Intertidal shellfish survey within Maketu Estuary
Bay of Plenty, New Zealand

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Abstract

Shellfish surveys are a useful first step in the restoration of estuarine environments. The following report summarises a baseline shellfish survey which aims to determine the distribution and abundance of intertidal shellfish within Maketu Estuary with particular focus on the size of pipi (*Paphies australis*) and tuangi/cockles (*Austrovenus stutchburyi*). Sampling was carried out on the 25th of October and 12-13th of November 2012, within three zones in Maketu Estuary (shellbank, sandbank and channel). Infaunal shellfish (under the surface) accounted for the majority of invertebrates surveyed (97.2%, *n* = 11727) and primarily consited of pipi (94.5%) and tuangi/cockles (5.5%). Epifauna (shellfish on the surface) consited of top shells (*Diloma subrostrata*) (47.5%, *n* = 162), whelks (*Cominella* sp.) (46.6%, *n* = 159), mussels (*Perna canalicula*) (2.3%, *n* = 8), sand dollars (*Fellaster zelandiae*) (1.5%, *n* = 5), mud crabs (*Helice crassa*) (1.8%, *n* = 6) and mud snails (*Amphibola crenata*) (0.3%, *n* = 1). Shellfish diversity was highest within the shellbank and channel zones, with very low densities on the raised sandbank. High mean densities of pipi (max. 2352 per m^2) occurred near the low tide mark within the shellbank and channel zones. Conversely, tuangi occurred at lower mean densities (max. 326 per m^2), primarily at the edge of the main channel. The majority (76.4%, *n* = 8467) of pipi measured during the survey were between 20 and 45 mm long; pipi larger than 45 mm were infrequent (6.8%, *n* = 749). Tuangi were primarily (83.3%, *n* = 483) between 15 and 29 mm long.

1 Introduction

New Zealand's harbours and estuaries are becoming increasingly endangered via sedimentation and nutrient inputs from land-based activities (e.g. Thrush *et al.,* 2004; Huteau, pers. comm.; Bramley, 2010). Iwi, schools and other community groups interested in improving coastal ecosystems are joining forces to monitor and help restore estuarine ecosystems that contribute to an overall healthier environment. This increased interest in monitoring is due, in part, to the declines in shellfish fisheries that are an important food source for people in the Bay of Plenty, reflecting traditions and a way of life dating back generations. Shellfish and other ecological surveys are a useful first step in the restoration of estuarine environments (Brumbaugh *et al.,* 2006). Further steps involve developing site strategies for restoration, implementation of those strategies and measuring the effect of implementation (Brumbaugh *et al.,* 2006). The following report summarises a baseline shellfish survey initiated by the Maketu Taiapure Committee within Maketu Estuary, Bay of Plenty, New Zealand.

1.1 Aim

To determine the distribution and abundance of intertidal shellfish within Maketu Estuary with particular focus on the size of pipi (*Paphies australis*) and tuangi/cockles (*Austrovenus stutchburyi*) to aid future management.

2 Methods

2.1 Study site

Maketu Estuary is a shallow intertidal estuary (2.3km^2) located in the Bay of Plenty, North Island, New Zealand (Figure 1; Goodhue, 2007). The Kaituna River contributes the largest freshwater flow into the estuary through control gates. The hydrodynamics of Maketu Estuary have been drastically altered by the artificial diversion of the Kaituna River in 1956, which led to sediment infilling and extensive build-up of sandy intertidal flats (Figure 1; Gregory, 1981; Burton & Healy, 1985; Domijan, 2000; Goodhue, 2007; Hume *et al.,* 2007). The gradual build-up of sediment and an increase in salinity have affected fish and shellfish stocks (e.g. Gregory, 1981), significantly reduced saltmarsh habitats (e.g. Donovan *et al.,* 1976; Bergin, 1994), degraded water quality (e.g. Goodhue, 2007; Bramley, 2010) and impeded access and navigation.

Water quality within Maketu Estuary is affected by elevated nutrients, faecal coliforms and high algae concentrations derived from the lakes as well as contributions from tributaries and industrial, farming and urban discharge (e.g. Goodhue, 2007). These high nutrient levels have led to seasonal blooms of macroalgae within Maketu Estuary, notably green alga *Ulva* spp. (e.g. Bramley, 2010).

Figure 1: Maketu Estuary from Town Point (Okurei), Bay of Plenty, New Zealand (Photograph: Julian Fitter).

2.2 Zones

Shellbank (A-B)

A gravelly/shelly bank habitat occurs between the sand bank and the estuary mouth (Figure 2). This area has small channels running through it, though parts are exposed at low tide.

Sandbank (C-D)

Coarse sand is found in a raised bank running parallel to the main channel from the boat ramp to the upper estuary (Figure 2). This area has a very shallow slope and is the last area to become inundated when the tide comes in.

Channel (E-I)

The main channel in Maketu Estuary tends to have a sandy substrate with occasional shelly banks. The channel is well defined at low tide, but is inundated at high tide (Figure 2). Shelly banks near the middle of the channel are exposed at lowest tide. The channel is influenced by both salt and fresh water inputs throughout the estuary.

Figure 2: Transect locations within Maketu Estuary, Bay of Plenty, New Zealand. Survey zones: shellbank (A, B), sandbank (C, D), channel (E-I) (Map: Google Earth).

2.3 Sampling methods

Sampling was carried out on the 25th of October and 12-13th of November 2012. Nine 30m transects were set 50m apart starting from the lower estuary (right of the boat ramp) and moving to the upper estuary (across from the Marae) oriented at 90° to the main channel (Figure 2). Six 0.25m^2 quadrats were placed 5m apart on each transect line (total of 54 samples). All samples were sieved through a 1cm mesh to a depth of 10cm. Counts of all live shellfish (including: molluscs, crustaceans and echinoderms) on the surface (epifauna) and under the surface (infauna) were made along with measurements of the maximum lengths (longest shell axis) of dominant bivalves (pipi, tuangi). All shellfish were returned to the collection point following each sample.

2.4 Data analyses

Pearson χ^2 tests were used to examine categorical variables (shell size, distance along transect). All statistical analyses were conducted using SPSS. Additional surveys following the same methodology will be completed on a bi-annual basis (October and April) in order to assess how the species assemblages alter over time.

3 Results

3.1 Distribution of epifauna (shellfish on the surface)

Epifaunal shellfish occurred throughout the three tidal zones surveyed and accounted for 2.8% (*n* = 345) of shellfish surveyed (within the top 10cm of subsrate). The majority of epifauna consited of top shells (*Diloma subrostrata*) (47.5%, *n* = 162) and whelks (*Cominella* sp.) (46.6%, *n* = 159); mussels (*Perna canalicula*) (2.3%, *n* = 8), sand dollars (*Fellaster zelandiae*) (1.5%, *n* = 5), mud crabs (*Helice crassa*) (1.8%, *n* = 6) and mud snails (*Amphibola crenata*) (0.3%, *n* = 1) were less frequent (Figure 3). Epifauna occurred most frequently within the shellbank and channel zones and were infrequent within the sandbank zone (Figure 3).

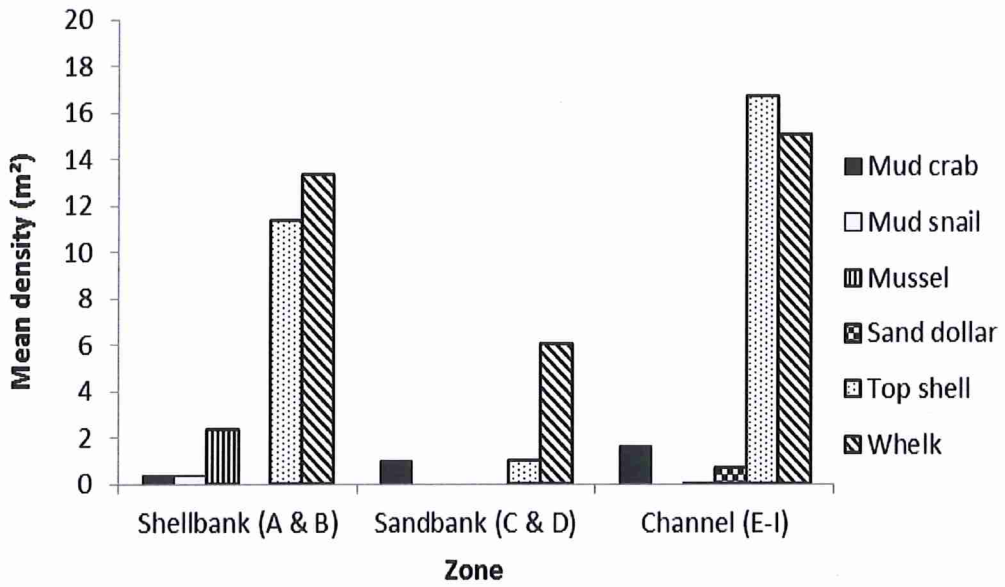

Figure 3: Mean density (m^2) of epifauna within three zones in Maketu Estaury, Bay of Plenty, New Zealand.

3.2 Distribution of infauna (shellfish under the surface)

Infaunal shellfish accounted for the majority of shellfish surveyed (97.2%, n = 11727) and primarily consited of pipi (*Paphies australis*) (94.5%, n = 11086) with tuangi/cockles (*Austrovenus stutchburyi*) (5.5%, n = 641) making up the remainder. The mean density of pipi was highest within the shellbank (263 to 2352 per m^2) and channel zones (556 to 1807 per m^2); pipi were infrequent on the sandbank (0 to 3 per m^2) (Figure 4). Tuangi occurred exclusively within the channel zone, primarily in the upper channel (transect I: mean = 326 per m^2) (Figure 3). Pipi and tuangi distribution differed significantly (Pearson χ^2: χ^2 = 343.347, df = 5, $p < 0.05$) in relation to the tide mark (distance along the transect line). Pipi were primarily distributed near the low tide mark within the shellbank and channel zones (Figure 5). Conversely, tuangi occurred at the highest densities at the edge of the main channel and decreased towards the low tide mark (Figure 6).

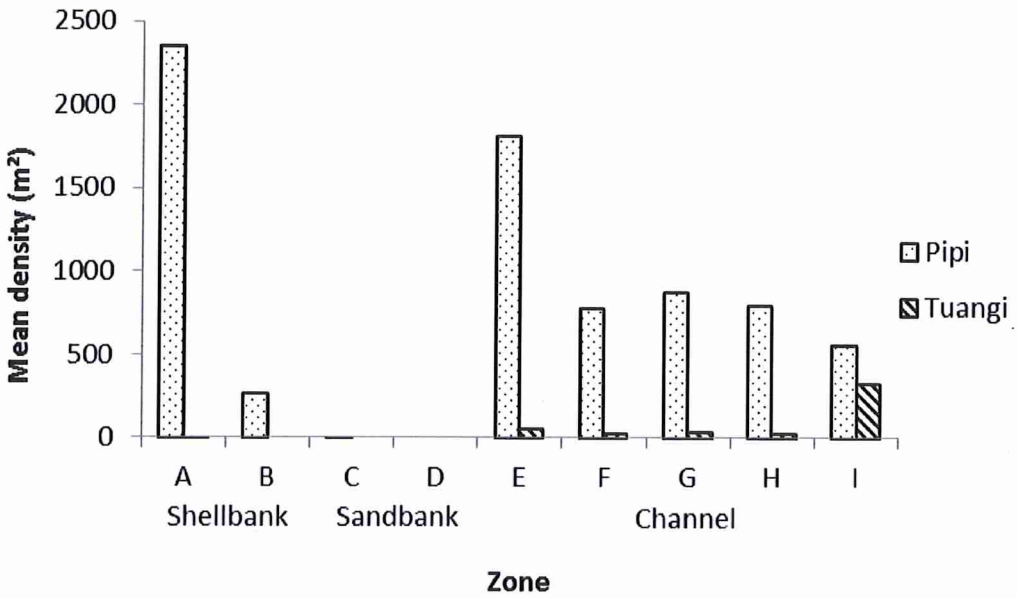

Figure 4: Mean density (m^2) of pipi and tuangi within three zones in Maketu Estuary, Bay of Plenty, New Zealand.

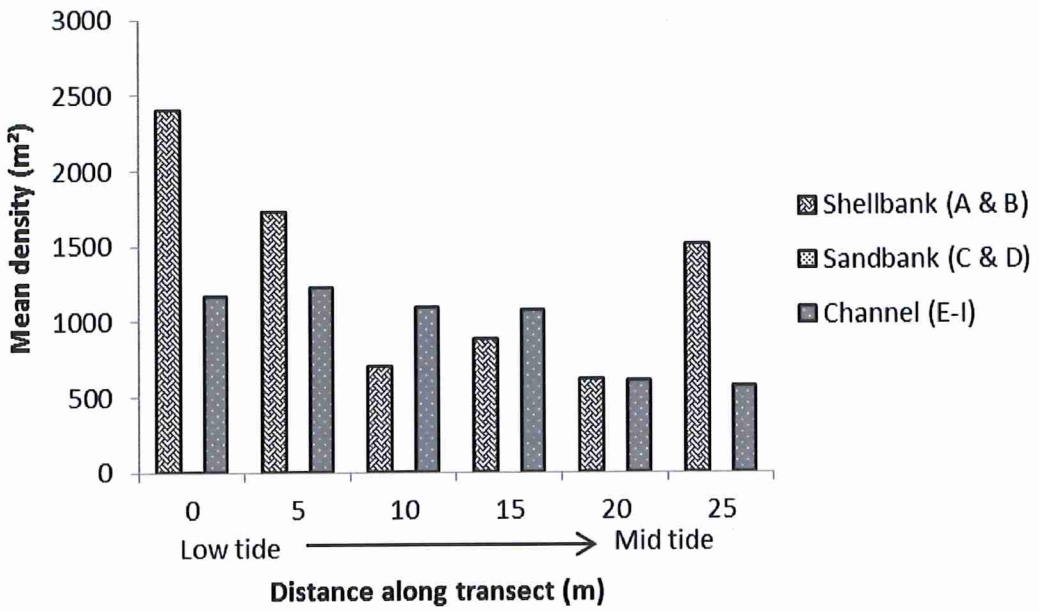

Figure 5: Mean density (m^2) of pipi in relation to the distance along the transect (m) within three zones in Maketu Estaury, Bay of Plenty, New Zealand.

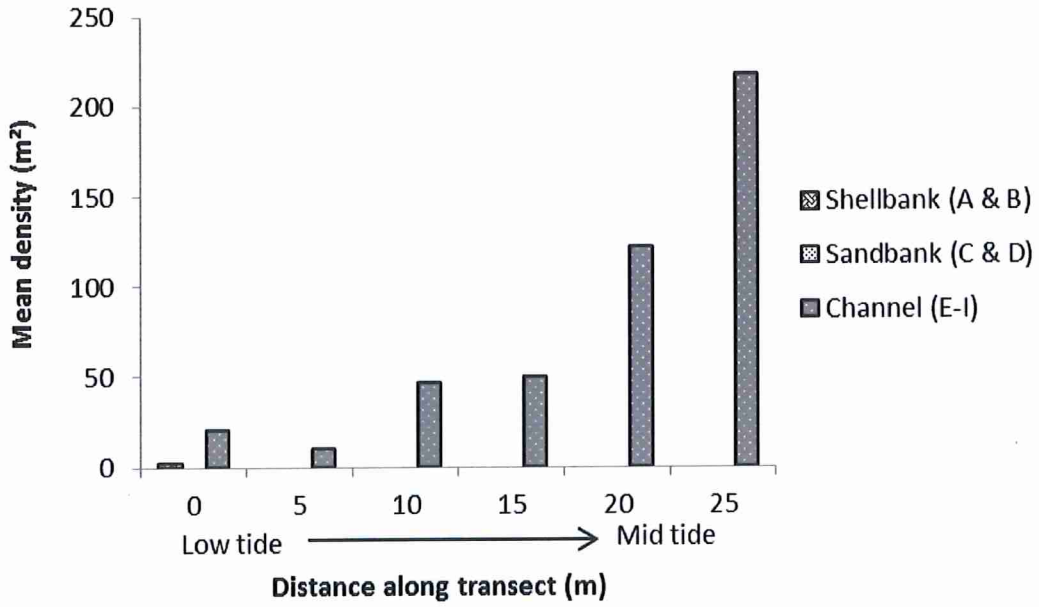

Figure 6: Mean density (m^2) of tuangi in relation to the distance along the transect (m) within three zones in Maketu Estaury, Bay of Plenty, New Zealand.

3.3 Pipi size

The highest proportion (76.4%, n = 8467) of pipi measured during the survey were between 20 and 45 mm long; pipi larger than 45 mm were infrequent (6.8%, n = 749) (Figure 7). The majority (67.7%, n = 1265) of small (<20 mm) pipi occurred within the shellbank zone (Figure 8). However, there was no significant difference (Pearson χ^2: χ^2 = 45.796, df = 2, $p > 0.05$) in the mean density of pipi size classes between the shellbank and channel zones.

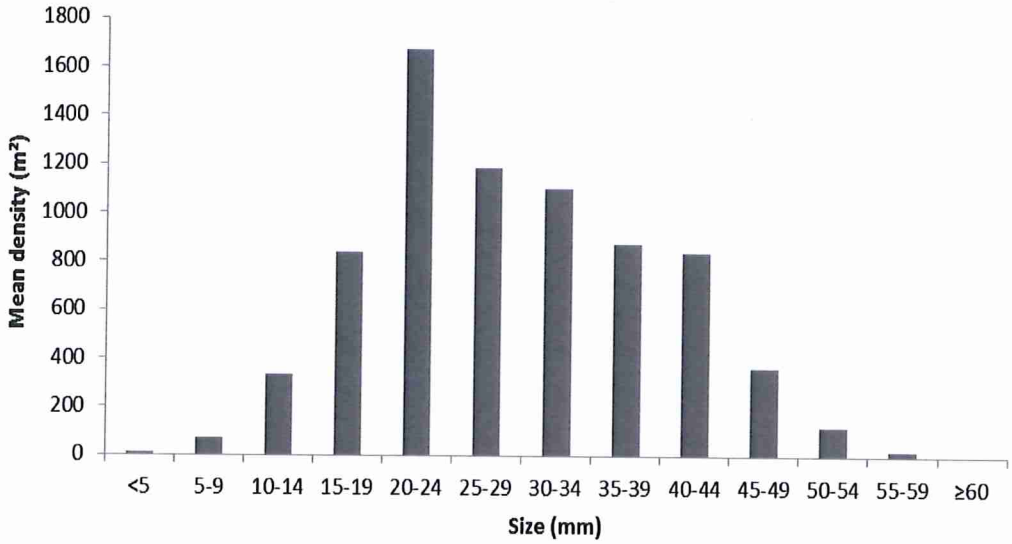

Figure 7: Mean density (m^2) of pipi size classes (mm) within Maketu Estuary, Bay of Plenty, New Zealand.

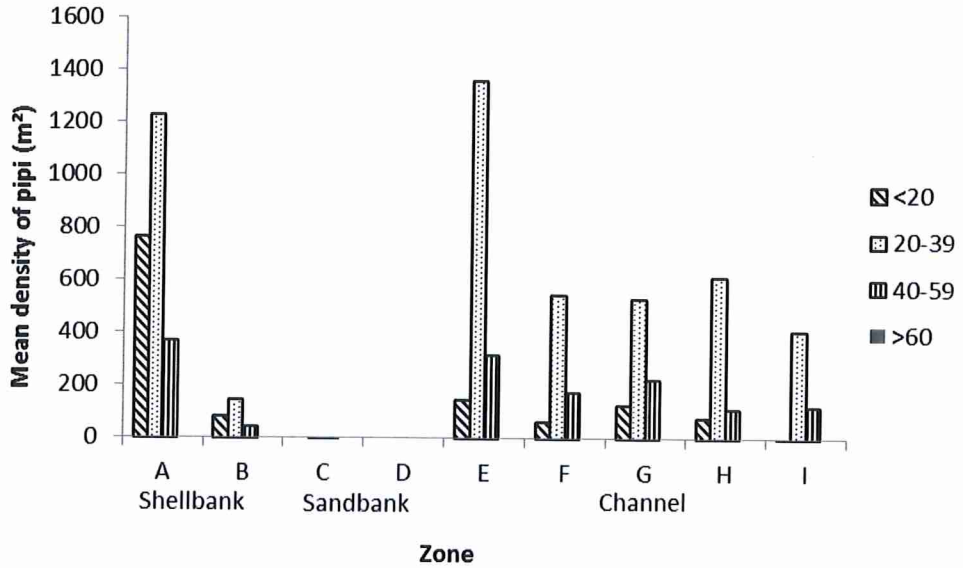

Figure 8: Mean density (m^2) of pipi size classes (mm) within three zones in Maketu Estuary, Bay of Plenty, New Zealand.

3.4 Tuangi size

The majority (83.3%, *n* = 483) of tuangi measured during the survey were between 15 and 29 mm long, tuangi larger than 30 mm were infrequent (5.5%, *n* = 32) (Figure 9). The majority (67.7%, *n* = 1265) of tuangi occurred in the upper channel zone (transect I) (Figure 10).

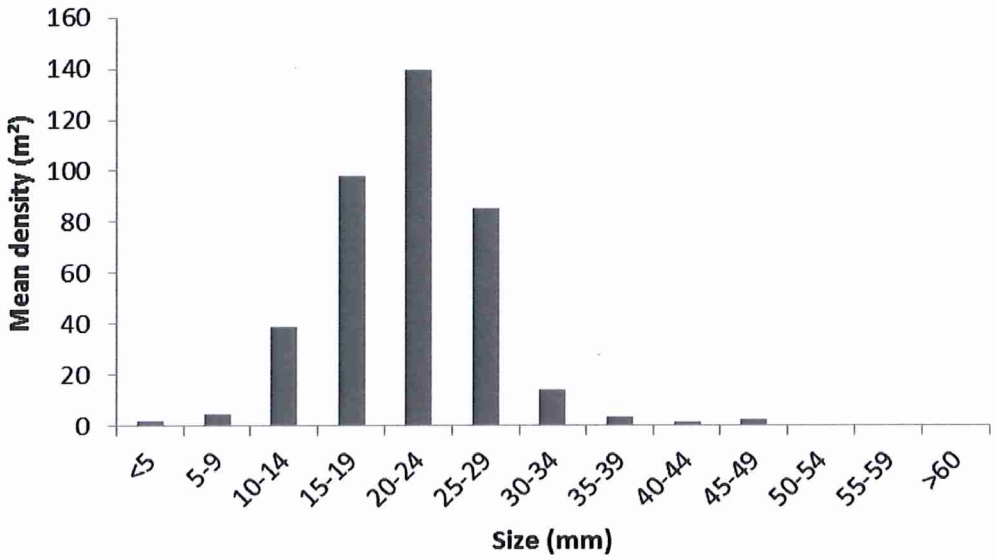

Figure 9: Mean density (m^2) of tuangi size classes (mm) within Maketu Estuary, Bay of Plenty, New Zealand.

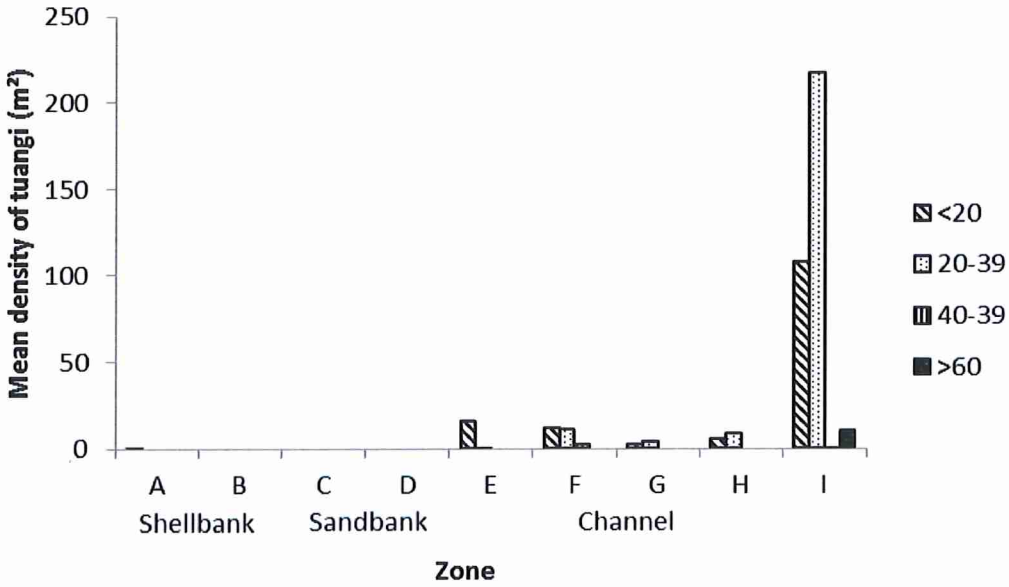

Figure 10: Mean density (m^2) of tuangi size classes (mm) within three zones in Maketu Estuary, Bay of Plenty, New Zealand.

4 Discussion

The diversity of shellfish in Maketu Estuary was relatively low within the survey area (max eight species per m^2). Species commonly found within the intertidal zone including horn (*Zeacumantus* sp.), trough (*Cyclomactra ovata*) and wedge shells (*Macomona liliana*) were absent during the present survey. This could possibly be attributed to trough and wedge shells being deep burrowers primarily occuring below the top 10 cm of sediment surveyed. This is further confirmed by the presence of empty trough and wedge shells within the estuary. Horn shells prefer moist muddy habitats which occur further up the estuary near the salt marsh habitat. Historic evidence suggests that mussel and oyster beds occurred within Maketu Estuary prior to the Kaituna River diversion (e.g. Gregory, 1981). However, only small numbers of juvenile mussels were found during the present study. It is likely that sediment infilling has caused the mussel and oyster beds to decline within the estuary, although, this requires further investigation. Shellfish diversity was highest within the shellbank and channel zones and very low on the sandbank. This concurs with previous reports from Matapouri Estuary in northern New Zealand where overall shellfish diversity was highest within channel and bank habitats (Alfaro, 2006).

Seagrasses were absent within the area surveyed, however extensive blooms of sea lettuce (*Ulva* spp.) occur within the estuary during summer months. Seagrass beds tend to be productive habitats with a high density and diversity of organisms (e.g. Connolly, 1997; Nelson & Waaland, 1997; Van Houte-Howes *et al.,* 2004; Alfaro, 2006). However, seagrasses are fragile ecosystems which require good water quality to sustain productivity. Nutrient and sediment loading from land-based activities is the primary reason for the decline in seagrass habitats both in New Zealand and worldwide (Short & Wyllie-Echeverria, 1996). High nutrient levels create ideal growing conditions for sea lettuce with Maketu Estuary (Huteau, pers. comm.; Bramley, 2010), these blooms result in extensive mats of algae which smother shellfish habitats and cause reduced oxygen levels in sediments and high levels of toxic hydrogen sulphide gas (Marsden & Bressington, 2009, Heteau, pers. comm.). Such conditions are detrimental to infaunal shellfish (Marsden & Bressington, 2009), and are hazardous to human health (Huteau, pers. comm.).

One of the greatest concerns to many locals and long-time users of Maketu Estuary is the demise of the pipi beds (e.g. Richmond *et al.,* 1990). Possible causes for the reduction in beds are the excessive rate of sedimentation smothering active pipi beds coupled with altered salinity levels within Maketu Estuary following the Kaituna River diversion (1956) (Burton & Healy, 1985; Norkko *et al.,* 2002; Thrush *et al.,* 2003; Park, 2003; Goodhue, 2007). Increased sediment run-off from land due to human activities has been recognised as a major threat to the marine environment (Gray, 1997; Ellis *et al.,* 2004; Airoldi, 2003; Thrush *et al.,* 2004). Pipi require coarse sedimentary environments and do not tolerate fine inorganic particles which clog their filtration mechanisms (McLachlan *et al.,* 1995). Modifications of catchments also alter salinity regimes which have

consequences for the distribution of estuarine species (e.g. Ysebaert *et al.,* 1998; Gillanders & Kingsford, 2002), there is evidence that pipi are intolerant of low salinity levels (McLeod & Wing, 2008), however, there is a lack of research into the influence of high salinity levels on pipi survivorship.

Pipi measured during the survey were primarily between 20 and 45 mm long, larger pipi were infrequent. This differs from historic evidence which suggests that large pipi were common within Maketu Estuary. The reduction in pipi size could be partially attributed to high harvest rates. Following extensive recreational fishing surveys within the Maketu Taiapure the pipi harvest within Little Waihi Estuary was estimated at a few million for the period 1999 to 2000 (Bradford *et al.,* 2001). A low rate of harvest was shown within Maketu Estuary during this period due to a Rahui (ban on harvesting) being in place from October 1999 to mid-2000 (Bradford *et al.,* 2001). It is highly likely that harvest rates within Maketu Estuary would have resumed to similar levels as observed in Little Waihi following the lifting of the Rahui.

In New Zealand, recreational shellfish gathering is currently managed by species specific daily bag limits and occasional area closures (Rahui). Despite these measures, there is public concern about the over exploitation of shellfish resources in highly populated areas (Hartill *et al.,* 2004). There are multiple stressors which impact on shellfish stocks, including: habitat requirements (sediment particle size, salinity), food availability, heavy metal contamination and harvest rates (Thrush *et al.,* 2008). Each estuary has a different level of stress associated to these factors; therefore, the only way in which to protect separate shellfish stocks is to conduct well-designed field surveys (e.g. Thrush *et al.,* 2008) with on-going monitoring within estuaries to create area specific catch limits. Pipi stocks within Maketu Estuary may benefit from this form of management as the area surveyed during this study appears to consist of primarily juvenile pipi (shell length less than 40mm – Hooker, 1995), smaller bag limits may enable the juvenile pipi to grow to sexual maturity (greater than 40mm shell length – Hooker, 1995) and spawn before being harvested.

Tuangi were less frequent within the survey area than pipi, this differs from historic evidence which suggests that tuangi thrived in the higher saline environment present since the Kaituna diversion (Goodhue, 2007). Tuangi are also more tolerant of fine sediment than pipi (e.g. Alfaro, 2006). Tuangi were primarily located in the upper channel which indicates that tuangi beds may extend beyond the area surveyed, further up the estuary. The majority of tuangi measured during the survey were between 15 and 29 mm long, tuangi larger than 30 mm were infrequent. This differs from anecdotal reports of large tuangi occurring in beds throughout Maketu Estuary.

Local Iwi and environmental groups have been calling for the re-diversion of the Kaituna River back in to Maketu Estuary for many years, with hopes of flushing out sediment and restoring habitats.

Negations are currently underway with ~~Western Bay of Plenty~~ Regional Council on how best to achieve this goal. It is not a simple process, as re-diverting the river will bring new erosive forces, higher water volumes, increased threat of flooding and changes in water quality (Tortell, 1985). However, it is clear that the health of the estuary has declined since the diversion (e.g. Gregory, 1981; Burton & Healy, 1985; Tortell, 1985; Richmond & Forbes, 1990; Goodhue, 2007) and on-going monitoring of shellfish within the estuary will form an integral part of the re-diversion process.

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