FORAMINIFERA AND GEOCHEMISTRY ANALYSIS IN A SHORT CORE, LYTTELTON HARBOUR, NZ

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ABSTRACT:
A short core was taken in Lyttelton Harbour where samples were analyzed for their abundance and diversity of foraminifera in relation to sediment grain size and trace element chemistry. This was done in order to see if there was a correlation between foraminifera and anthropogenic impacts to the environment. Pre-European levels of trace element chemistry were not found in the core, though differences in their levels were found in relation to depth and foraminiferal abundance. Few foraminifers were found near the surface, where sediment was finer grained and richer in organic material, the opposite being true in deeper samples. Low number of foraminifera found in the upper levels of the core could be an indicator of rapid sediment accumulation from dredging within the harbor. The disturbed nature of the foraminifera in the surface and upper level samples could indicate a breakdown of calcareous samples. Higher number of Trochammina inflata may indicate a change in the tidal profile in this area. Future studies, and multiple cores taken at different areas throughout the harbour will be necessary to fully understand this subject.

INTRODUCTION:

Over the past century human impact on marine life in coastal settings has increased dramatically. Harbours may be at particular risk changes from pollutants and increased infrastructural because of their enclosed nature, lack of water circulation and physical closeness to human activities (Hayward et al. 2003). Currently much is being done to reduce the amount of harmful waste being released into waters, as there is a desire to return the oceans to a pre-human "healthy" state (Hayward et al. 2004). Yet, frequently there is no record or baseline of what this original state looked was like. One method for discerning pre-human baseline and marking changes in a marine environment is the analysis of foraminifera.

Foraminifera are single celled organisms that grow a calcareous shell usually only a few millimeters in size. Living in waters, when they die their shells sink to the ocean floor where they mix with the sediment and leave a fossil record (Campbell, 2012).

Their rapid evolution and abundance make foraminifera useful in dating rocks, but they can also be good indicators of overall harbour health (Hayward, 2013.) When looked at in addition to sediment grain size and trace element chemistry, correlations can be made between foraminifera and anthropogenic environmental impacts. Water circulation patterns, the relative acidity of a region, and the overall response of a biota to pollutants are just a few of the indicators foraminifera can reveal (Hayword, Hollis 1981). Within brackish areas correlations can also be found between foraminifera species, salinity and depth (Figure 2). In New Zealand, where human contact is relatively recent, less than a thousand years old, short cores are an affordable and easy way to gain access to sediments deposited prior to people (Gina).

Studies looking at benthic foraminifera as indicators of overall harbor health have already taken place in New Zealand, in Waitemata Harbour, Auckland (Hayward et al. 1997) and Manukau Harbour, Auckland, New Zealand (Mathews et al. 2005). However, the Canterbury region is still largely understudied. Dr. Catherine Reid is doing ongoing work in the Avon-Heathcote Estuary (Reid, 2013), but other than that the majority of research in the area has been on offshore foraminifera (Hayward, 2010.)

The purpose of this study is to gain a clearer picture on how anthropogenic changes may be affecting marine life within Lyttleton Harbour by collecting a short core at Governors Bay (Figure 1) and analyzing foraminifera, sediment size, and trace element chemistry. We compare data from this paleorecord with modern foraminifera and sediment and geochemical data being collected concurrently at multiple surface locations throughout the harbor. This allows us to understand how changes in the foraminifera record compare geographically as well as through time. This study aims to add to the ongoing collection of information on foraminifera in the Canterbury region, which has been understudied thus far.

GEOLOGIC BACKGROUND:

The location of our core is in the intertidal mudflats of Governors Bay, in the Northwest corner of Lyttelton Harbor, Canterbury, NZ. Lyttelton Harbor is a 15km wide inlet located in the northern section of Banks Peninsula (Figure 1.) the harbor was created out the remains of seven inactive volcanoes, whose composition may contribute to the high levels of iron and magnesium in the water.

The area was originally inhabited by Maori 700 years ago, but officially became a port in 1848 (Lyttleton Harbour Information Center, 2009). Since this time human activity in the harbour has only increased. The effect of added shipping infrastructure, deforestation, pollutants, increased run-off and dredging on marine life has not been thoroughly studied. Major deforestation occurred in the area between 1860 and 1890 (Vries 2007). Dredging occurred in the harbour as the port shifted to containerization, the affects of which are detailed in a study by Curtis in 1985.

This location was originally chosen because it was considered far enough back in the harbour for floor sediments to be unaffected by harbour dredging, yet due to the nature of the harbors water circulation would still share the regions overall geochemical makeup. In areas continuously accumulating sediment at a rate exceeding 1-2mm y^{-1} it is possible to reconstruct a recent historic record using preserved foraminifera (Murray 2006). Recent studies of sediment accumulation in Lyttleton Harbor have found rates to be that much or higher, making this site appropriate for this study (Goff 2005.)

METHODOLOGY:

A site was chosen at low tide in the mudflats at Governors Bay. A surface sample of sediment was taken using a hand spade. Using a hand auger, a half-meter long and six cm diameter core was inserted into the ground and removed in two segments, receiving roughly 100 cm of mud. Another 33 cm was gathered using a smaller 2cm diameter core. The samples were brought back to the lab. Here, cores were scraped for clean surfaces and then lithological logged. Samples were taken roughly every 10cm for foraminiferal analysis, with a portion set aside, dried and crushed using a mortar and pestle.

Foraminifera samples were wet sieved through a 63-µm mesh. The retained sand fraction was then was then floated using carbon tetrachloride and dried. Methods were based off of Hayward, 2004. The surface sample was stained with Rose Bengal, so that live foraminifera could be identified and excluded from the census counts. Samples were microsplit, but due to the low number of foraminifera available the entirety of what was left was left. for identification and census count. Counts were standardized as percentages. Diversity and Evenness of species, as well as cluster

Trace element chemistry was analyzed in samples using the methods of "Trace Elements in the Sediments of Lake Forsyth/Wairewa", a study done in Canterbury in 2012. Carbon and Nitrogen were tested in the samples using an Isotope Ratio Mass Spectrometer.

RESULTS

Sediment size increased with depth, with muddy samples towards the surface, and sandier samples at greater depths. Shell layers were found throughout the core, with increasing frequency at greater depths. At 58 cm basaltic clasts up to 8mm diameter were found. Largest shell pieces were up to 3cm in length. Percent carbon and nitrogen both decreased with depth. Lead, zinc and copper all also decreased with depth.

Abundance of foraminifera in the core increased with depth, going from as low as 5 at the surface to 122 at 118cm depth. Species diversity also varied with depth. A cluster analysis in PAST revealed there were three main groupings of species, though more can not be inferred from this in relation in

Agglutinated species such as *Trochammina. inflata* were only found in the first four samples, but not lower than 58cm. Lower that 58cm all samples were entirely calcareous.

Surface samples were often fragmented, and showed signs of decay compared to lower samples, which were almost entirely completely intact.

DISCUSSION:

Trochimina inflata are a species more commonly found above the mean high water mark (Figure 2) and was only found in upper samples, 53cm and higher. *Ammonia parkinsoniana, Haynesina depressula, Elphidium excavatum* are calcareous found in a more marine setting, and found widley in our deeper samples. The differences in species diversity could reflect a shift in the tidal profile, from a more submerged setting to shallower region.

H. depressula and *A. parkinsoniana* were both found in surface samples, but they were usually fragmented and showed signs of deteriorating. The upper samples also had relatively higher organic material, which acidifies pore fluid as it decomposes and could be breaking down the record of more calcareous species. T. inflata is and agglutinated foraminifera and is thus resistant to breaking down from acidification, so any record of these species would have been preserved in deeper samples, but were not found.

Compared with a core taken at the Avon Heathcote Estuary (Reid), the relative change in Pb, Zn and Cu were not enough to indicate that the Lyttelton Core went deep enough to show pre-European levels in the harbour. The levels of heavy metals found throughout the core were low enough to be comparable to that of the Avon pre-European levels, implying these chemicals may be in fewer concentrations than expected at this location. This study was unable to provide a baseline for harbour health prior to human activity. However, the large amount of mud at the surface of the core, coupled with the low abundance of foraminifera from upper samples may be due to increased sedimentation in the harbour caused by dredging.

Similar studies done in Auckland which found a low number of foraminifera and heavy metals in the surface of their harbour cores argued that it could have been due to the outwash of these materials (Hayward 2005). However in Lyttelton it would be expected that if foraminifera at the surface has been washed away, so would the finer sediment, and these upper samples are mostly composed of mud with a few thin sand layers.

This study has shown that there are foraminifera in Lyttelton Harbour and Governors Bay, and that coring is an effective method of analyzing them. When compared to the surface sample work done by K. Berger concurrently with this study (Berger 2014), the surface samples taken at this cores location differed significantly in both diversity and abundance from samples

taken in other areas around the harbour. Future studies are encouraged to a) compare cores at multiple locations, b) take deeper cores in the hopes of finding evidence for pre-European baseline information, c) take a larger sample size throughout core. One limitation to this study was the loss of samples between 83-97 cm when the core was being collected. Repetition and more time could create a more thorough analysis.

CONCLUSION

The original goal of finding pre-European levels of trace element chemistry and foraminifera in Lyttelton harbour was not achieved, because the core length would need to be longer than originally hypothesized. New information was gathered on surface levels of foraminifera, and has raised questions on the affects of dredging on harbour life.

In future studies much can be done to improve upon this study. Grain size could be more accurately and thoroughly measured with depth,

The low number of foraminifera found in the upper levels of the core could be an indicator of rapid sediment accumulation from dredging within the harbor. The disturbed nature of the foraminifera in the surface and upper level samples could indicate a breakdown of calcareous samples. The higher number of Trochammina inflata may indicate a change in the tidal profile in this area.

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FIGURE CAPTIONS:

Figure 1a.Location of Lyttelton Harbour within New Zealand. **1b**. Location of Governors Bay within Lyttelton Bay.

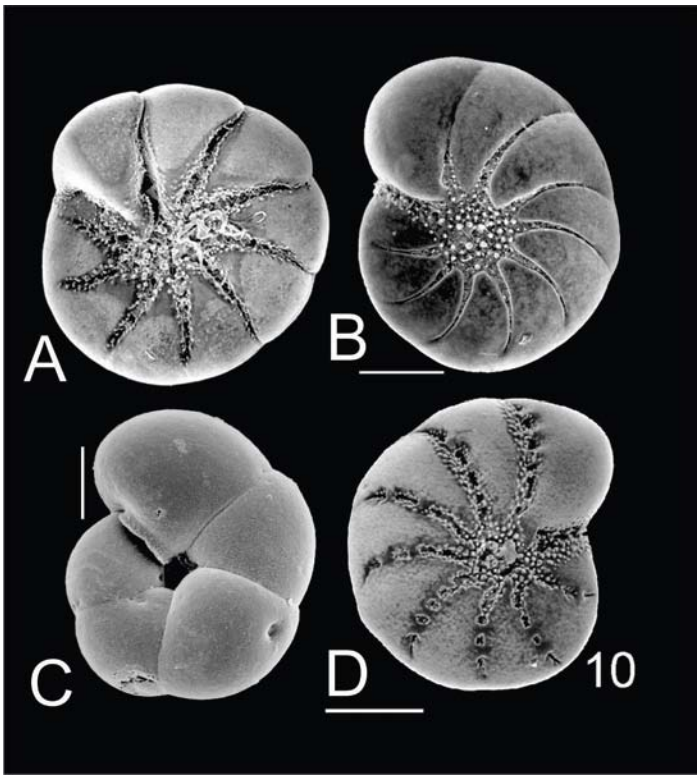
Figure 2. Schematic diagram summarizing the ecological distribution of ten brackish foraminiferal associations in enclosed spaces such as harbours in New Zealand. Of particular note for this study are *Trochammina. inflata*, A. parkinsoniana, and E. excavatum Figure courtesy of B. Hayward (1999).

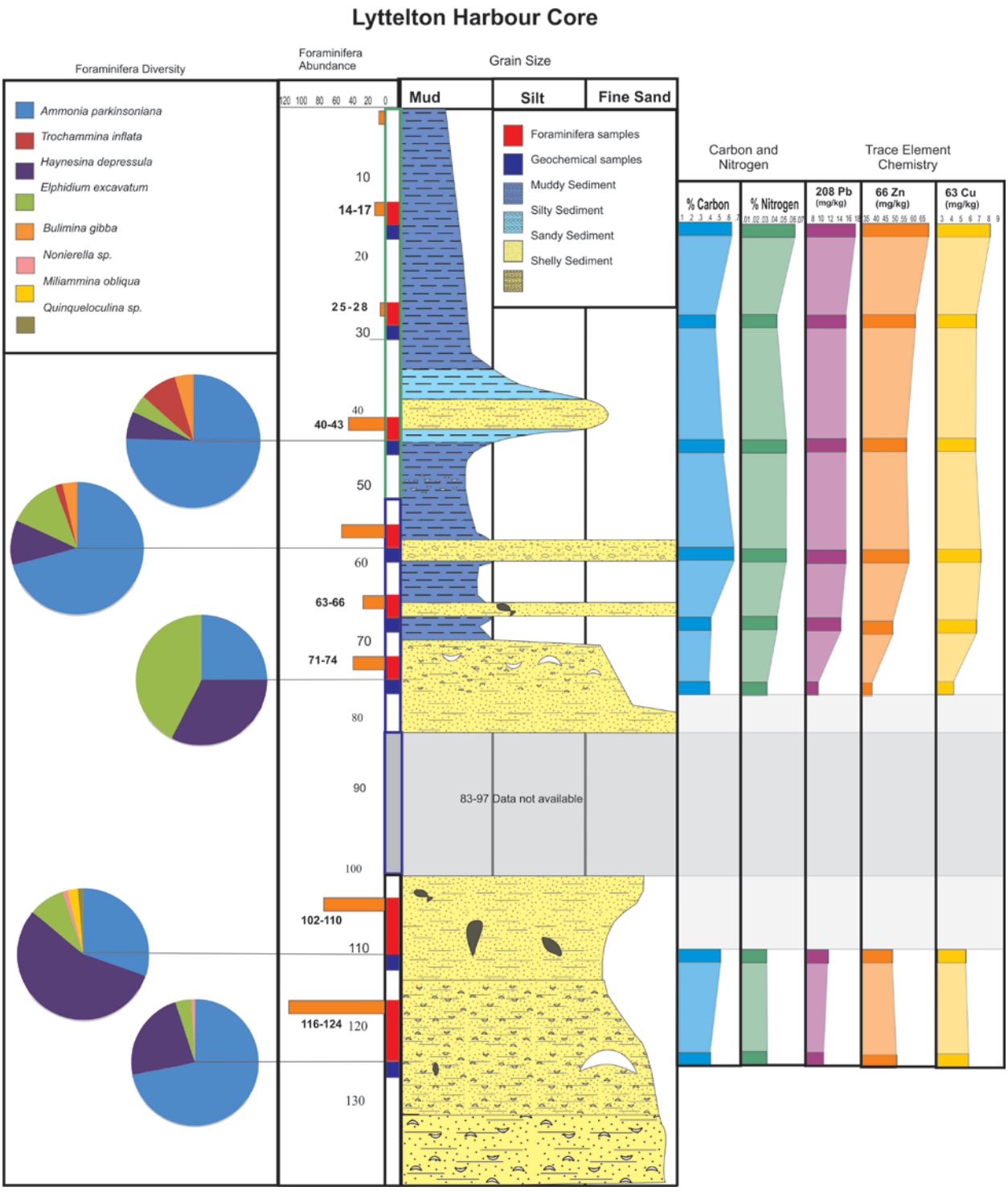
Figure 3: In order from left to right, (1) Foraminifera diversity with pie graphs representing ratios of different species at varying depths in the core. Graphs only created for those samples with an abundance greater than 60. (2) Foraminifera abundance graphed against depth. (3) Detailed lithology of core. (4) Percent carbon and nitrogen plotted against depth. (5)Trace element chemistry, Pb, Zn and Cu plotted against depth.

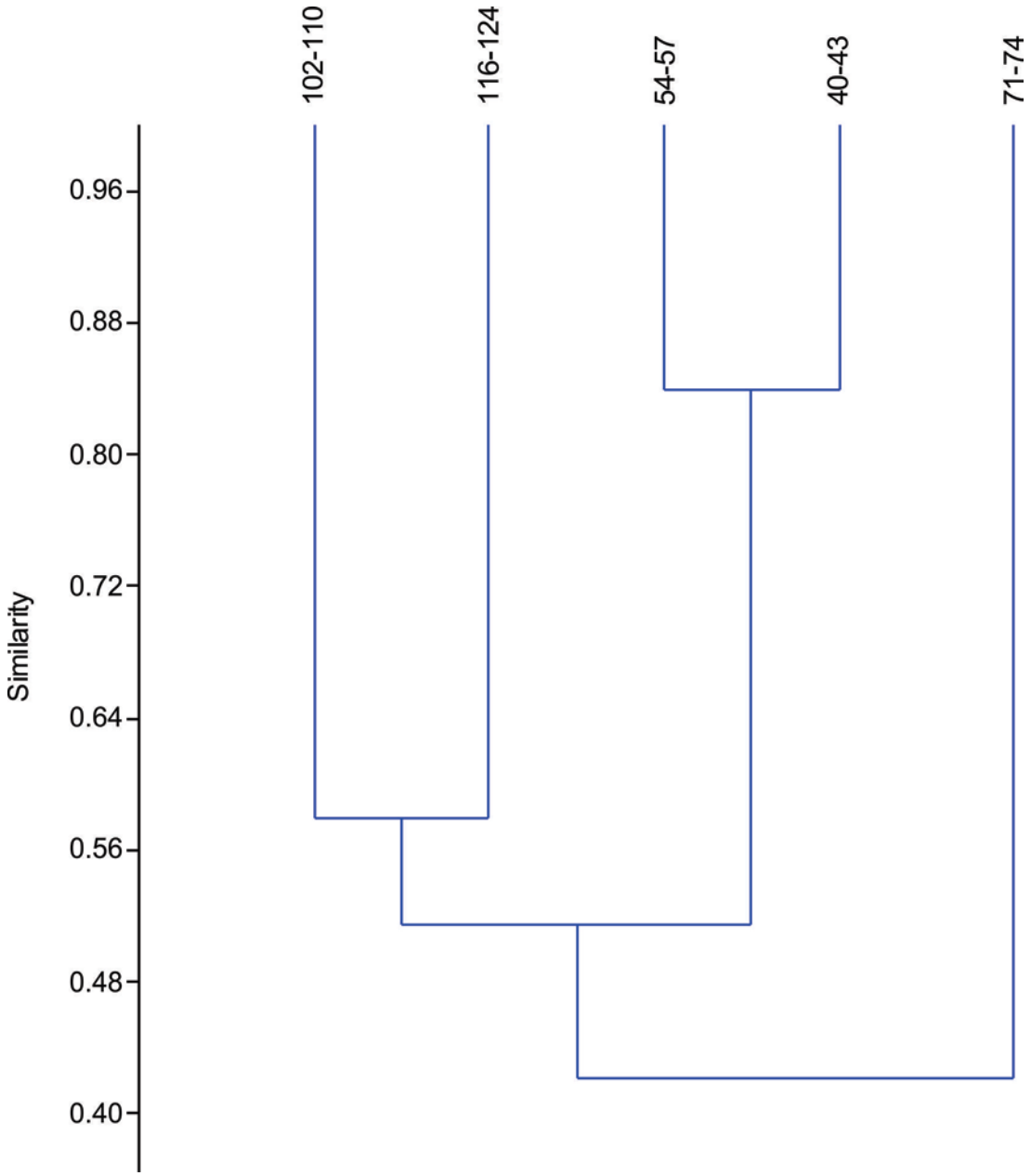
Figure 4. Images of four most common foraminifera found in Lyttelton Core: (A) Ammonia parkinsoniana, (B) Haynesina depressula, (C) Elphidium excavatum, (D) Trochammina inflata I


Hauraki Gulf
Bay Of Plenty
North Island
a
South Taranaki Bight
Wellington
Lyttelton Harbour Core
South Island
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
500 km
Christchurch
Lyttelton
b
Lyttelton Harbour Core
Image © 2014 DigitalGlobe
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2014 Google
Image © 2014 CNES / Astrium
10.00 km

180
181


A
B
C
D
10


Lyttelton Harbour Core
Foraminifera Diversity
Foraminifera Abundance
Grain Size
Ammonia parkinsoniana
Trochammina inflata
Haynesina depressula
Elphidium excavatum
Bulimina gibba
Nonierella sp.
Miliammina obliqua
Quinqueloculina sp.
120 100 80 60 40 20 0
Mud
Silt
Fine Sand
Foraminifera samples
Geochemical samples
Muddy Sediment
Silty Sediment
Sandy Sediment
Shelly Sediment
Carbon and Nitrogen
Trace Element Chemistry
% Carbon
% Nitrogen
208 Pb (mg/kg)
66 Zn (mg/kg)
63 Cu (mg/kg)
10
14-17
20
25-28
30
40
40-43
50
60
63-66
70
71-74
80
90
83-97 Data not available
100
102-110
110
116-124
120
130


102-110
116-124
54-57
40-43
71-74
Similarity
0.96
0.88
0.80
0.72
0.64
0.56
0.48
0.40

184

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