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Restoring the Mauri to Te tehuna o rangataua bay:
Impact of Wastewater treatment plant and land clearance on shellfish abundance and Mauri

Author: Abigail Smith, Student of the School of the Environment at University of Auckland, 2012

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Abstract

This is a study that combines information from a current ecological assessment and a Mauri Model test to evaluate the environmental, social, cultural, and economic impact on local Maori, specifically those members of the Tahuwhakatiki marae, in the Te tehuna o rangataua bay. The bay is a small inlet in the southern section of the greater Tauranga Harbour in the North Island of Aotearoa New Zealand. This study focuses on the Te Maunga wastewater treatment plant and historic land use change as drivers for overall degradation in the Tauranga region. Results are drawn from a current ecological assessment that measures titiko density, and a Mauri Model assessment that includes pre land use change, post land use change, and post WWTP. Other essential information is drawn from recent ecological assessments that measure the impact of the WWTP and accounts from Maori elders that measure the approximate abundance of titiko in the past. Ecological assessments indicate that wastewater pollution reduces biological productivity. Sedimentation, which increases with land clearance and agricultural activity in the catchment basin, is another reason for a degraded shellfish habitat. The Mauri assessment indicates that Mauri has been diminishing ever since initial land clearance and the effects of the WWTP continue to degrade Mauri. This study provides a comprehensive assessment of current conditions of the Te tehuna o rangataua bay and how Maori have been impacted over time. This study is important because it will provide a baseline for future management regimes of the Tauranga harbour.

key words titiko, waste water, land use, Mauri, Tauranga Harbour, environment

Introduction

Maori arrived in New Zealand from polynesia over 1000 years ago and they have spread out and inhabited both islands. There are 24 iwi on the shores of the Tauranga Harbour and each one shares a similar attraction and well-developed connection to the harbour. The area is a physical and spiritual symbol of identity for all whanau, hapu and iwi living in the harbour catchment area (Bay of Plenty Regional Council 2012). There is a plethora of local knowledge indicating that the harbour used to be ecologically thriving and able to provide homes with an abundant and reliable food source. After the 1870's, significant European settlement resulted in extensive land clearance for urban spaces and farming. Historic land use change is one reason for current degradation to the marine environment. In the 1970's a wastewater treatment dump site was established and also contributes to decreasing shellfish health and availability.

Data taken from ecological assessments are useful in comparing past and present environmental conditions. This is essential in determining the cumulative impact of the new waste site and land use change. Data is reinforced by an appraisal of the harbour through first hand Maori knowledge. The Mauri Model is used to critically analyze environmental, social, economic, and cultural impacts of a given event or landscape. It is used to incorporate the subsequent impact on Mauri, "life force."

The purpose of this study is to integrate an analysis of current ecological data with traditional Maori knowledge to produce a comprehensive report that assesses the economic, social, cultural and environmental impacts of the Te tehuna o rangataua bay. This is important not only to assess the negative impacts of modern human activity but also to evaluate the

consequences for local Maori-- those who have been living and using the land longer than any other group.

Background

Tauranga Harbour is on the northern shore of the Bay of Plenty, New Zealand (Figure 1). It is a large estuary covering an area of 210 square kilometers in Tauranga. Te tehuna o rangataua bay is the southernmost inlet of the harbour (Figure 2).

Figure 1. Tauranga Harbour

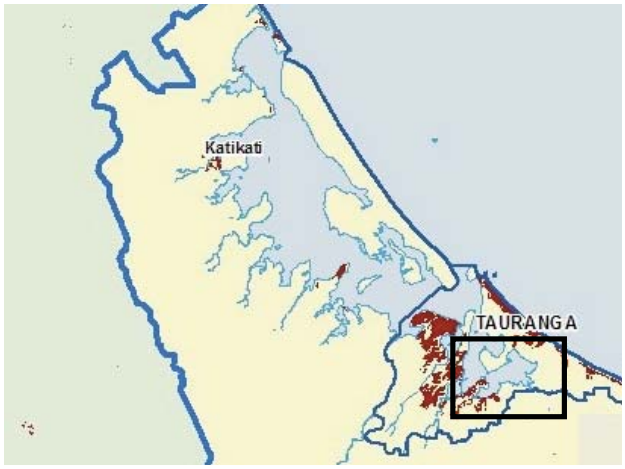

Figure 2. Te tehuna o rangataua bay

Land use change and its effects on the Te tehuana o rangataua bay

There is an extensive land use history of the Tauranga harbour catchment area. The land has been used by the Maori for hundreds of years due to its rich soils and abundant flora and fauna. Cultivation has been regular, through rotational cycles of burning, then planting and

cultivation and all the while “leaving the land lay to fallow” (Hale 2010). Significant European settlement began after the 1870’s. The land was now subject to more exploitation, modification, and clearance through farming, logging and mining (Hale 2010). After the 1950s and 60s Tauranga became increasingly urbanized and was proclaimed a city, with a population of 21,500 in 1963 (Hale 2010). Land was being reclaimed and reshaped and urbanization has continued to grow. Table 1 shows land use cover types in the Tauranga Harbour catchment as of 2004.

Table 1. Land use cover type (2004) taken from Lydia et al.

Land cover type	Percentage
Pasture	39
Indigenous forest	36.4
Orchard & crops	9.5
Forest	8.5
Urban	1.7
Other	2

Changes in land use around the Tauranga catchment area is negatively impacting the water quality and ecological health of the harbour and its adjoining water bodies. Sedimentation is viewed as one of the most serious issues facing Tauranga Harbour. As land clearance has progressed, more sediment is transported through streams, especially those that flow through pastoral lands, and deposited into the Tauranga harbour and its bays. Sedimentation creates a myriad of threats to the marine environment such as loss of sea grass (Zostera) beds and decreased productivity, mangrove spread (loss of wetland vegetation, loss of recreation, access, views), loss of shellfish beds and decreased productivity, loss of juvenile fish habitat (Bay of Plenty Regional Council). Sedimentation makes sheltered estuaries muddier and shallower and reduces water clarity (Sinner et al, 2011). Direct impacts are likely to include clogging the gills of filter feeders (e.g. cockles, pipi, scallops), reductions in the settlement

success and survival of larval and juvenile phases of shellfish, reductions in the foraging abilities of finfish (e.g. juvenile snapper) and decreases in the food available to benthic species (Sinner et al, 2011).

Colin Reeder, head of the Tahuwhakatiki Marae, expressed concern over the increased sediment loads and the associated mangrove invasion. Colin explains that the mangroves have never existed in the harbour until recently. Locals share a similar opinion, "Mangroves are clearly a major concern to many residents around Tauranga Harbour. The public feedback processes gave a fairly consistent message to 'get rid of the mangroves'" (Bay of Plenty Regional Council). The expansion of mangrove habitats are just one of the several visible differences seen the Tauranga Harbour today. Their presence is surely associated with an increased sediment load which itself, originates from agriculture and development in the hinterland.

Sediments are not the only reason for the degrading state of the harbour. Nutrients and toxins originating within the catchment are produced by urbanization, agricultural activities, vegetation clearing and industry and eventually end up in the harbour (Scholes 2005) and have major implications for water quality and the marine ecosystem. Sediments trap contaminants and transport them downstream which make estuaries a sink for sediments *and* their associated toxins (Hale 2010). Different types of land use are host to different sediment losses. For example, nutrients, pesticides and herbicides are common from agricultural activity whereas urban areas usually give off the metals zinc, lead and hydrocarbons (Park 2009). This means that a combination of contaminants derived from all types of land cover in the Tauranga harbour are eventually transported to the water.

The above table shows that farming practices (a combination of pasture land and orchard and crop land) comprise nearly 50 percent of total land use cover. Nutrient pollution from increased nitrogen and phosphorus loads are typically associated with agricultural land use, and therefore, can be attributed to much of the degraded Tauranga harbour water quality. These nutrients pose major threats to the natural functioning of marine ecosystems. Nitrogen and phosphorus can lead to harmful and persistent algal blooms. This can create anoxic marine conditions and it is difficult for organisms to adapt and survive. Another contaminant originating from agricultural land use is effluent run-off from livestock (Hale 2010). This is harmful to both marine and human health because it increases the levels of pathogens.

There has been distinct changes in land use cover since major European settlement. A land that was primarily native bush, wetlands, and coastal dunes has been cleared and transformed into an urban center and agricultural hub. Sedimentation and excess pollutants are the major reason for degraded water quality and ecological abundance in the Tauranga Harbour.

Wastewater treatment plant and its effects on the Te tehuna o rangataua bay

The Tauranga Harbour has two wastewater treatment plants, Chapel Street and Te Maunga. This study focuses only on Te Maunga because it is adjacent to the Te tehuna o rangataua bay. It provides treatment for domestic, commercial and industrial communities from the Mount Maunganui and Papamoa catchments–a population of about 36,500 people (Tauranga City Council 2011). The Te Maunga WWTP consists of pre-treatment and secondary treatment. Waste is then brought to two pre-existing ponds. One is a sludge conditioning pond, established in 1979. The other is an oxidation pond, established in 1983. Wetlands at Te Maunga are the final

stage in the waste treatment process before it is finally discharged into the ocean. The wetlands work to reduce nutrient levels and biological oxygen demand. Waste is brought to the ocean through a pipe resting 3 meters underground and extending 950 meters offshore of Papamoa beach.

The sewage system has created an unstable relationship between local iwi and government officials because the Maori treaty, "The Crown," was not considered in any litigation. Colin remembers the initial tension that the government stirred amidst the Maori: "When the ponds were first established, elders would congregate on the crest of the hill and protest all day long."

Figure 3. Sewage pond and the bay

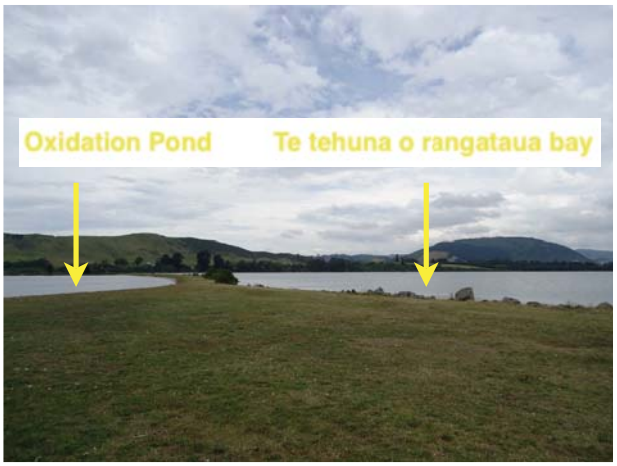

Figure 3 is a photo showing the close proximity of the pond and the harbour—approximately 5 meters at the narrowest width. During storm events washovers can instantly pollute the harbour water through leakage. Figure 4 and 5, respectively, show sewage material trapped in riparian vegetation and sewage material floating in the harbour.

Mandatory assessments of seepage into the Rangataua Bay by the Tauranga City Council show that the harbour is being negatively affected by the wastewater ponds. Seepage areas were identified and their impact level was measured against water quality and titiko populations. The council reports, "Seepage areas were identified visually while walking along the intertidal sand flats at low tide. From previous surveys it is known that the seepage can cause a distinctive green

Figure 4. Sewage material in the bay

Figure 5. Sewage material on land

discoloration on the intertidal area sediment surface, *as was found during this survey*" (Tauranaga City Council 2010). Ten sites were checked for seepage and two came out to have substantial seepage. Evidence in both locations were grey/green discoloration on sand surface, permanently wet sand, and absence of biota, including mud crab burrows which are found elsewhere on the sand flats at a higher density (Tauranga City Council 2010).

Previous shellfish abundance surveys indicate that populations have been on the decline. Titiko have disappeared from two of the sampling sites from 2006 to 2008, declined from two other sites and remained fairy stable at the others (Tauranga City Council 2010). The average shell size has decreased in size since the 2008 survey at every site (Tauranga City Council 2010). The results of this recent study indicate that shellfish health and abundance is directly related to wastewater seepage. Evidence suggests that sediment exposed to oxidation pond leaks does not provide a healthy habitat for titiko. In such areas, biological activity has decreased and will continue to do so if waste seepage is not blocked from entering the harbour.

Maori and the Te tehuna o rangataua bay

The Te tehuna o rangataua bay has long served as a '*he pataka kai'* (food cupboard) for nearby iwis. Stories and knowledge passed down through generations prove that the land used to be nutritious and rich with shellfish, herring, flounder, and Amphibola crenata (mud snails or Titiko). These small molluscs filter feed on algae during low tide, literally covering the tidal flats. Colin is a major advocate for the health and restoration of Te tehuna o rangataua bay.

Colin and numerous other local Maoris have watched the deterioration in shellfish abundance for many years now and notes that populations are not nearly as plentiful. The late Hoani Farrell had much to say about memories of his youth at Te tehuna o rangataua bay. "You could see heaps of fish when looking to the sea from Tahuwhakatiki marae. When we were sitting out in front of the wharenui we could see these snapper with their tails in the air digging for little cockles" (New Zealand Geographic Board). Te Aohuakirangi Woodhouse shared similar memories of the bay, explaining that the Rangataua Bay was "carpeted with titiko and flounder." Merepaora Webster remembers her whanau "gathering flounder digging for kuharu soft shelled pip found in the banks of the channels and ever thick and plentiful titiko. Gathering kai from the tahuna was a daily activity" (New Zealand geographic Board). All of these accounts testify to the abundance and quality of marine life that once occupied all of the Te tehuna o rangataua bay.

Colin stated that the Rangataua Harbour "literally teemed with life that sustained Nga Potiki for many centuries" (New Zealand Geographic Board). Nga Potiki are the descendants of Tamapahore, who is considered to be the founding ancestor of the Tauranga Harbour iwis it is believed that the rich biodiversity of Te Tahuna o Rangataua has sustained Nga Potiki communities over many centuries (New Zealand Geographic Board). A close relationship

between Nga Potiki and Te Tahuna o Rangataua is reflected in a *pepeha* (a boast or proverb) attributed to the Ngati Haua war chief Te Waharoa (New Zealand Geographic Board). Sometime in the mid 1830's during a visit to Nga Potiki, he gazed upon the multitude of crabs and shellfish littering the harbour and uttered the words '*Nga papaka o Rangataua'* which means "the crabs of Rangataua". This was adopted by Nga Potiki as a traditional tribal saying. Another tribal boast '*He paruparu te kai he taniwha nga tangata'* is also attributed to the war cheif Te Waharoa and eludes to how the delicious titiko were *once abundant* on the Te tehuna o rangataua (New Zealand Geographic Board).

These two tribal phrases and past accounts from Maori elders show the intimate connection between Maori and the Te Tehuna o rangataua bay and their reliance on shellfish as a food source. Sustenance is not the only reason for their dependance on the harbour. Maori have also developed a strong cultural tie to the land and consider it to make up a piece of their identity. Colin expressed his concern for the apparent decrease in the mud snail population believing that "The health of the harbour and the people are one in the same."

Methods

An ecological assessment was conducted on Thursday, February 16, 2012 at 8:30 am during low tide which was used to measure current titiko density in the Te tehuna o rangataua bay. Titiko were counted and recorded at two separate sites on the tidal flat to the true right of the estuarine river. This was at the mouth of the estuary, approximately 80 meters from the Tahuwhakatiki car park. This first location was at an elevation of 8 meters and at E 2795037 and N 6382624. A transect was drawn, 9 meters wide and 6 meters long, and observations were recorded every square meter. Total area was 54 square meters.

This was repeated in an identical fashion at the second transect site, although stretching 10 meters long and 6 meters wide. The entire quadrant was 60 square meters. This was at E 2795044 and N 6382797. This was approximately 100 meters from the true right of the river, farther into the harbour and closer to the mangrove community. The density values of each sample site are averaged. The final titiko density is a proxy for total current titiko population in the Te tehuna o rangataua bay. This study deals with current *living* populations of titiko so results do not include dead organisms found in the transects. Crabs and cockel were observed in some areas but are not considered in these results as well.

The Mauri Model is the second component to this study and is used to integrate the impact of the wastewater system and land use change on Mauri– "life force." It reinforces tangible scientific data while integrating another piece of the puzzle–indigenous knowledge and expertise. Figure 3 shows a scaling system of the Mauri Model and its associated numerical values.

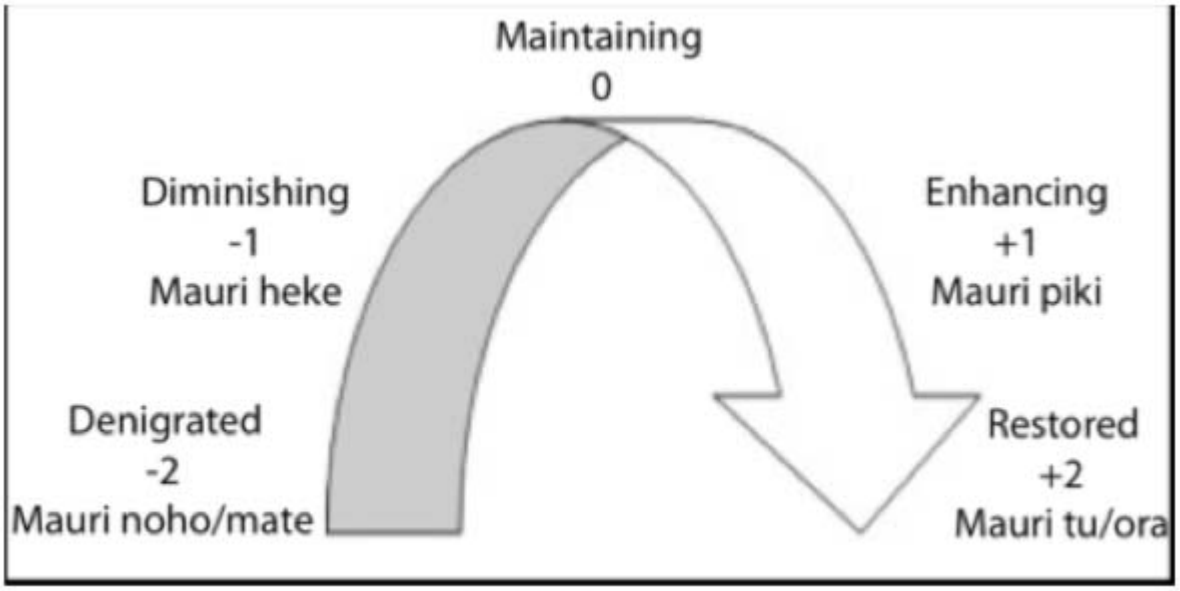

Figure 3. Mauri Model number scale (From Hikuroa, Dan et al. *Integration of Indigenous Knowledge and Science*. Journal of Science in Society. Jolume 2, 2011)

Environmental, social, cultural, and economic indicators are determined by their relevance to the given event or time series. Each indicator is then assigned a numerical value which denotes the impact of Mauri. -2 reflects a completely denigrated scenario and -1 means Mauri is still present but diminishing. A score of 0 means conditions are maintained and there has been no substantial change to Mauri. +1 indicates that Mauri is enhancing and +2 signifies optimal conditions and a restored Mauri.

Using the Mauri Model is beneficial in future management plans and local involvement. "The combined contributions of the two knowledge systems provides the potential for integrated decision making that can enhance the practice of sustainability for the benefit of our future generations, and find solutions for problems that cannot be provided by either knowledge system in isolation" (Hikuroa 2011).

Results

Ecological Assessment

Average density = 24.4 titiko/square meter

Transect 1.
Number of titiko in a 9x6 meter transect
Density calculation: 11 total titiko/ 54 meters = 0.2 titiko/square meter

0	1	0	0	0	0	1	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
2	0	1	0	0	0	0	1	1
0	1	1	0	0	0	0	0	2
0	0	0	0	0	0	0	0	0

Transect 2.
Number of titiko in 6x10 meter transect
Density calculation:
2913 total titiko/ 60 square meters = 48.55 titiko/square meter

72	60	72	85	60	55
61	62	41	72	40	72
36	35	42	80	45	70
25	30	38	59	65	37
34	28	30	58	62	80
52	34	56	59	53	42
47	23	45	67	60	23
48	46	57	69	48	23
54	32	33	71	19	13
51	51	49	60	12	10

Mauri Model

This study requires three different sectors to be considered in the Mauri Model–pre land clearance, catchment clearance, and post wastewater treatment. Pre-land clearance refers to the time prior to major European settlement and subsequent development, timber clearing, and farming. This is when the land was occupied by Maori and the environment was almost of pristine quality. Catchment clearance refers to the time of major land clearance–post 1870 to the 1970's. Post wastewater treatment refers to time after the establishment of the sewage ponds up to present day. This includes impacts from both the wastewater system and past land use change. Mauri is the strongest during pre land clearance (1.83), slightly diminished during catchment clearance (-0.83) and the most degraded post wastewater treatment (-1.17).

	Indicator	Pre land clearance	Catchment clearance	Post WWTP
Environmental	Habitat and species loss	2	-1	-1
	Anthropogenic contaminants	2	-1	-1
	Sedimentation	2	-2	-2
Cultural	Mahinga kai	2	-1	-1
	Waahi tapu	2	-1	-1
	Presence of human waste	2	2	-2
Social	Iwi & gov relationship	0	-1	-1
	Recreation and fishing	2	-1	-1
	Aesthetic of the land	2	-1	-1
Economic	Food source	2	-1	-1
	De-value of land	2	-1	-1
	Infrastructure costs	2	-1	-1
Mauri Assessment		1.83	-0.83	-1.17

Discussion

Ecological assessment

The two ecological surveys show contrasting results. Although the two sites were chosen under no certain criterion, they represent how dramatically varied shellfish populations are in the bay. The first area was typical of the empty tidal flat. Titiko populations were scattered and close to non-existent. The second transect was chosen in a location with a higher density of titiko. This is probably more typical of past titiko populations–the sand is evenly scattered with shellfish. The average of 24.4 titiko/square meter is somewhat arbitrary and is not a holistic representation of titiko abundance. This biological density survey indicates that shellfish populations are indeed scattered and varied in the harbour today but have not been entirely depleted.

Comparing this data with past Maori observations of an ecologically thriving harbour is difficult because different methods were used. Nevertheless, it is certain that titiko populations are not nearly as impressive as they used to be. Because the two sample sites are not exposed to seepage from the waste water ponds, there must be another reason for the decline in biological productivity. Sample sites were taken close to the inflow river and close to the shores of the Tahuwhakatiki Marae. As mentioned before, fluvial inputs into estuaries carry heavy sediment loads from the catchment area. This sediment can also transport pollutants associated with agricultural practices and urbanization. While this poses substantial threats to the entire marine environment, the mouth of the river is where sediment loads are first deposited so this area could be more heavily impacted. The ecological survey results are reflect this hypothesis. The tidal flat that was directly adjacent to the estuarine river had nearly any titiko. Site two was a greater distance from the river mouth and titiko populations were fairly substantial.

Mauri Model

Indicators were chosen according to their extent of impact on Mauri. They are measured under three time periods of the Te tehuna o rangataua bay–pre land clearance, catchment clearance, and post wastewater treatment. All current conditions are considered to be at -1 rather than -2 Mauri (with an exception of the presence of human waste) because the harbour still exists, regardless of the diminished appearance and ecological productivity. Pre land clearance represents optimal conditions of the harbour which Mauri is +2 for almost every indicator (except for relationship between Iwi and government).

Indicators and discussion

Environmental	There has been a visible decrease in habitat and species abundance but because the environment is not completely stripped of life after both catchment clearance and wastewater treatment, Mauri is -1. Anthropogenic contaminants are released from both catchment clearing activities and wastewater treatment so Mauri remains at -1 ever since initial human interference of the land. Sedimentation jumps from a +2 to -2 once the catchment area is cleared. It is at -2 Mauri purely because it exists in the Tauranga harbour and would not occur irrespective of human activity.
Cultural	Mahinga kai is the tradition of shellfish collection. Mauri is reduced to -1 ever since catchment clearance because that was when populations were first subject to decline. Waahi tapu means ‘sacred areas’ and Mauri is impacted due to the same reasons. Human waste was not present before the wastewater treatment plant and therefore had no impact or relevance to Mauri. Now it is present in the harbour which makes Mauri entirely degraded.
Social	Iwi and government relationship is not applicable prior to land clearance which makes Mauri 0. It is -1 after catchment clearance because political turbulence exists (but is not at the level of a denigrated Mauri). Recreation/fishing and aesthetic of the land decrease from a +2 Mauri to -1 ever since catchment clearance. The harbour still *exists,* regardless of its diminished appearance.
Economic	All economic indicators are initially at +2 Mauri and reduce to -1 after initial catchment clearance. Shellfish are still present so a viable food source has not entirely disappeared. Value of land has experience a significant downfall but it is still able to be sold (therefore not a -2 Mauri). Similarly, infrastructure costs for Tauranga City have been substantial but finances are not completely depleted.

Conclusions

Shellfish abundance has declined since initial catchment clearance of the 1870s and continues to do so after the wastewater treatment plant was commissioned in the 1970s. This has been determined from previous studies measuring the impact of waste seepage on ecological productivity and a current ecological assessment measuring impact of sedimentation in the Te tehuna o rangatata bay. Mauri has also diminished over the decades. When Maori were primary residents of the coastal area, urbanization had not yet flourished and farming and land clearance was not significant. During this time, accounts of shellfish collection proved to be highly profitable and Mauri was nearly at its optimal value of +2.

Analysis of ecological productivity is important for future mitigation and attempts to restore Mauri. Maori have inhabited the shores of the Tauranga Harbour for over 1000 years and withstand strong cultural ties to the natural environment. Titiko decline has limited shellfish collection (Mahinga kai). Shellfish abundance and the ecological health of the bay make up a large piece of iwi identity and population losses are similarly affecting mana and well-being. Maori have great reason to be concerned for the future of the Te tehuana o rangataua bay. Government interference, such as the establishment of the wastewater treatment system occur without consideration to Maori and their rights presented in the “Crown.” This can create political turbulence and loss of respect between iwi and government officials. If Maori opinion is not considered and respect is not given, Mauri will continue to diminish.

Determining the specific effects that sedimentation and sewage seepage has on the harbour will help to outline future management regimes. For example, understanding that seepage will reduce titiko abundance should indicate that affected areas must be prioritized in future

wastewater management. There is evidence of increased sedimentation in the bay and areas of high sediment deposition are lacking in titiko populations. This means more stringent management is required to decrease the harmful effects of sedimentation.

Urbanization, farming, and development is on the rise in the Tauranga region due to inevitable population rise and resource demand. This means that subsequent effects on the environment could be amplified if proper management regimes are not undergone as soon as possible. Maori have a well developed and intimate connection Te Tehuna o rangataua bay and in order to ensure its health and preservation for future generations, action must be taken today.

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Author Notes Abigail Smith is an international student at the School of Environment at

Auckland University. E-mail: asmi542@auckland.ac.nz or asmith2@skidmore.edu