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Integrated Sediment Habitat Mapping for Aquaculture Zoning

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ABSTRACT

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The benthic environment of the nearshore to inner-shelf within the Bay of Plenty, New Zealand, was sampled and surveyed to classify sedimentary environments and benthic habitats. Reef and soft sediment habitats are characterised, delineated, and the potential impacts of suspended bivalve aquaculture considered. An integrated approach is used, utilizing a GIS database to combine remote sensing techniques such as multi-beam sonar and underwater video capture, with physical sampling of the soft sediments using sediment grab samples and in-faunal organism identification. Soft sediment habitats, comprised of fine silty and muddy sediments with low organic contents, are determined to be the most suitable benthic environments above which to site suspended bivalve aquaculture. Transfer of knowledge from the study is maximised through the creation of a CD-ROM complete with hyper-linked analysed data and video files, thematic data layers and a freely available, query-able GIS viewer package.

ADDITIONAL INDEX WORDS: *GIS, Bay of Plenty, Mussel farming*

INTRODUCTION

With a worldwide increase in shellfish aquaculture and a growing awareness of the potential environmental impacts there is a clear need to ensure that any possible effects are minimised and mitigated efficiently. Mapping and delineation of benthic habitats on the continental shelf are essential for coastal and marine managers who must ensure that activities carried out within this zone such as aquaculture, dredge tailing dumping, and sand mining do not adversely affect critical habitats. Thematic mapping of the benthic environment is therefore essential in protecting critical habitats and ensuring the sustainable use of marine resources. In selecting Aquaculture Management Areas (AMAs) within the coastal marine environment there is a need to be informed of relevant environmental parameters in order to provide the greatest opportunity for a genuinely sustainable aquaculture industry. Bivalve aquaculture has the potential to modify the benthic environment through the settling of live bivalves, broken shells, faeces, pseudo-faeces, and farm debris (e.g. DAHLBACK and GUNNARSSON, 1981; TENORE et al., 1982; KASPAR et al., 1985); the relative influence of each being dependent on local environmental factors such as benthic habitat, sediment character, water depth, current regime, culture methods, *etc* (e.g. HARTSTEIN and ROWDEN, 2004; MALLET et al., 2006). While these inputs to the benthic environment are in many ways unavoidable, careful management with appropriate data collection and analysis at the planning stages can aid in mitigating potential impacts through intelligent placement of AMAs. Planning to alleviate these impacts requires a detailed and reliable understanding of the nature, extent, and characteristics of existing benthic environments. This paper describes the collection and analyses of data to not only be informed about the benthic environments but to also allow preferential positioning of AMAs over areas of low conservation value and where impacts on the benthic environment will be minimised. Until now, relatively little knowledge exists of nearshore benthic environments within the Bay of Plenty and the only data available comprise either large scale charts interpolated from sparse data sets or disconnected local-scale detailed observations. The present study aims to gather benthic habitat information for the purposes of aquaculture zoning within the Bay of Plenty (Figure 1), and to determine its suitability to cope with bivalve aquaculture (specifically *Perna canaliculus*, the New Zealand Greenshell® mussel). Accompanying studies will consider additional features such as the hydrodynamic regime, food availability, *etc*. To maximise data transfer to interested stakeholders, a CD-ROM was created, containing hyper-linked analysed data, video files, thematic data layers and a freely available, query-able GIS viewer.

Aquaculture and the Benthic Environment

Mussel farms can modify the benthic environment. The filtering action of dense bivalve populations effectively diverts the primary production energy from pelagic areas to the benthic food webs. In addition, it results in the packaging of fine suspended material into larger faeces and pseudo-faeces which rapidly settle to the seabed, especially under conditions of limited water flow (CRANFORD et al., 2003). Though the specific dynamics of bivalve faeces/pseudo-faeces deposition (settling velocity, dispersal, resuspension) is relatively poorly understood, enhanced sedimentation and organic enrichment is well documented (HATCHER et al., 1994; CRANFORD et al., 2003; HARTSTEIN and ROWDEN, 2004).

The fall out of the largely organic faeces and pseudo-faeces from cultured shellfish can create significant bio-deposition loadings on sediments, given the specific stocking densities of the site (Mitchell, 2006), along with other factors such as current speeds, depth, and food availability (Chamberlain et al., 2001; Costa and Nalesso, 2006). The sedimentation of these bio-deposits can lead to organic enrichment of the sea floor (Kaspar et al., 1985; Kaiser et al., 1998; Inglis et al., 2000), enhanced nutrient regeneration through the remineralisation of organic material (Dahlback and Gunnarsson, 1981; Tenore et al., 1982; Kaspar et al., 1985; Gibbs et al., 1992; Hatcher et al., 1994; Grant et al., 1995; Ogilvie et al., 2000), development of anaerobic and acidic conditions within the sediment profile (Dahlback and Gunnarsson, 1981; Tenore et al., 1982; Kaspar et al., 1985) and the physical effects of smothering, coverage and build up of deposits on the seabed (Dahlback and Gunnarsson, 1981; Grant et al., 1995; Mitchell, 2006).

Deposition rates as high as 10 cm/yr of combined bio-deposits and shell litter have been measured from bivalve aquaculture sites in sheltered environments (Dahlback and Gunnarsson, 1981; Mattson and Linden, 1983). Reported ranges for the increase in organic material within sediments as a result of bivalve aquaculture vary from a six fold increase (Feuillet-Girard et al., 1994 in Mitchell, 2006), to 2.3 - 3 times higher (Dahlback and Gunnarsson, 1981; Grant et al., 1995; Chivilev and Ivanov, 1997), and no significant changes (Grant et al., 1995; Chamberlain et al., 2001; Crawford et al., 2003; Costa and Nalesso, 2006; Mallet et al., 2006). Increases in the organic content of sediments beneath bivalve aquaculture sites has been shown to be the cause of changes in benthic community structure (Levin and Gage, 1998). Sediment organic content, which is strongly linked to sediment particle size (Milliman, 1994), itself often a function of hydrodynamic regime (Dunbar and Barret, 2005), has been shown to be negatively correlated with benthic in-faunal species richness (Levin and Gage, 1998).

Changes in community structure within and on top of the seabed beneath bivalve aquaculture sites have been observed due to both organic enrichment of the sediments from falling bio-deposits (Pearson and Rosenburg, 1978; Dahlback and Gunnarsson, 1981; Tenore et al., 1982; Kaspar et al., 1985; Chivilev and Ivanov, 1997; Inglis et al., 2000), and also due to the fallout of shell litter (Kaspar et al., 1985; Stenton-Dozey et al., 1999; Grant et al., 1999; Crawford et al., 2003). Where these changes in community structure have been attributed to organic enrichment, an increased abundance of opportunistic species such as deposit feeding polychaete species is often noted (Tenore et al., 1982; Mattson and Linden, 1983; Kaspar et al., 1985; Levin and Gage, 1998; Buschmann et al., 1996; Chivlev and Ivanov, 1997; Stenton-Dozey et al., 1999; Crawford, 2003; Hartstein and Rowden, 2004). The increased abundance of opportunistic deposit feeders is often at the expense of overall benthic biodiversity (Pearson and Rosenburg, 1978; Kaspar et al., 1985). The fallout of shell litter from bivalve aquaculture sites can also induce changes in the benthic macro-faunal species composition. Both Grant et al. (1995) and Stenton-Dozey et al. (1999) observed an increasing dominance of scavenging gastropods, feeding on the fallen mussels. Whilst Kaspar et al. (1985) noted some differences between species composition beneath mussel farms and at reference sites which were attributed to fallen shell material in addition to changes resulting from organic enrichment. Crawford et al. (2003) determined that fallen shell material was the main influence at their sites rather than organic enrichment of the sediments.

Clearly the magnitude and specific details of observed impacts of bivalve aquaculture on the benthic environment varies greatly between sites. Relatively rapid water currents are generally cited as the main contributing influence to minimise organic enrichment of sediments beneath the farms (Pearson and Rosenburg, 1978; Buschmann et al., 1996; Kaiser et al., 1998; Chamberlain et al., 2001; Hartstein and Rowden, 2004; Costa and Nalesso, 2006; Mitchell, 2006). The currents act to enhance the dispersal of the falling bio-deposits and spread the fallout over a much greater area. Hartstein and Rowden (2004) observed a clear difference between sites with low relative hydrodynamism and accompanying fine sediments (9.1 ϕ, 0.002 mm) where organic enrichment, deposition of shell litter, and subsequent changes in species composition were recorded, and sites with relative energetic regimes and accompanying coarse sediments (4.4 ϕ, 0.047 mm) where no such changes occurred. In contrast, Kaspar et al. (1985) observed higher sediment organic contents, along with associated changes in species composition at a site with ‘strong tidal currents’. In addition to the hydrodynamic regime, specific stocking densities of the farm (Chamberlain et al., 2001; Crawford et al., 2003; Mallet et al., 2006), water depth (Chamberlain et al., 2001), and the food availability of the mussels (Chamberlain et al., 2001; Mitchell, 2006) have also been cited as potential explanations for the range in observed impacts.

The natural benthic environment at the site plays a key role in defining the magnitude of any potential impacts. The depositional impacts from an aquaculture site will depend in part on the existing habitat type, e.g. a rocky reef community will be more affected than a soft muddy sediment community. Soft sediment areas with a diverse benthic community will be able to break down sedimented material more efficiently and effectively than areas lacking a range of benthic organisms (Mitchell, 2006). Mallet *et al.* (2006) identify the natural concentration of organic matter in the sediment as an important factor in assessing the potential impacts of shellfish culture. Sediments with little natural organic content are unlikely to be able to cope with additional inputs from an aquaculture development.

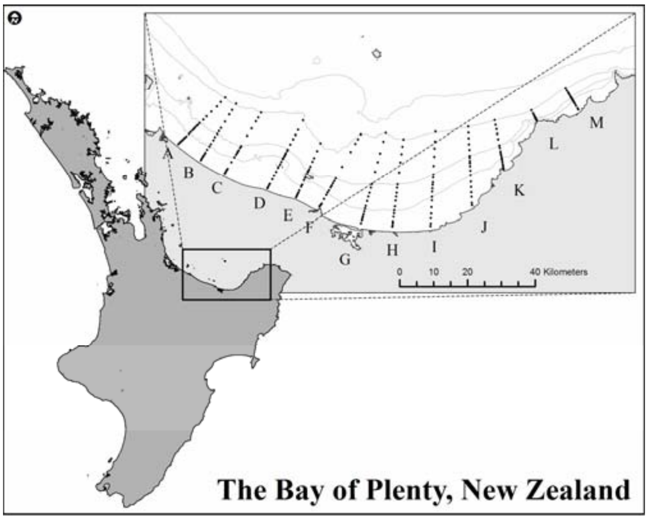

Figure 1. The Bay of Plenty, located on New Zealand’s North Island. Locations of transect sampling shown as dots on inset.

METHODS

Sediment samples, underwater videography, and both in-faunal and epi-faunal organisms were collected from 13 shore normal transects extending from 10 m to 100 m depth (Figure 1). Sediment samples (n = 118) were obtained at each 10 m depth contour along each transect using a ‘SHIPEK’ grab sampler.

Under optimal conditions the sampler obtains a sediment volume of 3000 mL from an area covering 0.04 m^2, with a bite depth of 102 mm. However, difficulty was experienced in obtaining a full sample over hard packed sandy sediments, limiting quantitative measurements of in-faunal community structure. These data are still useful to indicate the range of organisms found at each site. A sub-sample, taken for grain-size and organic content analysis was placed on ice until subsequent analysis. The remaining sample was sieved through a 1 mm mesh, all organisms retained placed in a labelled sample jar and preserved in 5% buffered formalin solution. A total of 200 video files were collected from the transects between 10 m and 80 m depth using a SplashCam® underwater camera unit connected to a Sony® digital video cassette recorder (GV-D800E). Sixteen files were obtained on each transect between 10 m and 60 m depth, and then a file at each 10 m depth contour from 60 m to 80 m. The site identification code, depth, time, date, and Global Positioning System (GPS) co-ordinates were recorded on a whiteboard and videoed prior to each deployment to aid identification. The camera was hand lowered with lights operating if necessary and the seabed recorded for a minimum of 60 seconds. Twelve dredge tows were conducted over distances from 130 to 322 m at depths of 20 and 40 m to obtain a semi-quantitative measure of epi-faunal organisms.

Analysis Methods

Sediment grain size samples were initially treated with 10% hydrogen peroxide to remove any organic material present prior to being analysed by either laser sizer (n = 111), or mechanical dry sieving (n = 9) if particles larger than 1.0 mm were present. The use of two different methods to obtain grain size information is not optimal, though with the range of sediment sizes collected and the available equipment was unavoidable. This limitation is viewed as acceptable in these circumstances as it is the gross sediment parameters which are of interest, and only a limited number of samples from a localised area of gravely sediments were analysed with the sieving methods. Direct comparisons between population distributions determined by the differing methods should, however, be made with caution. The sieved distributions (those with particles > 1.0 mm) will be systematically finer than those analysed with the laser sizer (SAHU, 1965; KENNEDY et al., 1985; RAWLE, 1995). Sediment grain size distributions complete with relevant statistics (sorting, skewness, *etc.*) are incorporated to the viewable GIS as hyperlinked images.

Sediment organic contents, as Ash Free Dry Weights (AFDW) were determined by loss on ignition methods at 400^oC for a period not less than 4 hours. Dry weight determinations were made after drying at 105^oC for 24 hours and cooling in a dessicator (e.g. HARTSTEIN and ROWDEN, 2004; MALLET et al., 2006).

Underwater videography was evaluated for habitat type/complexity with additional biogenic characteristics and any epi-faunal organisms observed being recorded. The underwater video was also used to ground truth multi-beam data surrounding reefs, and edited representative clips of each site saved for incorporation to a viewable GIS as hyperlinked video files.

Sediment characteristics were gridded within the rectangular co-ordinate system of the New Zealand Map Grid (1949) using Golden Software's SURFER® (v 7.0). A krigging algorithm was used to interpolate the data sets over a grid resolution of 2000 m (East-West) and 1000 m (North-South). Areas of known rocky reef or boulder reef were excluded from these interpolations. While it is acknowledged that the interpolation of data across such distances will have inaccuracies at small scales, the method provides valuable information over larger scales and provided this is kept in mind is justifiable given the scale of the environment under study.

Multi-beam bathymetric data were collected by the University of Waikato at targeted sites within the study area during August 2005 aboard the MV *Macy Gray*, equipped with a Triton Imaging®/Simrad® EM3000 multi-beam bathymetric system. This system produces up to 127 beams arrayed over an arc of 130^o and operates by ensonifying a narrow strip of sea floor across track, and detecting the bottom echo with narrow across track listening beams (KONGSBERG, 2006). The swath of sea floor imaged on each survey line was 5 to 6 times the water depth. Regular profiles of the speed of sound were obtained and the multi-beam unit adjusted accordingly, providing accuracy in the vertical plane of ±0.5 m. A Real Time Kinematic (RTK) GPS was used when available for navigation and incorporation into the multi-beam files, when the RTK system was offline Differential GPS (DGPS) was used, providing positional accuracy of ±2 m. Soundings were binned into 0.5, 1.0, and 1.5 m cells for depth ranges of 0-30 m, 30-60 m, and 60 m+ respectively to maintain manageable file sizes. Raster grids were created within the ArcGIS® platform. Multi-beam data were collected from numerous locations throughout the region to delineate reef habitats, determine their morphologic structure and to increase the knowledge of the detailed bathymetry surrounding significant features within the Bay of Plenty. Due to the size of the study area, not all reef habitats within the Bay could be surveyed, the multi-beam investigation focused on offshore reef habitats in areas which are more likely to be proposed as aquaculture zones, i.e. those in the middle of the bay, rather than the relatively inaccessible (for an aquaculture project) regions near Cape Runaway in the far east of the study area. Boundaries for these reefs have been digitised from 1:100,000 and 1:300,000 hydrographical charts (LINZ, 1997, 2002).

RESULTS

Soft sediment grain sizes, characterised by the 50^{th} percentile grain size (D50), vary greatly throughout the region (0.5 – 7.0 ϕ or 0.71 – 0.008 mm). The coarsest sediments are found in the nearshore regions off Pukehina (Figure 2), where they are interspersed with patchy cobble reef. In other nearshore regions fine sandy sediments dominate. Silty and muddy sediments are found in depths beyond 50 m with the exception of sandy sediments in deep water (> 80 m) offshore from Whakatane, and transects F and G (Figures 1 and 2). Strongly bimodal sediment distributions were found in the offshore regions in the west of the study area, off Pukehina (Figure 2). Sediment organic contents ranged from 0 to 6% of the dry weight. Relatively high organic contents (> 4.5 %) were found in deeper areas (60 – 80 m) with high mud contents. Sediment organic content was negatively correlated with the D50 grain size (R^2 = 0.7, n = 118). No correlation was found between sediment D50 grain size and seabed complexity observed from the underwater video camera.

A total of 2270 individual organisms, representing 101 different species from 12 groups were identified from the 118 grab samples. No known rare or endangered species were found in the grab sample or dredge tow fauna. Large variations in species and abundance were found in the grab sample data, demonstrating the patchy distribution of benthic organisms. Polychaetes and crustacea (mainly isopods) tend to be the dominant species in the sub-tidal soft sediments between 10 and 100 m depths, with bivalves also present in large numbers. All three groups were found throughout the range of depths surveyed (10 – 100 m) within the study area, though some trends were apparent in their distribution. Amphipods were found in higher numbers in the

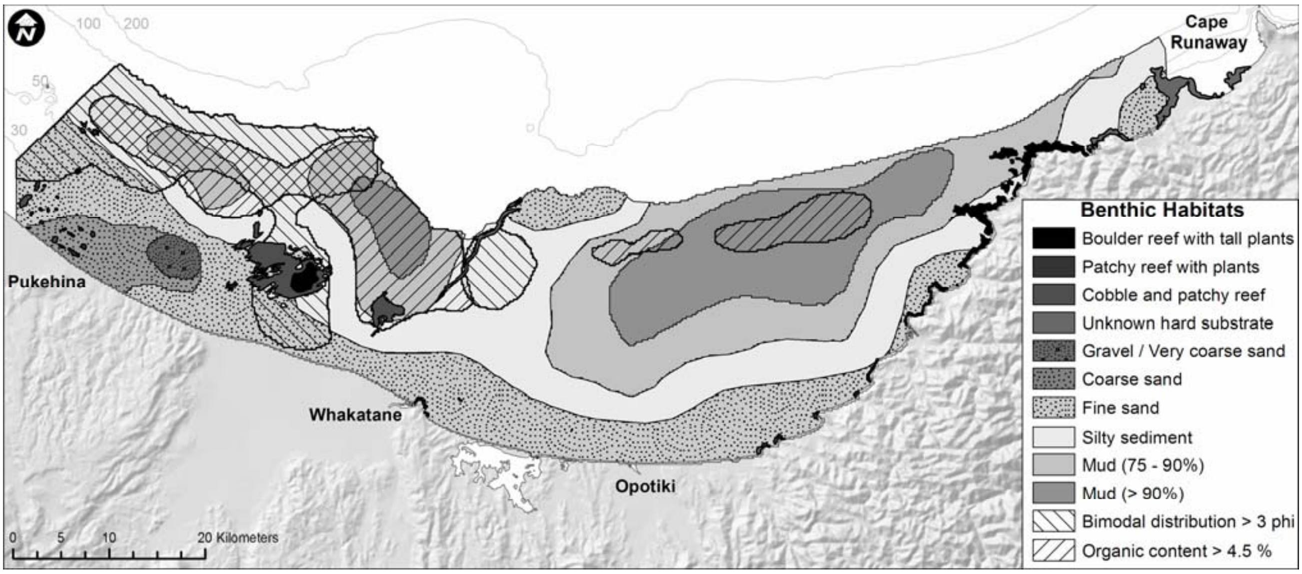

Figure 2. Benthic habitats within the Bay of Plenty, New Zealand, inferred from sediment samples, underwater videography, and multi-beam sonar. Rule based classification scheme to define habitats is defined in Table 1.

shallower (< 50 m) areas with fine silty sediments whilst polychaetes were dominant in the slightly coarser sediments with higher organic contents found in the offshore areas of transects A, B, and C (Figure 1). A wide variety of bivalves was found spread throughout the region. Echinoderms (brittle stars and sea cucumbers) and foraminifera were also common within the samples. Whilst the echinoderms were relatively widely spread, the foraminifera were restricted to sites deeper than 60 m.

Multi-beam bathymetric surveying of targeted areas within the study region clearly delineated the boundaries and determined the detailed morphology of specific reef habitats which are of high preservation value (Figure 2).

Sediment habitats (Figure 2) were defined, using a hierarchical rule based classification scheme, utilising analysed sediment properties such as the D50 grain size, organic content, separation of bimodal peaks, and dominant in-faunal organisms (Table 1), akin to that of Kostylev et al. (2001), Baxter (2003), Jordan et al. (2003) and Urbanski and Szymelfenig (2003). Fine sands with low organic contents and high numbers of amphipods dominate the nearshore (< 30 m depths) of much of the study region, with coarser sands being found in the west near Pukehina, and reef areas nearshore in the east near Cape Runaway.

DISCUSSION

Potential impacts of suspended bivalve aquaculture vary depending on the benthic environment over which the aquaculture is located. Areas of hard substrate, including reef areas are not generally depositional environments and should be avoided as the biologic communities are ill equipped to deal with potential inputs from bivalve aquaculture. Though they are often sites of high currents, which may mitigate potential impacts significantly, they make up a small percentage of the study area (3.5 %, Table 1) and so are of high preservation value. Within the Bay of Plenty, areas of reef and hard substrate have been graded as 'unsuitable' to be located beneath suspended bivalve aquaculture (Table 1 and Figure 3). Within New Zealand, aquaculture farms are 'almost always' sited over soft sediment habitats (Gibbs, 2004). The choice remains however, whether to locate over relatively coarser silty sediments or finer muddy sediments. The international literature contains recommendations for both (e.g. Crawford et al., 2003; Hartstein and Rowden, 2004; Mallet et al., 2006).

Relatively coarser silt sized sediments are generally indicative of a more active hydrodynamic regime, where the potential for build up of bio-deposits is reduced (Hartstein and Rowden, 2004). Where sediments are frequently resuspended by wind and storm events, the ability of the sediments to remain oxygenated and prevent the build up of bio-deposits is enhanced (Mallet et al., 2006). Hartstein and Rowden (2004) found minimal impacts on the benthos (organic enrichment and species assemblages) when a mussel farm was located in a relatively high energy hydrodynamic environment, over relatively coarse sediments (4.5 ϕ or 0.044 mm). Farms located over sandy sediments can, however, displace some native species as the pseudo-faeces and bio-deposits are finer than the native sediments (Grange and Cole, 1997). Sediment particle size has a strong influence on seabed ecology, the deposition of different sized particles will likely impact on the benthic fauna. The sandy sediments found within the Bay of Plenty also had very low organic contents (< 1.5 %), indicating the associated biota will be less able to cope with the potential inputs from aquaculture (*Mallet et al.*, 2006). For the purposes of aquaculture zoning within the Bay of Plenty, areas of coarse and fine sand sized sediments with very low organic contents have been graded as 'relatively unsuitable' (Table 1 and Figure 3).

Finer sediments composed of muds and clays generally represent existing low energy and depositional environments (Dunbar and Barret, 2005), where the benthic fauna will be adapted to at least some degree of sedimentation and organic loading. However, these sediments typically have a higher native organic content (Pearson and Rosenburg, 1978; Crawford, 2003), an important factor in assessing potential aquaculture sites (Mallet et al., 2006). Very high native sediment organic contents along with fine sediments (indicative of a low energy regime) increase the potential for the development of low oxygen layers and anoxia within the sediment profile (Pearson and Rosenburg, 1978). Crawford et al. (2003) note that sediments with high percentages of silts and clays were 'less than ideal', presumably for the reasons previously noted. There is, however, little understanding as to the specific levels of organic matter required to initiate community level changes. Though the organic contents of sediments within the Bay of Plenty are low (< 6%)

Table 1: Classification scheme, characteristics of habitats and their abundance (%) within the study area of the Bay of Plenty.

Habitat Level 1	**Habitat Level 2**	**Additional characteristics**	**Definition criteria**	**Potential habitat specific impacts of aquaculture**	**Aquaculture suitability**
Reef (3.5%)	Boulder reef (0.9%)	Tall plant life	Digitized from multibeam survey, charts and video observations	Smothering through increased sedimentation, shading of plants, significant changes in species composition	Unsuitable
	Patchy reef (0.03%)	Small plant life	As above	As above	Unsuitable
	Patchy cobble reef (1.6%)	No plant life	As above	Smothering through increased sedimentation, significant changes in species composition	Unsuitable
	Unknown hard substrate (0.9%)		As above, no video observations to ground truth.	As above	Unsuitable
Gravel (0.8%)		LOC[1]	Modal sediment size coarser than 0 phi (1 mm)	Sedimentation of non-native particle sizes, increased organic matter, changes in species composition	Relatively unsuitable
Sand (28.6%)	Coarse sand (2.8%)	LOC	D50 sediment size coarser than 2 phi (0.25 mm)	As above	Relatively unsuitable
	Fine sand (22.2%)	Unimodal[3], LOC, amphipods	D50 sediment size 2 - 4 phi (0.25 – 0.063 mm)	As above	Relatively unsuitable
	Fine sand (3.6%)	Bimodal[4], LOC	Bimodal peak separation > 3 phi	Increased organic matter, changes in species composition	Relatively unsuitable
Silt (30.8%)	Silty sediments (19.8%)	Unimodal, LOC	D50 sediment size 4 - 6 phi (0.063 - 0.016 mm)	Increased organic matter	More suitable
	Silty sediments (1.0 %)	Unimodal, HOC[2]	Organic content > 4.5 %	Organic enrichment may lead to anoxic conditions	Less suitable
	Silty sediments (6.9%)	Bimodal, LOC, polychaetes	Bimodal peak separation > 3 phi	Increased organic matter	More suitable
	Silty sediments (3.1%)	Bimodal, HOC, polychaetes	Bimodal peak separation > 3 phi, organic content > 4.5 %	Organic enrichment may lead to anoxic conditions	Less suitable
'Light' mud (21.4%)	'Light' mud (14.9%)	Unimodal, LOC	Mud content 75 - 90%	Increased organic matter	More suitable
	'Light' mud (4.3%)	Unimodal, HOC	Organic content > 4.5%	Organic enrichment may lead to anoxic conditions	Less suitable
	'Light' mud (2.3%)	Bimodal, HOC	Bimodal peak separation > 3 phi, organic content > 4.5 %	As above	Less suitable
'Heavy' mud (14.6%)	'Heavy' mud (10.2%)	Unimodal, LOC	Mud content > 90%	Depositional environment	More suitable
	'Heavy' mud (4.3%)	Unimodal, HOC	Organic content > 4.5%	Organic enrichment may lead to anoxic conditions	Relatively unsuitable
	'Heavy' mud (0.1%)	Bimodal, HOC	Bimodal peak separation > 3 phi, organic content > 4.5 %	As above	Relatively unsuitable

[1]Low Organic Content (LOC, < 4.5%), [2]High Organic Content (HOC, > 4.5%), [3]Unimodal sediment distribution, [4]Bimodal sediment distribution

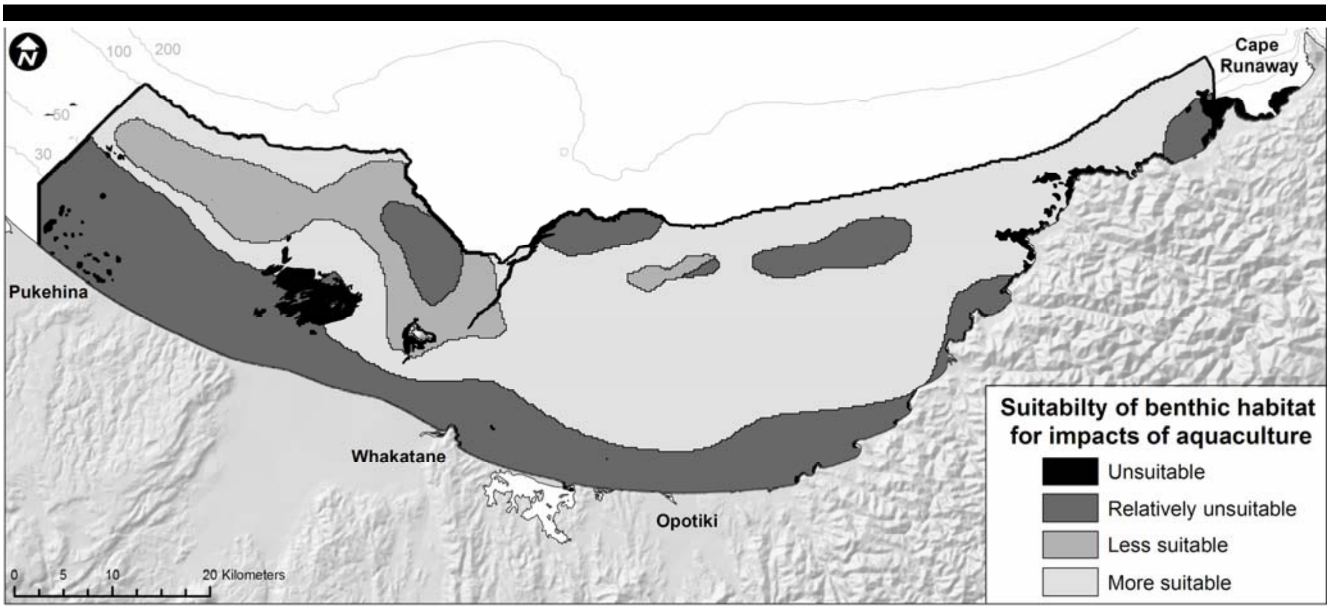

Figure 3. Suitability of benthic habitats within the Bay of Plenty, New Zealand to cope with the potential impacts of bivalve aquaculture.

relative to many other sites, those habitats with organic contents above 4.5% have been graded as ‘less suitable’ (Table 1 and Figure 3) if sediments are silt sized, and ‘relatively unsuitable’ if there is a large (>90%) proportion of mud sized particles, enhancing the potential for anoxia.

Bivalve aquaculture has the potential to modify soft sediment benthic regimes due to the deposition of shell material (Grant et al., 1995; Gibbs, 2004). In some cases the variety and density of fish and crustaceans can increase as a result of the shell litter (Grant et al., 1995; Hartstein and Rowden, 2004). Over muddy sediments, bivalve aquaculture can enhance the diversity of benthic animals, bio-deposits can be ingested by deposit feeders, while shell litter *etc*, increases habitat heterogeneity and allows colonisation by additional species more suited to hard substrates (Grange and Cole, 1997). Muddy and silty areas with relatively low organic contents (< 4.5%) have been graded as ‘more suitable’ (Table 1 and Figure 3) for the purposes of aquaculture zoning within the Bay of Plenty as they represent the benthic environments most suitable to deal with the potential fallout from suspended bivalve aquaculture. These areas are generally located deeper than 35 m and are in the central and eastern regions of the Bay of Plenty.

The production of a viewable GIS based data CD has enabled the data and information from this study to be available in a readily accessible, spatially referenced, intuitive and convertible format. This method has maximised knowledge transfer and data dissemination to interested parties.

SUMMARY

A sustainable shellfish aquaculture industry requires that impacts on the environment be minimised and mitigated. Detailed analyses during the planning stages can aid the mitigation of negative impacts. The Bay of Plenty, New Zealand has a range of benthic habitats and sedimentary environments which vary in their ability to cope with inputs from open coast bivalve aquaculture. This study has found areas in the central and eastern Bay of Plenty deeper than 35 m to be the best equipped to deal with the inputs from suspended bivalve aquaculture. These sites comprise of silt and mud sized sediments with relatively low organic contents.

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