HAWKE'S BAY COASTAL HAZARDS

ECOLOGICAL MONITORING PLAN

COAST & CATCHMENT
ENVIRONMENTAL CONSULTANTS

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Shane Kelly

Carina Sim-Smith

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1 CONTENTS

2 BACKGROUND

The Clifton to Tangoio Coastal Hazards Strategy 2120, developed by Napier City Council (NCC), Hastings District Council (HDC) and Hawke's Bay Regional Council (HBRC) (hereafter referred to as 'the Councils'), aims to make coastal communities, businesses and critical infrastructure from Tangoio to Clifton (Figure 1) resilient to the effects of coastal hazards. The proposed interventions include:

- around 6 km of coastal seawalls, 20 km of coastal beach renourishment, with sand and gravel, including the (re)creation of gravel banks and barriers on beaches, and sand deposition in subtidal areas to create offshore sandbars that migrate shoreward and raise foreshore levels;
- control structures placed along 18 km of coastal beach, including groynes and breakwaters that curb or constrain coastal erosion and the construction of seawalls that act as a physical barrier to coastal erosion and inundation;
- the potential construction of an inflatable storm surge barrier to protect people and property around the outer Ahuriri Estuary during significant events;
- dune planting; and,
- retreating back from the coast (Table 1; Bendall, 2018; Beya & Asmat, 2020; 2021).

The Councils are seeking to ensure that sufficient data are available to be able to assess and mitigate any ecological effects that the proposed interventions may have on the local ecological communities. It is anticipated that the overall project is to be carried out over six phases covering:

1. An initial analysis of information gaps.
2. Mana whenua and community engagement.
3. Development of a proposed monitoring plan to fill key gaps.
4. Implementation of the monitoring plan.
5. Preliminary ecological input on Assessment of Ecological Effects (AEE) requirements to support any consent application(s).
6. Provision of detailed ecological input on AEE(s).

Coast and Catchment completed Phase 1 in 2021 (Kelly & Sim-Smith, 2021) and have been commissioned to undertake Phase 3 of the project, which includes:

- provision of a brief summary of the ecological information gaps identified during Phase 1 (Kelly & Sim-Smith, 2021);
- discussion of the priority areas identified by the Councils and issues to target monitoring towards key issues, taking into account proposed timeframes for implementing hazard controls;
- provision of a detailed package of work for the next 10 years;
- provision of a detailed ecological sampling methodology for carrying out that work, and general advice on data analysis and reporting requirements;

- highlighting any issues where other assessments/monitoring (e.g., modelling and turbidity monitoring) may be beneficial to inform the interpretation of ecological results.

It should be noted that the magnitude of the ecological impact will depend on numerous factors including the type of intervention chosen, methods used to implement/construct the intervention, the location of the intervention, and site-specific information on the ecology of the area. Given that only high-level information is currently available on the proposed interventions, this monitoring plan has been designed to fill in broad-scale key knowledge gaps. It is likely that more detailed site-specific surveys will be required in addition to this monitoring plan prior to finalising the choice and design of any particular invention.

Figure 1: Map of Clifton to Tangoio Coastal Hazard Strategy Project Area. Note that the assessment units shown in this figure differ from those used for the final preferred pathways (Table 1).

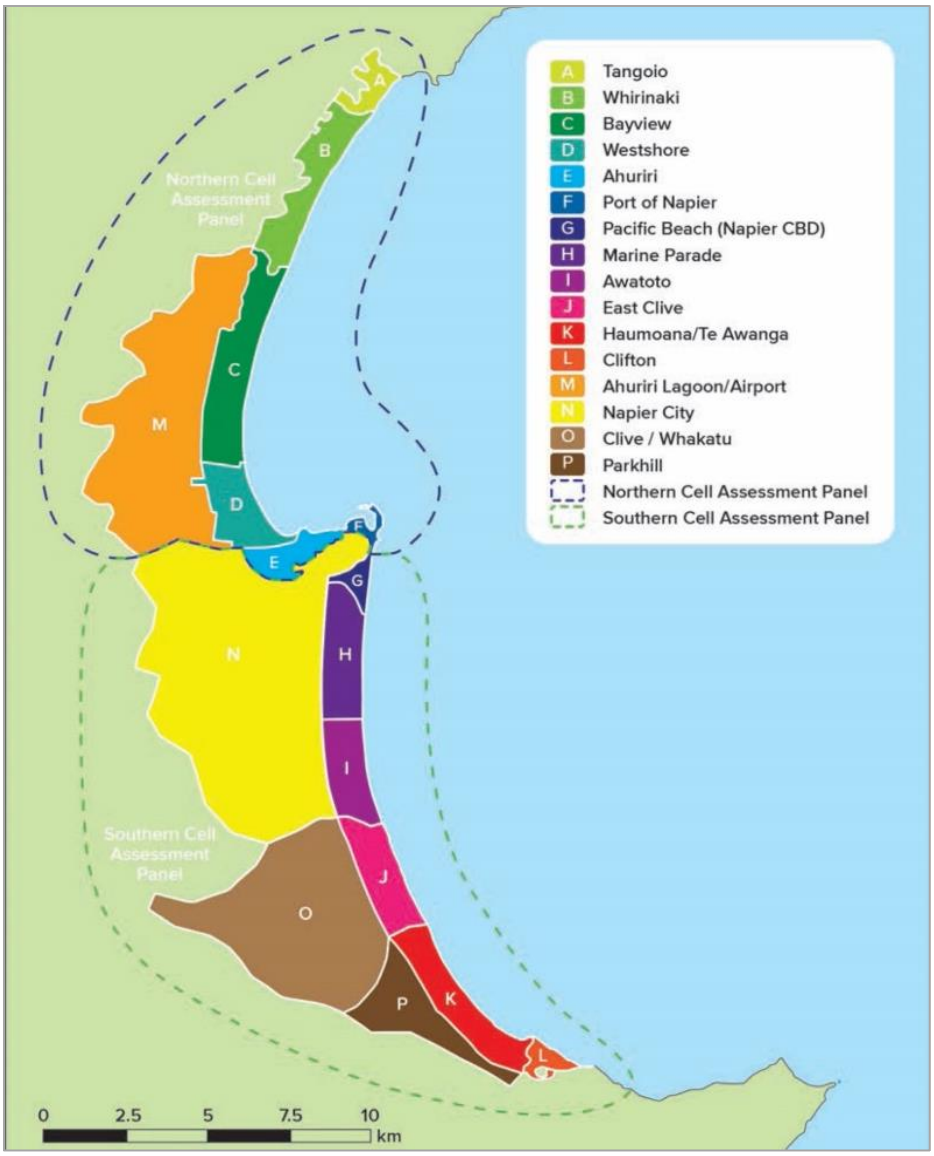


Table 1: Final preferred pathways (provided by Simon Bendell).

	Unit	Short term (0–20 years)	Medium term (20–50 years)	Long term (50–100 years)
Northern Cell	Whirinaki	Status Quo / Renourishment	Renourishment + Control Structures	Sea wall
	Bay View	Status Quo / Renourishment	Renourishment + Control Structures	Renourishment + Control Structures
	Westshore	Renourishment	Renourishment + Control Structures	Renourishment + Control Structures
	Ahuriri[1]	Status quo	Sea wall	Sea wall
	Pandora[2]	Status quo	Storm surge barrier	Storm surge barrier
Southern Cell	Clive / East Clive	Status quo	Renourishment + Groynes	Retreat the Line / Managed Retreat
	Haumoana	Renourishment + Groynes	Renourishment + Groynes	Managed Retreat
	Te Awanga	Renourishment + Groynes	Renourishment + Groynes	Renourishment + Groynes
	Clifton	Status quo	Sea wall	Managed Retreat

3 SUMMARY OF THE INFORMATION GAPS IDENTIFIED IN PHASE 1

The areas potentially affected by proposed mitigation measures are likely to be confined to the intertidal and shallow (< 15 m depth) nearshore subtidal habitats, including intertidal beaches and subtidal sediments, the surf zone, reefs, and the water column. Kelly and Sim-Smith (2021) identified available information on the coastal marine ecology of the area in relation to the proposed interventions and identified key gaps. Table 2 and Table 3 provide a summary of the key issues and areas where Kelly and Sim-Smith (2021) identified knowledge gaps for assessment of the ecological impacts of coastal hazard interventions. For the purposes of this plan, the gaps identified in the previous assessment have been summarised and grouped into primary and secondary considerations.

The primary gaps are considered to be:

1. A lack of ecological data for subtidal seafloor communities in the Bay View, Clive and Te Awanga and Haumoana units (see Figure 2 for existing data coverage).
2. Predictions of sediment dispersal and deposition away from the primary deposition sites used for beach renourishment. Note that the assessment of sediment dispersal and deposition requires expertise in hydrodynamics and coastal processes, rather than marine ecology. However, outputs from hydrodynamics and coastal process assessments are a key input into ecological assessments.
3. The lack of data from subtidal reefs at the northern and southern extents of the proposed intervention units (i.e., Tangoio reef complex and Clive Hard). The potential for adverse ecological effects on those systems depends on whether

[1] Interventions in the Ahuriri Unit actually involve the seawall along Hardinge Rd.

[2] The Pandora Unit is located within the outer Ahuriri Estuary.

materials are going to be deposited or dispersed onto them. An assessment of ecological effects would be informed by information derived from (2) above.

4. The paucity of benthic ecological information from the outer Ahuriri Estuary. The significance of that gap will depend on the interventions selected.

Gaps of secondary importance are considered to be:

1. Information on shoreline ecology, although it is assumed that related effects are likely to be minor due to the likely paucity of intertidal beach fauna (apart from the areas around Rangatira Reef and towards the Port).
2. Site specific information on avifauna values that may be affected by the proposed interventions. Key issues are likely to be the identification of species that utilise the areas affected, and potential effects on their breeding, roosting and foraging habitats. It is recommended that scientific advice is sought from an avifauna specialist around one year prior to consenting, so that any assessment includes information from the breeding seasons of any bird species that would potentially be affected (generally spring–summer).
3. Site specific information on vegetation values that may be affected by the proposed interventions. It is recommended that actions are taken to fill this gap around one year prior to consenting.
4. Specific information on loss of habitat (those habitats where effects can not be avoided, remedied, or mitigated) to inform offsetting or compensation discussion.
5. Specific information on reductions associated with ecosystem service loss from those habitat losses where the effects cannot be avoided, remedied, or mitigated.
6. The long-term, cumulative ecological effects of the sediment deposition, together with other activities carried out in the area are uncertain. The lack of knowledge of about that issue is considered to be a key gap. However, a robust assessment of the cumulative effects of sediment in the Hawke Bay would be a significant undertaking well beyond the scope of this project and more suited to a stand-alone study. Information generated through proposed monitoring could be fed into such a project.

This report focuses on monitoring to fill the **primary ecological gaps** listed above, and for efficiency, coincidental information gathering on shoreline ecology during proposed marine surveys. However, it is noted that information on secondary gaps is also likely to be important when determining the ecological impact of the intervention, and therefore, needs to be considered prior to choosing the final intervention design. Information on the secondary gaps for particular sites may need to be collected once further site-specific details on the proposed interventions are available.

Figure 2: Distribution of open coast sampling stations identified from a selection of relevant assessment and monitoring reports (Barter & Keeley, 2002; Sneddon & Keeley, 2004; Golder Associates, 2007; Smith, 2008; Sneddon, 2011; Smith, 2013; Smith, 2015; Smith, 2017a; Sneddon *et al.*, 2017b; Sim-Smith & Kelly, 2019; Sneddon, 2019a; 2019b; Apex Environmental Limited, 2020; Sneddon, 2020; Carter *et al.*, 2021; Sneddon, 2021; Sneddon & Dunmore, 2021).

Table 2. Units where there are knowledge gaps for the assessment of the ecological impacts of coastal hazard interventions. Units that are affected by the intervention are shaded in blue, and areas where there are knowledge gaps are shown by a tick mark (summarised from Kelly and Sim-Smith (2021)).

	Northern Cell					Southern Cell			
Knowledge gaps	Whirinaki	Bay View	Westshore	Ahuriri	Pandora	Clive/East Clive	Haumoana	Te Awanga	Clifton
Smothering by deposition									
Intertidal seafloor communities						✓	✓		
Subtidal seafloor communities		✓						✓	
Impacts on shoreline communities	✓	✓	✓			✓	✓	✓	
Impacts on rocky reefs							✓	✓	
Sediment suspension									
Site specific impacts	✓	✓	✓			✓	✓	✓	
Burial beneath structures									
Habitats and communities present	✓	✓	✓	✓	✓	✓	✓	✓	✓
Hardening of the shoreline									
Habitats and communities present and community development post-intervention	✓	✓	✓	✓	✓	✓	✓	✓	✓
Changes in coastal processes									
Habitats and communities present and how coastal processes will change	✓	✓	✓	✓	✓	✓	✓	✓	✓
Physical disturbance during construction									
Habitats and communities present and construction methods	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 3: Summary of gaps identified in the Phase 1 report.

Issue	Units potentially affected	Potential significance of effects	Contextual gaps	Ecological gaps
Smothering of seafloor and intertidal communities by deposited or redistributed sand and gravel	Whirinaki, Bay View, Westshore, Clive/East Clive, Haumoana, Te Awanga	At least minor adverse effects are expected, but significant adverse effects are unlikely unless sensitive habitats are affected, and if depth of sediment deposits are not minimised.	Precise locations of primary deposition areas. Secondary areas potentially affected by the distribution of deposited material.	Information on subtidal seafloor communities, particularly for the Bay View, Clive, Haumoana, and Te Awanga areas. Lack of ecological information on subtidal reefs. Lack of ecological information on intertidal shoreline communities. The long-term, cumulative ecological effects of the sediment deposition, together with other activities carried out in the area.
Sediment suspension	Whirinaki, Bay View, Westshore, Clive/East Clive, Haumoana, Te Awanga	Significant adverse effects unlikely, potential to briefly compound a significant existing issue.	Site specific information on the potential generation and dispersal of sediment plumes, particularly where sites adjoin areas of reef.	Lack of ecological information on habitats and communities potentially affected.
Accelerating the spread and proliferation of marine pests	All	Potentially significant, but preventable if precautions are taken.	Continuously evolving issue.	The current absence of a biosecurity management plan.
Burial of benthic communities beneath control structures	All	Minor localised impacts, but could become cumulative.	Confirmation of the type of intervention and areas potentially affected.	Lack of ecological information on the habitats and communities within them.
Shoreline hardening by artificial structures	All	Minor localised impacts, but could become cumulative.	Information on the type and location of structures.	Lack of ecological information for most of the habitats and areas potentially affected.

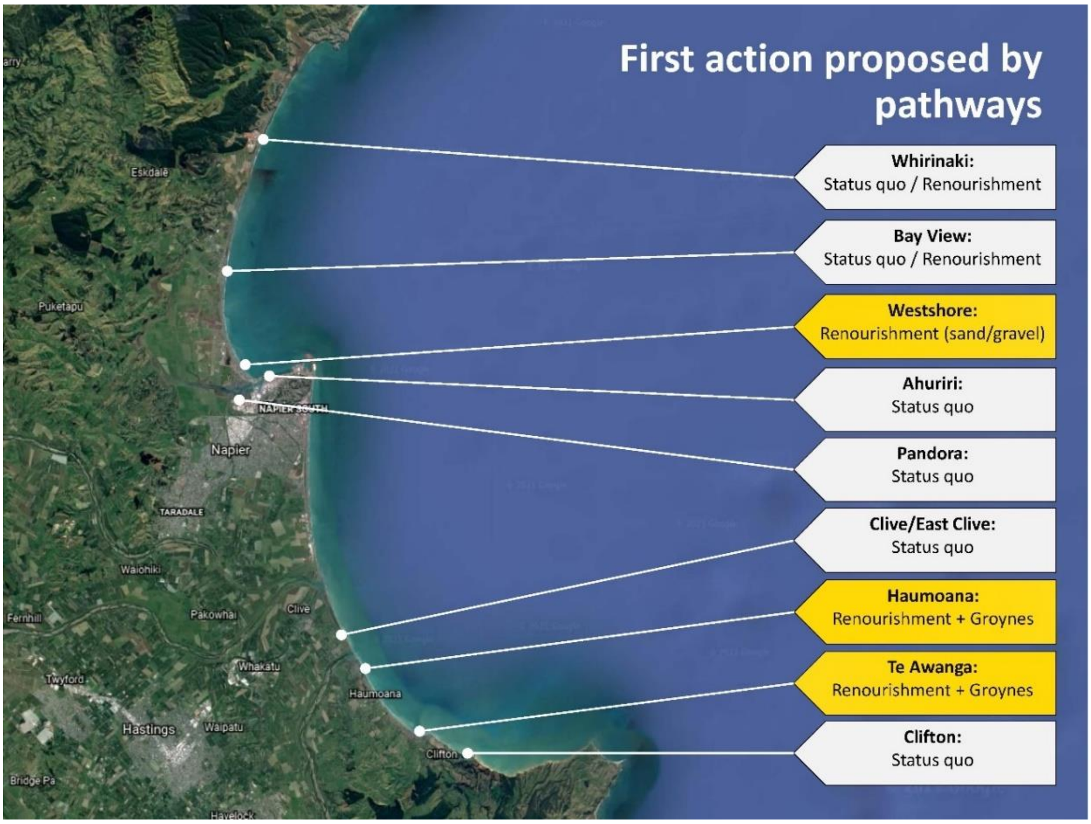
Issue	Units potentially affected	Potential significance of effects	Contextual gaps	Ecological gaps
Changes in coastal processes from interventions	All	Relatively minor, localised impacts are likely, but effects could be more substantial if the structures are large in scale, numerous, and/or affect sensitive habitats.	Information of likely physical changes and specific areas affected.	Lack of ecological information on the habitats and communities within those areas.
Physical disturbance during construction and beach renourishment	All	Relatively minor, localised impacts are likely.	Information construction methods and specific areas affected.	Lack of ecological information on the habitats and communities within those areas.
General effects on Ahuriri Estuary	Pandora	Will depend on the design and physical effects of the proposed storm surge barrier or alternative interventions.	The design, construction methods and physical effects of the proposed barrier or alternative interventions.	Lack of ecological information from the upper and lower estuary.
General effects on coastal vegetation	Most	Will depend on the characteristics of the inventions, the scale and degree of physical effects and the types and values of vegetation and habitats effected.		Site specific requirements for information can be addressed during the design and consenting stages, and to inform mitigations, offsetting or compensation.
General effects on birds	All	Potential for relatively localised impacts, which could be positive for some species and adverse for others.		Site specific assessment should be sought at least one year prior to consenting.
General effects on fish	Whirinaki, Bay View, Westshore, Clive/East Clive, Haumoana, Te Awanga	Potential for relatively localised impacts, which could be positive for some species and adverse for others.		Desktop exercise likely to be sufficient. Consolidated report could be produced that covers all areas.

4 PRIORITY UNITS

The first action priority units identified by the Councils are Te Awanga, Haumoana and Westshore (Figure 3).

1. **Te Awanga**: Proposed short-medium term actions include the creation of a larger beach through renourishment and groynes. Regular renourishment will be used to offset erosion losses and groynes will be built to reduce erosion losses and the impact of storms. Longer term, groynes may be raised and lengthened to account for sea level rise and to maintain the standard of protection.
2. **Haumoana**: Proposed short-medium term actions include the creation of a larger beach through renourishment and groynes. Regular renourishment will be used to offset erosion losses and groynes will be built to reduce erosion losses and the impact of storms. There is an acceptance that increasing the beach and groyne size will not be practical in the long-term and managed retreat is likely to be required.
3. **Westshore**: Proposed short-term actions include regular gravel and sand renourishment to offset erosion losses and raise foreshore levels, with beach maintenance and planting complimenting those actions. Sand will be deposited offshore and allowed to migrate northwards and towards the beach. In the medium-term, groynes will be constructed and additional replenishment will occur. Longer term actions include lengthening and raising groynes, and further replenishment.

Figure 3: First action priority units.



4.1 EXISTING INFORMATION: TE AWANGA & HAUMOANA

The foreshore of Te Awanga and Haumoana comprises a narrow gravel beach that grades from pebbles/gravel on the upper beach to sand in the lower intertidal area (Figure 4A & 3C). Tukituki River intersects the beach north of Haumoana, and Maraetotara River intersects the beach at the southern end of Te Awanga Beach. Herbfields comprising ice plant (*Disphyma australe* subsp. *australe*), pōhuehue (*Muehlenbeckia complexa*), ngaio (*Myoporum laetum*) and non-indigenous marigolds (*Tagetes erecta*), are present behind the northern part of Te Awanga, and ngaio and iceplant are present behind Haumoana Beach (Stevens & Robertson, 2005).

No specific information could be found on the intertidal beach fauna of Te Awanga or Haumoana, but they are likely to be depauperate due to the high bed shear velocities and strong wave actions. Smith (2017b) visually surveyed the adjacent Clifton Beach and found no obvious infauna present on the beach.

The nearshore subtidal substrate of both areas is predominantly sand (Smith, 1968), and based on nearby locations, the substrate further offshore is likely to be a mixture of sand and mud (Golder Associates, 2007). Rock interspersed with sand is present in the nearshore subtidal areas of Te Awanga, while sand and gravel dominated the entrance of Tukituki River of Haumoana (MetOcean, 2011 in Haggitt & Wade, 2016).

No specific information could be found on the subtidal communities around Te Awanga and Haumoana, but sampling around the Hastings Wastewater outfall (approximately 3 km offshore between Tukituki and Clive Rivers) found that the infaunal community more than 500 m[3] from the outfall was numerically dominated by the polychaetes *Ampharete* sp. and *Paraprionospio* sp., a Gammeridae amphipod, and the bivalves *Dosina* sp., *Linucula hartvigiana*, and the non-indigenous *Theora lubrica* (Golder Associates, 2007). Dominant infaunal species within the wider Hawke's Bay include: the bivalves *Nucula nitidula*, *Maorimactra ordinaria*, *Moerella huttoni*, *Dosinia lambata, Tawera spissa, Purpurocardia purpurata, Glycymeris modesta, Tucetona laticostata, Gari stangeri, Scalpomactra scalpellum* and *Oxyperas elongatum;* and the echinoderms *Echinocardium cordatum* and *Amphiura aster* (McKnight, 1969).

A complex cobble and pebble seabed habitat, interspersed with large areas of muddy sediment, known as the Clive Hard is present between Tukituki River and Cape Kidnappers, which comes within 500 m of the beach between Haumoana and Te Awanga (Figure 5). Benthic samples obtained from around Clive Hard in the 1960s found that the community was dominated by the bivalves *T. spissa, Vernericardia purpurata, T. laticostata, G. modesta* and *G. strangeri* (McKnight, 1969). Recent habitat data has been obtained from the Clive Hard using Multibeam Echo Sounders and Remotely Operated Vehicles (HBRC, pers. comm.).

Clive Hard is an important habitat for juvenile fish, particularly snapper (Morrison *et al.*, 2014a), and is particularly popular for recreational fishers. Targeted species include various flatfish such as yellow-bellied flounder (*Rhombosolea leporina*), sole (*Peltorhamphus novaezelandiae*), red gurnard (*Chelidonichthys kumu*), kahawai (*Arripis trutta*), snapper (*Chrysophrys auratus*), trevally (*Pseudocaranx dentex*), tarakihi (*Nemadactylus macropterus*),

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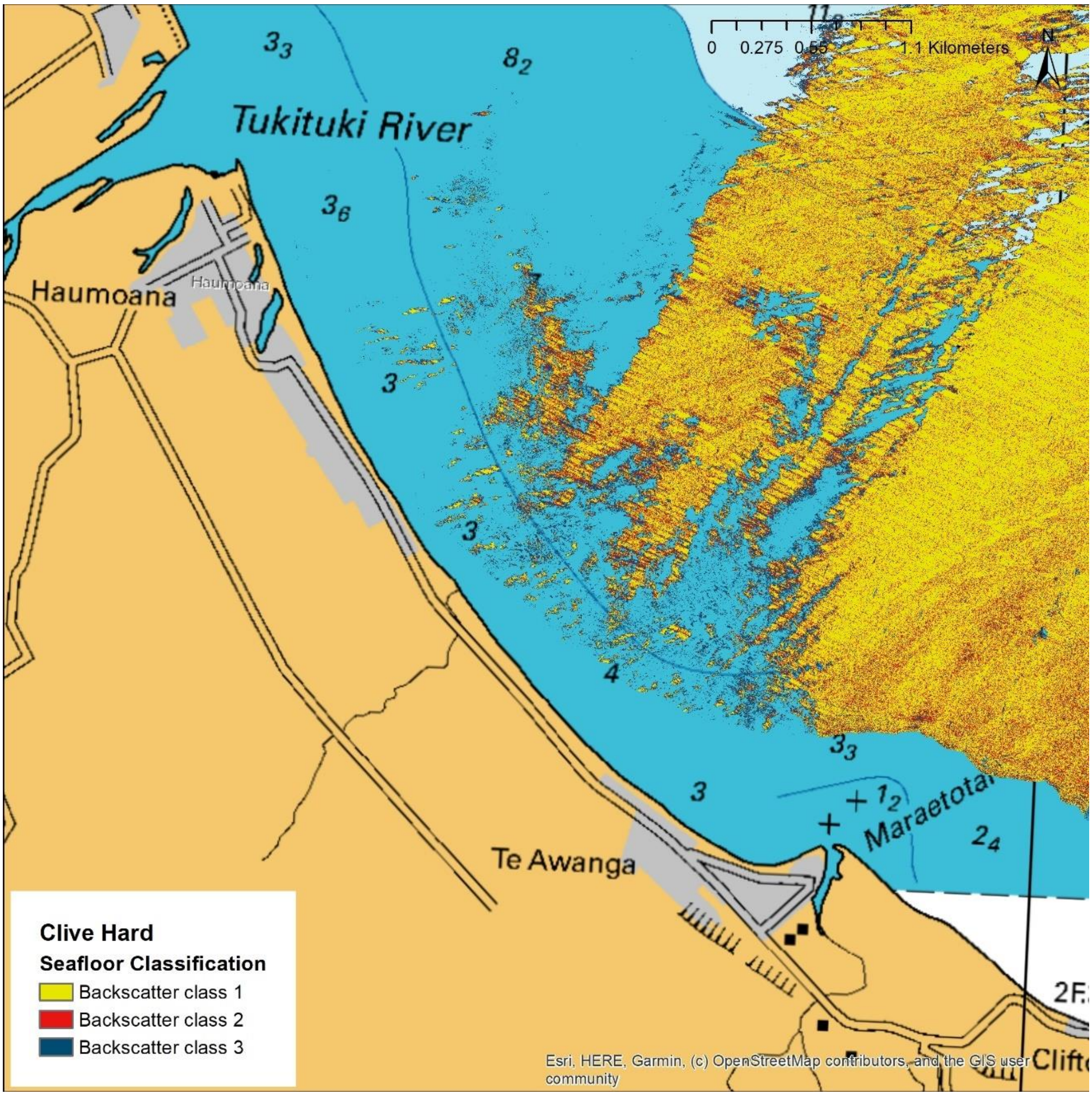
[3] Benthic communities in this area were similar to reference communities located 2,500 m from the outfall.

John Dory (*Zeus faber*), rig (*Mustelus lenticulatus*), moki (*Latridopsis ciliaris*), and red cod (*Pseudophycis bachus*) (Morrison *et al.*, 2014b; Haggitt & Wade, 2016; Jones *et al.*, 2016; Smith, 2017b).

A small shallow subtidal reef exists adjacent to the mouth of the Maraetotara Lagoon, that is a popular mussel (*Perna canaliculus*) harvesting site. However, water quality in the area is poor, and water quality monitoring shows that the site often fails to comply with *Escherichia coli* thresholds for safe shellfish harvesting or recreational water use (Gilmer *et al.*, 2014; Madarasz-Smith *et al.*, 2019; LAWA, 2023).

Figure 4: Examples showing the general characteristics of foreshores (left) and marine biota washed up on the shore (right) along A–B) Te Awanga C–D) Haumoana, and E–F) Westshore.

Figure 5: Multibeam data obtained by NIWA, showing the proximity of the Clive Hard to Te Awanga and Haumoana.



Around 28 sea and shorebirds have be recorded on the coastline between Westshore Beach and Te Awanga (Table 1). Of particular note were numerous breeding pairs of banded dotterel found on beaches between Westshore Beach and Haumoana and breeding colonies of pied stilt found around Ahuriri Estuary and Tukituki River mouth (McArthur *et al.*, 2021).

Table 4. Seabirds and shorebirds observed between Westshore Beach and Te Awanga. Data from McArthur *et al.* (2021) and eBird (2023)[4]. Note that many eBird observations are made by the general public and are unverified. Conservation status is from Robertson *et al.* (2021).

Common name/Maori name	Scientific Name	Conservation status
White heron/kōtuku	*Ardea alba*	Threatened: Nationally Critical
Australasian bittern/matuku-hūrepo	*Botaurus poiciloptilus*	Threatened: Nationally Critical
Black-fronted tern/tarapirohe	*Chlidonias albostriatus*	Threatened: Nationally Endangered
Caspian tern/taranui	*Hydroprogne caspia*	Threatened: Nationally Vulnerable
Wrybill/ngutu pare	*Anarhynchus frontalis*	Threatened: Nationally Increasing
NZ dotterel/tūturiwhatu	*Charadrius obscurus aquilonius*	Threatened: Nationally Increasing
Lesser knot/huahou	*Calidris canutus*	At Risk: Declining
Banded dotterel/pohowera	*Charadris bicinctus*	At Risk: Declining
South Island oystercatcher/tōrea tuawhenua	*Haematopus finschi*	At Risk: Declining
Black-billed gull/tarāpuka	*Larus bulleri*	At Risk: Declining
Red-billed gull/tarāpunga	*Larus novaehollandiae*	At Risk: Declining
Bar-tailed godwit/kuaka	*Limosa lapponica*	At Risk: Declining
White-fronted tern/tara	*Sterna striata*	At Risk: Declining
Black-fronted dotterel	*Elseyornis melanops*	At Risk: Naturally Uncommon
Little black shag/kawau tūī	*Phalacrocorax sulcirostris*	At Risk: Naturally Uncommon
Royal spoonbill/kōtuku ngutupapa	*Platalea regia*	At Risk: Naturally Uncommon
Black shag/kawau	*Phalacrocorax carbo*	At Risk: Relict
Little shag/kawau paka	*Phalacrocorax melanoleucos*	At Risk: Relict
Variable oystercatcher/tōrea pango	*Haematopus unicolor*	At Risk: Recovering
Pied shag/kāruhiruhi	*Phalacrocorax varius*	At Risk: Recovering
White-faced heron/matuku moana	*Egretta novaehollandiae*	Not Threatened
Pied stilt/poaka	*Himantopus himantopus*	Not Threatened
Kelp gull/karoro	*Larus dominicanus*	Not Threatened
Australasian gannet/tākapu	*Morus serrator*	Not Threatened
Ruddy turnstone	*Arenaria interpres*	Migrant
Whimbrel	*Numenius phaeopus*	Migrant
Pacific golden plover/kuriri	*Pluvialis fulva*	Migrant
Pectoral sandpiper	*Calidris melanotos*	Vagrant

[4] For grid squares BF85, BG85, BG86 & BH86

4.2 EXISTING INFORMATION: WESTSHORE

A reasonable amount of information is available from the Westshore area, particularly the subtidal communities, which is why it is not listed as a gap. Westshore Beach is a steep beach, predominantly comprising fine sand (Figure 4E). Boulder fields, some human-made, are present at southern end of beach, as well as Rangatira Reef (Stevens & Robertson, 2005). The entrance to Ahuriri Estuary is located at the southern end of Westshore Beach, and Hardinge Rd Reef (within the Ahuriri Unit) is located along the shore between Westshore Beach and Port Napier (Figure 6).

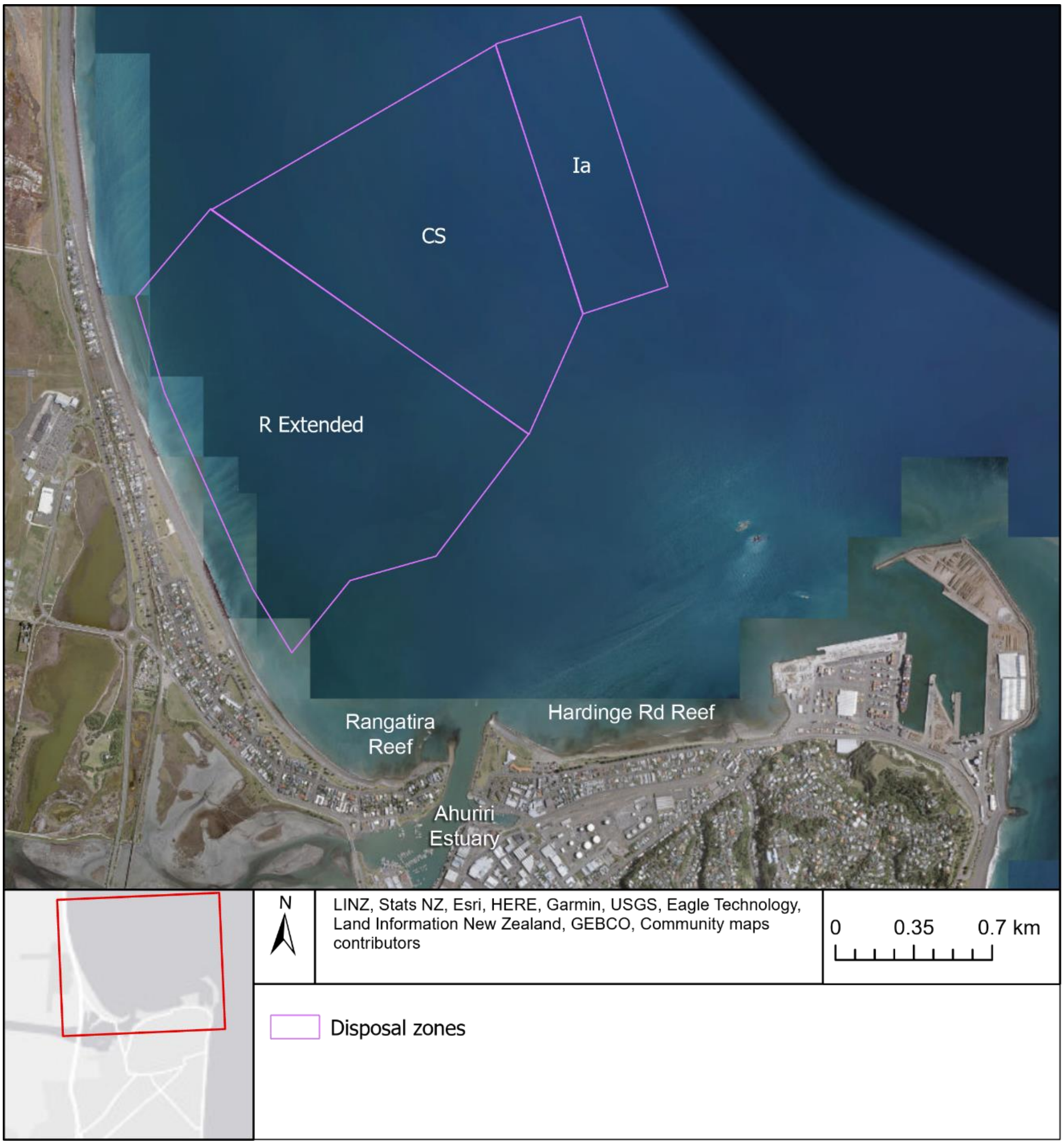
Information on the intertidal biota of the sandy/gravel areas of Westshore Beach is very scarce. Fincham (1977) sampled the beach for peracarid crustaceans (e.g., amphipods, isopods, cumaceans) and only identified one species, *Waitangi chelatus*, from Westshore Beach.

The subtidal soft sediment communities off Westshore Beach have been well surveyed, with most of the information collected through ecological monitoring surveys associated with the disposal of sediment from Port dredging. The seabed in the area is highly dynamic and there is a persistent near-bed layer of high turbidity. Grainsize composition is predominantly fine and very fine sand (~80–90%), with little difference between disposal and non-disposal sites (Figure 6), though deeper sites generally had a slightly higher proportion of fine particles. This indicates that sediment texture is strongly influenced by wave-shear effects close to shore. However, there was relatively high variation in grainsize among surveys, indicating that temporal variability is moderately high (Sneddon *et al.*, 2017a; Sneddon & Atalah, 2018; Sim-Smith & Kelly, 2019).

Infaunal benthic communities in nearshore subtidal areas off Westshore Beach typically had moderately low numbers of taxa (mean ~10, range 5–26/core) and individuals (mean ~30, range 5–200/core), moderate diversity (Shannon's; 2–2.5), and moderately high evenness (Pielou'0.7–0.8). Monitoring detected little, if any, consistent difference between community diversity, evenness, abundance or number of taxa between the control (CIa) and disposal site (Ia). Disposal site R-extended is located closer inshore that the other two sites, and had a slightly different community composition to the other two sites (Figure 6). Benthic communities in all areas were dominated by the polychaetes *Prionospio* spp., *Heteromastus filiformis, Armandia maculata, Magelona dakini, Goniada* sp. and *Spiophanes* sp., and amphipods. Comparisons between disposal and non-disposal sites using multivariate analyses indicated that there were minor differences in community composition between the disposal and non-disposal sites. However, temporal variability between 5-yearly surveys was significant, and this variability was much larger than the difference between disposal and non-disposal sites within a year (Smith, 2008; Sneddon *et al.*, 2017a; Sneddon & Atalah, 2018; Sim-Smith & Kelly, 2019).

Epifaunal subtidal communities in nearshore regions were largely dominated by sand dollars (*Fellaster zelandiae*). Other common taxa captured in dredge tows included the gastropods (*Amalda* spp. and *Zethalia zelandica*), the clam (*Myadora striata*), hermit crabs (Paguridae), paddle crabs (*Ovalipes punctatus*) and New Zealand sole (*Peltorhamphus novazelandiae*) (Smith, 2008; Sneddon *et al.*, 2017a; Sneddon & Atalah, 2018; Sim-Smith & Kelly, 2019).

Figure 6. Aerial photograph of northern Napier showing the dredge disposal sites off Westshore Beach and the location of Rangatira and Hardinge Rd Reefs.



RANGATIRA REEF

Rangatira Reef is a shallow (< 5 m) rocky region at the south-eastern end of Westshore Beach (Figure 6). The substrate comprises a mixture of boulders and cobbles, interspersed with pebbles and sand. The reef is exposed to oceanic swells and typically has very low water clarity (Smith, 2013).

Green-lipped mussels (*Perna canaliculus*) used to be common in the intertidal parts of the reef, but the population decreased significantly between 1997 and 1998, and by 2004, mussels had disappeared from the reef. There is some evidence that intertidal mussels were smothered by sand that was discharged on the foreshore (Anderson, 1998). No kina (*Evechinus chloroticus*) were found on the reef in the 1998 or 2004 surveys (Anderson, 1998; EMS, 2004). No ecological reports on the intertidal area could be found post-2004.

Smith (2013) conducted a subtidal survey of the reef in 2008 and classified the area into six habitat types:

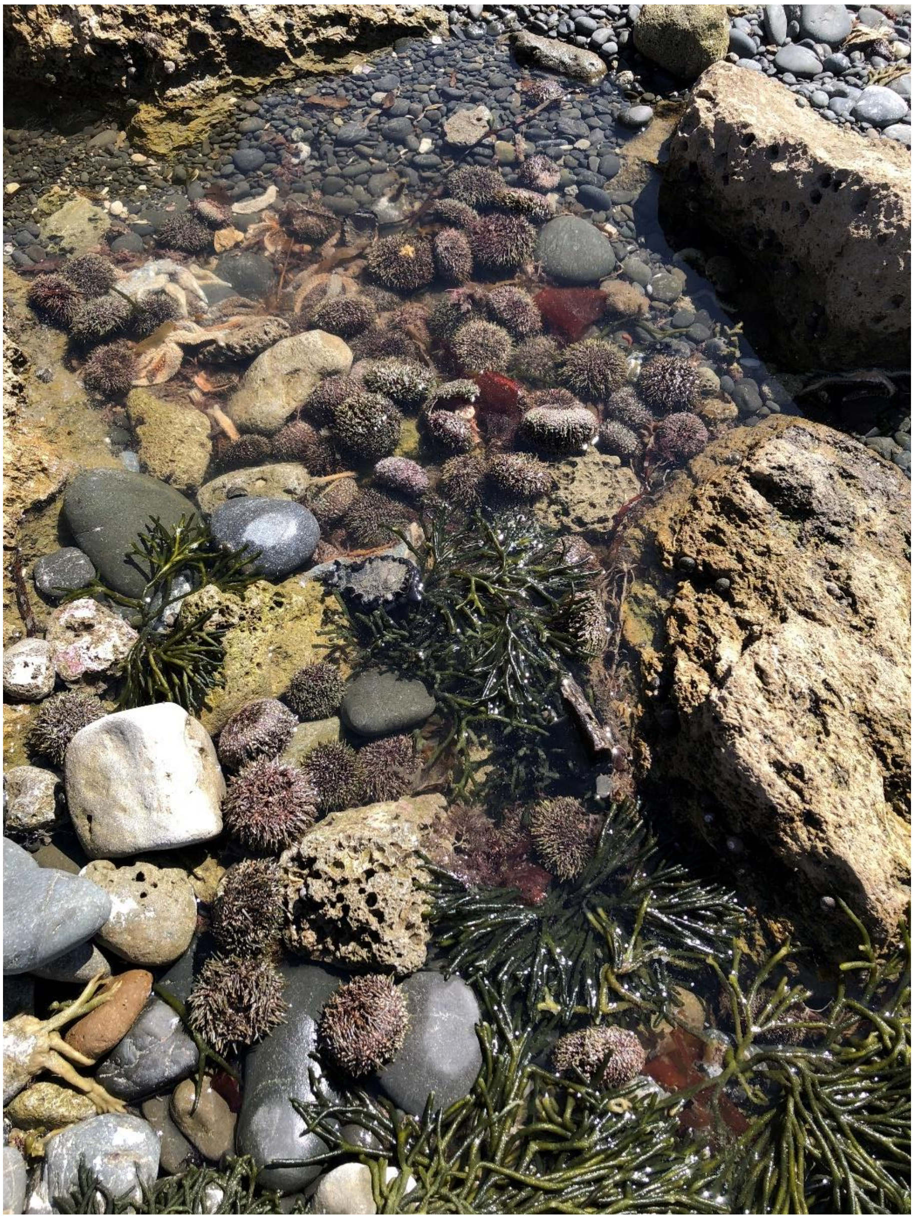
1. Encrusting invertebrates—gravelly mud interspersed with cobbles, sessile invertebrates common.
2. Cobbles—cobbles with a lack of large brown macroalgae.
3. Turfing algae—pebbles interspersed with cobbles, covered with turfing algae.
4. Shallow *Carpophyllum*—cobbles and pebbles covered with large brown macroalgae, predominantly *Carpophyllum* spp.
5. Red foliose algae—boulders and cobbles covered in red foliose algae. Low abundance of brown algae.
6. Sand—coarse sand dominant with a general absence of hard reef substrate.

The first three habitats were the most common habitats present on the reef, with smaller areas of shallow *Carpophyllum* and red foliose algae.

In total, Smith (2013) recorded 15 macroalgae species and 17 animals from Rangatira Reef. These species are common, representative species of rocky reefs in the region. The most common species were: the macroalgae *Carpophyllum* spp., *Coplomenia durvillaei*, *Codium fragile* and coralline turf; the ascidian *Cnemidocarpa bicornuta*, the anemone *Actinothoe albocincta*, and the cushion star *Patiriella regularis.* Notably, discrete, low density beds of horse mussels (*Atrina zelandica*) were found across the surveyed area (Smith, 2013). The reef was resurveyed by Sim-Smith and Kelly (2019), who found similar habitats and species on the reef, with the exception that no horse mussels were observed in the latter survey. The unwanted organism, wakame (*Undaria pinnatifida*) is present on the Rangatira Reef (Sim-Smith & Kelly, 2019).

More recently, large numbers of invertebrates including crayfish, kina, starfish and sea cucumbers, were killed during a mass mortality event, arising from low oxygen levels caused by an algae bloom that followed heavy rainfall and an extended period of warm, calm conditions in February 2023 (Shanahan, 2023, Figure 7).

Figure 7: Dead kina and starfish on intertidal reef inshore from Rangatira Reef.



HARDINGE RD REEF

Hardinge Rd Reef is a mainly intertidal reef located along the shore between Westshore Beach and Port Napier (Figure 6). An existing seawall is located at the top of the intertidal area, which proposed to be extended in the Coastal Hazards Strategy (under the Ahuriri Unit). The reef has been monitored quarterly by HBRC since 2011 as part of their State of the Environment monitoring. Reef monitoring surveys found medians of 9, 11 and 12 taxa/m^2 and 128, 140 and 124 ind./m^2 on the upper, middle and lower shore, respectively. The most common taxa observed on the reef were coralline turf and paint, the macroalgae *Gigartina* spp. and *Colpomenia* spp., cat's eyes (*Lunella smaragda*), top snails (*Diloma aethiops*), cushion stars (*Patiriella regularis*), horn snails *(Zeacumantus* spp.) and hermit crabs (*Pagurus* spp.). Wakame is also present on the Hardinge Rd reef (Madarasz-Smith & Shanahan, 2020).

5 PROPOSED MONITORING

5.1 PURPOSE

The purpose of this 10-year monitoring plan is to provide a programme for obtaining relevant ecological baseline data, and to provide details on monitoring methods. The information gathered will be used to inform future assessments of ecological effects for the various interventions proposed in the Clifton to Tangoio Coastal Hazard Strategy 2120.

Various interventions are proposed for the short- (0–20 years), medium- (20–50 years) and long-term (50–100 years), and therefore, not all the data is required immediately. This monitoring plan outlines a programme for the collection of baseline data in the affected units, particularly for areas where knowledge gaps have been identified, and details of likely methods to be used (to be confirmed after the initial survey in year 1). The collection of baseline data is proposed to be conducted over a 5-year period to spread the survey costs over several years. It is proposed that monitoring methods are annually reviewed and improved if required, with a comprehensive review conducted in year 6 when all the baseline data has been collected.

5.2 LIMITATIONS AND ASSUMPTIONS

Key decisions regarding the design, specific locations, timing, construction, and maintenance of interventions are yet to be made. Consequently, this plan has been developed based on the largely conceptual, strategic information available at this stage. The focus of the monitoring plan is therefore on obtaining broad-scale, general information on marine ecological features and values in the areas of interest to inform decisions about the specific location, design and consenting of interventions. Given that recent mass mortality (Shanahan, 2023) and flooding events have (or potentially have) had a substantial impact on the coastal environment, it is also recommended that ecological data that is older than 5-years be updated. Additional, site-specific information may also be required prior to choosing the final design or when consents are sought.

We have assumed that HBRC will continue to monitor the reef community at the Hardinge Rd Reef as part of their State of the Environment monitoring, therefore no additional monitoring has been proposed for the Ahuriri unit.

High turbidity (which impedes visual assessments) and the presence of cobble and other rock (which impede grab samplers from closing) in nearshore subtidal habitats means that the most cost-effective techniques commonly used elsewhere (such as grab sampling, drop cameras and towed video) may not be suitable for use in the areas of interest. It is possible that diving (which is considerably more expensive than other survey methods) may be required to obtain seabed core samples and may be the only way to conduct reef surveys (if visibility permits).

Another issue is uncertainty about the occurrence and extent of reef and rocky habitat in areas likely to be affected by proposed interventions around Te Awanga and Haumoana. NIWA multibeam data and beach flotsam suggests that in places, scattered, nearshore reef may come within 140 m of the shore at Haumoana. However, the closest the multibeam survey came to the Te Awanga shoreline was around 500 m, so the substrate <500 m from the shore is unknown.

Monitoring recommendations provided in this report have been designed prior to a detailed analysis of cost or available budget, and therefore, the monitoring design may need to be amended to make it cost-viable.

Based on the above, it is recommended that a staged approach be taken to monitoring. This will also spread the cost of monitoring over several years. We have prioritised the monitoring of the units depending on their priority for intervention and the type of intervention proposed.

5.3 STAGING

The following sequencing of monitoring effort is proposed (noting that this can be modified depending on priorities):

Year 1: Testing of sampling methods at various intertidal and subtidal sites to determine what methods are practicable.

Conduct a subtidal survey to confirm whether reef habitats are present in nearshore areas of Te Awanga and Haumoana, and if so, identify suitable reef sites for monitoring.

Survey the nearshore reef sites identified above.

Subtidal monitoring of sediments (grain size[5]) and benthic infaunal and epifaunal communities at Te Awanga and Haumoana.

Intertidal monitoring to determine if the shoreline sustains a marine invertebrate community, and if so, the characterisation of that community.

Review and report.

Year 2 Subtidal monitoring of the nearshore areas of Westshore to obtain up-to-date data on sediments (grain size, heavy metals, and total organic carbon) and benthic infaunal and epifaunal communities.

Survey of Rangatira Reef to obtain up-to-date data on the reef's habitat types and marine benthic communities.

Intertidal monitoring of Westshore Beach to determine if the shoreline sustains a marine invertebrate community, and if so, to characterise that community.

Review and report.

Year 3 Subtidal monitoring of nearshore areas of Bayview and Whirinaki to obtain data on sediments (grain size) and benthic infaunal and epifaunal communities.

Intertidal monitoring of Bayview and Whirinaki to determine if the shorelines sustain marine invertebrate communities, and if so, to characterise those communities.[6]

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[5] Heavy metal and organic carbon analysis is not required because the sites are remote from major urban or industrial sources.

[6] This component could be dropped if nothing is found at the sites sampled in earlier years.

Review and report.

Year 4 Subtidal monitoring of nearshore areas of Clive to obtain data on sediments (grain size) and benthic infaunal and epifaunal communities.

Intertidal monitoring of Clive to determine if the shoreline sustains a marine invertebrate community, and if so, to characterise that community.[6]

Subtidal monitoring of sediments (grain size, heavy metals, and total organic carbon) and benthic infaunal and epifaunal communities in the outer section of Ahuriri Estuary (Pandora unit).

Review and report.

Year 5 If required, intertidal monitoring of sediments and sediment dwelling communities in Ahuriri Estuary, and the shoreline between the Port and entrance to Ahuriri (to be confirmed once better information on intentions for Ahuriri and Pandora have been firmed up).

Review and report.

Year 6 Conduct a detailed programme review. This will involve a summary of overall findings and outcomes of previous monitoring, and consider these results in light of any changes in strategic priorities, more detailed on the proposed interventions (designs, locations, and timing), information requirements for consent applications, and specific requirements arising from consent conditions.

Years 7 to 10 Implement decisions arising from the review.

Table 5. Summary of the proposed monitoring staging for years 1–5.

Year	Unit	Intertidal communities	Subtidal communities	Reef
1	Te Awanga & Haumoana	Method testing Infauna	Method testing Grain size Infauna Epifauna	Reef investigation and survey if present.
2	Westshore	Infauna	Grain size Total Organic Carbon Metals Infauna Epifauna	Rangatira Reef survey
3	Bayview & Whirinaki	Infauna	Grain size Infauna Epifauna	
4	Clive	Infauna	Grain size Infauna Epifauna	
	Pandora (outer Ahuriri Estuary)		Grain size Metals Total Organic Carbon Infauna Epifauna	

5	Pandora and Ahuriri Estuary	TBC		TBC

5.4 SURVEY METHODS

SUMMARY OF TRIAL SURVEY METHODS

An initial survey will be carried out in Year 1 to trial several methods and identify those most suitable for sampling nearshore subtidal habitats (both reef and sediment within 400 m of Mean High Water Spring (MHWS)). Focal areas for the survey will be Te Awanga, Haumoana and Westshore.

The trial survey will be conducted between February and April, when weather conditions are most likely to be optimal (an extended period of clear, calm weather is required).

Trial methods for sampling subtidal sandy or gravel habitats will include:

- grab sampling (using a 6 L Van Veen sampler) to sample infauna, and if that does not work (because of gravel preventing the grabs from closing properly), core sampling by divers for the analysis of macrofaunal invertebrates and sediment characteristics;
- video tows to survey large epifauna, and if that does not work (because of low visibility), dredge sampling to survey epifauna and large (>10 mm) infauna.

Trial methods for sampling subtidal reef or cobble habitats will mainly focus on diver transects, aimed at characterising reef habitats and communities. However, the use of towed underwater video will also be trialled.

GENERAL METHODOLGY

Based on the results of the trial survey the most suitable methodology for each area will be selected for future use. Detailed sampling methodology may need to be adapted slightly depending on the method selected and the interventions proposed for each unit but should be based on the general methods described below. Further details and recommendations on sampling methodology will be provided after the trial survey has been conducted.

Given that the precise locations and designs of the proposed interventions are not known at this stage, a best-guess approach was taken to determine the extents of each monitoring area. Until further information is available, this has been defined as the area adjacent to shoreline residential development, out to 400 m offshore from MHWS.

SUBTIDAL SEDIMENT SAMPLING

Preliminary, coastal subtidal areas of interest within each strategic unit were defined as the shoreline from MHWS to 400 m offshore, in areas with coastal residential development. To ensure good coverage of each area, stratified random sampling stations were generated by:

- subjectively assigned 10, 15 or 20 subtidal sampling stations to each area, depending on area size;
- randomly subdividing each area into sub-areas of near-equal size (using QGIS), based on the number of sampling stations;
- randomly allocating one sampling station to each sub-area using QGIS.

Sediment samples will be collected from each station, with samples collected by diver or grab, depending on the substrate. At each station:

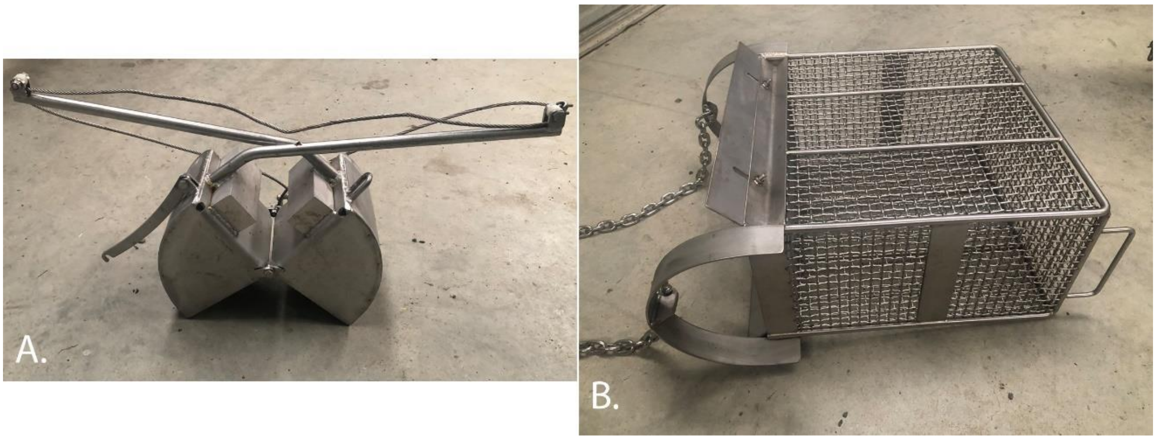
1. An infauna sample will be collected using a standard 13 cm diameter by 150 mm deep sediment corer, or alternatively, a Van Veen grab sampler (or similar) that provides a comparable sample size. Samples will be sieved through 500 µm mesh in the field, photographed, and all infauna retained on the sieve will then be transferred to labelled sample jars, preserved in ethanol or isopropanol, and sent to an experienced benthic taxonomist for taxa identification and enumeration.
2. A surface sediment sample (top 5 cm) will also be collected for analysis of grainsize (and total organic carbon and metals in units with substantial sources of those contaminants). Samples will be transferred into labeled laboratory jars, cooled and sent to an accredited laboratory for analyses within 2 days of collection.

If water visibility is suitable (>1 m visibility), then footage from five, approximately 100 m, georeferenced, towed video transects will be obtained from each the unit to characterise the seabed and check for the presence of biogenic habitats and large biota (see Figure 8 for examples of images obtained from video tows). If water visibility is not suitable for video, then five ~50 m sample dredge (10 mm mesh) tows will be conducted to characterise the large epifaunal and infaunal community (see Figure 9 for examples suitable sampling equipment). Dredge samples shall be sorted, and biota photographed, identified and counted in the field (samples may need to be retained if biota cannot be identified in the field).

Videos will be viewed post-survey and the location of any biogenic habitats, large biota growing on the seabed, or distinct habitat types (e.g., sand, cobble, reef) will be recorded. The abundance of epibiota in video footage will be semi-quantitatively assessed, as ‘rare’, ‘occasional’, ‘common’, or ‘abundant’.

Figure 8: Examples of images (screen shots) obtained using underwater video tows.

Figure 9: Example of a suitable sampling equipment: A. Van Veen grab sampler, and B. Sampling dredge with a 500 mm × 250 mm throat and 10 mm mesh.



SUBTIDAL REEF SAMPLING

In areas that potentially contain reef habitat, systematic surveys using a boat sounder will be undertaken to check for the presence of significant reef structure within 400 m of the shore. If reef structure is identified, then methods adapted from Sneddon (2020) (for monitoring sediment effects on Pania Reef) will be used, with the number of transects taken depending on the size of the reef area found. For Rangatira Reef, it is proposed that a minimum of three transects be taken.

If visibility allows, reef sampling shall be carried out using weighted 50 m transect lines, tagged at 10-m intervals along their length. These shall be laid along the survey sites using preplanned GPS starting waypoints and headings, or if the extent of reef is unknown prior to the survey being carried out, using haphazardly placed staring points and headings in areas identified as reef during systematic survey.

Two divers will swim along each transect line, one recording notes on the presence and relative abundance of conspicuous biota, the other taking quadrat photographs and recording video. If visibility permits, photos will be taken of five 0.25 m^2 quadrats around each 10 m tag will be taken at the transect line distance tag. Video footage will be recorded along the transect between each tag.

The second diver will record notes using a field sheet template, with a separate record for each 10-m section of the transect. Each record will include water depth, habitat / substrate type, and the relative abundance / percentage cover of major algal and key faunal species, including fish and conspicuous surface-dwelling or encrusting organisms. Abundance / coverage data shall be subjectively ranked as ‘rare’, ‘occasional’, ‘common’, or ‘abundant’. The information gathered shall be used to characterise habitats and communities on the reef.

If water visibility is suitable (>1 m visibility), then the additional footage will also be obtained using towed underwater video (approximately 100 m towed video transects, with numbers depending on reef extent).

INTERTIDAL SAMPLING

Based on the existing literature it is anticipated that the intertidal infauna of units will be depauperate. Therefore, planned sampling is mainly investigative to characterise the intertidal community present.

Three transects will be located down the beach within the area of interest, depending on its size. Along each transect 3 stations will be sampled, one around the high tide mark, one around the mid tide mark and one around the low tide mark. At each station aa 13 cm diameter by 15 cm deep core will be obtained, sieved to 0.5 mm, preserved in isopropanol, and sent to an experienced benthic taxonomist for the identification and enumeration of any infauna.

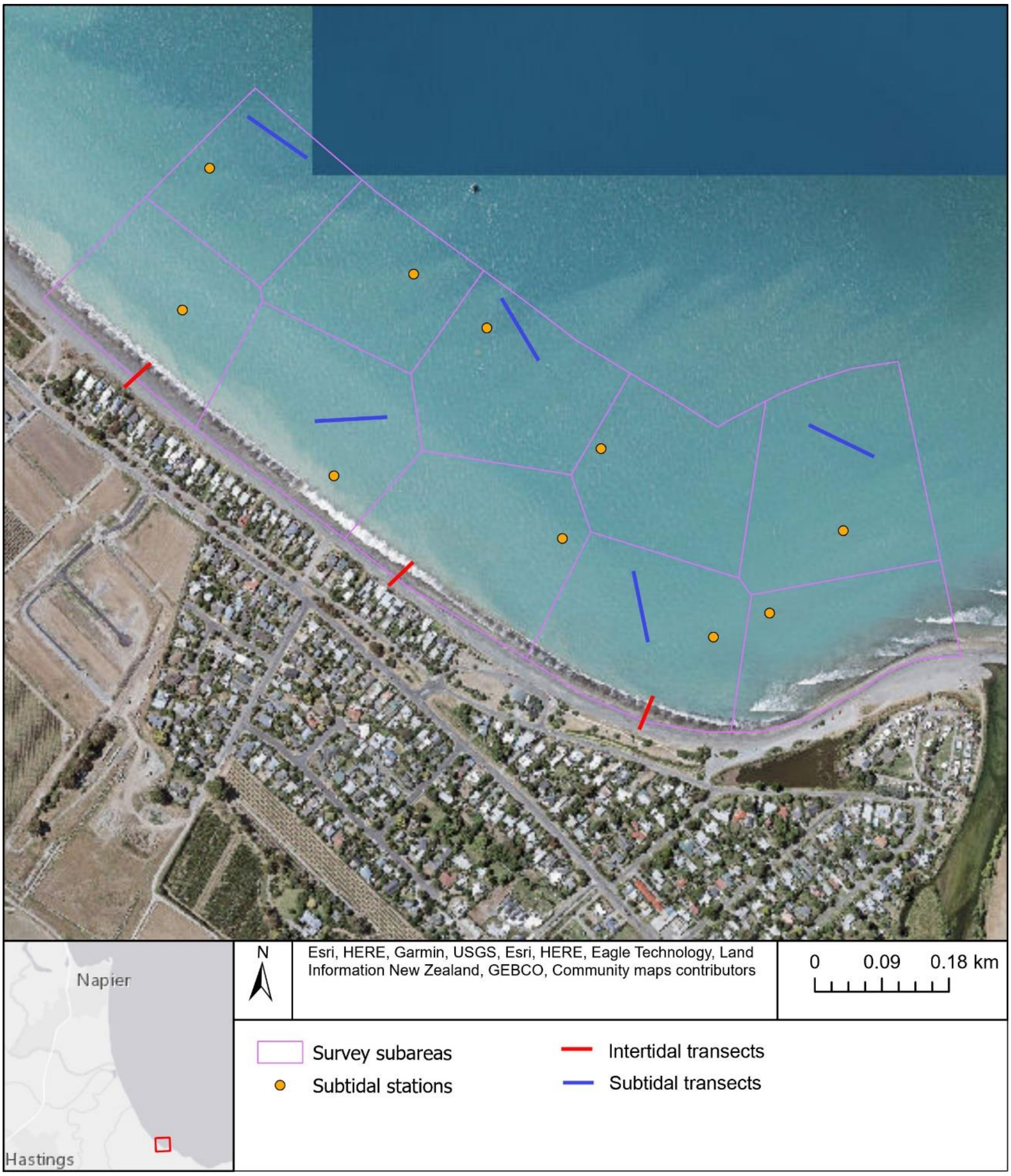
YEAR 1 SURVEY

TE AWANGA

In Year 1, a survey of Te Awanga will be conducted that will include the following (Figure 10):

- Sediment samples will be collected by grab sample or diver cores, from 10 subtidal stations along ~1.3 km of the shoreline for the analysis of grainsize and infauna;
- Five, ~100 m video and/or ~50 m dredge tows will be conducted to characterise the epifauna; with each transect located in a different sub-area.
- A systematic survey shall be carried out to determine whether substantial areas of reef are present within 400 m of the shore. If reef is present, then ~50 m diver transects will be conducted over the reef area. The number of transects surveyed will depend on visibility and the size of the reef area.
- Three intertidal transects will be run down the beach and infaunal samples shall be collected at three stations (high, mid and low-tide) along each transect to determine whether macrofauna are present, and if so, to characterise the intertidal community.

Figure 10. The proposed sampling stations and methods in the Te Awanga area of interest. Note that the subtidal transects apply to towed video. If dredge sampling is used then the tow length will be around half that shown for subtidal transects.



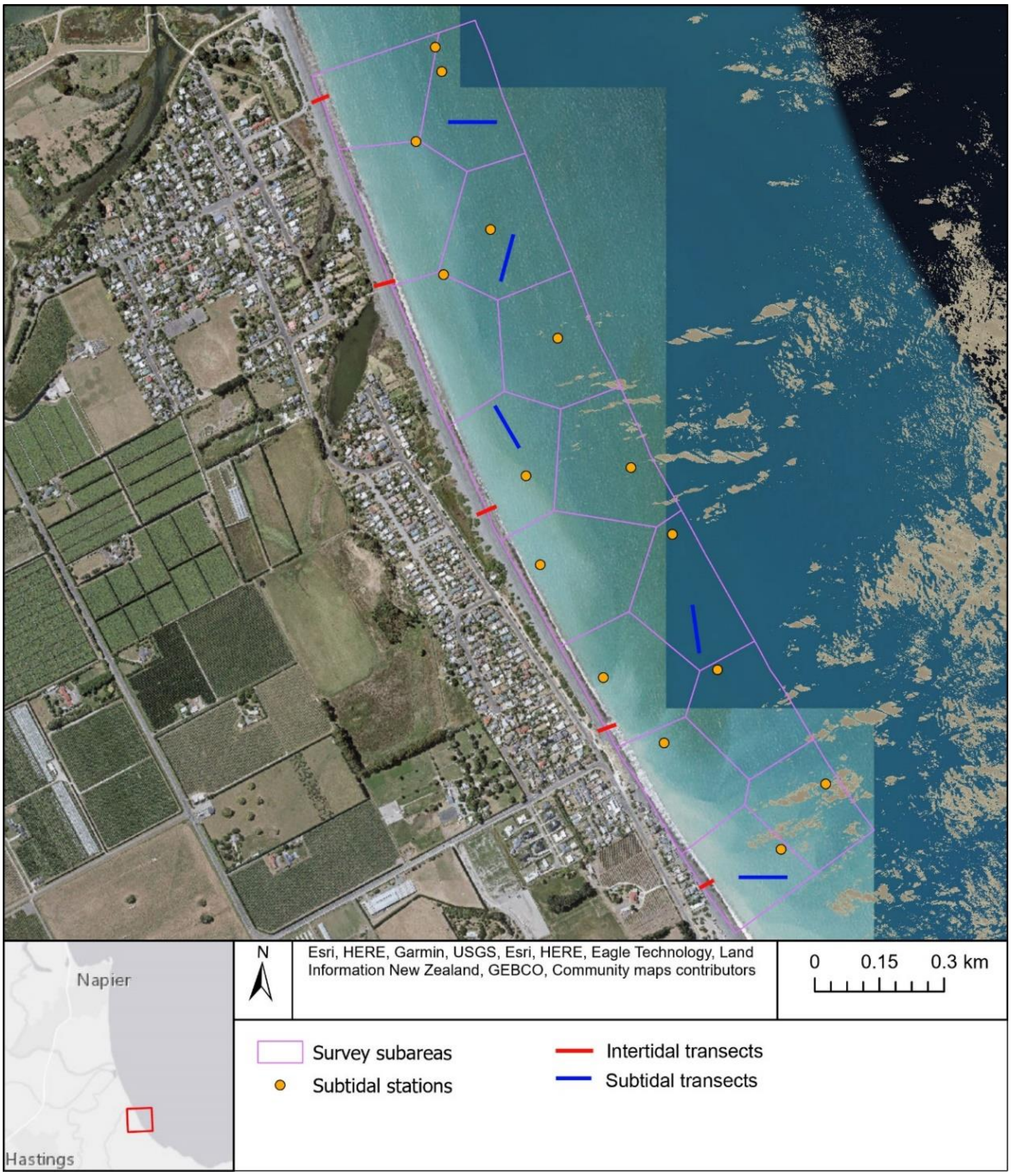
HAUMOANA

In Year 1, a survey of Haumoana will be conducted that will include the following (Figure 11):

- Sediment samples will be collected by grab sample or diver cores, from 15 subtidal stations along ~2.2 km of shoreline for the analysis of grainsize and infauna;
- Five, ~100 m video and/or ~50 m dredge tows will be conducted to characterise the epifauna; with each transect located in a different sub-area.

- A systematic survey shall be carried out to determine whether substantial areas of reef are present within 400 m of the shore. If reef is present, then ~50 m diver transects will be conducted over the reef area. The number of transects surveyed will depend on visibility and the size of the reef area (indicative transects shown in Figure 11).
- Five intertidal transects will be run down the beach and infaunal samples shall be collected at three stations (high, mid and low-tide) along each transect to determine whether macrofauna are present, and if so, to characterise the intertidal community.

Figure 11. The proposed sampling stations and methods in the Haumoana area of interest. The brown shading shows potential rocky substrates in the Clive Hard. Note that the subtidal transects apply to towed video. If dredge sampling is used then the tow length will be around half that shown for subtidal transects.



DATA ANALYSES

The type of data analyses used will depend on the data collected, but in general:

1. Infaunal samples will be analysed by graphs (e.g., bar graphs, shade plots), univariate statistics (e.g., mean, range) of standard diversity indices (abundance, richness, Shannon diversity, Pielou's evenness), and multivariate methods (e.g., nMDS, cluster analysis, SIMPROF, SIMPER).
2. Epifaunal quadrat samples will be analysed by graphs (e.g., bar graphs, shade plots), and univariate statistics (e.g., mean, range) of standard diversity indices (abundance, richness). It is unlikely that sufficient numbers of biota will be recorded to be able to analyse the data by more complex univariate statistics or multivariate statistics.

5.5 REPORTING

The monitoring report after years 1–5 will contain details on:

- a summary of the ecological information available for the units surveyed that year;
- survey methods;
- results of the survey, highlighting any high value ecological areas, habitats or taxa found, or any habitats or taxa that are likely to be adversely affected by the proposed interventions;
- any recommendations for improvements to the methods, and regarding survey design for the following year(s).

The Year 6 report will include a comprehensive summary of all the monitoring results obtained in Years 1–5, and recommendations for monitoring to be conducted in years 7–10, depending on the monitoring results and specific details of the proposed interventions to be implemented.

5.6 OTHER REQUIREMENTS

Modelling work that estimates areas of sediment deposition caused by the proposed interventions would be useful for focusing sampling areas.

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