Quantitative and Qualitative Analyses of Diversity and Richness of Taonga Species in Rangataua Bay, Bay of Plenty, New Zealand

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Abstract

Rangataua Bay, Bay of Plenty, New Zealand has been an importance source of food, utility, industry and identity for centuries. The Maori of Nga Potiki consider themselves as kaitiaki, or guardians of the bay, and the health, or mauri, of the bay, has implications for the identity in terms of sense of place of the local Maori peoples. Taonga species are species which are deemed treasured or valuable because of their importance in the cultural landscape. Using a combination of qualitative anecdotes from local Maori, and present day quantitative ecological surveys, it is possible to determine the abundance of taonga species over time in Rangataua. The combined techniques revealed that Rangataua Bay is being fundamentally changed by sedimentation, and that there are positive feedback mechanisms in place further promoting sedimentation. By applying a variety of approaches to understand changes that have taken place, the best course of action for future restoration can be determined.

Key Words: Rangataua Bay, Tauranga Harbor System, ecology, taonga species, sedimentation, mangroves.

Introduction

Evaluating diversity and richness of species in a given environment over time can provide insight into the health of the ecosystem and the changes that have taken place in the area. Doing an ecological survey can elucidate the current status of diversity and richness, but does not give evidence to what past conditions may have existed. Therefore, it is advantageous to use a variety of techniques to try to gain a more complete understanding of changing ecosystem health over time.

Rangataua Bay of the Tauranga Harbor system has been a high population density area since before the arrival of Europeans. The Tauranga harbor system provided an ideal environment for early Maori settlement; the massive wetland intertidal system provided plentiful food sources, and the widespread waterways with access to the ocean provided means of transportation and communication among different Maori peoples of the region (Figure 1, 2).[1]

The abundance of food availability and the ease of access to waterways made the Tauranga Harbor system an ideal location for Maori populations to proliferate centuries prior to European arrival (Figure 3). The Maori culture has a strong connection with sense of place; the identity of distinct lines of ancestry is intimately tied with the environment they inhabit, cultivate, and protect. For example, when preforming a mihimihi, introducing oneself, a Maori person will introduce their iwi, their ancestor or ancestral lineage, their maunga, mountain, and their awa, river. However, it should be noted that "their" mountain, and "their" river does not refer to ownership of these places, but rather responsibility to these places for their perseverance and protection. Traditional Maori values place importance on the mauri of their environment, the life-force, instead of the economic resource-value of their environment. Therefore, the concept of kaitiakitanga, stewardship, is

[1] Reeder, Colin. Personal Communication February 12th and 13th 2013.

paramount to traditional Maori values in terms of preserving their sense of place, the mauri, and their identity for present and future generations. [2]

Being a kaitiaki means working to preserve or restore the mauri of an environment. For Maori, oral tradition provided insight into how mauri had changed over time. Another means of evaluating mauri over time may have been the designation of taonga, or special species. Taonga, meaning prized, highly-valued, and treasured, was conferred onto species of plant and animal due to their importance for utility or their importance in the cultural landscape and therefore the identity of the Maori of an area. Taonga species can therefore be used as a proxy for measuring mauri over time.

The objective of this study is to use both qualitative and quantitative means to assess the diversity and richness of taonga species in Rangataua bay over time. A combination of approaches: interviews with local Maori, ecological survey, geologic information, and other studies focused on the Tauranga Harbour system, can provide greater insight into changes which have taken place in Rangataua which affect the mauri.

Background

Prior to European arrival, the Maori of Rangataua bay practiced kaitiakitanga in terms of their taonga species, or "sustainable exploitation," referring to the extraction of resources for utility, but on such a scale which could be maintained for generations. However, since the arrival of Europeans, the region has undergone a series of land-use changes. In the early 1800s the British Navy established a flax industry in the area, in which flax was taken from the harbor and exported to Sydney, AU to be manufactured into rope, and then to London, UK for sale and use.

[2] Hikuroa, Daniel. Personal Communication February 11th 2013.

The Maori had a variety of uses for flax. It was important for the construction of fishing nets, clothing, and as a building component. The development of a flax industry was the first major change to the mauri of Rangataua. [3]

By the 1900s the mauri of Tauranga Harbour and specifically Rangataua Bay had been seriously affected by the establishment of larger scale agriculture and farming, industry, animal use and population growth. The Maori people were increasingly reliant on "western" or imported foods with the use of domestic animals. The change in diet had adverse affects on the health of local Maori populations, just as the increased land-use for agriculture had adverse affects on Rangataua Bay which had previously been the main food source. The simultaneously degrading Maori health and harbor health re-emphasizes the linkage in terms of identity of the local peoples with their environment. [4]

One of the European introduced development projects was a rhyolite quarry which was placed on the Waitao stream for easy access to water, upriver of Rangataua, for the construction of roads and infrastructure. The quarry remained in operation in the region until the 1960s. During that time, it contributed vastly to local sedimentation, and environmental degradation. Another development project, the establishment of a sewage treatment plant in the 1970s, has also had long-lasting affects on the physical makeup of the bay. In the 1970s the local council utilized the Mount Maunganui Borough Reclamation and Empowering Act to acquiesce seventy-five hectares of harbor/ocean floor despite local Maori opposition. Twenty-three hectares of land in the harbor were used as wetland-type holding tanks for the sewage treatment plant. Clearly this development had serious ramifications for the mauri of the area. Rangataua Bay, the source of food, transport and identity, became a holding tank for sewage. If that were not offensive enough, pipes of sewage were run through old cemeteries. In 2012 the settling ponds were

[3] Reeder, Colin. Personal Communication February 12th and 13th 2013.
[4] Ibid

closed after nearly thirty years due to the combined efforts to repeal the Act by local Maori and local government. [5]

The environment of Rangataua Bay has been affected by the changes in land-use in the area. In the mid 1900s it was first reported that the previously marsh-dominated Tauranga Harbor system was becoming increasingly overcome by mangrove trees. In Rangataua Bay, mangroves have become the dominant vegetation in the past two to three decades. The change to a mangrove-dominated environment has also had affects on the taonga species, specifically titiko (*Amphibola crenata*) and pāpaka (*Helice crassa*). Titiko, or the mud snail, is a food source and considered a delicacy by the Maori. Pāpaka, or the tunneling mud crab, existed in extremely high densities in the region such that they were an important distinguisher of the cultural landscape and therefore influenced the identity of the peoples. The Kaupai around Rangataua explains that nearly two centuries ago a warrior arrived in Rangataua and equated the large population of people with the prevalence of crabs and thereby referred to the people as Nga pāpaka O Rangataua, the mud crabs of Rangataua. [6]

Changes in taonga species richness over time can be evaluated by using a combination of different analyses including qualitative interviews with local Maori on historical conditons, and present day ecological surveying techniques.

Methods

I. Qualitative Assessment of Historical Abundance

In order to understand historical abundance of taonga species, the importance of the land to the Maori and some of the changes which have taken place in the area, a series of interviews were conducted with Colin Reeder. Mr. Reeder is the chairman of the Nga Potiki a Tamapahore Trust. The people in Mr. Reeders' Iwi

[5] Reeder, Colin. Personal Communication February 12th and 13th 2013.
[6] Ibid.

trace their ancestry in the Rangataua region back to the 14th century Maori leader and warrior Tamapahore (Nga Potiki) whose descendants now fill the region. The first interview, on February the 12th 2013, was conducted at the site of our ecological survey. Mr. Reeder described how dense the populations of titiko and pāpaka used to be in the bay. Notes were taken on the specific rhetoric that he used describing the density. The second interview, on February the 13th 2013, was conducted offsite, and Mr. Reeder described the history of land-use change from European arrival in the area. He also emphasized Rangataua Bay as crucial to the cultural landscape and therefore identity of the Nga Potiki people among others. These interviews provided insight into historical conditions of both taonga species and land-use change, and provided clues to which projects were negatively affecting the mauri of the bay.

II. Quantitative Ecological Survey

The ecological surveys of Rangataua Bay were preformed on February the 12th and 13th 2013 between 1pm and 3:30pm on each day. On February the 12th, a dozen meter-squared transects were placed along the beach face of Rangataua Bay. The transects were all 30 meters long, and titiko and pāpaka were counted from half a meter on either side of the transect. Crab holes were counted as a proxy for the crabs themselves, which were believed to retreat into the holes with human presence. The first transect was preformed in the mud bank abutting the Waitao stream, and was a non-linear transect due to the high density of mangrove roots, and the contours of the stream. (Figure 4) Due to the environmental obstructions of the first transect, titiko and pāpaka were only counted on one 50 cm side of the transect and then multiplied by two to estimate total density per transect. Transects 2-6 were each 30 meters apart from each other, and used the edge of the Waitao stream as a reference point. (Figure 5) Notes were taken on what part of the transect held the highest density of crab holes and snails. Transects 7,8,9 were done in muddier substrate after a thick bank of adult mangroves interrupted the beach face (Figure 6).Lastly, transects 10,11,12 were preformed on the left bank of the

Waitao stream, in an intertidal marsh mixed substrate environment, using an old white bait pier as a reference (Figure 7).

On Februrary 13th, five meter-squared quadrats were placed semi-randomly on the upper shore of the right bank of the Waitao (Figure 8). It was observed that the snail densities in the area were much higher than the previous day, so quadrats were placed in areas of hypothesized maximum snail density. These quadrats were intended to be a potential proxy for historical abundance, as well as provide a maximum density for future monitoring. GPS coordinates were taken of each quadrat location (Figure 8).

Results

I. Qualitative Results – Interviews with Colin Reeder

The first interview with Colin Reeder took place on February 12th at 3pm in the midst of sampling in Rangataua Bay. Colin described historical abundance of titiko and pāpaka: they used to be "like a carpet," and that one was always in danger of stepping on the organisms. Rangataua Bay was at times referred to in Maori as "the storehouse," and "fridge" for the community. He described the huge biodiversity which used to exist, particularly the range of species though the landscape that is now dominated by the two taonga species. Colin described the bay as "the lifeblood of the people there," and the main sources of change occurring after a quarry was built in the mid 1900s and agricultural growth.

The second interview with Colin Reeder took place on February 13th at 7pm in Te Puke at an accommodation facility. In this interview Colin described his knowledge of the history of land-use change in Rangataua Bay, and the importance of the environment to the identity of his iwi. Information about the Maori culture and the people of Nga Potiki include the concepts: cultural landscape, kaitiaki, desirability of the bay for early Maori, and the local Maori responses to government

approved “development” projects in the mid 20th century. He also described the history of the bay: the arrival of the British Navy for the flax industry, the loss in mauri from industry, farming, agriculture, animal use, and growth in population after the establishment of European settlement in the region, the rhyolite quarry built upstream in operation until the 1940s, the sewage treatment plants established in the 1970s, and most recently the domination of mangrove vegetation, and the closing of the sewage treatment holding tanks following the repeal of the Mount Manganui Borough and Reclamation Act.

II. Quantitative Results

The transects and quadrats revealed distribution patterns and densities of titko mud snails and pāpaka mud crabs. For both species, substrate type had an impact on organism abundance. For pāpaka , the greatest abundance by far was in the first transect which abutted the Waitao Stream (Figure 9). As stated in the methods, this transect was partially submerged in some places, was non-linear, and had very dense mangrove roots, so crab holes were only counted on one side of the transect and then multiplied by two, so this may have caused some over-reporting. For transects 2-6 it was noted that the vast majority of both titiko and pāpaka were counted within the first 10 meters of the 30 meter transect, which were closer to the edge of the stream, and relatively muddier than the overall sand-flat environment.

In the transect data,it does not appear that the titiko and pāpaka inhabit the same spaces, as the abundance patterns of the two species do not seem to correlate. The titiko density across 12 transects shows the snails preference for the left bank of the Waitao, which was a more heavily marsh-dominated environment, and experience more regular submergence (Figure 10).

In contrast to the data from the transects, the snail quadrats were all preformed in a predominantly muddy substrate on the right bank of the Waitao, and

were taken to represent maximum snail density. The quadrats show that maximum titiko density in Rangataua Bay is up to forty-five snails per meter squared (Figure 11).

There was a correlation between substrate type and species density for both titiko and pāpaka, they both preferred mud substrate environments. Despite the fact that the transect data of the two species did not seem to match, when including the quadrats for the titiko, it was found that both species prefer mud, to sand, or mixed mud and sand (Table 1).

The results show that both titiko and pāpaka prefer mud substrates. The results also depict a different story in terms of species abundance, than that given by Colin as a means of understanding historical abundance. Colin described the titiko as "like a carpet" whereas the measured maximum density of forty-five snails per meter squared could hardly be dense enough that one couldn't avoid stepping atop of them. It can be inferred from this comparison that present abundance is much lower than historical abundance of the taonga species.

Discussion

The purpose of this study was to use a combination of qualitative and quantitative analyses to evaluate the abundance of taonga species over time in Rangataua Bay. The results support the hypothesis that present day abundance of titiko and pāpaka is far less than historical abundance. This leads to the inevitable question: what has changed?

The results revealed that both of the taonga species in question had a preference for mud substrate environments. In order to understand why they held a preference for mud substrates, research was done on the ecology of the two species in question. Titiko, *Amphibola crenata,* or the mud crab is a unique intertidal species in that it is neither fully marine, nor fully terrestrial, but has an operculum

and breathes air. It is a deposit feeder: it eats predominantly diatoms, bacteria, algae, and decomposing matter from within sediment. Titiko have planktonic larvae which are dependent on marsh environments for larval settlement and development. Therefore, titiko are dependent on marsh, and associated mud environments for their reproductive success and food supply. [7]

Pāpaka, *Helice crassa,* or the tunneling mud crab, is so named due to the intricate and complex mud burrows they build. The mud burrows often have multiple entrances, and the crabs may plug some entrances for protection, and return to burrows during the day to wet their gills.[8] The fact that mud burrows may have multiple entrances, and may have plugged entrances, has implications on the results obtained based on each hole in a transect representing an individual crab. However it would be very difficult to count the crabs in any other way, or to estimate how many crab holes represent a single crab. Future research on the tunneling mud crab should be done to estimate an average crab burrow in terms of entrances and depth and width in the mud. Like titiko, pāpaka consume diatoms, algae and decomposing matter, which they obtain from the sediment. Pāpaka are considered "ecosystem engineers" meaning their behavior and ecology has a fundamental impact on the ecosystem they inhabit. They are cited as an ecosystem engineer for their role in the nitrogen cycle, consuming and repurposing decomposing matter. They are also considered ecosystem engineers because their complex mud burrows create an ideal environment for mangrove roots to take place. [9]

The information on the ecology of the taonga species elucidated the findings in the results. Both titiko and pāpaka are dependent on muddy environments providing a food source. Titiko are also dependent on marsh grasses for larval settlement, while pāpaka facilitates the establishment of mangroves.

[7] Juuti, Petri (2007)
[8] **http://www.niwa.co.nz/publications/wa/vol13-no3-september-2005/more-than-just-a-crab-hole**
[9] Ibid.

In a large survey done on the Tauranga Harbor system, *Health of Te Awanui Tauranga Harbor***,** it has been noted that wetlands have decreased by over 80%, and Tauranga has become instead a mangrove-dominated environment. In the tropics, mangroves are important habitat for juvenile fishes, and as natural filtration system, trapping sediments and pollutants from entering coastal waters. In contrast, the mangroves in New Zealands sub-tropical environment appear to have more detrimental impacts than beneficial as their tropical counterparts.[10] In a New Zealand study which attempted to analyze the environmental effects of controlled mangrove removal, it was noted that "mature mangrove habitats had less total abundance and fewer taxa than all the other habitats sampled and were dominated by pulmonate snails (*Amphibola crenata)* and mud crabs (*Helice crassa)*," (Alfaro 2010: 1087). It was hypothesized that mangrove domination occurs in New Zealand due to increased sedimentation from human-derived catchment changes, cooler temperatures inhibiting effective nutrient recycling, and the lack of intertidal plant competitors.

For Rangataua Bay, increased sedimentation is likely the primary cause of mangrove domination. From the 1800s with the establishment of the flax industry, to last year when the sewage holding tanks were finally removed, the variation in land use around Rangataua has changed the sediment regime of the bay.[11] Further evidence of the bay infilling can be seen in the low water movement in Rangataua. In "The hydrodynamics of the southern basin of Tauranga Harbor," it was found that residence times, the time a give particle remains in an area, "are higher in sub-estuaries with constricted entrances, such as Rangataua Bay and Welcome Bay with residence times being some five days or so longer than in the main channel" (Tav 2013: 14-15). The prolonged residence time and low water flow is likely another contributing factor to mangrove establishment: there is not enough water energy to flush out mangrove seeds before the settle. Therefore Rangataua Bay can be seen as part of a positive feedback mechanism for sediment: land use changes have caused

[10] Alfaro (2012)
[11] Reeder, Colin. Personal Communication February 12th and 13th 2013

increased sedimentation and infilling of the bay, increased sedimentation facilitates the establishment of mangroves, mangroves further entrap sediment which leads to further sedimentation in the bay. The positive feedback is also enhanced by the role of the pāpaka: the crabs create burrows in the mud, the burrows facilitate mangrove establishment, mangroves increase sedimentation, sedimentation is problematic for the crabs dependent on mud for their burrows and for their food supply.

Rangataua Bay appears to be in a state of infilling. But if the bay fills with mangroves and sediment, what will happen to the taonga species, and what will the implications be for the cultural identity of the Nga Potiki people?

Conclusions

By using both qualitative historical anecdotes from Colin Reeder, a present day ecological survey, and research done on the hydrodynamics and sediment of the Tauranga Harbor system, a more comprehensive understanding of Rangataua was achieved. The abundance of taonga species, titiko and pāpaka is reflective of the larger trends of change in the bay. The main changes affecting the taonga species and the mauri of Rangataua are: land-use change driving sedimentation, and mangrove domination. Sedimentation is occurring due to the low energy hydrodynamic regime, the transformation of marsh land to agricultural uses, the pāpaka mud burrows facilitating mangrove establishment, and the positive feedback mechanisms of mangroves furthering sedimentation.

In the future, work should be done on establishing a sediment budget for Rangataua Bay, and the Tauranga Harbor system in its entirety. A sediment budget is a management tool for coastal geomorphology which spacially represents the sources and quantity of sediment inputs and outputs of a system. Establishing a sediment budget for Rangataua would confirm if the bay is in a state of infilling, and would elucidate the primary sources of sedimentation. Secondly, the bay of plenty regional council and local peoples should actively work at restoring the marsh environment which used to dominate in Tauranga harbor. This could prove contentious as most of the marsh land has been converted into agricultural pasture,

but marsh plants are crucial to the future health of taonga species and the mauri. Lastly, future research should continue to be done on mangrove removal in New Zealand. The study cited earlier found their study inconclusive due to spatial and temporal limitations. Mangrove removal should only occur after a sediment budget has been created and marsh lands have been restored, as it not the solitary cause of sedimentation, but a product of previous changes.

The harbor should also continue to be monitored for abundance of taonga species, and monitoring efforts should include the local Maori who have a cultural investment in Rangataua Bay.

Acknowledgements

Special thanks to Dan Hikuroa and all of the Frontiers Abroad crew for making this study and semester possible. Thanks to Colin Reeder for all of his help and knowledge. Thank you too Julia Clark, Alana Springer, John Stockman, Eleanor Beckwith, Hannah Tennent, Cam Adams, Nick Kraus and Rob Ventura for helping with my data collection and being a wonderful group of people with whom to share ideas and friendship. Lastly, thanks to George, Laura, and Sarah Tannenbaum for supporting me always in my many travels to distant lands.

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