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Assessment of Potential Effects on Benthic Ecology from proposed rezoning of areas in Waikawa Bay

RESEARCH BASED SOLUTIONS

CAWTHRON

Assessment Of Potential Effects On Benthic Ecology From Proposed Rezoning Of Areas In Waikawa Bay

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LIST OF ABBREVIATIONS

Abbreviation	Definition
AFDW	Ash free dry weight
ANZECC	Australia New Zealand Environment Conservation Council
cm	centimetre
Cr	Chromium
Cu	Copper
ha	Hectares
ISQG-High	Interim Sediment Quality Guideline – High threshold
ISQG-Low	Interim Sediment Quality Guideline – Low threshold
km	Kilometre
m	Metre
m^2	Square metre
mm	Millimetre
Ni	Nickel
PMNZL	Port Marlborough New Zealand Ltd
Pb	Lead
SCUBA	Self contained underwater breathing apparatus
SVOC	Semi-volatile organic compounds
Zn	Zinc

1. INTRODUCTION

1.1. Background

Waikawa Marina is currently a 600 berth facility located approximately four kilometres north-east of Picton in the Marlborough Sounds. The marina was first established in 1983 with 450 berths. Subsequent to consent being obtained in 1992, it was extended with a northern section of 150 berths. The current marina zone encompasses the existing marina and extends approximately 210 m north-east of the current East Mole and breakwater, allowing for future expansion of marina facilities. Port Marlborough NZ Ltd (PMNZL) are applying for a Plan Change to expand the marina zone to include a further 8 ha section of the coastal marine area adjacent to the north-western shoreline of the Bay (Figure 1).

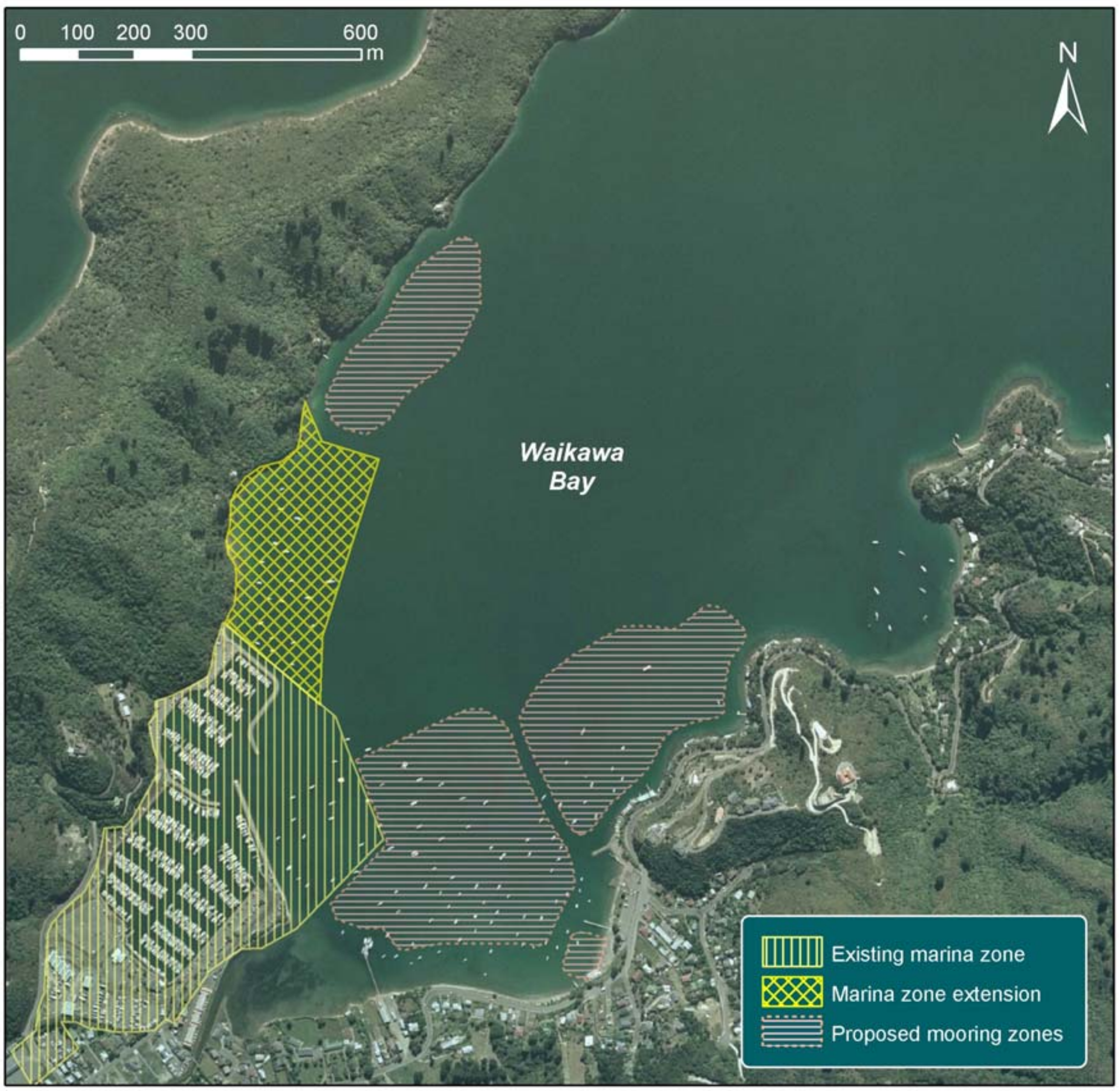

Figure 1. Aerial photograph of Waikawa Bay and its existing marina with current and proposed marina and mooring zones overlaid.

In part because future expansion of the marina into either the current or proposed marina zone will displace many existing swing moorings, part of the Plan Change application is also to rationalise placement and management of swing moorings

The Cawthron Institute (Cawthron) was contracted by (PMNZL) in May 2009 to assess the potential and expected effects on benthic ecology and marine resources of the re-zoning of these areas should they be utilised according to the revised plan.

1.2. Scope of assessment

The scope of the investigation involved two components:

1. To describe the intertidal and subtidal habitats within the areas proposed for re-zoning.
2. To assess the potential marine ecological impacts of expansion of the marina facility and establishment of swing mooring fields in the re-zoned areas.

Cawthron has carried out three benthic surveys for PMNZL within Waikawa Bay since 2007, the latest in May 2009 to characterise the benthic environment within the proposed swing mooring zones. Much information on the habitats and nature of the seabed in the Bay has been compiled, and forms the basis of this assessment.

2. WAIKAWA BAY MARINE ENVIRONMENT

Waikawa marina is situated at the head of Waikawa Bay, a deep semi-sheltered embayment extending approximately 2 km south-west from Queen Charlotte Sound. Waikawa Bay covers a sea area of approximately 235 ha, has a coastline length of approximately 6800 m and is approximately 1350 m wide at its entrance. Although essentially surrounded by land, the Bay is somewhat open to the north-east, with a maximum fetch in that direction of some 5-7 km. Consequently, the largest waves are generated from winds from the north to north-east, but Bay waters are effectively sheltered from the effects of southerly winds.

The area of the inner Bay in the vicinity of the existing marina is fairly typical of much of the mid-region of the Marlborough Sounds. The habitats include rocky intertidal and shallow subtidal reefs, gravel and sand substrates, cobble and boulder areas and a sand-flat/seagrass area. Waters of shallow to moderate depths to the north and east of the existing marina are occupied by approximately 200 swing moorings, and several jetties. Tidal range based on Picton tidal data varies from 0.4 m to 1.5 m. The centre of the Bay deepens steadily to the north-east, reaching depths of approximately 30 m at its entrance (New Zealand hydrographic chart NZ6153).

The south-western head of the Bay receives freshwater inflow from Waikawa Stream. During dry weather, flows in the stream are relatively low; however significant flood flows may be experienced during high rainfall events. The stream outflow runs alongside the marina’s Eastern Mole reclamation, with an adjacent sand-flat delta area which extends up to 150 m south-east of the stream channel. The delta represents a broad, gently shelving sand-flat area of approximately two hectares with seagrass (*Zostera* sp.) representing the dominant macrophyte cover. Cockle beds are also a feature of this area.

The shoreline of the inner Bay has been substantially modified with building works, jetties and reclamation associated principally with the marina, but in the central to outer Bay further to the north-east, more of the natural character of the shoreline has been retained. Both west and east shores in the mid- to outer-Bay feature narrow sandstone reef which often extend for a short distance subtidally, and are overlain with cobbles and boulders. Gravel/sand and shell substrates border the subtidal reefs and characterise the sub-littoral slope off the beach areas.

3. WAIKAWA BAY BENTHIC SURVEYS

3.1. Survey overview

Surveys within the inner Bay, covering the current marina zone and its proposed north-west extension, were relatively comprehensive, in keeping with both the current level of modification and human activity, and the greater potential impacts of further development. The approach utilized benthic sample collection at a series of seabed stations spread over the areas of interest, including some stations within the existing marina in order to better assess the likely impacts of further development. The emphasis for these inshore sample stations was the establishment of contaminant status and its relationship to seabed and shoreline ecology. Intertidal surveys within these areas sought to characterize habitats and communities, generating taxa lists with a record of relative abundance.

In order to interpolate between the benthic sample stations and compile a comprehensive record of the pattern and uniformity of benthic habitats, broad-scale survey methods were used. These comprised side-scan sonar imaging of the seabed, diver observations and video transects and a semi-random pattern of benthic photoquadrat images taken via automatically operated drop-camera.

Within the sections of the central Bay proposed to be re-zoned as swing mooring areas, surveys were principally limited to broad-scale methods (side-scan sonar and photo-quadrat) to establish the prevalence and variability of broad categories of benthic habitat.

All field sampling was conducted either from shore or from the Cawthron survey vessels *Cawmarin* and *Waihoe.* All diving operations were carried out by Cawthron scientists using SCUBA. Surveys were conducted on 23-25 July 2007, 24-25 January 2008 and 21 May 2009.

Spatial coverage of the Waikawa Bay marine environment by the principal survey components, in relation to the proposed zoning changes, is shown in Figure 2. Although a proportion of the survey work was not specifically targeted at producing this assessment, all relevant results were considered in its compilation.

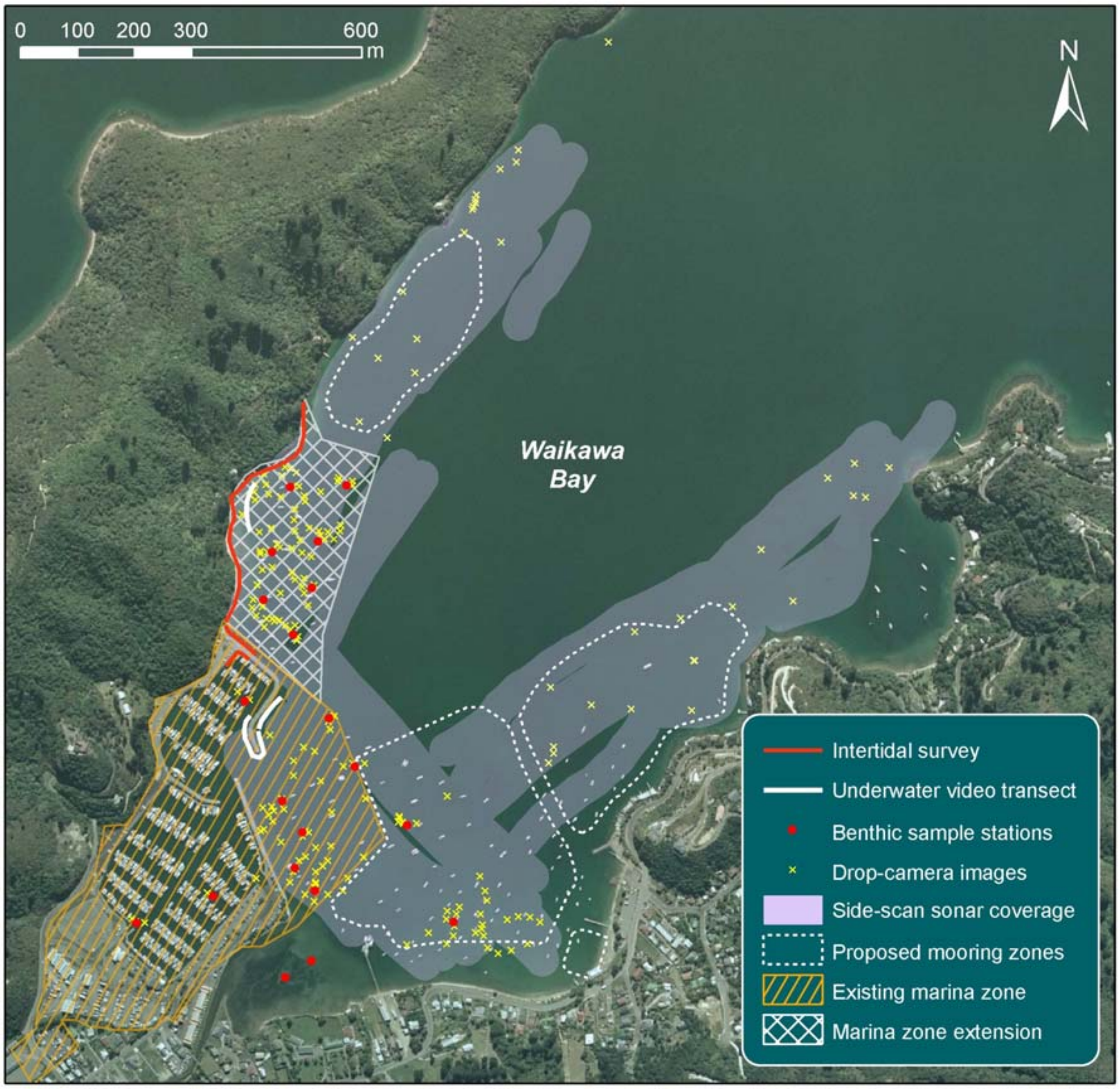

Figure 2. Spatial layout of benthic survey components in relation to the proposed marina and mooring zones.

3.2. Summary of methods

3.2.1. Benthic sample stations

The arrangement of benthic sample stations had the aim of achieving appropriate spatial coverage, but with consideration also for key variables such as water depths or tidal zonation, likely habitat distribution and potential impact. The role of these stations was to provide accurate data on the physical, chemical and ecological nature of benthic sediments. At each station, divers collected sediment and biological samples for a range of analyses which are summarised in Table 1.

Table 1. Summary of sampling and analytical methods used for sediment physico-chemical and ecological characterisation.

Sample collection	Analysis type	Description
Sediment core samples: 60 mm diameter cores driven approximately 10-15 cm into sediments. Surficial 3 cm subsequently sub-sampled for analysis.	Particle grain size distribution (sediment texture)	Wet sieved through screens to isolate seven distinct (Udden-Wentworth) particle size classes from gravel to silt and clay.
	Organic Content	As Ash-Free Dry Weight (AFDW). Sample dried at 105°C then ashed at 550°C.
	Trace metals (Cu, Pb, Ni, Cr, Zn)	Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) following aqua regia acid digestion.
	Semi-volatile organic compounds, trace (SVOC, BNA)	Sonication or ASE extraction, GC-MS, full scan.
Infauna core samples: 130 mm diameter cores driven approximately 10 cm into sediments. Core contents rinsed through 0.5mm mesh. Residue preserved in 3% glyoxal / 70% ethanol.	Counts and statistical analysis of sediment-dwelling macroinvertebrate taxa	Taxonomic classification and counts carried out via binocular microscope. Count data analysed to ascertain levels of abundance, species richness and standardised indices of community diversity and evenness for each station. Indices were compared between stations and significant differences interpreted with respect to key factors such as water depth and substrate characteristics. Infaunal assemblages were contrasted using non-metric multidimensional scaling (MDS) ordination and cluster diagrams using PRIMER v6 statistical software

3.2.2. *Intertidal surveys*

The purpose of the qualitative intertidal surveys was to describe the general habitats and communities occurring in areas that may be directly or indirectly affected by the expansion of marina facilities.

A survey of the rocky intertidal shoreline on the north-western side of the Bay north of the marina zone was carried out over low tide on the morning of 24 July 2007. This encompassed 450 m of shoreline extending from the northern breakwater of the existing marina (Figure 2). On the same day, general observations of habitat and community composition were also recorded for marina inner and outer breakwater intertidal sites, the objective being to gain an indication of the type of communities that would establish on the breakwaters and facing materials of any future extension. During this survey, two samples of blue mussels (*Mytilus galloprovincialis*) were collected from the intertidal zone; one from the rocky western shoreline north of the marina and one from the inner face of the northern marina breakwater. These were analysed for trace metals (Cr, Cu, Ni, Pb and Zn), a suite of semi-volatile organic compounds (SVOCs) and for indicator bacteria (*E. coli*).

A preliminary survey of the sand-flats of the Waikawa Strem delta was also undertaken, with a more comprehensive follow-up survey completed on 24-25 January 2008 focusing on the established seagrass and cockle bed.

Notes were compiled on the physical characteristics of the habitats surveyed (substrate, relief, general dimensions and gradient) and the occurrence and relative abundance of flora and fauna within both the intertidal zone and the immediate subtidal.

3.2.3. Diver observations and transects

After dives at each of the benthic sample stations, diver observations were recorded regarding habitat/substratum type, algal species and cover, and conspicuous surface-dwelling fauna. In addition to this, subtidal hard substrate habitats and communities were recorded along two underwater video transects (Figure 2). The first transect was south along a 100 m section of the reef on the western shoreline which extended up to 20 m subtidally (from low water mark). The second ran for approximately 100 m southward along the outer face of the western breakwater, then for approximately 60 m north along its inner face inside the marina. The second diver took notes and still-camera images of substrate and conspicuous macrofauna and macroflora along each transect.

3.2.4. Remote seabed photography

An automatically triggered drop-camera was deployed at semi-random points over the benthic areas of interest to compile a series of (0.1 m^2) photo-quadrat images of the seabed (each with coordinates fixed by GPS) for substrate and epibiotic community analysis. During the field collection of this data, the density of images collected over different areas could be varied according to seabed variability and features and the expected impact of potential developments.

3.2.5. Side-scan sonar imaging

A side-scan sonar survey of the seabed within the current marina zone, its proposed extension and current mooring areas in the south of Waikawa Bay was conducted on 23 July 2007. This was followed up with a further survey of the proposed mooring zones in the central Bay on 21 May 2009.

Side-scan outputs were used to evaluate the variability of the seafloor with respect to low-resolution changes in substrate texture (*e.g.* a change from mud to cobble or reef substrate) and to detect benthic features of potential ecological significance. A Tritech™ sonar 'fish' was towed at a speed of approximately 2.4 knots, using a swathe width of 30 m either side of the vessel. GPS position tracks were simultaneously logged, along with bathymetry data and the side-scan sonar output, to an onboard computer using Tritech™ software. This enabled the relocation of any areas of particular interest for subsequent verification. The sonar fish was towed throughout the site where depth permitted in a pattern of vessel passes over the site and adjacent waters to achieve sufficient coverage to ensure that significant seabed features were not missed. To ground-truth the side-scan sonar images, they were matched to drop-camera photoquadrat images and information from benthic sample stations, including diver observations.

4. BENTHIC HABITATS

4.1. Intertidal

4.1.1. North-western shoreline

Physical

The shoreline on the northern side of the Bay extending north-east from the existing marina is a mixture of sandstone rocky reefs, cobble habitats, and sand and gravel beaches which are exposed to north-easterly wind-generated waves and boat wakes. Approximately 80 m of the 430 m stretch within the proposed marina zone extension was beach, composed of coarse sands and gravel, with areas of pebble and cobble. Two small jetties were located within the proposed zone. The width of the intertidal zone was mostly ≤5 m, but ranged from 8-15 m wide at some points. The rocky reefs at the central and southern end of the shore are gently sloping and extend approximately 8 m into the subtidal. The intertidal reef at the northern end of the zone has a much steeper profile and in some places extends approximately 20 m subtidally. The subtidal zones consist of either rocky reef or gravel/sand substratum, with overlying cobble and small boulders.

Epibiota

The communities present were typical of those found in the wider area of the Marlborough Sounds, dominated by sessile invertebrates in the intertidal zone, and macroalgae in the immediate subtidal. A total of 52 invertebrate and 17 algal taxa were recorded from the shoreline and immediate subtidal within the proposed extension to the marina zone.

The upper mid- to high-tidal zones were dominated by bare rock, small acorn barnacles (*Chamaeosipho brunnea* and *Chamaesipho columna*), periwinkles (*Austrolittorina antipodum* and *Austrolittorina cincta*) and the ornate limpet (*Cellana ornata*). The mid- to low- shore was dominated by the blue mussel (*Mytilus galloprovincialis*), ribbed mussel (*Aulacomya atra maoriana*), acorn barnacles, various molluscan grazers (*e.g. Melagraphia aethiops*, *Turbo smaragdus* and *Cellana radians*) and the green alga, *Codium convolutum*. Larger isolated specimens of the Green-lipped mussel (*Perna canaliculus*) were common at and below the low tide mark. In some areas, patches of Neptune's necklace (*Hormosira banksii*) occurred on the low shore. The brown alga, *Cystophora congesta* (a habitat-forming fucoid) and *Undaria pinnatifida* (a non-indigenous invasive species) were abundant in the immediate subtidal, as was the sea urchin, *Evechinus chloroticus* and the cushion star, *Patiriella regularis*. Red epiphytic algae, and encrusting and turfing coralline algae were also common on the low shore and immediate subtidal. The presence of two small jetties along this shoreline created a shaded environment in which several species thrived, including the introduced bryozoan, *Watersipora* sp., the anemone, *Actinothoe albocincta* and the sea squirt, *Pyura rugata*.

The shoreline further north towards The Snout was similar, in both physical character and community make-up, to that within the proposed marina zone extension. Barnacles in the higher tidal zone and the three mussel species (*M. galloprovincialis, A. atra maoriana* and *P. canaliculus* in succession towards low tide) were obvious features.

4.1.2. Marina breakwaters

The existing marina breakwaters have relatively steeply sloping intertidal and subtidal profiles and are composed of boulders and large cobbles. The outer faces are exposed to similar wave climates (northerly and north-easterly generated waves) as the natural reef areas on the north-western shore, but the inner faces are very sheltered.

The breakwater outer face was observed to support similar assemblages to those of the natural rocky reef, with *Chamaesipho* spp. barnacles and the limpet *C. ornata* dominating the high shore, and algae dominating the low shore and immediate subtidal. Turfing and encrusting coralline algae often covered the boulders, and epiphytic red algae, *U. pinnatifida* and *Colpomenia* sp., were abundant. *T. smaragdus*, *S. pelliserpentis*, *C. radians* and *P. regularis* were also common. Obvious differences to the natural reef shoreline included fewer mussels inhabiting the breakwater faces, absence of the alga *C. congesta*, and presence of the large brown alga *Sargassum sinclairii* which was relatively common.

The inner face of the breakwater supported comparatively fewer species, comprising a more limited intertidal community assemblage, with most species inhabiting the subtidal zone. *U. pinnatifida*, *Colpomenia* sp., *Ulva* spp. and encrusting brown algae were the only algae observed. *T. smaragdus* was common and the snakeskin chiton, *Sypharochiton pelliserpentis* was present. Mussels (*Mytilus galloprovincialis*, *Aulacomya atra maoriana* and *Perna canaliculus*) were common (being more abundant than on the outer face of the breakwater), and Pacific oysters (*Crassostrea gigas*), and the sea stars *P. regularis* and *Coscinasterias calamaria,* were present.

4.2. Subtidal habitats and epibiota

Subtidal areas within Waikawa Bay exhibited several different types of habitat, varying with factors such as depth, distance from shore and proximity to the subtidal slope. Substrates observed included soft semi-consolidated muds, mixed coarse sands, pebble and shell-hash, cobble and shell, sandstone reef and the introduced boulders of the breakwaters.

4.2.1. Proposed north-western extension to the marina zone

Physical

In the southern part of the proposed extension to the marina zone, the seabed is comprised mainly of coarse sands and gravel. Sample stations in the north of the area, and in deeper waters (>10 m) further offshore, featured finer sediments similar to those occurring within the existing marina. Drop-camera images indicate that this soft substrate (dominated by the silt fraction and very fine and fine sands) is typical of the deeper areas of the central and outer Bay, including much of the present marina zone. Side-scan sonar imaging of the seabed showed the benthic substrate in offshore areas to be largely uniform with the deeper areas surveyed (>8 m) showing relatively flat and featureless substrates of soft muds or silty sand.

The north-western shoreline has shallow fringing subtidal reefs with overlying sand, cobbles and small boulders (~20-40 cm diameter). The rocky subtidal extends 8-20 m, and the bordering areas and beach frontage are characterised by a sandy, silty substratum with relatively sparse epibiota. The immediate subtidal zone of the north-western shoreline, beyond the fringing sandstone reef and cobble areas of the near-shore, features a sub-littoral slope which becomes steeper towards the outer Bay. This slope is made up of coarse shell, pebble and gravel material with interstitial silt and fine sands. Side-scan sonar coverage indicated that the slope exhibited few high-relief features.

Apart from the breakwater structures, the only hard substrates of any significance identified within water depths greater than 4 m were mooring blocks. Due to the catenary of extra chain required on a swing mooring, the top surfaces of these blocks and the immediately adjacent soft substrates are continually swept as the vessel swings to the ambient wind field. Although only occurring at isolated points, physical disturbance represented by chain-sweep is therefore a significant feature of the benthic environment of inner Waikawa Bay.

Epibiota

Rocky substrates were encrusted with coralline and brown algae, and patches of red macrophytes were present. The brown algae *U. pinnatifida*, *C. congesta*, and *Colpomenia* sp. were abundant. The dominant fauna were sea urchins (*Evechinus chloroticus*), cat's eye snails (*T. smaragdas*) and cushion stars (*P. regularis*). Sea cucumbers and the eleven-armed sea star (*C. calmaria*) were also common.

The mud- and sand-dominated substrates generally had sparser epibiota than reef and cobble areas. The sea star *Patiriella regularis* and the horse mussel *Atrina zelandica* were observed at most benthic sampling stations in the proposed extension to the marina zone. At some stations, patches of red macroalgae were present, and ascidians, sea cucumbers (*Stichopus mollis*), and scallops were observed. Close to the shore, larger cobbles characterised the substratum, with an increase in sporadic encrusting biota (*e.g.* ascidians, mussels, rhodophytes) which continued down the sub-littoral slope. More mobile species included *S. mollis, P. regularis, C. calmaria* and crustaceans such as *Notomithrax ursus* and pagurids. A small patch of sabellid tubeworm habitat was identified at the base of the slope in the north.

South of the proposed marina zone extension, red macroalgae (*Rhodymenia* sp., *Polysiphonia* sp. and *Gracillaria* sp.) dominated a soft-sediment area of 7-10 m water depth in the approaches to the existing marina entrance. Isolated green lipped mussels (*Perna canaliculus*) were observed in the algal patches. Areas clear of algae were characterised by silty mud or shell/cobble. Although a subtle change in the sonar image appeared to coincide with the occurrence of the fine weed cover, the low relief and soft nature of this feature did not allow accurate delineation of its extent.

Sediment infauna

Infauna abundance and diversity varied between benthic sites, with abundance and species richness ranging 33-365 individuals and 10-11 taxa, respectively, per 0.013 m^2 core. This variation could be explained largely by the effects of substrate characteristics, depth and distance from shore. Overall, infaunal community assemblages featured common benthic macroinvertebrates such as crustaceans, a variety of polychaetes, and small bivalves that are characteristic of a surface detritus mud/sand habitat. Most stations supported an abundance of amphipods, the polychaetes *Prionospio* sp. and *Heteromastus filiformis*, and the bivalves *Theora lubrica* and *Arthritica bifurca*. .

4.2.2. Marina

The marina breakwaters consist of boulders (0.5–1 m diameter) that slope steeply down to the natural sediment seabed. The boulders on the outer face were encrusted with coralline and brown algae. *U. pinnatifida* and *Colpomenia* sp. were particularly abundant, and *S. sinclairii* and fine red macroalgae were also common. The dominant epifauna were grazing gastropods (*T. smaragdus*), large mussels (*P. canaliculus*), sea stars (*C. calmaria*, *P. regularis*) and urchins (*E. chloroticus*).

The inner face breakwater habitat had the same physical substrate supporting a similar assemblage of dominant species to that of the outer breakwater; however, the more sheltered areas (further from the marina entrance) exhibited a sparser, less diverse community. A notable difference, compared to the outer face site, was the reduction in the abundance of macroalgae, in particular *U. pinnatifida*.

The seabed within the existing marina was relatively diverse in habitat. Soft mud substrates dominated in deeper areas (>4 m), and an overlying microalgal/diatom mat was often observed, and also patches of fine red macroalgae. Large *P. canaliculus* shells, sea stars (*P. regularis*) and sea cucumbers were present. Shallow areas in the south-west featured firmer sandy silt dominated by tubeworms (*Polydora* sp.) and benthic microalgal mat with pathes of drift algae (*Sargassum sinclairii*) also occurring. Although the three marina benthic stations exhibited lower infauna diversity, the physical differences in habitat from those outside the breakwaters meant that this could not be conclusively attributed to elevated copper and zinc levels in marina benthic sediments.

4.2.3. Proposed swing mooring zones

Due to the large seabed areas involved and the significantly smaller impact expected from the establishment and maintenance of swing mooring fields, the survey coverage of these areas was less intensive than for the marina zones (Figure 2).

The shallower mooring zone in the south of the Bay (which is currently occupied by near-maximum density swing moorings) comprised a flat bed of sand/gravel/shell substrates with occasional patches of small cobbles.

The proposed mooring zone adjacent to the north-western shoreline effectively continued the sub-tidal profile and habitat range identified for the proposed extension to the marina zone, with a relatively steep sub-littoral slope of firmer shell/gravel/coarse sand which levelled out to a deeper soft mud/sand substrate further offshore.

A similar range of habitat types was also identified within the proposed mooring zone along the eastern shore of the central to outer Bay. Again, the intermittent fringing sandstone reef did not extend far sub-tidally but changed to a sub-littoral slope of cobble, shell, pebble and course sand and gravel material which became a gently sloping soft mud substrate in deeper water. The sub-littoral slope was often not as steep on the eastern shore and shallower areas extended further offshore at the more prominent rocky points.

Maximum depths in the offshore regions of the proposed mooring zones in the central to outer Bay area along both shorelines reached 20 m.

Side-scan sonar output showed no seabed features in these zones which could be interpreted as significant subtidal reefs or biogenic structures. Drop-camera images showed no conspicuous epibiota in the deeper soft sediment areas and confirmed the epibiotic assemblage described in section 4.2.1 for the sub-littoral slope and other areas of cobble/shell/coarse sand.

5. ASSESSMENT OF EFFECTS

5.1. Expansion of the marina zone

To assess the ecological implications of the proposed change to the marina zone in Waikawa Bay, the assumption is made that the marina facility would be expanded to fill the areas so-designated as this would be the outcome with potentially the highest impact. The existing marina zone covers approximately 24 ha of the inner Bay, including reclaimed areas, but only approximately 17 ha of this is presently occupied by marina facilities (Figure 1). The total area of Waikawa Bay is some 235 ha.

5.1.1. Intertidal and subtidal habitat potentially lost

The expansion of the marina facility along the north-western shoreline of Waikawa Bay would most likely result in the loss of approximately 430 m of the existing intertidal and shallow sub-littoral habitat. Of this, approximately 80 m is beach comprised of coarse sands and gravels with areas of pebble and cobble. The rest is a narrow sandstone reef of varying profile.

The intertidal reef community on this shoreline was dominated by sessile invertebrates (mussels and barnacles), with a number of molluscan grazers present. These included common species of limpets, snails and chitons. The low shore had a limited diversity of macroalgae, dominated by turfing and encrusting coralline algae. This type of intertidal community is characteristic of many shores within the wider Marlborough Sounds area and is not considered to be of unique ecological or scientific value.

Of the benthic areas surveyed, the immediate subtidal reef area of the north-western shoreline was the most ecologically complex and varied. It extends no more than 20 m into the Bay from the low tide zone but exhibits relatively high diversity with beds of habitat-forming fucoid algae (*Cystophora congesta*) a notable feature. The invasive alga *Undaria pinnatifida* was also abundant. The area of this sub-tidal reef habitat existing within the proposed marina zone extension is relatively small (approximately 0.25 ha). Field observations indicate that similar habitat extends for much of the remaining 1.2 km of the north-western shoreline to The Snout at the entrance to the Bay and also significant sections of the southern shoreline. Consequently, although of moderately high ecological value, it is not believed to be a habitat which is particularly limited in extent either within Waikawa Bay or the wider area of the inner and central areas of the Marlborough Sounds.

The introduction of artificial hard substrates in the form of facing materials for breakwaters and any shoreline reclamation will significantly offset the loss of intertidal and shallow subtidal reef areas. The linear distance of such substrates represented by these structures is likely to be substantial. The area for colonisation represented by any rip-rap armour rock substrates is also relatively high, since they are of a more 3-dimensional nature than the low-relief sandstone reef existing currently along the western shoreline. Underwater video transects showed that the sub-tidal faces of the existing breakwaters support a diverse ecological assemblage sharing many of the dominant species with that observed for the natural reef areas. It should be noted, however, that there were also distinct differences recorded between the breakwater and natural reef habitats. Therefore, although the increased hard substrate area may more than offset the loss of general ecological productivity, the introduced substrates cannot be treated as a direct replacement for the habitat lost.

The construction of solid marina breakwaters and any shoreline reclamation would also likely displace an area of soft-sediment benthic habitat. However, this would represent only a very small proportion of similar habitat in inner Waikawa Bay. Soft sediment habitat in this area is largely of two general types:

1. Coarse silty sand and pebble/shell/cobble substrates of the sub-littoral slope.
2. Flat soft mud/sand substrates of the wider seabed of the Bay.

Neither of these sediment habitats is unique or limited in the wider area. Most of the subtidal area of the Bay surveyed in waters greater than 7 m deep comprised relatively clear unconsolidated silty sand with an increasing proportion of soft muds in greater water depths.

5.1.2. Modification of benthic habitats

An area of soft-sediment habitat of up to approximately 7 ha may be enclosed within the breakwaters of an expansion of the marina into the proposed zone extension area. Although only a small proportion of this area would be directly displaced by marina structures, it would unavoidably undergo some alteration from that characterised by the field surveys. This modification would result principally from the higher degree of shelter from the wave and current climate presently existing in inner Waikawa Bay. Less water movement and circulation will create more favourable conditions for deposition and the sediments may eventually become finer in texture, in turn resulting in differences to the types of infauna and epibiota supported. Seabed communities are likely to be similar to those identified within the existing marina (section 4.2.2).

The presence of artificial structures such as driven piles and moorings for floating jetties will also result in changes to benthic ecology. A relatively high density of floating structures, including moored vessels, will result in some attenuation of incident light reaching the seabed. Ongoing disturbance in the form of vessel movements will also be a factor, especially for shallower areas where propeller wash may impinge on the seabed.

Contaminant inputs, including those from vessel hull anti-fouling compounds, are also likely to be a factor, but possibly not to the extent noted for the existing marina[1] if any new marina section receives no run-off from hardstand areas. It is noted though, that observations and analyses conducted at the three sample stations within the existing marina indicated a relatively healthy benthic environment in terms of diversity and infaunal abundance.

[1] All but the innermost of the three marina benthic stations sampled had sediments with trace metal concentrations lower than ANZECC (2000) trigger levels, and with semi-volatile organic compounds (SVOCs) generally below detection limits. However, analytical results indicated slightly elevated levels of copper and zinc within marina sediments.

5.1.3. Notable ecological features within the proposed zone extension

A patch of sabellid tubeworm habitat was identified at the base of the sub-littoral slope in the northern end of the proposed zone extension and is noted as a feature of relative uniqueness in the areas surveyed. This habitat has been identified in other parts of the Sounds, including Picton Harbour. Tubeworm beds of greater than 10% cover have been noted by DOC (1995) as being of some concern for the siting of marine farms. Subsequent field investigation has indicated that the extent of the bed within the zone extension area is very limited. It is also considered likely that the habitat occurs elsewhere along the sub-littoral fringe within Waikawa Bay.

DOC (1995) also lists scallops (at densities exceeding 0.1 per m^2 in a distinct zone) and horse mussels (*Atrina zelandica*; at densities exceeding 0.2 per m^2 in a distinct zone) as examples of species of ecological importance in the Marlborough Sounds. Although both these species were noted to be present within the areas surveyed, it is unlikely that densities as high as the cited trigger levels were attained.

5.1.4. Introduced hard substrates - biosecurity issues

Together with breakwater and pile structures, the floating structures associated with an expanded marina facility represent a suitable substrate for encrusting biota. These surfaces are effectively permanently in shade and despite being close to the water surface, experience no tidal variation. Therefore, they represent somewhat unique habitats which do not occur naturally at the scale represented by the development. As well as providing new area for colonisation by local encrusting communities, these new substrates may be colonised by a new array of species.

The appearance of relatively large areas of entirely new and uncolonised hard substrate is something which occurs naturally only rarely in coastal marine areas. When this is coupled with the presence of artificial vectors for the introduction of new species (in this case vessel movements), the biosecurity implications should be recognised. By acting as "stepping stones", structures such as wharf piles and floating pontoons allow species with poor dispersal mechanisms to cover greater distances (Glasby & Connell 1999). This not only allows native taxa to expand into new areas (range expansions), but also may facilitate establishment of exotic taxa that may be introduced by vessel movements.

Based on research conducted overseas, it appears that the assemblages that develop on artificial structures can be quite different to those in adjacent rocky areas (Connell 2001). A relevant example of an opportunistic invasive species is the brown algae *Undaria pinnatifida,* indigenous to the temperate regions of Japan, China and Korea, which was introduced to New Zealand in the 1980s and has since become established over large stretches of coastline, including the Marlborough Sounds and Waikawa Bay.

The proposed extension of the marina zone represents the potential expansion of an existing activity and, while it is recognised that the spread of invasive species potentially constitutes an adverse impact which could eclipse those resulting directly from any single development, it is accepted that a biosecurity code of practice to address these issues could not be applied to such a development on an *ad hoc* basis. Consequently, beyond acknowledging the issue as it applies to the proposed Waikawa Bay zone change, no specific actions are recommended in this case.

5.1.5. Effect on hydrodynamic processes in Waikawa Bay

The installation of any large structure will have an effect on hydrodynamic conditions; at least in immediately adjacent areas. However, since further development of the marina in the proposed zone extension area would be effectively limited to the western side of Waikawa Bay, such development is considered unlikely to significantly obstruct wave energy and water movement in the areas further east and south.

5.1.6. Potential construction impacts

Although any future expansion of the marina facility into the zoned area will almost certainly result in some construction-related effects within the coastal marine environment, it is not possible to assess these in any detail without reference to a specific structural design and construction methodology. Construction procedures may be managed to minimise the scale of these impacts and confine them as far as practicable to the project area; however, components such as reclamation, breakwater construction and piling operations would directly displace areas of seabed and result in varying amounts of disturbance to adjacent benthic areas.

Detailed assessment would be required to accompany any application for consent to expand the marina facility within the marina zone; however, the types of impacts and stressors expected of such construction activities may be summarized in general terms as follows:

Direct disturbance of benthic habitats
Physical disturbance of soft-sediment benthic habitats are likely to be localised and temporary in nature, with recovery of faunal communities via migration and recruitment expected to be correspondingly rapid (weeks to months). However, as noted above, benthic communities within areas confined by new marina breakwaters would be expected to be permanently altered to a greater or lesser extent due to changes in hydrodynamic processes, ongoing disturbance and potential contaminant effects.

Release of sediment-associated contaminants
Disturbance of benthic sediments is also known to facilitate the release of contaminants into the water column and, where contamination is significant, the spatial extent of chemical impacts tends to mirror the fate of the suspended sediments (Roberts 1992). In this instance, the concentrations of trace metals (Cr, Cu, Ni, Pb, Zn; indicative of general levels of contamination) in Waikawa Bay sediments were all below the corresponding ANZECC (2000) ISQG-Low guideline levels and semi-volatile organic compounds (SVOCs) were universally

below trace-level detection limits; hence their disturbance is not expected to result in toxic effects to marine life.

Release of sediment nutrients and organic material

Resuspension of sediments can have the effect of releasing nutrients and/or significant amounts of organic material into the water column. The deep and open nature of Waikawa Bay means that water column oxygen levels are unlikely to be significantly affected during construction works. The identified low to moderate organic content of benthic sediments has the potential to create only minimal short-term oxygen demand during and shortly after disturbance. Moreover, the level of resuspension anticipated from construction activities is relatively small in the context of local dispersion processes. Although the nutrient levels of sediment samples were not directly analysed, the organic content and the lack of significant evidence for reduced conditions in sediment cores suggests that this was generally relatively low.

Turbidity plumes and increased levels of suspended solids in adjacent areas

High suspended sediment levels reduce the feeding efficiency of filter-feeding organisms such as horse mussels and scallops. However, these species can tolerate short-duration high-turbidity events such as those generated during storms where both high suspended solids in run-off and wave resuspension of marine sediments may both contribute. Well-managed construction of breakwaters need not be a major source of turbidity and depths within the proposed marina zone extension are such that dredging activity is unlikely to be a significant component of a future marina development. Reclamation components may result in turbidity being elevated above background levels in adjacent waters during periods of active construction but may be effectively limited by utilisation of appropriate sediment control measures. Turbidity effects are likely to be attenuated somewhat by the dispersal capacity of Bay flushing processes such as tide, current and wave climate. With suitable sediment control measures, areas outside those immediately adjacent to construction work areas (*i.e.* beyond metres to tens of metres) would not be expected to experience turbidity conditions which significantly exceed natural episodic events.

Smothering impacts to benthic communities through increased sediment deposition

Subtidal soft-sediment communities are expected to be generally more tolerant of turbidity and sediment deposition than those associated with shoreline hard substrates. Such tolerance is generally ascribed to the majority of soft-sediment taxa identified by the surveys in inner Waikawa Bay. Furthermore, deposited fine sediment layers would be expected to be negligible in areas other than immediately adjacent to the source activity and generally within the tolerance of soft sediment biota. Reef communities were not identified in situations deeper than a few metres in Waikawa Bay; hence wave action is expected to limit the build up of deposited layers on reef areas adjacent to construction activities.

5.2. Marina operation

It is assumed that future expansion of the marina facility into the marina zone would represent an increase in an existing activity with no entirely new activities anticipated.

The area of current marina zone presently unoccupied by the facility is approximately 7 ha. The area of the proposed expansion of the marina zone is approximately 8 ha. Together, these represent a potential effective increase in the size of the marina facility of the order of 90%. It can be further assumed that such development will require the amount of hardstand/maintenance area (approximately 5,000-6,000 m^2 currently) to be increased correspondingly, representing a general expansion also of the current industrial/services zone of the marina.

5.2.1. Contaminant sources

Contaminants which may be discharged to the marine environment from boat maintenance activities include heavy metals, sediments and particulates, hydrocarbons, solvents, acids and alkalis and nutrients and bacteria (ARC 2005). Effective design of marina facilities, management of operating practices and regulation of users can help to minimise such contamination sources. Waikawa Marina was awarded “Clean Marinas” certification in 2006. This is a voluntary accreditation system promoted by the Marina Operators Association of New Zealand supporting the development of good environmental practices for marinas, yacht clubs, boat clubs, slips, boatyards and associated industry operators. The programme outlines operational guidelines for a range of environmental management applications, including processes for pump-outs, hull cleaning, turbidity, emissions, management of wastewater and accidental spills as well as staff training and education of boat owners.

Heavy metals such as zinc, lead, iron, copper, cadmium, chromium, nickel, mercury, tin, and arsenic may be contained in paint particles removed from boats during sanding, sandblasting, water-blasting and general boat washing (ARC 2005). Copper, especially, continues to be the most widely used active elemental agent in anti-fouling paints for recreational vessels, whereas mercury, arsenic and organotin compounds are no longer used as paint additives in New Zealand. The five metals analysed in Waikawa Bay sediments collected during the surveys (chromium, copper, lead, nickel and zinc) are hence considered indicative of general levels of contamination associated with marina activities. Those which were found to be elevated in marina sediment samples relative to those collected outside the breakwaters in Waikawa Bay were copper (Cu) and zinc (Zn). As a widely used active agent in hull paints, copper is typically elevated above background levels in port and marina situations. Zinc is also used in many antifouling paints as well as being used for sacrificial anodes installed on boat propeller shafts and rudders to resist corrosion. However, only Cu exceeded the ANZECC (2000) ISQG-Low level, above which a biological effect is considered possible, and then only at a “worst case” location adjacent to both a stormwater outfall and a travel hoist facility where vessel hulls are pressure-washed. In no instance was the ISQG-High criterion exceeded. The other two marina benthic stations sampled, adjacent to the floating docks, are expected to be more representative of any new sections dedicated to vessel berthage.

Although sediment copper and zinc levels within the marina were not particularly high, they were elevated with respect to sediments outside the breakwaters. A significant increase in hard-stand area is likely to result in a corresponding increase in the amount of run-off. If an increase in contaminant loading to marina or Bay waters of a similar order is to be avoided, an upgrade in treatment or a stricter regulatory framework for users of vessel maintenance areas will be required.

An expansion of marina capacity will require a corresponding increase in parking area and result in increased road traffic and the amount of impermeable surfaces generating runoff. This represents an incremental increase in traffic-related stormwater contaminants such as PAHs, petroleum hydrocarbons and metals.

Marinas can be significant sources of various categories of hydrocarbon contaminants from fuelling operations, runoff from maintenance activities, bilge and boat exhaust or from accidental spillage of solvents and oils. Within sheltered ports and vessel berthage facilities, hydrocarbons can often be seen as an iridescent sheen on the water surface, even at very low concentrations, or as heavier slicks. Intertidal substrates are especially vulnerable to deposition of such contaminants and may result in changes to community composition of encrusting biota. Components of hydrocarbon contamination such as PAHs may persist in sediments or accumulate in the tissues of marine organisms. The sparser intertidal communities observed on inner breakwater substrates do not appear to reflect these impacts; however, since levels of semi-volatile organic compounds within both sediments and intertidal mussel tissues were very low.

5.2.2. Microbial contamination

Run-off from marina surfaces, animal sources and illegal discharges of sewage may result in decreased microbiological quality of marina waters, although provision of adequate shore-side and vessel pump-out facilities can significantly limit human health risks. Some level of impact to bacterial water quality would be expected due to the large number of vessels already accommodated in the inner bay and water quality may be reduced with an increase in vessel number and density; however, the degree to which this occurs may be limited by the application of best-practice management.

Samples of the blue mussel (*Mytilus galloprovincialis*) collected from both the marina breakwater inner face and from the north-west shoreline reef were tested for the faecal indicator bacteria *Escherichia coli* in line with national guidelines for the testing of shellfish for human consumption (NZFSA 2006). Both results (at 40 and 20 MPN/100 g, respectively) were well below the trigger level of 230 MPN/100 g used for the harvesting of live mussels for export[2]. However, it is noted that considerable temporal variability can occur and samples from a single point in time may be misleading.

[2] Based on the classification of harvesting areas for bivalve molluscs in the United Kingdom using *E. coli* levels in shellfish flesh, as defined in EU Directive 91/492/EEC (Donovan *et al.* 1998).

5.2.3. Physical disturbance

Expansion of the marina facility would increase the level of disturbance to Waikawa Bay benthic habitats currently associated with marina operation. These are likely principally to be those associated with vessel traffic and include boat wakes and propeller wash (in shallow areas).

Apart from visible chain-sweep effects associated with swing moorings, the field surveys did not identify any specific impacts to benthic ecology outside the current breakwaters which could be attributed to operation of the marina facility. With management of the facility carried out within an effective operational and regulatory framework, it is not expected that an increase in existing activities would result in more than minimal physical disturbance effects outside of marina breakwaters.

5.3. Swing mooring zones

It is understood that the principal intention of the proposed swing mooring zones shown in Figure 1 is to accommodate the existing number of mooring applications and not to further expand the total number of swing moorings within the Bay.

5.3.1. Physical disturbance

Some disturbance of the seabed will result from placement of anchoring systems for moorings. Most of the current mooring anchors in Waikawa Bay appear to be blocks which rely on mass and partial settling into soft substrates to secure vessel position. Other options include mushroom anchors and helical screws which achieve similar holding strength for lighter mass. All anchor types directly impact only a relatively small area of seabed, but may be deployed in multiple arrangements to increase holding and decrease vessel swing arc. Even at maximum vessel densities, the anchors themselves have a very limited benthic footprint. In Waikawa Bay, they have resulted in a slight alteration of habitat due to the small amount of introduced hard substrate they represent in otherwise fairly uniform areas of soft sediments. Their relative small size and low density, coupled with moderate water depths, also means that they will have negligible influence upon Bay circulation compared to sheltering structures such as breakwaters.

However, conventional swing moorings can also impact the adjacent seabed via the arc swept out by the excess chain necessary to allow for tidal rise and fall and to form a catenary against lift and shock loading from the moored vessel. The catenary curve given by the weight of the chain also presents a lower angle of pull on the anchor, raising the level of force it will resist before dragging. The greater the excess chain length (and the heavier its weight), the more effective the catenary effect; however, this must be balanced against the increasing arc of vessel swing, which limits mooring density.

Especially in cases where a single mooring anchor is used, the mooring chain is dragged across the seabed repeatedly with changes in tidal currents and wind direction. With repeated scouring, the chain can completely clear a circular area defined by the length of excess chain and angle of sweep. A boat that swings 360 degrees around the mooring will form a circular mooring ring scar (Figure 3).

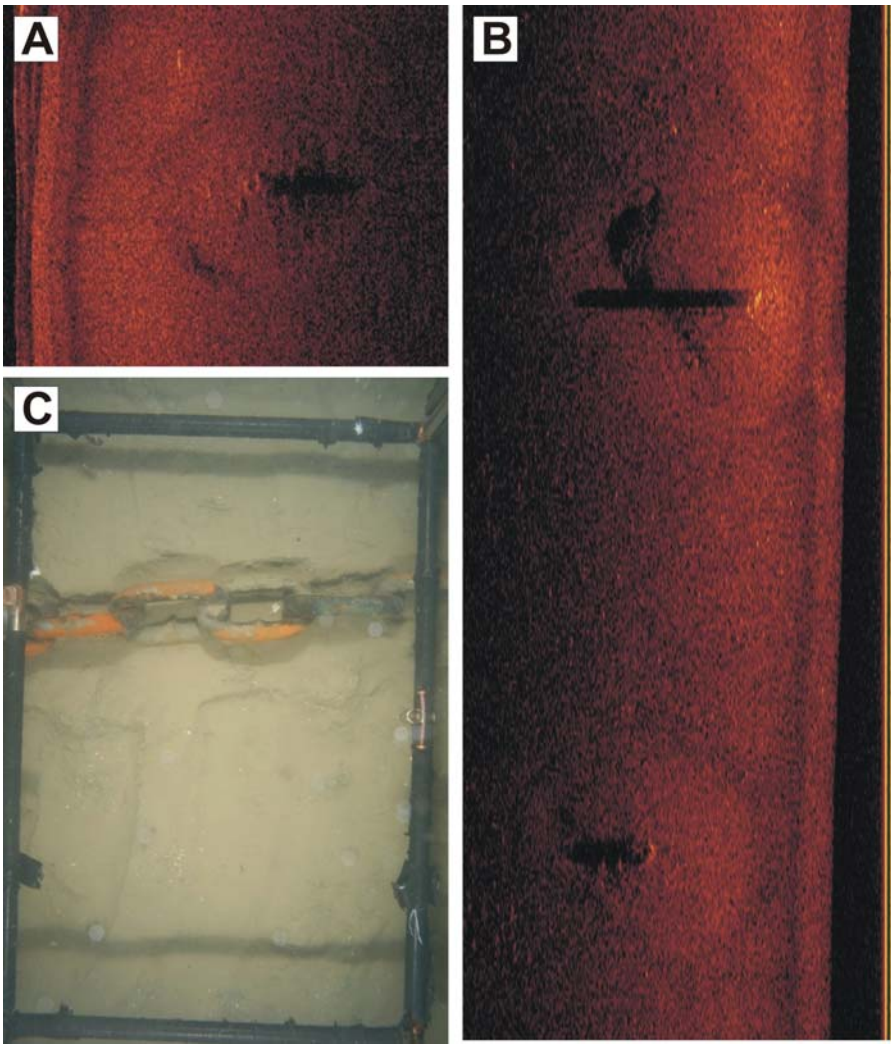

Figure 3 Mooring chain sweep effects in Waikawa Bay: **A,B.** Circular mooring scars, shown by side-scan sonar imaging, within the existing mooring field adjacent to the southern shoreline. Scars are 14-20 m in diameter in water depths of 8-14 m. Sonar shadows are cast by the central mooring block depending on its height off the seabed. **C.** Drop-camera image of mooring chain showing sweep imprint in soft mud/sand substrate.

The formation of mooring scars has been identified as an issue of concern overseas for benthic areas characterized by high conservation value biogenic features (*e.g.* seagrasses, corals, shellfish beds). However, although visible mooring scars are associated with the swing moorings in Waikawa Bay, these are not considered to represent more than a minor ecological impact to soft sediment areas due to the following factors:

- The small benthic areas affected relative to the amount of similar soft sediment habitat in the wider area
- Relatively depauperate epibiotic communities over much of the area proposed for the swing mooring zones, especially those in water depths greater than 7 m.
- Absence of significant biogenic structures
- Resilient sediment infauna assemblages characterised by relatively high mobility, short generation times and high rates of recruitment and migration

Chain sweep effects can be minimised or avoided by employing mooring systems that have a smaller footprint and keep the mooring tackle off the bottom (*e.g.* Seaflex™ moorings). Instead of a length of chain, which causes the most damage, an elastic rode can be attached to the anchor. The length of the rode is short enough to stay off-bottom during low water conditions but can stretch to accommodate an increase in water level. Due to their expense, such systems are normally only used to enable greater vessel densities or in particularly sensitive benthic environments.

Utilisation of swing moorings shares a number of potential impacts with marina berthage, principally related to discharge of contaminants, but also disturbance from vessel traffic (*e.g.* wakes). However, the proposed swing mooring zones represent the spatial expansion of an existing activity, but not necessarily a significant increase in intensity. At current mooring densities, the proposed swing mooring zones will not in themselves result in a significant increase in the overall number of vessels in Waikawa Bay, or vessel traffic, especially if the zones only serve to accommodate the number of vessels displaced by expansion of the existing marina. As such, they will not result in adverse effects over and above those currently associated with swing moorings in the Bay.

5.4. Potential effect on fisheries resources

No specific information was sourced describing the fisheries resources or the current level of fishing pressure within Waikawa Bay. The marina is used by recreational fishers as a base from which to cover the full Marlborough Sounds region, targeting a wide range of species. An increase in the numbers of such vessels operating out of Waikawa Bay potentially represents a corresponding increase in recreational fishing pressure in the wider Sounds area.

Recreationally and commercially targeted fish species which are likely to occur within the 234 ha benthic area of the Bay include snapper (*Pagrus auratus*), blue cod (*Parapercis colias)*, kahawai (*Arripis trutta)*, gurnard (*Chelidonichthys kumu)*, yellow-eye mullet (*Aldrichetta forsteri*) and flatfish (*Rhombosolea* sp.). Red cod (*Pseudophycis bachus*) are also likely to be present but are usually not a target species. Snapper are routinely targeted in the inner Sounds region during summer months although there is no information which suggests that Waikawa Bay is comparatively more important for this species.

While benthic areas within the area proposed for marina zone expansion may be utilised either directly by these fish species as forage or nursery areas, or indirectly via the life-cycles of prey species, the surveys did not identify benthic habitats which are known to be special or significantly limited in relation to the sustainability of fish stocks.

The introduction of breakwaters, pilings and floating structures of marinas provides extensive hard substrate surfaces for colonisation by encrusting biota and therefore potentially represents a localised increase in secondary productivity. Where they occur in well-flushed areas, they are likely to represent suitable habitat for a number of demersal fish species and in this way may offset the loss or modification of other benthic areas.

There are also significant areas of intertidal and subtidal habitat in Waikawa Bay that support shellfish species of customary and recreational importance such as cockles, mussels, and scallops. Although the future expansion of the marina along the north-western shoreline would replace some mussel habitat with a potentially less suitable breakwater substrate, the overall proportion of the resource lost would be very small relative to that available in the wider area.

Although scallops were observed in areas of clear silty sand within the proposed expansion to the marina zone, it is uncertain whether they were present in harvestable quantities at the time of the field survey. However, scallop densities are known to vary considerably even within suitable habitats. While the expansion of the marina may represents the potential loss of several hectares of suitable scallop habitat, much of the seabed of Waikawa Bay is likely to support this species and it is not expected that it would significantly affect such habitat existing outside marina boundaries.

There is no evidence from the field survey of the area which indicates that the existing marina is a source of contaminants at levels which would be expected to result in significant toxic or tissue accumulation effects within local populations of important fisheries species.

While they could potentially add to the total number of vessels accommodated within the Bay and therefore add incrementally to the potential sources of contaminants and disturbance, the relatively low vessel density of swing mooring fields means that they are not expected to result in significant additional stressors to fisheries resources. It is also recognised that the installation of swing moorings makes these areas difficult and unattractive to target by recreational dredgers, resulting in potentially less overall physical disturbance to the seabed.

6. CONCLUSIONS

Future expansion of the marina along the north-western shoreline, enabled by the proposed changes to the marina zone, would potentially result in the loss of approximately 430 m of intertidal and shallow subtidal reef habitats. Although the reef habitats are considered to be of moderate ecological value, they are not believed to be particularly limited in extent with regard to Waikawa Bay or the wider area of the inner and central Marlborough Sounds. Based upon investigation of existing marina structures, in terms of ecological productivity and diversity, the loss of this habitat would be significantly offset by the introduction of new structures such as breakwaters.

The soft sediment benthic area within the proposed extension to the marina zone consists of the mixed shell/gravel/sand/cobble substrate of the sub-littoral slope and the less consolidated depositional muds and silty fine sands of the floor of the Bay. Although some ecological features were noted for these areas, both habitat types are relatively extensive within the wider Bay and central Sounds region.

Investigation of benthic sediments from within the existing marina showed that, although the metals copper and zinc were slightly elevated relative to sediments from outside the breakwaters, overall levels of contamination were relatively low. Marina mussel tissues were also found to have very low contaminant levels. This is indicative that, with appropriate management practices, the future expansion of the marina facility need not represent a major source of contamination to the wider area.

The release and re-suspension of fine sediments in the form of turbidity plumes has been identified as a principal concern with the future construction phase of an expanded marina facility. However, with suitable sediment control measures, it is considered that areas outside those immediately adjacent to construction work areas (*i.e.* beyond metres to tens of metres) could be effectively protected from turbidity conditions which significantly exceed natural episodic events.

Surveys did not identify any specific impacts to benthic ecology outside the breakwaters of the existing marina which could be attributed to its operation. With management of a future expanded facility carried out within an effective operational and regulatory framework, it is not expected that such an increase in existing activities will result in significant adverse ecological effects to benthic areas outside its boundaries.

Although swing moorings represent a continuing physical disturbance in the form of chain sweep effects on the seabed, the absence of significant biogenic features, the ubiquitous nature of the mooring zone substrates and the relatively small areas affected lead to the conclusion that the establishment of the proposed mooring zones will result in adverse benthic effects which are no more than minor.

Inner Waikawa Bay is largely taken up by the marina and swing moorings and is not known to support a significant recreational fishery, although shellfish such as cockles, mussels and scallops occur in harvestable numbers and sought-after fish species such as snapper and blue cod are found in the wider region. While the loss of some benthic habitat may have implications for fisheries species on a local scale, these effects would be expected to be minimal and the principal fisheries impact likely to result from a future expanded marina facility is the increased fishing pressure engendered by increased numbers of recreational vessels operating out of Waikawa Bay.

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