Of the various catchments comprising the Hawke's Bay region, parts of the Wairoa generates the highest sediment yields (Hicks *et al*. 2000; Hicks and Shankar 2003; Hicks *et al*. 2011) (Fig. 7.1).

"Severe storm events like the Esk Valley floods in 1938 left extensive areas of hill country covered in shallow slips. Farmers realised that the poor quality of the pastures may have contributed to the slipping as well as the loss of forest cover..... (Hicks and Anthony 2001)"

Coastal cliff erosion is particularly widespread across the Mahia Peninsula and throughout the southern Hawke's Bay (Figs 7.2), which is an incessant process and a legacy effect, in part, from the removal of coastal vegetation and is acerbated by the predominance of pastoral farming in the region (Fahey and Marden 2000; Glade 2003; Miller 2007). Of particular note more recently were the large landslides that occurred in April 2011 in southern Hawke's Bay, when approximately 650 mm of intense rain fell over a four day period. This coupled with a 4.5 magnitude earthquake resulted in a significant amount of sediment being delivered to the southern coast (est. 150,038 m^3) from multiple landslides - 50, 202 m^2 - in total extent described by Macpherson (2013) as "catastrophic coastal landslides". Landslides occurred across the coastal domain with the most hard-hit areas being Aramoana and Te Angiangi Marine Reserve intertidal (Rod Hansen personal communication in 2016). This lead to a complete smothering of the intertidal zone and resulted in massive declines in paua, kina and various marine algae (Macpherson 2013) some of which are only beginning to recover now. In addition, at high tide erosion of these slips is still occurring with wave action generating a persistent sediment plume from Stingray Bay offshore (Fig. 7.2). Much of the sediment is thought to have moved into the nearshore and settled amongst deeper reefs > 30 m depth and remains problematic for commercial lobster fishing, i.e., lobster pots are getting buried within the thick sediment adjacent the reefs (Dave Patton *personal communication in* 2016).

Based on SoE monitoring it is becoming apparent that there is a general increase in the muddying of Ahuriri, Porangahau, Wairoa, and Waitangi estuaries (summarised in Section 4.5), and in some cases mud contents are within or above thresholds levels defined as "severe sediment stress" within those systems (see Robertson 2016). With the exception of these monitored estuaries the scale to which the above sedimentation-related effects are occurring within the Hawke's Bay subtidal area has not been quantified in great detail, save for anecdotal reports of increased sediments on rocky reef habitat. Morrison *et al*. (2009) does however report that much of the seabed comprising the Hawke's Bay–Wairarapa region is predominantly covered by 'modern' sediments (clays and muds) that have been generated from the highly-erodible sediments of bordering coastal catchments - this coastline is certainly one of the most sediment-prone in New Zealand (Hicks *et al*. 2011). A point highlighted by Morrison *et al*. (2009) that is worth reiterating here, is that based on sediment and pollen composition from a marine core taken from east of Poverty Bay, sedimentation rates have been shown to have increased by an order of magnitude following European conversion of native scrub and forest into pasture (see Wilmshurst *et al*. 1997). Based on this evidence it has been widely hypothesised that ***an entirely different subtidal benthic assemblage existed*** pre-European settlement (see Morrison *et al*. 2009).

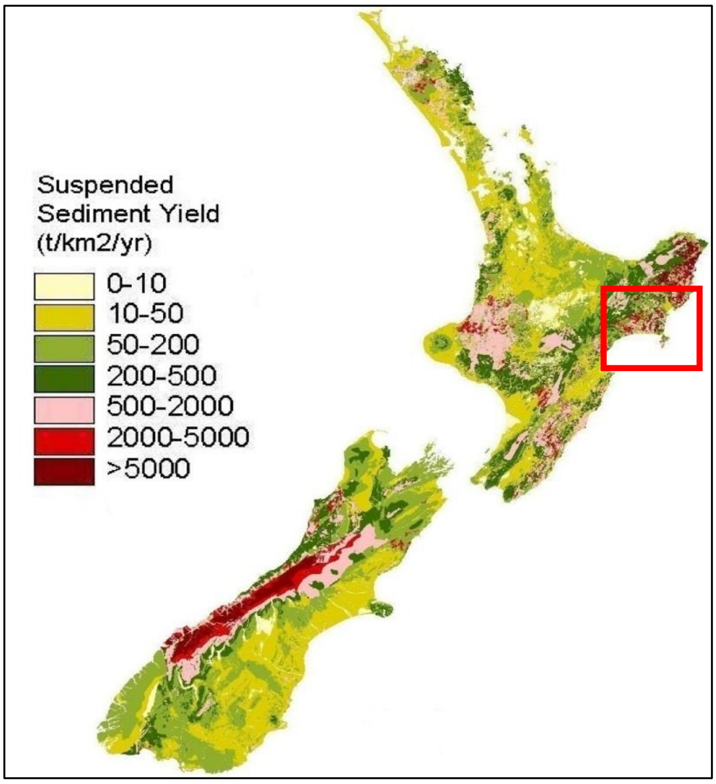


Figure 7.1. Catchment sediment yields across New Zealand. Northern Hawke's Bay catchments generate some of the highest sediment yields in New Zealand. Source Hick's *et al*. (2000).

As much of the terrestrial sediment enters the coastal environment during periods of major flooding (Hicks *et al*. 2011) freshwater sediment-laden outwelling plumes (Fig. 7.3) are a very common feature over large areas of coastline across Hawke's Bay. Specifically, these carry catchment-sourced materials (nutrients, suspended sediments, and chemical and microbiological contaminants) throughout the coastal environment and often 10s-100s km along the coastline and offshore (Gillespie 1997).

While it is a commonly held view that fine sediments are carried away from the shallow nearshore and eventually settle-out in deeper water or embayments (Gillespie 2007), in instances where sediment plumes persist along the coast or sediments settle in relatively shallow-water e.g., < 30 m depth, resuspension through persistent wave activity, tidal currents, and wind-driven mixing, - all common to Hawke Bay - can invoke long periods of high turbidity (Fig. 7.4). Sediments entering the marine environment can in turn influence coastal habitats in multiple ways from direct and catastrophic smothering of major species, alteration of community composition, scour and abrasion of tissues, reduction in productivity (reduced photosynthesis), to reduce feeding efficacy and foraging ability (see Airoldi 2003 for review).

Across the Hawke's Bay region accounts of fine (muddy) sediment accumulation in the nearshore < 50m depth have only been documented from isolated studies, e.g., extensive muddy areas of seabed north-west of the Wairoa Hard were observed by ROV and side-scan sonar (Thrush *et al*. 1997) and attributed to terrestrial sediments washed off the land. Equally, effects-based monitoring associated with the Pan Pac outfall (Smith 2015) and wastewater outfalls (Smith 2011) all infer that silt and organic accumulation in sediment samples are influenced greatly by the proximity of the monitoring sites to the Esk River (Pan Pac) and combined Clive, Tutaekuri and Clive Rivers (Napier and Hastings wastewater treatment plants) rather than the outfalls in isolation *per se*.

For rocky reef habitats even less is known on how sedimentation may have affected species distributions. As the Hawke's Bay region is of moderate wave exposure species would have evolved some capacity to withstand a degree of scour and abrasion, How the described changes in water clarity may affect algal (especially kelp) depth distributions and productivity remain unknown.

Figure 7.2. A: Erosion of cliff margin adjacent Te Angiangi Marine Reserve; B: Extensive sediment plume emanating from Stingray Bay Te Angiangi marine reserve and C: erosion of coastline south of Kairakau Beach.

Figure 7.3. Freshwater outwelling plumes for A: Tukituki River; and, B: Wairoa River

Figure 7.4. Sediment in resuspension for A: northern Hawke Bay; and, B: Te Mahia intertidal reefs.

7.2 Nutrients

Coupled with terrigeneous sediment, river plume outwellings, particularly in flood, can deliver substantial amounts of nutrients (N and P) and heavy metal contaminants into the marine environment. Cornelisen (2013) reports that rivers and streams in the Hawke Bay catchments collectively contribute an estimated 6,021 tonnes of nitrogen (N) per annum, however this may vary considerably among years depending on variability in rainfall and river flows. The sources of nutrients to waterbodies are diverse, ranging from atmospheric deposition, groundwater flow, agricultural runoff, fertiliser use, aquaculture discharges and sewage (Rees, 2009). As an example of the latter, the East Clive and Napier City Council (NCC) outfalls contribute an additional 1,010 and 1,271 tonnes of N per annum (an additional 25 %), into southern Hawke Bay respectively (Cornelisen 2013).

The potential effects of nutrient enrichment within Hawke Bay has recently been summarised by Cornelisen (2013) with respect to the Tukituki River as a consequence of the Ruataniwha Water Storage Scheme (RWSS) and Plan Change 6, which is geared towards changes in irrigation and land use in the Tukituki catchment. In that review it was forecast that the RWSS and Plan Change 6 will result in an increase in river nitrogen and phosphorus of 32% and 6 %, respectively. In turn it was predicted an increase in nitrogen loads from the Tukituki River represents around a 4 % increase in total annual inputs for all rivers and the East Clive and NCC wastewater outfalls combined, and a ~9 % increase for the southern region that includes inputs from the Tutaekuri / Ngaruroro / Clive, Tukituki and Maraetotara Rivers together with the East Clive and Napier City Council wastewater outfalls.

While increased nutrients into a system can often be viewed as positive in terms of increased coastal productivity and maintenance/strengthening of trophic linkages, when in excess, eutrophication may occur often resulting in rapid acceleration of phytoplankton and/or macro algal growth and resultant biomass (Anderson *et al*. 2002; Rees 2009). In instances when such augmentation cannot be consumed, a range of negative downstream effects including reduced water clarity, reduced dissolved oxygen concentrations leading to hypoxia, and toxic algal blooms leading to an imbalance in the trophic structure have been shown to occur. Cornelisen (2013) suggests other downstream effects may include the development of dead zones where anoxic conditions in both the seabed and water column occur. Smith (2013b) in his Environment Court evidence against the RWSS and Plan Change 6 based on his experience of the area suggested the southern Hawke's Bay nearshore at times presently experiences symptoms of nutrient enrichment (phytoplankton blooms and low demersal dissolved oxygen), therefore careful consideration must be given to any activity or change that may result in excessive nutrient enrichment. For the present case it is unclear how nutrient enrichment may or may not affect changes in nutrient ratios (N:P or N:Si) which can have negative flow on effects to fisheries. Similarly, long-term cumulative effects associated with freshwater plumes remain unknown across Hawke Bay.

7.3 Storm water

With increasing urbanisation and development comes the predictable change from natural landforms and vegetative cover to an invariable increase in impervious surfaces. During rain events, this transition typically results in increase in water quantity (urban hydrology) and change in water quality (non-point source pollution). As excess water flows into storm water networks (drains and pipes) it collects various contaminants including - suspended sediments, oxygen demanding substances, pathogens, metals, hydrocarbons and oils, toxic trace organics and organic pesticides, nutrients, and litter: These may be augmented when combined with sewage and/or other contaminants (Auckland Council 2010). The Hawke's Bay has in place a storm water management guide which details the range of effects and preferred treatment options for storm water (Shaver 2009). As summarised in that report there are a range of potential negative effects that storm water can have on estuarine and coastal environments many of which have been evaluated by Ausseil (2011) for the wider Hawke's Bay region.

In summary, Ausseil (2011) identified several areas within the Ahuriri Estuary and the Napier Harbour (Iron Pot), where sediment contaminant concentrations were above environmental guidelines and primarily in the vicinity to storm water outlets. Exceedance of guidelines were reported to be localised rather than imposing far-field effects. Perhaps of greater concern at the time was a general lack of information regarding the nature and likely effects of the storm water discharges generated by Hastings District urban areas, which contain the region's largest urban and industrial zones. As the Waitangi Estuary is the final receiving environment/end-point for this storm water, Ausseil (2011) highlighted a general lack of monitoring and understanding of areas at risk from storm water-derived containments within that system. Following on from Ausseil (2011), HBRC now undertakes regular SoE sampling within the Waitangi Estuary. Results collected to date indicate minimal storm-water related effects; although these results may also reflect the sampling location and may require further substantiation.

A range of storm water outflows are also present along the intertidal gravel beaches flanking Marine Parade in Napier City (Fig. 7.5). Presently it is unknown what the long-term effects of discharging storm water into this section of coastline is having, particularly those cumulative in nature.

Figure 7.5. Storm water outfall adjacent Marine Parade – Napier City.

7.4 Ocean Outfalls

Waste disposal into the marine environment has had a somewhat chequered history within Hawke Bay and has been a bone of contention with Maori for decades. Three ocean outfalls presently discharge wastewater into nearshore marine environment of Hawke Bay. These are the Napier Wastewater Treatment plant, Hastings Wastewater Plant, and the Pan Pacific pulp mill. For all locations, initial monitoring studies detected benthic effects adjacent to the outfalls, although through various modifications in waste treatment the scale of these effects have likely lessened through time. In addition the Affco and Silver Fern Farms meat works and Wairoa municipal outfalls all discharge into the Wairoa River/Estuary.

History

In order to better manage sewage the Napier wastewater treatment plant was established in 1973 at Awatoto. It initially consisted of a comminutor station (to cut up solids) grit ponds, and ocean pipeline 1.5 km offshore. In 1991 a milliscreen plant was constructed that passed sewage through 1mm screens before being discharged into Hawke Bay (primary treatments). Further modifications in the form of a Biological Trickling Filter (BTF) plant providing secondary treatment was completed in 2014.

A similar wastewater treatment plant with a communitor station and grit ponds and accompanying ocean outfall 2.9 km offshore was established for Hastings City in 1981 at East Clive. Prior to this there was no plant at East Clive, the first inland sewer (1939) and the second inland sewer (1960) travelled down Richmond Road to the beach where it discharged into the sea through a short ocean outfall. Improvements with screening were made in 1993 and BTF treatment also completed in 2014.

Monitoring of the environmental effects of both these sewage treatment plants, initially as investigative studies and later to meet resource consent renewal requirements have provided not only information on impacts to the benthos and water column, but hard data on the benthic composition of these coastal areas which is described below and would have otherwise been absent.

Hastings

The first study of pollution effects of the Hastings municipal outfall prior to the 1983 extension was undertaken in 1976 (Knox and Fenwick 1981). At that time, waste matter was disposed 50 m offshore consisting of raw sewage and effluents from meat processing works, wool scouring plants, large fruit and vegetable processing factories, and a range of other industries. I was noted that vegetables and fat globules were often abundant on the gravel beaches or floating on the surface for some distance around the outfall. Employing a systematic sampling approach, Knox and Fenwick (1981) identified 5 main faunal groupings (A-E) that were apparent with increasing distance of offshore and 3 zones that spanned the transition from polluted to normal. Of particular note was the inshore shallow zone that was obviously polluted whereby the capitellid *Heteromastus filiformis*, a species synonymous with impacted environments, occurred in enormous densities of up to 36,950 m^2. The bivalve *Maorimactra ordinaria* was another species found in higher abundances close to the outfall. Also of note was a dense band of holothurians between 8-10 m depth, described as “unique” to New Zealand shores. Faunal composition was also shown to differ according to grain size with deposit-feeders dominant in finer sediments and suspension feeders dominated coarser sediments.

An additional study of the Hastings outfall following its extension (Roper *et al*. 1989), revealed demonstrable impacts in benthic faunal composition and diversity with increasing distance away from the diffuser. Peaks in readily oxidisable carbon (ROC), total Kjeldahl nitrogen (TKN), oils, grease, and volatile solids, occurred immediately adjacent the diffuser. A gradient in sediment contaminants, excluding oil and grease, was also apparent moving away from the diffuser interpreted as being caused by the discharge under the influence of a strong north-south current. In terms of biota, it was found that the ophiuroid *Amphiura aster* and holothurian *Paracaudina chilensis*, were the most sensitive to the effects of the outfall. Changes in benthic community structure followed Pearson and Rosenberg's (1978) model of successional change with increasing distance away from a pollution source. A "polluted" zone typified by "a peak in opportunistic species" was evident within 200 m of the diffusers (based on diversity and species compositions) and a transition zone occurred within 400 and 1600 m from the diffuser. The opportunist peaks surrounding the Hastings outfall were mainly caused by the polychaetes *Paraprionospi pinnata, Heteromastus filiformis, Pectinaria australis*, and the bivalve *Mactra ordinaria*. These localised effects and changes in benthic communities are still apparent today.

Recent wastewater modelling of the East Clive outfall indicated that on-average, the plume dilution was around 50,000:1 at approximately 1.5 km off the shoreline with median bacterial guideline values are expected to be met within a maximum distance of 2.3 km from the outfall, with dispersion during El Niño greater than La Niña periods; sediments discharged from the outfall are predicted to settle within an ellipse biased to the southeast. The dominant fraction of the particles in the effluent are the inorganic components of size <0.10 mm. The model results indicate that 99% of these sediments will settle to the seabed within 3-4 km of the outfall diffuser (MetOcean and Cawthron 2013).

Napier

For the Napier municipal outfall routine monitoring of the benthic communities and sediment texture and contaminants (organic enrichment and trace metals) have been evaluated in 1995, 2002, 2005 (sediment survey only), and 2011. Effects remain consistent with minor changes to the sediment geo-chemistry together with benthic faunal diversity and community composition within the zone of reasonable mixing ≤ 300 m from the outfall (Smith 2011). Effects are largely evaluated based on replicate sites "proximate" (≤ 300 m) and "distant" (≥500m) from the outfall. In the most recent study, organic enrichment (total volatile solids) was most-apparent at sites closest to the outfall (within 50 m) with an increase in fine sediment and community variability also apparent at distant sites to the west and south of the outfall. Species underpinning this community variability were the usual species considered tolerant of fine sediment, i.e., *Prionospio aucklandica*, *Pectinaria australis, Heteromastus filiformis,* Cirratullids, Capetellids, nematodes and nemerteans and thus share a degree of commonality with the findings of the East Clive outfall (localised effects with a gradient to the west and south). Bivalves such as *Dosinia anus, Soletellina siliqua*, the polychaete, *Aonides oxycephala,* and *Amphiura* sp. were synonymous with less-impacted sites characterised by sandier sediments.

In addition to variations in benthic community composition Smith (2011) found that the benthic area of southern Hawke Bay is higher in Cu, Cd, and Hg than average and that there were some sites surrounding the outfall that were elevated compared to background levels. These higher levels were attributed to a combination of both the geology of the adjacent catchment and the long-term effects of the major riverine and municipal wastewater discharges in the area. In addition, elevated levels of metals at sites close to the outfall were identified as likely to be a result of the outfall discharge, although none surpassed relevant environmental guidelines, and were thus deemed to be unlikely to constitute an adverse effect as they were not accumulating over time.

Pan Pac

Pan Pacific Forest Products Ltd operates a pulp mill and integrated sawmill, with the raw material predominately *Pinus radiata*. Waste material from the various processes is deposited into Hawke Bay off Whirinaki. As for the two municipal outfalls resource consent monitoring of benthic invertebrate diversity and community composition and sediment physio-chemical characteristics surrounding the outfall have been undertaken every 4-5 years since a baseline survey was carried out in 1988. These surveys including the have been carried out by a variety of agencies with specific surveys in 1996, 2002, 2007, 2009, and 2015. Only sediment characteristics were investigated in 1991.

An upgrade to the effluent waste stream was made in 1996-1997 that included changing from 0.5mm screening to Dispersed Air Floatation (DAF) secondary treatment. This treatment reduced both the volume and nature (reduction in small particulates). Presently there is an issue with the frequency of the plume being conspicuous at the water's surface beyond the zone of reasonable mixing (150m from the outfall), which occurs when the sea surface is calm with minimal cloud cover (Smith 2015). As such, 1 of 3 options considered to minimise this effect was to extend the outfall a further 2km into Hawke Bay. The most recent survey undertaken in 2015 (Smith 2015) surveyed the benthos within and at set distances away from the existing outfall, also including the proposed outfall extension of 1.70 km.

The findings of Smith (2015) identified that surficial sediments at all sites were comprised of fine/very fine sands (63 μm – 250 μm) and organic content measured as total volatile solids (TVS) were lowest at the outfall, suggested as being due to the scour resulting from turbulence caused by outfall structure (increased shear forces and winnowing of fine sediments, including organic matter). Highest TVS were recorded at 50 m from the outfall and in deeper water monitoring sites and at sites north of the outfall. Sediment cores at sites close to the outfall (50N, 150N and 50S) had visible bands of darkened sediments close to the sediment surface (<10 cm) indicating reduced oxic conditions at these sites. Analysis of sediment texture in 2015 indicated that mud content was much higher across sites than for earlier 2007, 2009 and 2013 surveys and the overall historical average. There was no clear pattern in mud content, e.g., decreasing with increasing distance from the outfall attributable to an "outfall effect". Rather it was suggested that elevated levels of mud, compared to the historical average, was attributable to major rainfall event in mid-December 2014 prior to sampling.

TVS content varied relatively little between surveys, with much of the inter-survey variability attributable to high results in early surveys (1988, 1991, 1996) compared to more consistent results in latter surveys (2002, 2007, 2011 and 2015). In addition TVS levels at sites in 2015 were within the average ranges reported among other comparable Hawke's Bay coastal sites. On the whole, mill derived fragments did not comprise a significant portion of the organic matter with the majority occurring at the outfall. For earlier surveys between 1996 and 2002 data show a dramatic reduction in the numbers of fibres and fragments observed in sediments, which coincides with the move from primary to secondary effluent treatment in 1996-1997.

Pan Pac Impacts to seabed and change in benthic species

Results of benthic sampling indicated that in general the proportions of infaunal species found at sites appeared unique and predictable, with subtle variations in community composition from north to south, and inshore to offshore that demonstrated some relationship to the sediment texture of wider area. Distinct temporal differences in community structure and composition were however, apparent with 1988 and 1996 surveys being compositionally different to 2006, 2011, and 2015 surveys - attributable to the (DAF) secondary treatment.

The differences (primarily between 1988 and later surveys) were due to a shift from a community characterised by polychaetes *Magalona dakini* and *Heteromastus filiformis*, and the surf clam *Dosinia anus*, to an increase in the polychaetes *Prionospio* species (both *Prionospio multicristata* , *Heteromastus filiformis* and a range of other bivalve taxa. The differences in 1996 were largely driven by the dominance of the sea cucumber *Paracaudina chilensis.* Smith (2015) suggests with respect to 2002-2015 surveys temporal variability has more influence on community structure than distance from the outfall. Interesting in 2015 large numbers of juvenile *Echinocardium cordatum* occurred around the outfall and explained as likely to be short-term variability associated with their recruitment cycle. Overall it was concluded from the 2015 survey apart from minor effects in and around the outfall major significant adverse effects were not apparent in the benthic fauna occurring as a result of the discharge.

For the proposed new outfall site sampling identified that the benthic community was very similar to the existing outfall in terms of key community drivers, being dominated by juvenile heart urchins *Echinocardium cordatum*, and polychaetes *Prionospio multicristata*, *Sagitta* sp. and *Magalona dakini*. The exception to this was *Heteromastus filiformis* that was relatively sparse among samples. As a result Smith (2015) suggested that with the exception of a possible increase in *Heteromastus filiformis* the expected community change from extending the outfall (post-discharge) would be relatively minor.

7.5 Dredging

Effects associated with dredge disposal are relatively similar to that associated with sedimentation such as direct smothering of benthic organisms, potential changes in sediment texture and composition, and increase in sediment contaminants. Water column effects such as increased turbidity may lead to reduced productivity although this is likely to be localised. Ultimately, the severity of effects will depend on the volume being disposed relative to the size of disposal area, level of contaminants within the dredge spoil, and the nature of the receiving environment (seabed characteristics).

Dredging and subsequent disposal of dredge spoil by Napier Ports has been undertaken within various locations across its management area since 1997 in an effort to maintain shipping channels, and reduced sediment accumulation under swing basins, berthing structures, and between and under wharfs (Table 7.1). Disposal of dredged material occurs in two locations immediately inshore and north of the Port (Fig.7.6). The most-inshore site **R Extended** is immediately offshore from Westshore Beach covering a depth range of 3-7 m with a second site **la** approximately 500 m offshore from **R Extended**. A control site **Cla** to the north of **la** is used to evaluate the change in sediment texture (based on grain size analysis) and epifaunal and infanual community composition through space and time. The volume and timing of disposed varies greatly across these locations (refer to Table. 7.1). Initial monitoring surveys were undertaken at **la**, **R**, and **Cla** in 1997 to facilitate baseline establishment with subsequent surveys undertaken in 2004, 2006, 2008, and 2012 (Smith 2013a).

Table 7.1. Overview of dredging works within Napier Port and spoil volumes within disposal sites between 2006-2012 (from Smith 2013a).

Date	Spoil volume Site la (m^3)	Spoil volume Site R (m^3)	Spoil depth (cm) la Rx	Location of dredging
June –Sept 2008	30,166		6.1	Between and under wharves
2008	Up to 48,800		14.4	Inner Harbour, Napier Sailing Club
September 2009	49,400		10.0	Swing basin and berths
Jan 2010	18,700		3.6	Swing basin and berths
Jan-March 2012	211,355	130,965	43.0 7.7	Fairway and approach channel
Total	358,421	130,965		

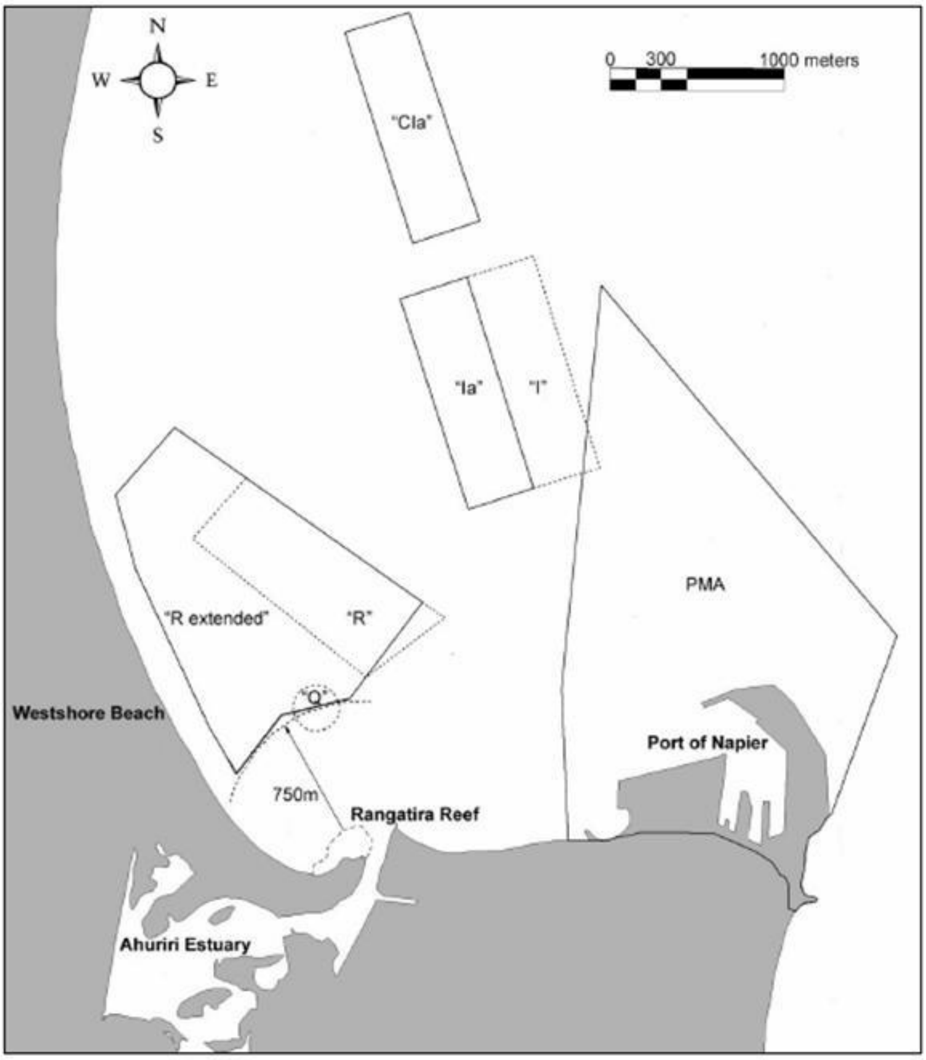


Figure 7.6. Locations of dredge spoil disposal sites west of Napier Port (Source: Smith 2013a). Site Cla is a control site.

Main trends

Effects identified over the course of monitoring within disposal site **la** has included changes in sediment texture, organic matter, reduced taxa richness, lower infaunal diversity and increased variability compared to the control site **Cla** all attributed to the recent deposition of large volumes of sediment prior to sampling, i.e., 211,355 m^3 – January to March 2012. Smith (2013a) suggests however that when viewed over the perspective of multiple-years the effects would not constitute an adverse effect. Species driving the change between **la** and **Cla** were the holothurian, *Paracaudina chilensis,* and bivalve *Divalucina cumingi* which were common at the control site **Cla** but not at the impact site **la**. Polychaetes *Prionospio multicristata,* and *Sagitta* sp. were common to both

For **R Extended** dredge spoil site the most recent survey found that there were no major changes across depth strata although there were subtle changes between the northern and southern regions of site in terms of diversity. This gradient was attributed to the greater disperseve nature of the northern area as it is slightltly shallower. While there is no equivalent control site for **R Extended**, it is apparent from multi-species ordinations that there was a substantial shift in infaunal species composition from the initial 1997 (pre survey) across all depth strata, which appears to have altered the community composition since (Fig. 18 in Smith 2015). Species responsible for this shift include *Heteromastus filiformis, Prionospio* sp., *Spiophanes bombyx*, Ostracoda and decrease in the polychaete Nephtyid. Furthermore, in the deepest depth strata (> 6.3 m) surveyed there has been a 3-fold decrease in the abundance of epifaunal organisms from 2004 onwards (Fig. 20. in Smith 2013a). A clear gap in the studies of dredge spoil disposal, is knowledge on contaminant levels within the dredged material prior to it being disposed of in the nearshore environs and cumulative effects through time.

7.6 Trawling

Trawling of the seabed has been demonstrated to disturb both physical and biotic elements in many ways. Direct effects can range from injury, death, and burial of surface-dwelling individuals, to the removal of non-target organism (bycatch), and an increase in scavengers preying on damaged or exposed organisms (Ramsay *et al*. 1996; Thrush *et al*. 1998). Changes to the actual seabed may include loss of heterogeneity, change in sedimentation rates and sediment-water column nutrient exchange, and sediment productivity. Certainly, the historical accounts of trawling within the Wairoa Hard have documented the loss of *Ecklonia radiata* habitat in the 1970s (Tai Perspectives 1996); however, apart from this account and anecdotal accounts from commercial fishers, as to what is contained within their trawl gear, it is largely unknown how the method of fishing may have altered the seabed structure across Hawke's Bay. Recent data collected by MPI on trawl fishing effort with Hawke's Bay demonstrates areas where highest levels of fishing intensity have occurred (Fig. 7.7).

Within New Zealand, studies on the effects of trawl gear on the nearshore benthos are limited. Thrush *et al*. (1998) provides some evidence of the likely effects within the Hauraki Gulf sampling a variety of seabed types and depth-strata. The study indicated that that between 15 to 20 % of the variability in macrofaunal community composition could be attributed to trawl fishing. Decreases in the density of deposit feeders, small opportunists, and, the ratio of small to large individuals of the infaunal heart urchin *Echinocardium australe* were observed whereas, in areas of reduced fishing pressure there were increases in the density of echinoderms, long-lived surface dwellers, total number of individuals, and richness. Studies done elsewhere have demonstrated increases in the migration, abundance and feeding activity of the hermit crabs *Pagurus bernhardus* following experimental beam trawling (Ramsay *et al*. 1996), although this was not apparent for the co-occur species *Pagurus prideaux.*

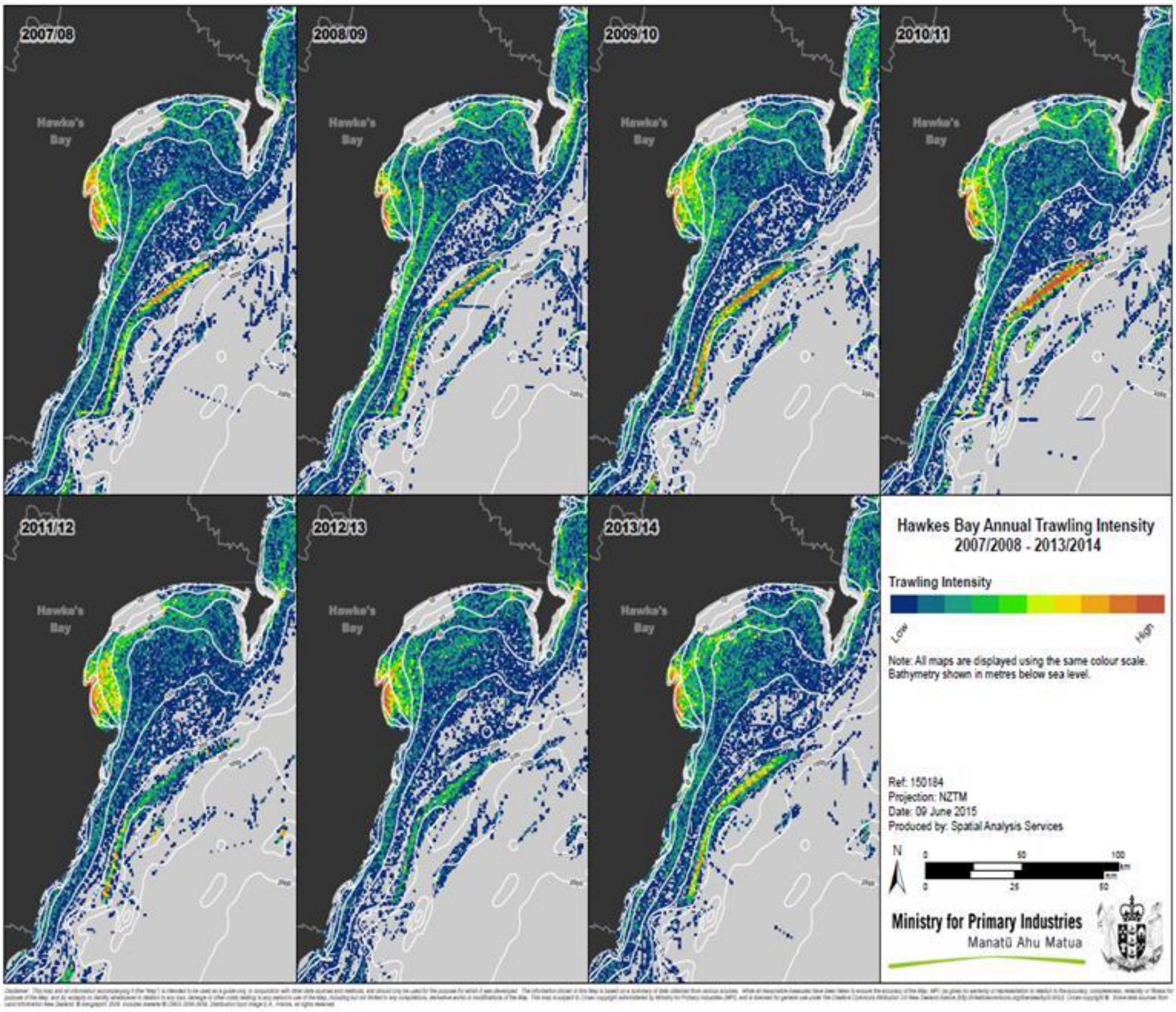


Figure 7.7. General spatial pattern of trawl intensity between2007/08-2013/14 across - Hawke's Bay region (Source MPI 2015).

7.7 Smaller-scale impacts to coastal habitats

Additional direct, but smaller-scale impacts (other than sediment deposition, nutrient and storm water-related effects) to coastal habitats described in previous sections of this report include: grazing and spraying of estuarine and coastal vegetation; infilling, draining, and reclamation of wetlands and estuaries (Fig. 7.8, 7.9); and, vehicle use on beaches and dune systems. While these may appear to be localised effects, should they occur persistently throughout the region, which collected evidence suggests (e.g., stock grazing within estuarine systems) then cumulatively their effect size can be viewed as quite significant.

Figure 7.8. Infilling of estuarine vegetation at the mouth of the Esk River, 2016.

Figure 7.9. Spraying of Manuka scrub (brown areas) – Mahia Peninsula, April 2016.

Table 7.2. Summary of main land-based and water-based stressors on the Hawke's Bay CMA.

Activity	Threat	Source	Effect type	Spatial scale	Evidence
Pasture grazing, horticulture and forestry	High	Erosion of hillsides Erosion of river and stream banks Cliff line erosion Soil erosion	Pulse and Press Localised to far-field; Cumulative	Widespread Estuaries - coastal	Increasing muddying of estuaries over short timescales (HBRC SoE monitoring); Persistent high nearshore turbidity since mid-1970s Large landslides in southern Hawke's Bay in 2011 with effects still eminent. Historic landslides well documented across coastal region Evidence of stock in estuaries and waterways Slumping of coastline evidenced at Clifton following recent forestry harvesting High nutrient and sediment loadings from main rivers Sedimentation of rocky reef and soft sediment habitats
Storm water	Moderate	Napier City Hastings City	Pulse Localised - possibly far-field Cumulative	Localised Estuaries - coastal	Increase in contaminants at some sites within the Ahuriri Unknown with respect to the Waitangi and Napier nearshore coastal environment
Waste water outfalls	Moderate	East Clive Outfall Napier CCC Pan Pac Outfall	Localised to far-field Cumulative	Localised Coastal	Increase in nutrient enrichment of nearshore coastal environment Increase in contaminants in sediment gradient dominant currents (S, SE) Localised effects on benthic community composition Localised effects on sediment texture (increase in fines)
Dredging and spoil disposal	Moderate to High	Port of Napier capital dredging	Pulse – scale of effect depends on volume of spoil disposed of Cumulative	Localised Coastal	Change in benthic composition Change in sediment composition Possible increase in dispersion of sediment bound contaminants (unknown)
Trawling	Unknown Potentially High	Napier local fishing fleet Gisborne fishing fleet Wellington fishing fleet	Pulse and Press depends on frequency Cumulative	Widespread Coastal	MPI – spatial trawl data Anecdotal evidence from customary, recreational and commercial sectors Change in benthic communities within trawled areas
Other Gravel extraction Vehicles on beach and sand dunes Fishing Coastal development	Potentially High	Commercial operation Various Various Various	Pulse and Press Cumulative	Widespread Estuaries - coastal	Erosion of coastline south of the Tukituki River Anecdotal evidence throughout Hawke's Bay

8.0 Knowledge Gaps

The summary of marine habitats that comprise the Hawke's Bay region presented in previous sections provides a starting point to begin to define gaps in the knowledge-base for the Hawke's Bay coastal marine area. Due to an absence of SoE monitoring pre-2006, regrettably many of the changes that may have occurred within various systems have gone either unnoticed, have not been rigorously quantified, or are largely anecdotal. The importance of having well-defined baselines from which the direction and magnitude of changes can be evaluated cannot be overstated. Without long-term robust monitoring and reporting it is very difficult to determine how the environments HBRC is tasked with managing are changing for better or worse; primarily due to the sliding baseline phenomenon (see Gaiti *et al*. 2015). Fortunately, HBRC has been proactive over the last decade in establishing consistent monitoring programmes. These will enable the council to identify threats to various coastal environments and habitats over which it can exert some management controls fin the foreseeable future. For the most part, data generated as part of their SoE programme can also be evaluated against locations elsewhere in New Zealand (Hewitt 2014).

Key GAPs with respect to marine habitats across the Hawke's Bay are numerous and often analogous across different sections of the CMA. These are bullet-point summarised below for various ecosystems.

8.1 Estuaries

For the majority of estuaries, the exception being the Ahuriri there is sparse information regarding the following**:**

- Understanding of the various functions and values of estuarine systems – with ongoing problems/issues still occurring (see Figs 6.5; 6.6);
- Hydrology;
- Hydrodynamics;
- Deposition points for sediment and contaminant accumulation;
- Water quality;
- Sources and downstream effects of nutrient enrichment and eutrophication;
- Variation in sediment texture and benthic faunal composition pre-2006;
- Historic loss/change of key or biogenic habitats (seagrass, horse mussel beds, wetland vegetation);
- Role of various habitat linkages as species transition through different life stages;
- Loss/change in key species particularly bivalves (pipi, tuatua, horse mussels), birds, and fishes;
- Effects of various land use practices on the wider environment including cumulative impacts;
- Response time of habitats and species to respond to restoration efforts;
- Most effective restoration techniques.

8.2 Intertidal environments (rocky reef and soft sediment)

- Change in habitats and dominant species pre-2006;
- Effects of stressors – sedimentation, harvesting, vehicles;

- Linkage between intertidal and subtidal environments.
- Abundance of kaimoana species/ condition of stocks?

8.3 Subtidal environments

For the majority of subtidal rocky reef habitats the exception being Te Angiangi marine reserve and bulk of subtidal soft sediment habitats, there is very sparse information regarding the following**:**

- Baseline data;
- Qualitative data on habitat distributions and community composition within rocky reef and soft-sediment habitats;
- Qualitative data on the abundance and biomass of dominant species (kelp, mussels, kina, crayfish, reef fish) for rocky reef habitat;
- Lack of information on sedimentation-related effects;
- Effects of other stressors, harvesting, pollution, invasive species *etc*;
- Change in soft-sediment benthic composition at region-wide scales.

8.4 Iwi

There are numerous gaps regarding Ngāti Kahungunu Tangata Whenua with respect to cultural knowledge and areas of cultural significance across the CMA some of the more obvious being :

- Cultural practices, beliefs and tikanga (custom, tradition, protocols);
- Key areas for harvesting kai moana;
- Environmental condition of kai moana areas?
- Histories of the coastal marine area preserved in purakau

It anticipated that through continued dialogue within various coastal hapu these gaps will begin to be bridged.

8.5 Fisheries

For the Hawke's Bay fin-fish fishery there is long history of boom and bust phases attributed to overfishing, climate variability or both. Equally the Hawke's Bay CMA has numerous fishing restrictions with new areas added as recently as 2015. Currently the state of fisheries within Hawke's Bay is an extremely contentious issue due to very low catches, particularly within the recreational sector relative to previous decades. Key gaps in the understanding of fisheries include:

- Climatic variability and its role in driving the Hawke's Bay fishery;
- Change in species distributions across Hawke's Bay through space and time including movement patterns of various fished species, e.g., red gurnard, John dory;
- The importance of various habitat types in supporting fishery production and different life history stages of fished species;
- Effect of land-based stressors on fisheries;
- Effect of trawl fishing on benthic communities and the physical structure of the benthos;

- Effects of bycatch on overall fisheries production;
- Effectiveness of various fisheries closures within Hawke Bay.

9.0 Key recommendations

As summarised in her judicious review of integrated coastal management in New Zealand, Peart (2007) describes New Zealand's present-day coastal management framework as disjointed and plagued by inconsistent management goals. This is partly due to the *ad hoc* development and disconnect between legislative frameworks that various agencies are bound by, together with a lack of information and resourcing that can be applied to many of the coastal management issues that may arise. It is therefore promising that key agencies and stakeholders are enthusiastic to collaborate and strive for better outcomes for the CMA, fish stocks and to reduce effects stemming from land-based pressures. Peart (2007) provides nine key recommendations to achieve better coastal management, many of which are relevant to the Hawke's Bay region.

The only effective way to evaluate environmental change and strive to minimise land-based effects is through strategic information gathering and routine monitoring against well-defined baselines. Information generated can then be used to guide future management decisions and inform and ensure environmental policy is fit for purpose (Peart 2007). The current monitoring framework employed by HBRC fits in with the National Environmental Monitoring framework reviewed by Hewitt *et al.* (2014) and encouragingly much attention has been placed by HBRC on various programmes within that framework over the last decade. As the temporal scale of this monitoring like for many other regions in New Zealand is on the low side, many of the environmental changes reported for Hawke's Bay e.g., the decline in coastal water clarity between 1970 to present are difficult to comprehend.

The following section outlines a set of eight recommended strategies to begin to bridge some of the gaps that have emerged for the Hawke's Bay coastal marine area through undertaking this information gathering exercise. The authors' stress that this list is not intended to address all issues affecting the CMA. Rather, it is anticipated that the review marks a step forward in beginning to tackle some of the more obvious gaps, with an ultimate goal of achieving improved integrated management within the CMA. By working thorough the various strategies presented here, it is anticipated that the recent across-agency alliances and union with other stakeholder groups within Hawke's Bay will be cemented further. Due to the broad range of issues for the Hawke's Bay CMA the strategies listed are not necessarily mutually exclusive and various synergies will exist between them. Each strategy is put forward with key objectives and action points.

9.1 Strategy 1 – Formalisation of inter-agency and stakeholder collaboration to work through and prioritise strategies

Key Objectives: Strengthen collaboration process; Prioritise recommended strategies; Attract research funding; Continue to develop strategies.

The first strategy is focused on the continued collaboration of key agencies (HBRC, MPI, DoC Ngati Kahungunu and other Iwi groups) including additional stakeholder entities (Area 2 Inshore Finfish Stakeholder Management Ltd, LegaSea, NZ Sport fishing Council, Napier Sport fishing Club, conservation groups) within Hawke's Bay with an impetus placed on working through and beginning to prioritise the range of strategies listed below. The formalisation of this collaboration with the development of a memorandum of understanding in tandem with working through the recommendations for enhanced integrated management provided in Peart (2007 – Chapter 15) as they apply to Hawke's Bay, would be particularly beneficial at this incipient stage of the collaborative process.

Once formally established the collaborating parties could then play a pivotal role in: 1) identifying across-agency synergies; 2) attracting funding to address the range of issues facing the CMA moving forward; 2) continued development/refinement of the strategies presented below; 3) guiding research programmes and evaluating outcomes of research; 4) ensuring environmental policies are fit for purpose.

9.2 Strategy 2 – Maintain exiting SoE monitoring at its current rate and explore ways to amalgamate and develop customary (Matauranga Maori) monitoring linkages

Key Objectives: Increase knowledge base on coastal environments; Empower and value cultural monitoring.

The current State of the Environment (SoE) monitoring undertaken by HBRC across the various marine habitats within its boundary (estuarine, intertidal soft sediment, intertidal rocky reef, and coastal water quality) is providing valuable data on the state of these systems. Data of this nature are imperative to evaluate trends (stability, deterioration, and improvements) in relation to land-based stressors and should be continued at the current level. Presently, water quality data for Porangahau Estuary and Maungawhio Lagoon are lacking. As these mark the southern and northern extremes of the Hawke's Bay region, their inclusion in the water quality monitoring – if feasible – would be beneficial. Additional components recommended for inclusion within the SoE monitoring framework are detailed below in supplementary strategies.

"*Embedding research within indigenous communities requires strong relationships to be built first. It is important that the wider cultural setting is understood if science is to be a good fit.*" Allen *et al.* (2011)

In addition to the coastal SoE monitoring HBRC undertakes, conservation work DoC carries out, and fisheries management MPI undertakes it would be of worth to amalgamate the environmental surveys currently done by various hapu into its monitoring framework/reporting in some capacity. For example, it is apparent that water quality sampling and eel/fish population monitoring is presently being undertaken by Allen and Christine Smith throughout the Wairoa River and surrounding tributaries. Similarly, Tom McGuire and whanau (Kohupatiki Marae), over and above orchestrating extensive riparian planting along the banks of the Clive River, have been proactive in monitoring eel and flounder populations within the Waitangi Estuary and parts of the Tutaekuri, Ngaruroro, and Clive Rivers.

Cultural-led monitoring has been largely motivated by a perception of deteriorating aquatic environments (diminished mauri) and in an effort to gain some insight into the current status of species of customary significance. Through undertaking discussions with various hapu across the Hawke's Bay there is a clear sense of abandonment and mistrust, (of regulatory bodies) and significant loss of mana stemming from the current state of their significant awa and wider moana. In saying that, there is also a genuine willingness and drive to restore mauri to the aquatic environments and find ways to work collaboratively with HBRC, MPI and DoC. This latter point resonates strongly within many Iwi/Hapu Management Plans.

In the review of Hewitt *et al*. (2014), which is focused on the development of a National Marine Environment Monitoring Programme (MEMP) for New Zealand, there is no reference to Maori-based monitoring of the coastal environment. While this may be an intentional omission, it is our view that a national monitoring programme should have a clear intent of weaving mātauranga Māori with western scientific disciplines. As it presently stands, there is no real mechanism other than the Marine and Coastal (Takutai Moana) Act (2011) that can aid the future relationship and engagements between Iwi and various government agencies.

Action-point

One potential way to amalgamate cultural knowledge into HBRC's and other agencies monitoring frameworks is through the development of a mauri-model that can be applied specifically to the coastal domain. This model could encompass a decision-making framework that provides a culturally derived template within which indigenous values such as Matauranga Maori, Kaitiakitanga, Tau utuutu and mana are explicitly empowered beside western-based science disciplines and guidelines (see Morgan 2006; Stephenson and Moller 2009; Allen *et al*. 2011). Hikuroa *et al*. (2011) provides a contemporary example of adopting and applying a mauri-based model to a degraded environment. Such an approach will also fulfil some of the aspirations outlined in the Ngati Kahungunu marine and freshwater fisheries strategic plan and various Iwi/Hapu management plans.

9.3 Strategy 3 –Develop integrated management plans for major estuarine systems

Key Objectives: Enhance estuarine management protocols; Reduce land-based impacts to estuarine environments; Combine diverse knowledge bases.

To better manage the range of estuarine environments throughout the Hawke's Bay region, development of strategic management plans for all major estuaries that adopt a more "holistic management approach" is strongly warranted. The over-arching aim of estuary-specific management plans would be that through understanding these ecosystems in greater detail i.e., from all avenues (values, land-use, catchment type, hydrological and environmental), agencies can have a much better chance of reducing the effects of various land-based stressors. In addition, novel catchment- and estuarine-specific restoration measures can be explored and established. Emerging examples of holistic catchment management are occurring within Hawke's Bay e.g., Whangawehi Catchment (Te Mahia) (Fig. 8.1) and lessons learned from these efforts could be applied to all major estuarine systems.

Action-points

To establish estuarine-specific management plans, initial workshops should be held with relevant stakeholders with the following objectives:

1. Identify and prioritise sub-catchments of concern;
2. Develop estimates of sediment yields from these catchments (e.g., CLUES modelling);
3. Evaluate hydrology and sources of various stressors (storm water, runoff, enrichment);
4. Develop criteria in accordance with EIANZ (2015) to evaluate: 1) the ecological values of a given estuarine system; 2) magnitude of environmental effects; and, 3) combine 1 and 2 in a matrix to determine the overall implications of different ecological impacts.

5. Use findings from 4) to identify habitats and species of high ecological value and those most at risk from sedimentation and other stressors (case by case basis). Note: the focus should be on habitats not only single species;
6. Identify indicator species, e.g., cockles, pipi, fish species that can be monitored effectively by various members of the community *etc*, to ensure engagement in the management process;
7. Identify habitats of value to fisheries within estuarine systems;
8. Collate and disseminate historical and cultural knowledge on what is valued and equally what has been lost;
9. Identify potential cumulative impacts;
10. Develop a set of strategic goals and restoration options for catchments (see Basher 2013) and estuaries with defined timelines.

Figure 9.1. Whangawehi catchment management information – Te Mahia.

Examples for select estuaries could be:

Ahuriri Estuary

- Develop a core set of environmental, cultural, and social values for the Ahuriri estuary;
- Evaluate significance of ecological impacts based on ecological value and magnitude of effects – prioritize areas of concern;
- Evaluate natural storm water treatment options to reduce storm water related effects e.g., establish natural wetlands (floating or fixed) to treat various stages of storm water, reduce nutrient inputs, and manage flood events;

- Develop a fan-worm management plan;
- Establish riparian planting measures;
- Develop stock management protocols;
- Develop Iwi-inclusive measures within SoE monitoring;
- Identify key habitats of value to fisheries and associated management of these.

Waitangi Estuary

- Develop a core set of environmental, cultural, and social values for the Waitangi estuary;
- Evaluate significance of ecological impacts based on ecological value and magnitude of effects – prioritize areas of concern;
- Develop stock management protocols e.g., fence all estuary and river margins to exclude stock – particularly on HBRC land;
- Continue supporting Iwi-led monitoring initiatives;
- Continue supporting Iwi-led riparian planting;
- Develop Iwi-inclusive measures within SoE monitoring;
- Evaluate storm water management and trade waste management options;
- Identify key habitats of value to fisheries and associated management of these.

Porangahau Estuary

- Develop a core set of environmental, cultural, and social values for the *Porangahau* estuary;
- Evaluate significance of ecological impacts based on ecological value and magnitude of effects – prioritize areas of concern;
- Develop stock management protocols e.g., fence all estuary and river margins to exclude stock;
- Instigate Iwi-led riparian planting of riverbanks and catchments of concern;
- Develop Iwi-inclusive measures within SoE monitoring;
- Identify key habitats of value to fisheries and associated management of these.

Wairoa Estuary

- Develop a core set of environmental, cultural, and social values for the *Wairoa* estuary;
- Evaluate significance of ecological impacts based on ecological value and magnitude of effects – prioritize areas of concern;
- Create a habitat map for the estuary;
- Instigate Iwi-led riparian planting of riverbanks and catchments of concern;
- Evaluate waste-water disposal into the Wairoa Estuary;
- Develop Iwi-inclusive measures within SoE monitoring;
- Identify key habitats of value to fisheries and associated management of these.

9.4 Strategy 4 – Incorporate subtidal monitoring into the SoE framework and undertake larger-scale surveys of important fisheries habitat

Key Objectives: Bridge gaps in the understanding of subtidal marine habitats within Hawke's Bay; Bridge gaps in the understanding of important fisheries habitat within Hawke's Bay.

A clear outcome from undertaking the information collation exercise was a distinct lack of information concerning how physical and biological subtidal habitats may have changed through space and time across the Hawke's Bay region. With the exception of limited subtidal rocky reef assessments done within Te Angiangi Marine Reserve, there are generally no data on how these systems are faring elsewhere, especially in terms of habitat distributions, habitat quality, and overall biodiversity. This is also true for subtidal soft sediment habitats and those habitats deemed important/significant for fisheries (see Morrison *et al*. 2014a,b). Obtaining information of this type will be invaluable for SoE and fisheries management purposes moving forward and also allow the possible detection of new species and/or incursions of pest/invasive species. At present there are no consistent/relevant subtidal baselines for Hawke Bay subtidal habitats, which is of concern.

9.4.1 Subtidal rocky reef monitoring

It would be beneficial for rocky reef monitoring to target biogenic habitats of significance (mussel beds, kelp and sponge habitats) and include species of cultural importance (kina, paua *etc*). It would also be advantageous to ensure sampling methodologies are consistent with the depth-stratified sampling presented in Shears and Babcock (2007) including, where relevant, methodological toolboxes for environmental monitoring currently being developed by DoC. Ensuring consistency with those methodologies has the advantage in so far as results generated can be compared at both regional and national scales. Assuming robust methodologies are developed, monitoring of this nature would not be required on an annual basis e.g., every 3-5 years would be sufficient. The subtidal monitoring would be consistent with the existing SoE monitoring aims and objectives.

Action-points

- As a starting point, 3 sites within Hawke Bay where subtidal rocky reef habitat is abundant should be established for monitoring purposes. Sites could include:
    - Pania Reef - due to its high customary and recreational value and proximity to Napier Port and City;
    - Tangoio Bluff - due to its customary and recreational value, physical makeup (boulder and more- isolated nature relative to Pania Reef; and,
    - Black Reef - due to its customary and recreational value, physical makeup (large size) and location.

  Te Mahia sites sampled by Shears and Babcock (2007) could also be added to the sampling programme if deemed feasible. Data collected would likely include biotic (species size, percent cover, biomass) and abiotic measures (depth, rock type, sediment cover).

9.4.2 Sidescan and drop-cam survey of the Wairoa Hard and other areas of fisheries importance

The significance of the Wairoa Hard as a nursery habitat for many fish species within Hawke Bay cannot be overstated (Chapter 5). Given its importance, a detailed survey of this area would be well justified. This will not only provide a long-overdue summary of the types of habitats present and their spatial extents, but also afford some insight to the degree this area has, or has not, been affected by sedimentation. It is the authors' opinion that previous surveys evaluating habitat types within the Wairoa Hard were not spatially explicit. As a consequence, we still lack a true understanding of the physical and biological makeup of this area.

In addition to the Wairoa Hard, other areas of fisheries importance such as the nearshore area between Napier Port and Tangoio Bluff could be surveyed with acoustic methods such as that done for the Hauraki Gulf (Morrison *et al*. 2003). Such an approach would start to shed some light on spatially significant benthic habitats across this area. Notably these larger surveys would require investment from a range of agencies/stakeholder groups.

Action-points

- Undertake a systematic survey of the Wairoa Hard using side-scan sonar, remote video and grab sampling (for ground truthing purposes). Use data generated to create a habitat map of the physical and biological environments across this coastal area.

- Undertake an acoustic survey of the nearshore benthic habitats between Napier Port and Tangoio Bluff. Again, data can be used to generate a habitat map of the physical and biological environments.

- Both datasets can be incorporated into the GIS database produced as part of this project and overlaid with fisheries data (see 8.0 below).

9.4.3 Subtidal soft sediment monitoring

Of equal importance is to develop a nearshore subtidal soft-sediment monitoring programme in some capacity that can be used as an independent baseline for all agencies. Presently there are a range of soft sediment monitoring programmes in place within Hawke Bay associated with effects-based monitoring e.g., waste-water outfalls and dredge disposal. While these studies are generally of high quality and follow a standard methodology, they are by default spatially limited. Moreover, due to evidence of historical degradation pre-monitoring, it is unknown if data measured across these programmes merely represent an already impacted environment. Consequently, it would be beneficial to establish 3 to 4 subtidal soft sediment monitoring sites across Hawke's Bay (e.g., Te Mahia, nearshore Napier, Ocean Beach).

The purpose of the monitoring would be to garner baseline data across a long-shore gradient from which changes in benthic community and composition through space and time could be further evaluated. Again, data of this nature could be compared at regional and national scales in order to evaluate how the Hawke's Bay "measures up" against other regions and be used to appraise wider environmental effects and change, e.g., assess shift in epifaunal communities, as is presently being reported by commercial fishers.
In a similar vein, the existing data derived from the various consent-based monitoring should be compiled within the GIS database produced as part of this project so that it can be used in supplementary "meta-analyses".

Action-points

- Establish 3-4 soft-sediment sampling locations across an environmental gradient (Mahia – Ocean Beach) that can be used for SoE monitoring and fisheries-related purposes. Sites could be sampled with a combination of techniques (dredge tows, grab sample) and like rocky reef sampling surveyed every 3-5 years.

- Compile resource-consent data and incorporate into GIS database.

9.5 Strategy 5 – Development of a hydrodynamic model for Hawke's Bay

Key Objective: Improve the understanding of coastal processes, climate change and impacts of various impacts on the CMA**.**

Given the extensive modifications from forest to pasture within the Hawke's Bay region over the last 100+ years and obvious far-field effects of river plumes (sedimentation and nutrient enrichment), together with the range of point-source discharges (municipal wastewater, Pan Pac, storm water), including dredging activities (which are expected to increase in the near-future), development of an "in-house" 3-D hydrodynamic model using Delft-3D that encompasses the entire Hawke's Bay CMA would be beneficial. Existing bathymetry, data collected by HAWQi, and wave data from the Napier Port would be readily available for input and establishing a robust hydrodynamic model. The advantage of the Delft 3D approach is that it highly flexible, open source, and is becoming the world-leader in hydrodynamic modelling.

Development of such a model would enable investigations to be made relating to:

- Nearshore and offshore hydrodynamics;
- Forecast guidance;
- Scenarios relating to climate change (inundation, wave runup *etc*)
- Sediment transport;
- Contaminant fates;
- Dredge disposal;
- Water quality scenarios for fluvial, estuarine and coastal environments;
- Oceanographic productivity and forecasts of harmful algal blooms;
- Cumulative impacts of various land-based and water-based activities.

Action-point

Construct/develop a hydrodynamic model for Hawke's Bay that will facilitate improved understanding of the Hawke's Bay CMA including the effects of a range of activities presently operating within the Hawke's Bay CMA.

9.6 Strategy 6 – Evaluate effectiveness of spatial fisheries management areas

Key Objectives: Improve the understanding of various spatial fisheries management areas within Hawke's Bay; Combine diverse knowledge bases.

As identified in Chapter 5.0 the Hawke's Bay region has had a long history of establishing fisheries management areas that restrict either certain fishing sectors, fishing methods, and/or vessel sizes (Fig. 5.4). Apart from the monitoring done sporadically within Te Angiangi marine reserve which invokes prohibition of fishing at one extreme of the protection landscape (complete no-take), it is not overtly clear how the various restrictions and closures (based on area and time) are, or are not, functioning within Hawke Bay, nor the habitat types associated with them. Appreciably, these areas are large, fish stocks may take some time to rebuild, and methods to evaluate recovery of target species would require some effort in developing (likely to be multifaceted) and require considerable resources (see Cochrane 2002). Given these various constraints it would be of immense value to the wider Hawke's Bay fishery to establish a working group and workshops with relevant scientists, stakeholders and agencies to work through the strategies underpinning these management areas, and in particular the sampling protocols required to evaluate their effectiveness.

Action-point

- Evaluate the effectiveness of fisheries management areas within Hawke's Bay, through formation of a specific working group. The working group would appraise the strategies underpinning the management areas, determine how to best assign them (location, time and size) and the best way to evaluate their efficacy.

9.7 Strategy 7 – Determine fisheries habitats-linkages within Hawke's Bay

Key Objective: Improve the understanding of the role of different habitat types and identify major habitat linkages for frequently fished species.

The role of various habitat types in fisheries production within New Zealand is gaining increasing attention in the ecological literature (see Morrison *et al*. 2014a,b). This focus primarily stems from a general paucity in our knowledge on the value of certain habitat types for various life history stages of commonly fished species. Many of the information gaps highlighted in review documents are directly attributable to the Hawke's Bay region.

Action-point

Undertake a workshop focusing on what the habitat linkages are important for key fished species within Hawke's Bay. Identify and prioritise research that addresses knowledge gaps in tandem with establishing protection/enhancement methods for those habitats.

9.8 Strategy 8 – Continue to develop GIS database developed for this project

Key Objective: Build further capacity within the GIS database

The GIS module developed as part of this project contains information regarding the range of physical and biological habitats that constitutes the Hawke's Bay CMA. This data varies considerably in nature and age and there is a real deficiency in finer-scale details of habitat composition. It is anticipated that as new data comes to hand various components (finer-scale data on habitats, customary information, fisheries information) will be updated accordingly and the knowledge base across Hawke's Bay will continue to build. As it presently stands there are a range of possible analyses that could be done within the GIS module. An obvious starting point would be to integrate fisheries trawl data available for Hawke's Bay (Fig. 7.7), recreational fishing data *etc*, and evaluate where key species are fished and the habitat types underpinning these areas. Again this type of analysis could be a starting point to drive supplementary investigations.

Action-Point

Continue to develop GIS database with marine-based information when and as it come to hand. Some of this data will be held by various agencies and other data is likely to be generated when various strategies outlined above are undertaken. It is envisioned that this database will become increasingly invaluable for coastal management purposes moving forward.

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Appendix 1.0 Geodatabase development for Hawke's Bay CMA

The following steps outlines the general development procedure for the GIS database (geodatabase) produced for the project. The database is underpinned by a grid that holds abiotic and biotic information termed the Hawke's Bay Marine Grid (HBMG)

1.0 Organizational functions

There are three main organisational functions required of the geodatabase developed for this project. In the first instance, the database must be a succinct organisational structure for information relevant to marine resource planning and management. Secondly, the database must inform the procurement of further studies. Lastly, it must function as a living structure, able to be updated when the further studies produce new information. As such a grid-based approach was deemed the most appropriate structure.

2.0 Source data

Data underpinning the geodatabase were derived from a variety of sources, including physical and biological habitat maps, side scan sonar, and anecdotal (local knowledge) information. Data derived from the stakeholder interview process that was inscribed onto paper maps included commonly targeted species, fish distributions including migration pathways within Hawke's Bay. Information contained on maps were then digitised and incorporated into the GIS database. Available digitized data of marine information and spatial extent of biological and physical habitat held by Hawke's Bay Regional Council and DoC were also incorporated into the database.

3.0 Creating study area

The creation of the study area grid (HBMG) followed four steps. First, a study area was outlined. Second, this study area was subdivided into depth ranges of 0-100 m, 100-200 m, and 200-400 m. A different sized grid was used for each range (100 m, 200 m, and 400 m respectively). This was because a 100 m grid over the entire study area would take considerable space and would slow the querying process. Third, the spatial grids were created within each of the subdivided zones of the study area. Finally the fourth step, which required attaching classification attributes to each grid cell based on the location of the cell. Attaching these attributes required a number of **spatial joins**. Fig. A1 depicts steps in the grid formation process.

Spatial joins describe the process of attaching attributes to a particular geometry based on the position of that geometry to another. In this case the join asked, for each and every grid cell in the spatial grid, "what habitat classification is under me". If more than one habitat classification was contained within the grid cell, it returned only that classification that took up the majority of its area.

A habitat classification scheme for coastal marine areas is currently being developed for New Zealand by the Department of Conservation, which broadly follows the Marine Protected Areas habitat classification scheme (DoC/MPI 2008). To facilitate future organization of marine habitat information the classification of physical and benthic habitats in the HBMG in part follows this classification scheme

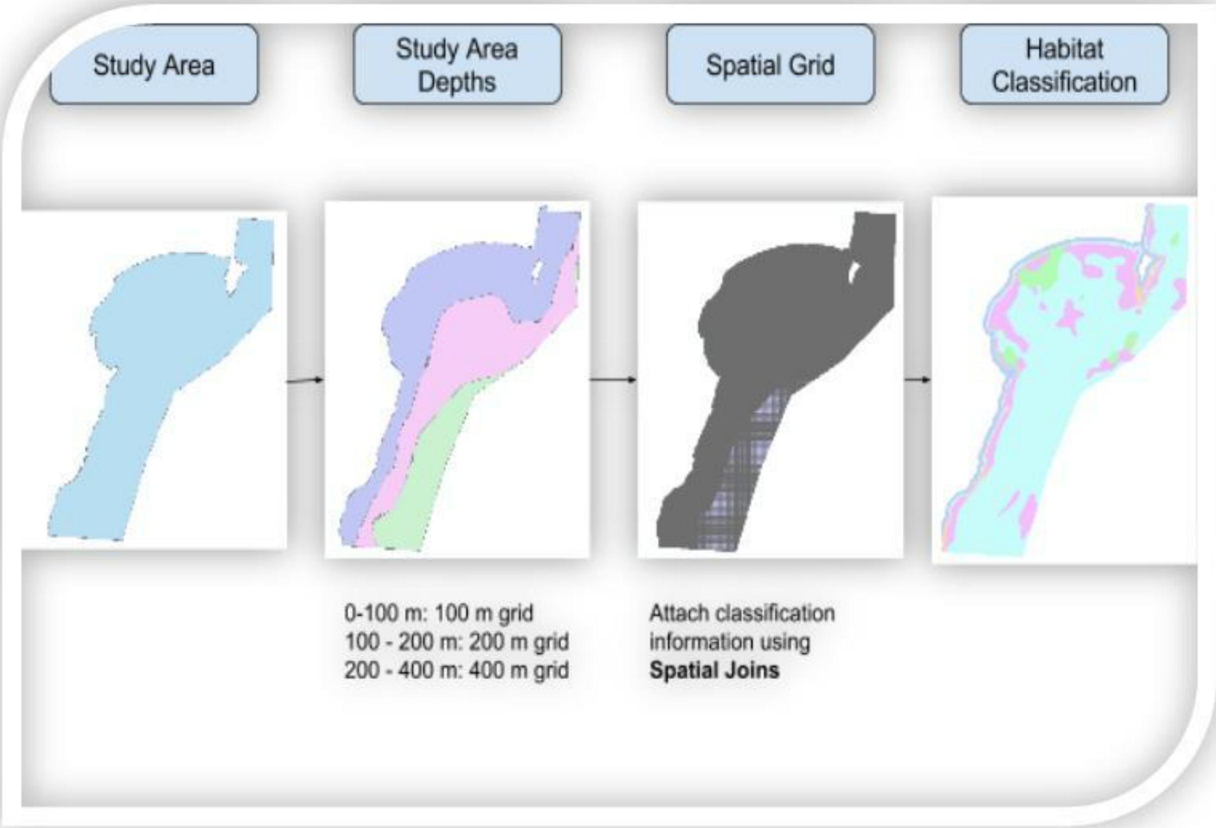

Figure A1. Sequential steps in the formation of the GIS Hawke's Bay Marine Grid HBMG) and database layers.

4.0 Structure of the geodatabase

Formats
The geodatabase is an ESRI file geodatabase. This format was chosen for two reasons: (1) it is fully supported by the ESRI ArcGIS software products used by the Hawke's Bay Regional Council (and will be well into the future), and (2) because the data size limitations for this database format fall well within the requirements of the HBMG. Within this format a single data layer can be up to 1 Tb in size, and can contain 65,000 columns and 2.5 million rows. The database itself can hold 2.1 billion individual data layers (ESRI2016). These limitations are well above the scope of the HBMG.

5.0 Layers

Hawkes'_Bay_Marine_Grid - This layer is the main output of the process. It contains the final result of stamping the various data sources to the study grid geometry.
Grid_Geometry- This layer contains the original grid geometry, without any of the attributes from the study.
Study_Area - This layer contains the geometry for the polygon that defines the study area.

Inputs - This is a feature dataset that contains the input layers used to stamp information onto the grid. The contained layers are what was stamped onto the grid geometry.
Abiotic - This layer contains the Abiotic attributes for the NZMHCS.
Biotic - This layer contains the biotic attributes for the NZMHCS.
Phys_Characteristics - This layer contains the Physical Characteristics attributes from the NZMHCS.
Iwi - This layers contains attribute info for Iwi boundaries and Takatai Moana.
Activities - This layer contains attribute info for consented activities within the study area.
Fisheries_Management - This layer contains attribute info for the fisheries management areas within the study area.
Fisheries - This layer contains attribute info for the species and methods used in the fisheries within the study area.

6.0 Source - This feature dataset contains all source material used to produce the classification presented in the "NZMHCS" layer.

7.0 NZMHCS Data Dictionary

Field name	**Type**	**Description**
MIN_X	Integer	Minimum X extent of grid cell
MIN_Y	Integer	Minimum Y extent of grid cell
MAX_X	Integer	Maximum X extent of grid cell
MAX_Y	Integer	Maximum Y extent of grid cell
Depth	Text	Mean depth within cell
Environment Type	Text	Broad description of geography within grid cell
Environment Type 2	Text	Sub-classification of geography
Exposure	Text	Level of exposure for that environment type
Broad Habitat	Text	Classification of broad habitat type
Physical Habitats	Text	Classification of benthic habitat
Substratum Texture	Text	Description of surficial geology
Physical Confidence	Text	Rating of confidence level for the info
Physical Data Type	Text	Type of source data used to determine abiotic information
Physical Data Source	Text	Type of source data used to determine abiotic information
Physical Reference	Text	Bibliographic reference of materials used in classifying abiotic information