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Piri Pāua: Mātauranga Māori and marine science approach to growth rate and length at maturity of pāua in the Bay of Plenty 2022–2024

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PLAIN LANGUAGE SUMMARY

Pāua is a highly regarded taonga (culturally important) species. Mai i ngā Kurī ā Whārei ki Tihirau (the Bay of Plenty Regional Iwi Customary Fisheries Forum) raised concerns about the current state of pāua in Te Moana-a-Toi (Bay of Plenty). This project utilised localised intergenerational observations of population dynamics in traditional harvesting areas to assess pāua productivity in the Tauranga Moana Mātaitai Reserve in Tauranga and Te Rohe Moana o Ngāti Awa in Whakatāne. The project combined mātauranga Māori alongside marine science field methods.

Results were compared with previous iwi-led research at Tauranga in 2013 and Whakatāne in 2010. The pāua population in 2023 had declined by almost half in Tauranga but remained relatively consistent across all sites in Whakatāne. However, pāua were small sized in both locations, with less than 1% of individuals reaching the Minimum Legal Size (125 mm) for harvesting. Growth rate surveys were conducted in the wild at both locations from June 2023 to the end of May 2024 and identified pāua as slow growing and, as a result, sexually mature at smaller sizes than in other regions of Aotearoa New Zealand.

EXECUTIVE SUMMARY

Paul-Burke, K. [1], Burke, J.[2], Gerrity, S.[3] (2025) Piri Pāua: Mātauranga Māori and marine science approach to growth rate and length at maturity of pāua in the Bay of Plenty, 2022–2024.

New Zealand Fisheries Assessment Report 2025/28. **20 p.**

This report combines mātauranga Māori (Māori knowledge) and marine science methods to better understand pāua population, growth rate and length at maturity in two Bay of Plenty areas, Te rohe moana o Ngāti Awa in Whakatāne and Tauranga Moana Mātaitai Reserve in Tauranga.

Pāua are revered by Māori as taonga (culturally important) species which are typically abundant on rocky areas in shallow coastal waters. For decades, the members of Mai i ngā Kuri ā Whārei ki Tihirau or the Bay of Plenty Customary Fisheries Regional Iwi Forum (hereafter MKWKT forum) have highlighted concerns over the lack of information regarding the state of the pāua population in Te Moana a Toi (Bay of Plenty) region.

This project builds on from previous iwi-led, mātauranga Māori and marine science population surveys conducted in the rohe moana o Ngāti Awa at Whakatāne and Tauranga Moana Mātaitai Reserve at Tauranga. Consistent with the previous surveys this project prioritised a combined mātauranga Māori and marine science methodology. The objectives were:

1. to collect intergenerational knowledge of pāua abundance, sizing and distribution in Tauranga and Whakatāne;
2. capability building of next generation hunga tiaki (iwi environmental practitioners) to access and participate in pragmatic mātauranga Māori and marine science effort in the field; and
3. evidence-based information on the current state of the pāua population, growth rate and length at maturity at the two identified locations.

The findings from this study were that pāua populations in traditional areas had declined by almost half in Tauranga across all sites including Motuotau, which recorded a mean average of 80 pāua per 10-minute timed count in 2013 compared with 42 pāua per 10 minutes in 2023. In Whakatāne the pāua population remained relatively consistent across all traditional sites surveyed.

However, pāua were consistently small sized, with the majority recorded between 65 and 144 mm length in Tauranga and between 65 and 104 mm in Whakatāne. The legal harvestable size for pāua is 125 mm length. Whakatāne recorded only 3 legal sized pāua in 2010 and 4 in 2023. In Tauranga 3 legal sized pāua were recorded in both 2013 and 2023.

Pāua in both areas are slow growing with a maximum annual average of 3.8 mm per year growth in Tauranga and 2.4 mm in Whakatāne. However, this study found that pāua are sexually mature at smaller sizes than in other regions of Aotearoa New Zealand such as Rakiura, Kaikōura, and the Wairarapa. In Tauranga it was estimated that 50% of pāua matured at 76 mm and 95% matured at 85 mm length. In Whakatāne 50% matured at 70 mm and 95% were sexually mature at 77 mm shell length.

This project serves as a preliminary assessment of growth rates and length at maturity of two pāua populations in the wild in Te Moana-a-Toi and provides cultural-ecological baseline data to inform management strategies moving forward.

[1] University of Waikato. [2]MUSA Environmental. [3]University of Canterbury.

1 INTRODUCTION

Previous mātauranga Māori and marine science population surveys by MUSA Environmental were conducted across traditional sites of significance in the rohe moana o Ngāti Awa in 2010, and Tauranga Moana Mātaitai Reserve in 2013 (Paul-Burke et al. 2010, 2013). Both survey series focused on pāua (*Haliotis iris*, Abalone) (Figure 1) alongside other species. The taonga (culturally important) pāua species was selected by tangata whenua, because of generational concerns about the declining state of the populations, lack of access to evidence-based information to assist management decision-making and because it was thought to be the species under the greatest harvesting pressure (commercial, recreational, and customary) in the area.

Figure 1: Pāua in te rohe moana o Ngāti Awa, Whakatāne, Aotearoa New Zealand, 2023.

In 2010 and 2013, mātauranga Māori or traditional place-based intergenerational knowledge was collected through semi-structured interviews using maps and boat field trips with kaumātua (tribal elders) and pūkenga taiao (environmental experts) from Ngāti Awa and Tauranga Moana. The information gathered was used to identify traditional pāua distribution sites and assist knowledge dissemination of historical abundance, size and environmental changes of taonga species and spaces over time, and across the marine mahinga kai (food harvesting areas).

Pāua findings from the 2010 and 2013 surveys confirmed that participating kaumātua/ pūkenga recollections regarding smaller sized pāua were consistent with the quantitative findings (Paul-Burke et al 2010). However, no further pāua research has been conducted and the previous survey information was over a decade old. Therefore, there was no ready access to mātauranga-led evidence-based information on the current state of pāua populations in Te Moana-a-Toi. Further, iwi customary fisheries managers had no quantitative information on growth rates and the length at which pāua are sexually mature and able to breed.

This report therefore provides an overview of the Piri Pāua research project conducted in 2022–2024 which used mātauranga Māori with marine science field methods to provide evidence-based information on 1) current state pāua population surveys, 2) pāua growth rates in the wild and 3) length at maturity across both locations. This study was initiated by the MKWKT forum which includes elected representatives from eight coastal iwi and the Ministry for Primary Industries. It was

anticipated that the findings of this project would assist local/regional management of taonga pāua species and spaces in Te Moana a Toi.

MĀTAURANGA MĀORI

Mātauranga Māori or Māori knowledge can be described as a complex and dynamic knowledge system originating from Māori ancestors, which adapts and changes but does not lose its integrity, nor sense of origin. It encompasses not only what is known but how it is known and includes Māori world views, language, principles, ethics and cultural practices (Paul-Burke & Burke 2016). Individual hapū (sub-tribe) and iwi (tribe) have their own localised mātauranga which is specific and relative to their environmental context, experiences, observations and understandings of species interactions and patterns of use which have been accumulated and grounded in the existence of people who have resided in one place for many consecutive generations (Cheung 2008, Jackson et al. 2017).

Mātauranga Māori world views of the natural world encompass a biological-cultural (bio-cultural) perspective which positions humans within nature and focusses on ways in which cultural understanding and intergenerational connection between people and their biophysical context assist in the retention and protection of biodiversity and ecologically sustainable ecosystems (Paul-Burke et al. 2020). Using mātauranga Māori to co-develop understandings of ecosystem stability, recoverability and resilience across consecutive generations, including culturally diverse management approaches and scientific endeavour, is increasingly recognised as an important tool for contemporary resource management across Aotearoa New Zealand and beyond (Forster 2012; Lyver et al. 2016, Kukutai et al. 2021; Awatere et al. 2021; Stevens et al. 2020; Paul-Burke et al. 2022).

2 METHODS

The aim of this project was to gather traditional localised knowledge alongside contemporary quantitative information regarding the state of pāua populations in Tauranga Moana Mātaitai Reserve and Te Rohe Moana o Ngāti Awa in Whakatāne (Figure 2) to assist informed decision making. The objectives included:

1. What is the current state of pāua in Te Moana-a-Toi, specifically in Te Rohe Moana o Ngāti Awa and Tauranga Moana Mātaitai Reserve?
2. What could an intergenerational mātauranga Māori led approach to pāua science and research look like?
3. What are pāua growth rates – how fast do they grow in the wild?
4. What size are pāua when they reach maturity and able to breed in the wild?

A deliberate intention of this study was to ensure that mātauranga Māori was positioned as a relevant and appropriate system alongside marine science. Further, this study created purposeful access for the next generation hunga tiaki (environmental trainees) to actively connect with their rohe moana through Māori centric in-water survey dive training embedded throughout the life of the research. The project methodology was grounded in tikanga Māori (Mead 2003; Te Awekotuku 1991), kaupapa Māori research methodology (Smith 1999), a whanaungatanga or collaborative approach to research (Paul-Burke et al. 2018) and the principles of kaitiakitanga or active guardianship (Jackson et al. 2017).

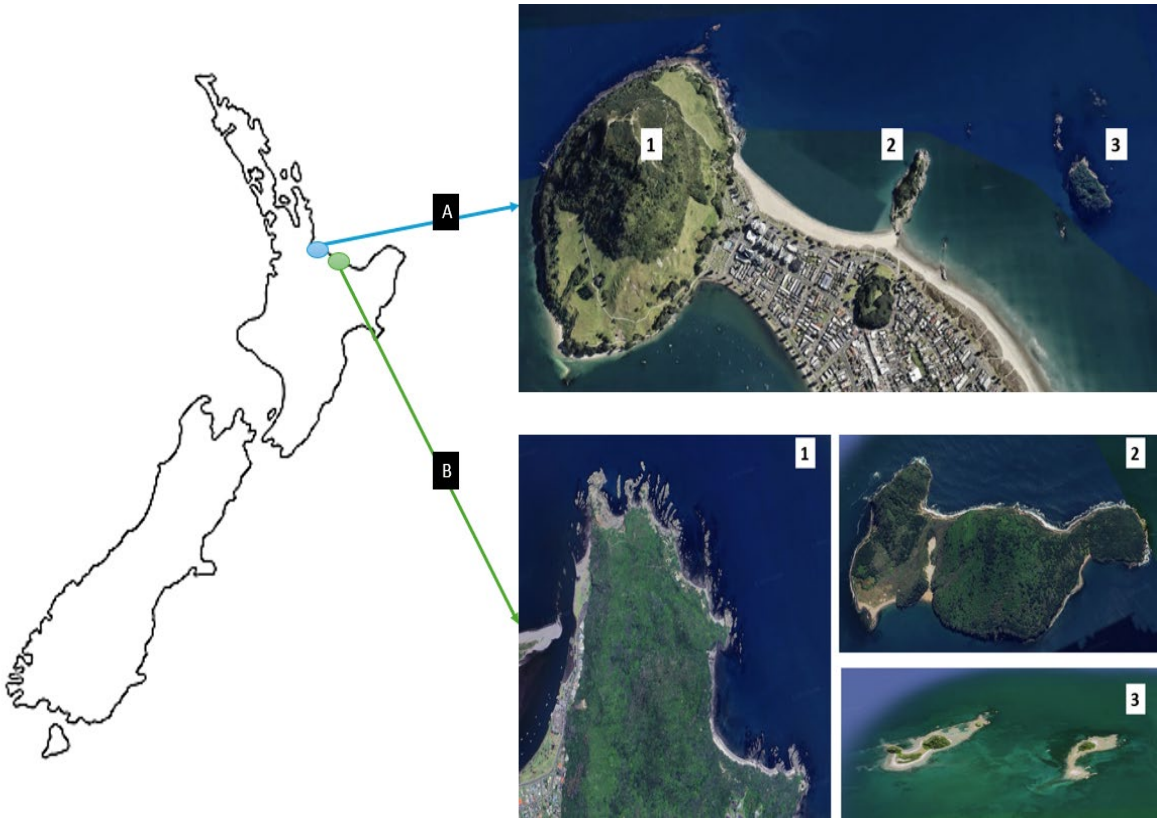

Figure 2: Map locations of piri pāua survey areas in Tauranga Moana Mātaitai Reserve (blue arrow A) with numbered Sites 1-Mauao, 2-Moturiki and 3-Motuotau. Survey areas in Te Rohe Moana o Ngāti Awa (green arrow B) with numbered Sites 1-Kohi, 2-Moutohorā, 3-Rūrima.

2.1 Kaupapa Māori Research Methodology

A kaupapa Māori approach to research is derived from the principles of mātauranga Māori. Whereby the validity and legitimacy of Māori ways of knowing, being and doing is a given. Kaupapa Māori is a theory and analysis of the context of research which involves Māori, and of the approaches to research with, by and/or for Māori (Smith 2009). It does not exclude a wide range of other methods but rather signals the interrogation methods in relation to cultural sensitivity, cross-cultural reliability, and useful outcomes for Māori and our wider communities (Cram 2002; Pihama 2010).

This project was grounded in Whanaungatanga which is recognised as the principle of working in meaningful, genuine collaboration to influence how mātauranga Māori and western science principles and practices are translated operationally in ways that recognise cultural values, knowledge systems and opportunities (Paul-Burke et al. 2018). The principles of whanaungatanga include:

- Kotahitanga, working together to achieve a common goal;
- Manaakitanga, responsibility to act in a manner that uplifts the mana or prestige of others;
- Kaitiakitanga, obligation to care for the environment and taonga (culturally important) species and spaces; and
- Rangatiratanga, coordination and affirmation of mātauranga Māori when working across agencies for collective decision-making.

2.2 Kaumātua and pūkenga knowledge

From a Māori worldview it is understood that not all cultural knowledge is open or accessible to everyone (Mead 2003). To promote and protect intergenerational customary fisheries information, all GPS waypoint coordinates identifying the exact distribution locations of the taonga pāua surveyed were omitted from all public reports, documents and presentations.

For the purposes of this project all mapped traditional and actual distribution dive locations are presented as yellow stars. The yellow stars represent the location of the dive line that the divers maintained while searching for pāua. The yellow stars do not identify the actual sites where pāua were recorded as present. No legends explaining actual pāua distribution areas are provided nor included in public maps. All information pertaining to kaumātua/pūkenga intergenerational 'private or secret' family dive spots were omitted from all documentation both public and private. This format is consistent for all distribution maps across all areas surveyed. If external individuals wish to access the culturally sensitive information, it is understood that they must make direct contact with the iwi authority knowledge holders (Paul-Burke et al 2010).

Protecting the cultural and intellectual property of participating kaumātua/pūkenga is supported by Royal (2006 p25) when he asserts "like all bodies of knowledge of this kind, there are aspects that are common to the community and there are aspects which are held by specialists". Smith (2012 p72) adds "Māori society valued knowledge highly, to such an extent that certain types of knowledge were entrusted to only a few members of the whānau... there were sanctions that ensured that it was protected, used appropriately and transmitted with accuracy."

2.3 Field methods

2.3.1 *Mātauranga mapping interviews & Hunga tiaki freedive training*

In the previous 2010 (Whakatāne) and 2013 (Tauranga) surveys, semi structured, small group focus interviews using a series of large coastal maps and boat field trips were conducted with kaumātua/pūkenga who are or have been active users of marine resources for 50+ years in the selected areas (Pauly 1995); and/or were identified as those most likely to have traditional ecological knowledge of customary species distribution patterns and/or socio-cultural knowledge of identified sites across time and space. Other ecological knowledge such as the depth range of harvesting (dive) sites, maramataka (Māori moon phases) and related tohu (natural world signs), coastal water, weather patterns, and habitat information was also discussed (O'Brien 2010).

The previous mātauranga mapping results and traditional sites identified by kaumātua/pūkenga in 2010 and 2013 were presented to the respective Ngāti Awa Customary Fisheries Manager and Tauranga Moana Iwi Customary Fisheries Trust in March 2023. This was to verify the previous dive sites and allow for any site extensions and/or any new information to surface.

Training of hunga tiaki to achieve a formal International SSI Level 1 Freedive qualification was led by MUSA Environmental a Māori-led marine consultancy with a team of dive instructors, scientific divers and a dive research vessel. Training included health and safety, kaitiakitanga (principles of active guardianship), basic oceanography, marine ecology, pāua biology, tohu o te moana (marine environmental indicators), and in-water connectivity.

Trained hunga tiaki then participated in supervised, hands-on, mātauranga Māori and marine science fieldwork including:

- on-boat tagging and at sea diver training to assist growth rate surveys;
- gonad identification to estimate the length of pāua at maturity; and
- ecological data collection for pāua population surveys.

2.3.2 *Population Surveys*

Pāua population surveys commenced in March 2023 on the GPS marks previously identified by kaumātua/pūkenga for the 2010 and 2013 surveys. Additional 2023 extension sites were identified on maps by iwi representatives with support to proceed received from Te Rūnanga o Ngāti Awa Customary Fisheries Manager in Whakatāne and TMICFT in Tauranga. The field surveys were conducted by qualified freedivers with scientific and professional pāua diving experience. Hunga tiaki buddy pairs gained experience with dive training observation exercises of pāua habitat and ecology including wider species identification.

The 10-minute timed pāua count method (McShane et al. 1994; Kingsford & MacDiarmid 1998) was used. The count started from when the first pāua was located. If no pāua were found within the ten-minute timeframe a nil count was recorded. All pāua were measured using a blunt pāua iron that was positioned adjacent to the pāua shell length to minimise disturbance (Kingsford & MacDiarmid 1998). At the end of each 10-minute timed count the diver ascended to the surface where the position of the diver in correlation with traditional landmark bearings was recorded and geographical coordinates (GPS) marked by the research boat person using a handheld GPS (Paul-Burke et al. 2013).

Pāua were measured in predetermined size classes of shell length using the following measurements:

- Size Class 1 = 0–24 mm;
- Size Class 2 = 25–44 mm;
- Size Class 3 = 45–64 mm;
- Size Class 4 = 65–84 mm;
- Size Class 5 = 85–104 mm;
- Size Class 6 = 105–124 mm;
- Size Class 7 = 125–144 mm;
- Size Class 8 = >145 mm.

2.3.3 *Growth rates*

In June 2023, 1000 pāua each from Tauranga and Whakatāne were measured and tagged in order to measure growth rates over a twelve-month period in the wild. Pāua were carefully collected by scientific/commercial pāua freedivers from reef rock surfaces using a flat pāua iron and transported to the anchored research vessel in a dive catch bag. On the boat, pāua shell length measurements were recorded using callipers, pāua were tagged and placed in a dive catch bag suspended in the water until returned to the reef. At the mid-way point (January 2024), tagged pāua were re-captured, re-measured and returned to the reef. A further 200 individuals across both locations were tagged to ensure growth rate data over the full twelve-month period. In June 2024, tagged pāua were re-captured and re-measured. Tags were removed from the pāua shell where applicable with all individuals then returned to their reefs. Hunga tiaki assisted with on-boat tagging and recording of pāua data to assess current growth rates across sampling sites.

Pāua measuring less than 45 mm were tagged with glue-on numbered label tags to the top surface of the outer shell (Figure 3, left side photo). Pāua 45 mm or larger in shell length were tagged through their outer respiratory pore (shell) with numbered Hallprint cable tie tags (T2175A) (Figure 3, right side photo). Tags that are attached through the respiratory pores provide a simple, replicable methodology which is unlikely to affect growth and likely to provide good retention and easy detection (Naylor & Fu 2016).

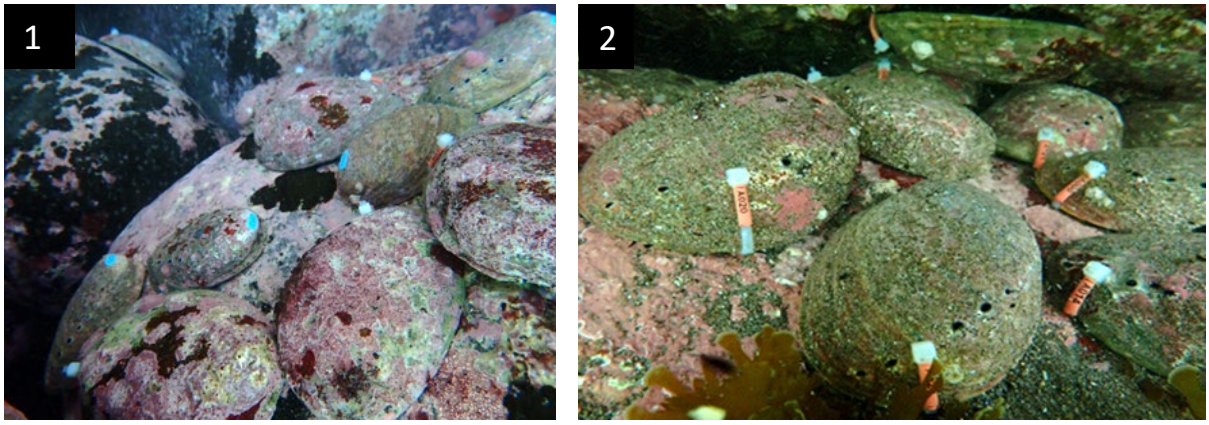

Figure 3: Image 1 (L) small sized pāua with blue numbered glue-on tags and image 2 (R) pāua with orange numbered Hallprint cable tie tags attached through the respiratory hole, in te rohe moana o Ngāti Awa, 2023.

2.3.4 *Length at Maturity*

Length at maturity (LAM) is the shell length at which the pāua gonads (reproductive organs) can produce eggs and sperm. LAM estimates combined with growth rates can be used to set minimum harvest size. (Naylor & Fu 2016). In Tauranga and Whakatāne, 60 pāua between 35–115 mm shell length were collected by freedivers in 5 mm size groups (e.g. 5 individuals between 35–40 mm, 5 between 40–45 mm, and so on). Pāua shell length measurements were recorded and the pāua was then carefully removed from the shell. Sexual maturation was determined by visual inspection of the gonad (reproductive organs). Gonads were scored using pre-determined coding as: mature female, mature male, partially mature female/male (in transition to sexual maturity) or immature (Naylor & Fu 2016). The pāua meat was donated to local mana whenua, the labelled shells were dried and preserved for potential morphological analysis if required by iwi. Hunga tiaki assisted with on-boat gonad identification and recording of data for length at maturity of pāua.

2.3.5 *Data Analysis*

Microsoft Excel spreadsheet, DataAnalysis Tool, PivotChart and PivotTable were used for basic computations. MapSource, Basecamp, GoogleEarth and GarminData were used for graphical imaging and mapping. Data from sub-tidal sampling surveys conducted in 2010 and 2013 were used as baselines to compare population numbers and sizes across identified locations 2022–2024. Size frequency distributions were calculated by adding individual samples together from each identified sample area. The data was analysed by collating the total number of species samples, per area. Sample populations were tabled by size and distribution at each location.

Population density numbers were estimated by totalling the number of individuals sampled. This was then divided by the total number of time-samples conducted to get an average or mean frequency. The 95% confidence interval for each mean frequency was calculated to enable the use of error bars. Each yearly mean was tested against the previous year's mean using independent two-sample t-test (Sokal & Rohlf 1995) with variance. This formula was also used for the yearly total size estimates. Values of p less than 0.05 were considered significant. The data was then tabled for ease of knowledge dissemination.

Length at maturity included the proportion of mature individuals within 5 mm size classes fitted to a logistic curve using a non-linear, least squares model in the statistical program R. The resulting curve was used to estimate length at 50% maturity (L50, or the length at which 50% of pāua are fully mature) and length at 95% maturity (L95, or the length at which 95% of pāua are fully mature). Individuals scored as Partially Mature Female or Partially Mature Male were considered Immature when calculating LAM, since they do not contribute significantly to reproduction due to low number of eggs or sperm per gonad (Naylor et al. 2006; Poore, 1972; Sainsbury, 1982). Length at maturity was assessed at both sites combined and each site separately.

Kaumātua/pūkenga knowledge from 2010, 2013 and 2023 determined traditional sites including start and end boundaries and/or specific spots of pāua distribution in their respective locations. The information shared by participants was based on their experiential harvesting knowledge and practices as kaitiaki (environmental guardians) and food gatherers. The information was substantiated by other participants when recounting conversations, observations, and practices of their people having harvested pāua from the same marine areas for many consecutive generations (Paul-Burke et al. 2018).

Information from interviews and boat field trips in 2010 and 2013 and separate online meetings in March 2023 with the Ngāti Awa Customary Fisheries Manager and Tauranga Moana Customary Iwi Fisheries (TMCIF) representatives was used to approve/verify the former 2010 and 2013 traditional dive sites and to identify any potential new survey areas for this project.

This information was then used to determine the location of all marine science sub-tidal (underwater) dive surveys for the project.

3 RESULTS

3.1 Mātauranga Māori mapping interviews and Hunga tiaki freedive training

In March 2023, the previous mātauranga mapping results and traditional sites identified by kaumātua/pūkenga in Ngāti Awa 2010 and Tauranga Moana 2013 were presented to the Ngāti Awa Customary Fisheries Manager and Tauranga Moana Iwi Customary Fisheries Trust to determine any new information and/or survey site extensions. Ngāti Awa chose to remain with the original 2010 sites for survey (Figure 4 and Figure 5). Tauranga Moana added an additional site (Site 2) and an extension to an existing site (Site 3A) for the 2022–2024 surveys.

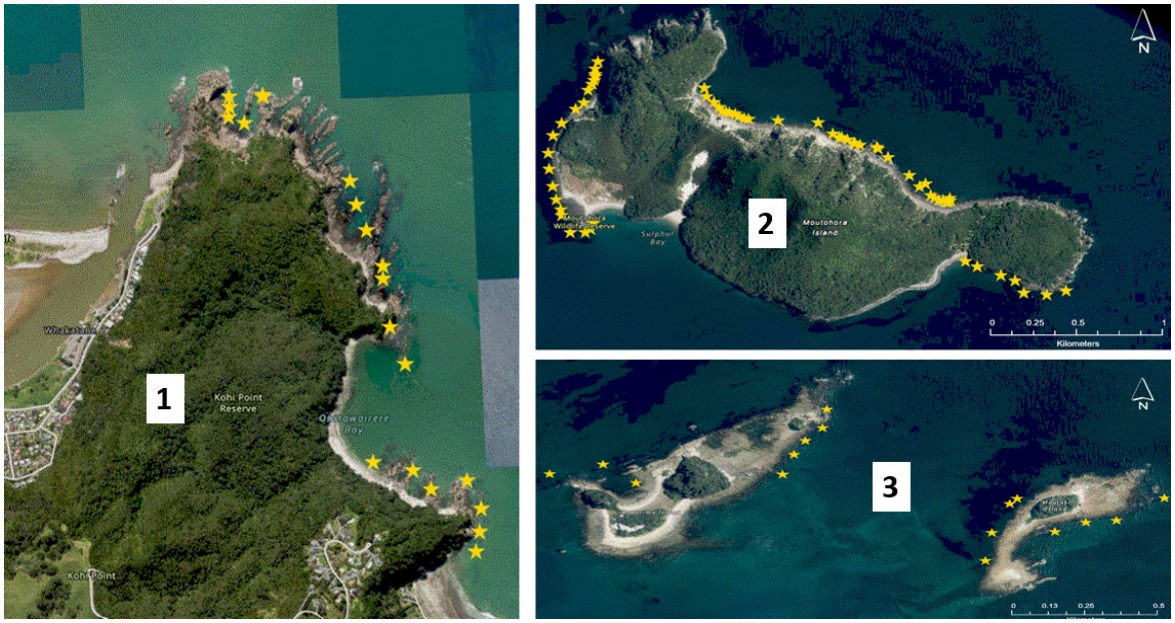

Figure 4: Pāua survey Site 1 (Kohi), Site 2 (Moutohorā / Whale Island) and Site 3 (Rūrima Islets) in Te Rohe Moana o Ngāti Awa. Yellow stars identify continuous diving across areas surveyed, consistent with original 2010 sites.

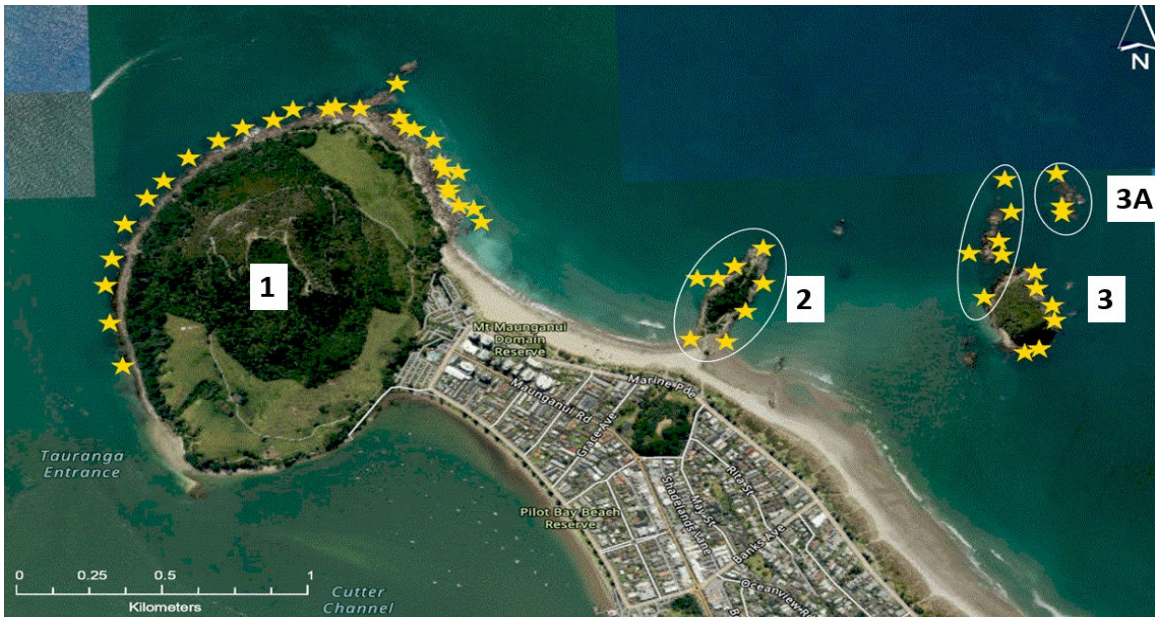

Figure 5: Pāua survey Site 1 (Mauao), Site 2 (Moturiki), Sites 3 & 3A (Motuotau) in Tauranga Moana Mātaitai Reserve. Yellow stars identify continuous diving in survey areas. White circles identify additional Sites 2 and 3A for the 2023 piri pāua dive surveys.

In January 2023, hunga tiaki from Ngāti Awa and Tauranga Moana were trained in the formal International SSI Level 1 Freedive qualification. Eight hunga tiaki participated in the training which also included health and safety, kaitiakitanga (active guardianship), tikanga moana (traditional ocean practices), marine ecology, pāua biology, tohu o te moana (marine environmental indicators), in-water connectivity and practical hands-on survey techniques, tools and training, basic skipper and dive master skills (Figure 6).

Once qualified, hunga tiaki assisted with in-water pāua ecology surveys, growth rate tagging and length at maturity on-boat data recording. All field work was conducted under the supervision of marine scientific divers and dive instructors. At the end of the field work component for this project, some of the participating hunga tiaki enrolled in their first year of university undergraduate degree programmes in marine science, marine engineering and te reo Māori; others have become avid divers with their whānau, and one is completing a PhD on kōura (crayfish) restoration in Tauranga Moana Mātaitai Reserve.

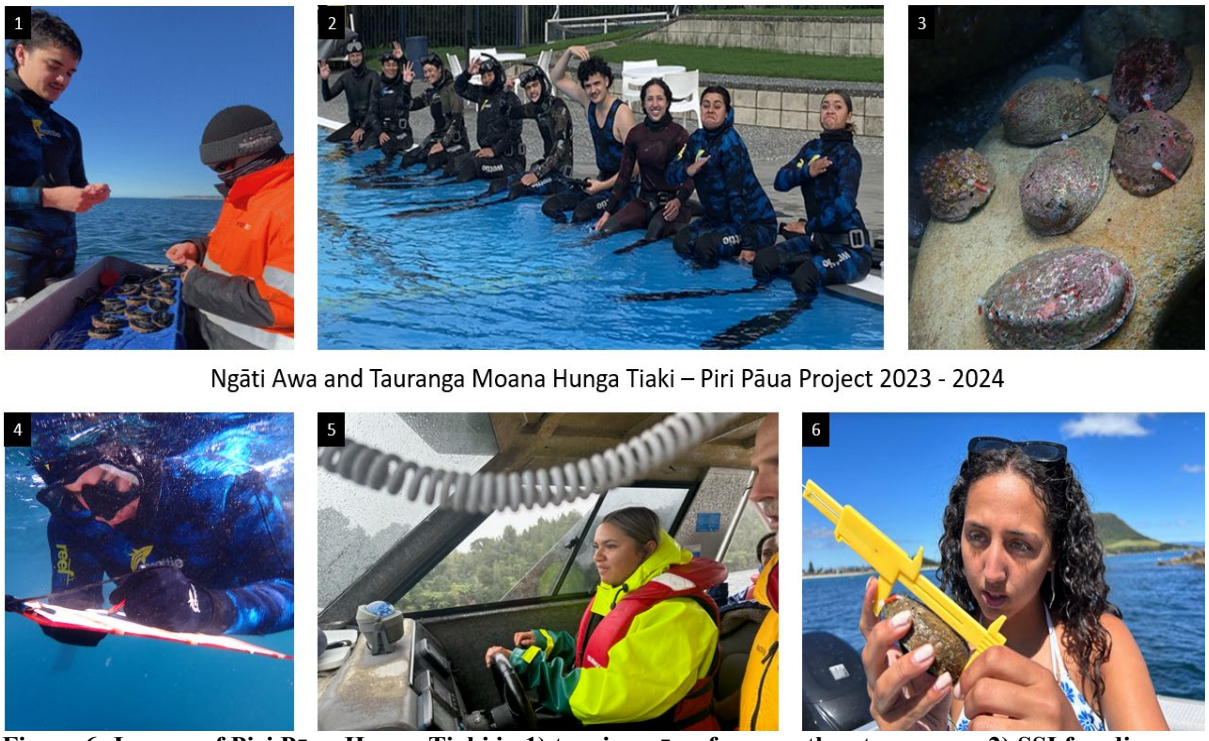

Figure 6: Images of Piri Pāua Hunga Tiaki in 1) tagging pāua for growth rate surveys. 2) SSI freedive qualification training. 3) tagged pāua in the wild. 4) conducting roving diver observations of pāua populations. 5) hands-on training, skipper/oceanography. 6) measuring pāua with callipers for data collection at sea.

3.2 Population Surveys – Te Rohe Moana o Ngāti Awa

At Whakatāne just over 4000 pāua in 2023 were counted and measured across all sites surveyed, compared with a total of 2524 pāua in 2010. The majority of all pāua surveyed were recorded at Site 2 with an average or mean frequency of 55 pāua per 10-minute timed count in 2023 compared to 42 in 2010 (Figure 7).

Results of an independent two-sample t-test with unequal variance found that the mean frequencies of pāua in te rohe moana o Ngāti Awa for the years 2010 and 2023 across all sites surveyed were not significantly different ($p = 0.65$).

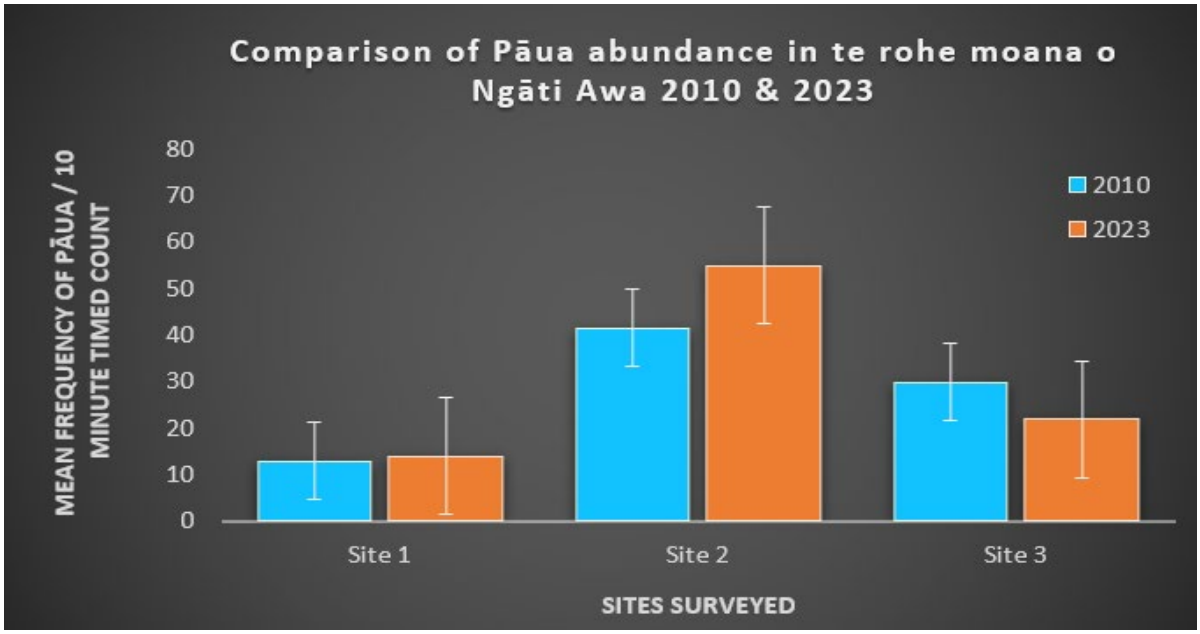

Figure 7: Mean frequency of pāua per 10-minute timed counts in te rohe moana o Ngāti Awa 2010 and 2023. Error bars indicate the 95% confidence interval on the mean frequency estimate.

In 2023 the mode of the pāua size distribution occurred in Size class 5 at Sites 2 (66%) and 3 (47%) with Site 1 recording 48% in Size class 5 (85–104 mm). In 2010 the highest percentage of pāua size distribution was found in Size class 5 (85–104 mm shell length) at Sites 2 (60%) and 3 (57%). Site 1 recorded 62% pāua in Size class 4 (65–84 mm shell length). (Table 1).

In 2023 a total of 4 pāua were recorded in Size class 7 (>125 mm shell length which is the Minimum Legal Size for harvesting). In 2010, 3 pāua were recorded in Size class 7. In te rohe moana o Ngāti Awa the findings from 2023 and 2010 found that 99% of all pāua measured were under the Minimum Legal Size with the majority between 65 mm and 104 mm across all sites surveyed.

Table 1: Size of pāua (percentage) in te rohe moana o Ngāti Awa 2010 and 2023. Coloured boxes highlight modes of the pāua size distribution in 2010 (blue) and 2023 (orange).

		Site 1		Site 2		Site 3	
		2010	2023	2010	2023	2010	2023
	Size class						
1	0–24 mm	0	0	0	<1	0	0
2	25–44 mm	3	<1	2	1	0	0
3	45–64 mm	22	7	2	10	0	5
4	65–84 mm	62	35	26	66	8	47
5	85–104 mm	13	48	60	21	57	43
6	105–124 mm	0	10	10	1	34	5
7	125–144 mm	0	0	0	<1	1	<1
8	>145 mm	0	0	0	0	0	0

3.3 Population surveys Tauranga Moana Mātaitai Reserve

In Tauranga in 2023 a total of 814 pāua were counted and measured across all sites surveyed, compared with a total of 1205 pāua in 2013. The majority of all pāua surveyed in 2023 were recorded at Site 1 Mauao with an average of 15 pāua found per 10-minute timed count compared with an average of 31 in 2013. At Site 3 Motuotau an average of 42 pāua was recorded in 2023 compared with an average of 80 in 2013. New added survey sites 2 and 3A recorded an average of 4 and 11 pāua per 10-minute timed count respectively in 2023 (Figure 8). The results of independent two-sample t-tests with unequal variance found that the mean frequency of pāua compared across sites surveyed in Tauranga Moana Mātaitai Reserve in 2013 and 2023 (at comparable Sites 1 and 3) are significantly different ($p = 0.02$).

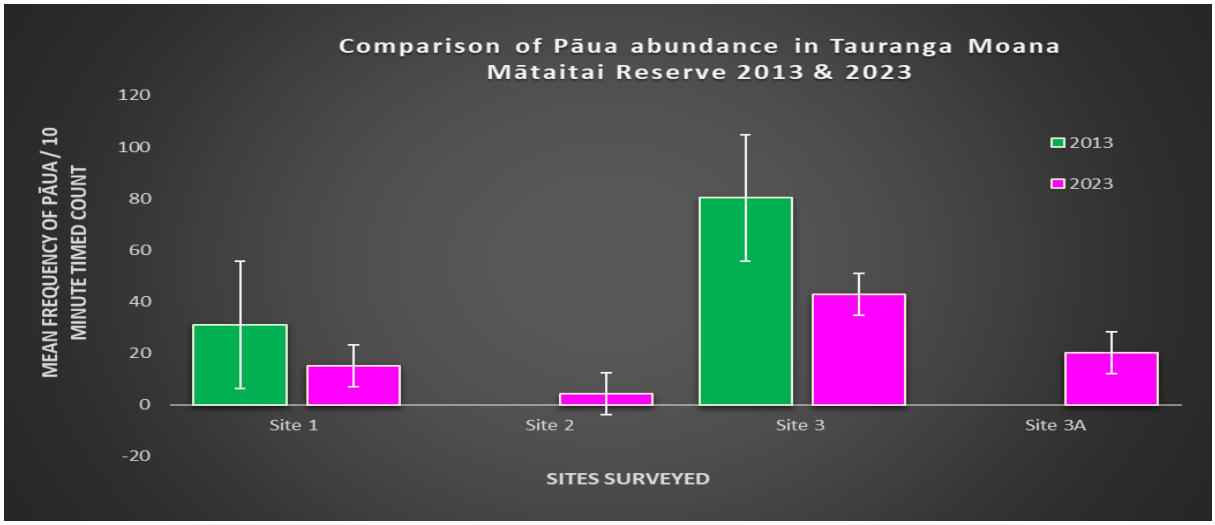

Figure 8: Mean frequency of pāua per 10-minute timed counts in Tauranga Moana Mātaitai Reserve 2013 and 2023. Error bars indicate the 95% confidence interval on the mean frequency estimate.

In 2023, the highest percentage of pāua size distribution at Site 2 was 65–84 mm, with 77% of pāua surveyed in Size class 4. Sites 1, 3 and 3A recorded 43%, 47% and 55% respectively of pāua surveyed in Size class 5 (85–104 mm). In 2013, the highest percentage of pāua size distribution at Site 3 was 105–124 mm, with 50 % of pāua surveyed in Size class 6. Site 1 recorded 51% of pāua in Size class 5. In both 2023 and 2013, 3 pāua were recorded in the legal harvest Size class 7 across all sites surveyed. In Tauranga Moana the findings from both 2013 and 2023 identify that 99% of all pāua are below the Minimum Legal Size with the majority between 65 and 124 mm across all sites surveyed (Table 2).

Table 2: Size of pāua (percentage) in Tauranga Moana Mātaitai Reserve 2013 and 2023. Coloured boxes highlight modes of the pāua size distribution in 2013 (green) and 2023 (pink).

		Site 1		Site 2	Site 3		Site 3A
		2013	2023	2023	2013	2023	2023
	Size class						
1	0–24 mm	0	0	0	0	0	0
2	25–44 mm	0	1	0	0	0	0
3	45–64 mm	3	12	13	0	6	5
4	65–84 mm	19	29	77	13	34	16
5	85–104 mm	51	43	10	36	47	55
6	105–124 mm	27	15	0	50	12	23
7	125–144 mm	0	0	0	1	1	1
8	>145 mm	0	0	0	0	0	0

3.4 Growth Rates

In June 2023, 1000 pāua each from Tauranga and Whakatāne were measured and tagged. In January 2024 tagged pāua were re-captured, re-measured, and returned to the reef. A further 200 individuals across both locations were tagged to ensure growth rate data over the full twelve-month period. In June 2024, tagged pāua were re-captured and re-measured.

In Tauranga the average annual growth rate of pāua in the wild was 3.8 mm. For the period from June 2023 – January 2024 (hōtoke - raumati or winter to summer) the average growth was 2.3 mm (Table 3). The range of growth of pāua in Size class 4 (65–84 mm) was between 0 and 17 mm over this 6-month period. In Size class 5 (85–104 mm) the maximum growth measured was 9 mm and in Size class 6 (105–124 mm) the maximum growth measured was 4 mm.

For the period from January 2024 – June 2024 (raumati – hōtoke or summer to winter) the average growth was 1.5 mm. The maximum growth measured was in Size class 4 pāua was 17 mm. In Size

class 5 the maximum growth measured was 7 mm and in Size class 6 the maximum growth measured was 2 mm.

In both periods and in all size classes no growth was recorded for some pāua.

In Whakatāne te rohe moana o Ngāti Awa the annual average growth rate was 2.4 mm. For the period from June 2023 – January 2024 the average growth was 0.5 mm compared with the period from January 2024 – June 2024 where the average growth was 1.9 mm. In Size class 4 (65–84 mm) the maximum growth measured hōtoke – raumati (winter to summer) was 3 mm. In Size class 5 the maximum growth measured from summer to winter was 5 mm.

Across both locations smaller sized pāua <64 mm were unable to be recorded as the glue-on tags designed for juvenile pāua (<60 mm) did not remain attached for the duration of the project. Only pāua that had been tagged through the respiratory hole were able to be re-caught and re-measured.

Table 3: Growth rates of pāua shell length in the wild at Tauranga Moana Mātaitai Reserve and Te Rohe Moana o Ngāti Awa June 2023 – June 2024.

Site	Time period	Size	Average growth (mm)	Range (mm)
Tauranga Moana	June 2023–January 2024	All	2.3	0–17
	Hōtoke - Raumati	Size 4		0–17
		Size 5		0–9
		Size 6		0–4
	January 2024–June 2024	All	1.5	0–17
	Raumati - Hōtoke	Size 4		0–17
		Size 5		0–7
		Size 6		0–2
Ngāti Awa Whakatāne	June 2023–January 2024	All	0.5	0–3
	Hōtoke - Raumati	Size 4		0–3
		Size 5		0–2
	January 2024–June 2024	All	1.9	0–7
	Raumati-Hōtoke	Size 4		0–4
		Size 5		0–7

3.5 Length at maturity

In November 2023, samples of 60 untagged pāua were collected by hand by freedivers at the traditional sites in Tauranga and Whakatāne. The sampled pāua ranged from 35–115 mm shell length. Pāua were removed from the shell so that the full gonad could be visually assessed. Gonads were scored (Figure 9) as: 1) mature female, 2) mature male, 3) partially mature female, 4) partially mature male, 5) immature (unable to distinguish sex) and 6) likely mature but no distinguishing colour (Naylor & Fu 2016).

Figure 9: Images of pāua as 1) mature female with green gonad. 2) mature male with white gonad. 3) partially mature female with mottled greed gonad. 4) partially mature male with mottled white gonad. 5) immature with small black gonad. 6) likely mature, larger grey gonad, but no distinguishing colour characteristics. Images by: Shawn Gerrity 2023.

Gonads were generally small and in poor condition, making it difficult to determine sex due to a lack of identifiable features. Of the pāua that could be sexed, in Whakatāne 57% were female and 43% male. In Tauranga 58% were female and 42% male. Transition from sexually immature to mature began between 60 and 78 mm shell length at both sites. The smallest fully mature pāua was 63 mm (Whakatāne) with the largest fully immature pāua at 75 mm (Tauranga). In Whakatāne, 50% of pāua were mature at 70 mm and 95% mature at 77 mm shell length. In Tauranga 50% of pāua were mature at 76 mm and 95% mature at 85 mm shell length (Table 4).

Table 4: Results summary including sample size, sex ratios, length of smallest fully mature individual, length of largest fully immature individual, length at 50% and 95% estimates from each site.

Site	Sample size	% Female	Smallest mature (mm)	Largest immature (mm)	Length at 50% mature (mm)	Length at 95% mature (mm)
Tauranga	60	58	80	75	76	85
Whakatāne	60	57	63	61	70	77

4 DISCUSSION

In this study it was found that pāua population numbers in traditional areas had declined by almost half in Tauranga across all sites including Site 3 (Motuotau) which recorded a mean average of 42 pāua per 10 minutes in 2023 compared with 80 pāua per every 10-minute timed count in 2013. In Whakatāne the pāua population remained relatively consistent across all traditional sites surveyed.

Across both locations, pāua were consistently small sized with the majority recorded between 65 mm and 144 mm length in Tauranga and 65–104 mm in Whakatāne. The legal harvestable size (Minimum

Legal Size) (customary, recreational, commercial) for pāua is 125 mm length. Whakatāne recorded 3 legal sized pāua in 2010 and 4 in 2023. In Tauranga 3 legal sized pāua were recorded in both the 2013 and 2023 surveys. Growth rates indicated that pāua are slow growing in these areas, with an annual average of 3.8 mm growth in Tauranga and 2.4 mm in Whakatāne.

Mātauranga mapping discussions held with kaumātua/pūkenga in 2010 (Whakatāne) and 2013 (Tauranga) and 2023 (both locations) identified traditional sites where pāua were most abundant in the Tauranga Moana Mātaitai Reserve and Te Rohe Moana o Ngāti Awa. Participants indicated that pāua were almost always 'small' (i.e. under the Minimum Legal Size of 125 mm shell length). This was consistent with Cook (2010) who suggested that pāua were small or 'stunted' in the east and west coasts of the upper North Island of Aotearoa New Zealand. Stunted pāua have a slightly more rounded appearance and are without the thin lip around the shell edge which are characteristic in faster growing individuals (Andrew & Naylor 2003).

Across both locations the highest growth rates occurred in Tauranga with a range of 0–17 mm growth in Size class 4 (summer to winter, 65–84 mm) with 0–7 mm range in Size class 5 (85–104 mm) and 0–2 mm range in 6 (105–124 mm). Whakatāne recorded consistently lower growth in size 4 (summer to winter) at 0–4 mm and size 5 at 0–7 mm.

This may be because small (young) pāua are still growing, with individuals in Size classes 5 and 6 approaching the upper limit of their growth. However, the growth rates of pāua are also highly variable spatially, with cooler, more wave exposed environments tending to have higher growth rates than other areas with higher numbers of stunted individuals in the population (Hooker et al. 1997; McShane & Naylor, 1995; Naylor & Fu, 2016). Estes, Lindberg & Wray (2005) note that larger pāua are generally found in colder waters - pāua in the South Island are consistently larger in size than those found in the warmer sub-tropical waters of Te Moana-a-Toi (Bay of Plenty, North Island). However, pāua found in the warmer waters of the Three Kings Island in the far North are similar in size to South Island pāua.

Searle, Roberts & Lokman (2006) suggest that the growth rates of juvenile pāua were largely affected by water temperature with individuals spawned later in the season found to be slower growing and smaller in size than those spawned in the warmer water part of the season. In this study, Tauranga recorded the overall highest growth range from winter to summer (June 2023-January 2024) with Whakatāne from summer to winter (January 2024-June 2024). Investigations into when pāua spawn in both surveyed locations would assist greater understanding of optimal spawning conditions in Te Moana-a-Toi.

This study found that pāua were also coming to sexual maturity at smaller sizes than in other regions (Rakiura, Kaikōura, Wairarapa) of Aotearoa New Zealand (Gerrity & Schiel 2024). In Tauranga it was estimated that 50% of pāua were mature at 76 mm and 95% were mature at 85 mm length. In Whakatāne, 50% were mature at 70 mm and 95% were sexually mature at 77 mm shell length. Length at maturity (LAM), the length at which pāua reach sexual maturity and can produce viable eggs or sperm, is an important metric of pāua population dynamics. At both locations, gonads were generally small and in poor condition. This may indicate a recent spawning event or underlying issues with gonad development such as environmental stressors (e.g. elevated sea temperature). Transition from sexually immature to mature began from 63–75 mm across both locations. Gerrity & Schiel (2024) found that 50% of pāua in the Taranaki region were mature at 59 mm shell length compared with Rakiura or Stewart Island where 50% were mature at 82 mm.

Kelp (seaweed) forests are indicative of overall ecosystem health and are a key ecological indicator in temperate reef ecosystems (Tait & D'Archino 2024). Poor kelp forest health is often associated with the degradation of a range of species including pāua. Abundance of kelp can be considered an excellent indicator of whole ecosystem health. During the earlier surveys, kaumātua and pūkenga suggested that access to food sources and the type of food sources available (type of kelp), may not be optimal for pāua in Te Moana-a-Toi (Paul-Burke et al. 2010, 2013).

Scientific freedivers in this study observed patchy kelp presence with high numbers of kina in some areas however, no formal data was recorded as it was outside of the project brief. Studies of kina dominating traditional pāua habitats have shown that pāua numbers and condition decline in correlation with increasing kina presence (Andrew & MacDiarmid 1999; Naylor & Gerring 2001).

In a study undertaken by McShane (1997) it was suggested that the opportunistic behaviour of pāua allowed them to feed on the kelp that was most abundant and/or available within their immediate area, with pāua often selecting red seaweed over brown kelp. In their research on *Feeding preferences of the abalone, Haliotis iris (pāua) in relation to macroalgal species, attachment, accessibility and water movement*, Cornwall et al. (2023) found that when pāua were exposed to a range of red, brown and green kelp they generally chose the large brown seaweed *Ecklonia radiata* or rimurimu over red or green. However, Cornwall et al. (2009) also found that when the stipes (stalks) of a whole brown seaweed were in an upright position pāua were more inclined to consume the smaller sized, more easily reached blades (leaves) of the red seaweed *Gigatina circumcincta*. This suggests that pāua are more likely to feed on kelp that is easily accessible as opposed to actively seeking a preferential type of seaweed. Currently, there is little to no evidence-based information on the state of kelp in known pāua habitats in Te Moana-a-Toi. Investigations into the state of kelp (seaweed) populations as a primary food source for pāua condition, growth rates and length at maturity would assist management options.

This study was spatially and temporally limited and provided a snapshot of current population abundance, sizes, growth rates, length at maturity and gonad condition across two locations in Te Moana-a-Toi. Assessment of different sites or during different seasons would better clarify the reproduction dynamics of these populations, and whether the poor gonad quality observed here is the result of recent spawning or of environmental stressors. Additional analysis of shell morphology (height and width), and breeding scars (the pattern present on the inside of the shell), may provide further insight on reproduction and growth rates here.

For coastal Māori there is a growing demand to investigate alternative ways of engaging with marine science to monitor degradation and assist recovery initiatives for culturally important species in Te-Moana-a-Toi. In order to achieve sustainable communities access to up-to-date evidence-based information is needed to assist decision-making and marine management actions. Finding ways in which hapū/iwi driven scholarship and place-based participatory practice can be utilised through co-developed transdisciplinary mapping methods to assist culturally important rohe moana, is a high priority.

The methods used in this project purposefully positioned a pragmatic intergenerational mātauranga Māori led approach to pāua science and research as real, relevant, appropriate, replicable and normal. The approach actively positioned mātauranga Māori/ā iwi alongside other knowledge systems as a ‘normal’ approach to research (Mane 2009; Paul-Burke 2011) and helps to alleviate a shifting baseline syndrome by using traditional intergenerational knowledge to provide a deeper understanding of ecological baselines over time (Pauly 1995).

Research on ways in which mātauranga Māori can be captured, in accordance with tikanga Māori (culturally appropriate practices) and incorporated into marine monitoring, restoration and management frameworks would strengthen Aotearoa New Zealand’s understanding of the impacts of change on local ecosystems and communities (Ministry for the Environment & Statistics NZ 2019).

This project serves as a preliminary assessment of growth rates and length at maturity of two pāua populations in the wild in Te Moana-a-Toi and provides cultural-ecological baseline data to inform management strategies moving forward.

5 POTENTIAL RESEARCH

There are a number of further opportunities to extend this pāua research in Te-Moana-a-Toi.

- Replication of project objectives in other locations for a wider representation of evidence-based information on pāua populations, growth rates and length at maturity.
- Assessments of different sites or during different seasons would better clarify the reproduction dynamics of these populations, and whether the poor gonad quality observed in this study is the result of a recent spawning or environmental stressors.
- Additional analysis of shell morphology (height and width), and breeding scars (the pattern present on the inside of the shell), may provide further insight on reproduction and growth rates.
- A trial longitudinal pāua re-seeding programme, for example in Tauranga Moana Mātaitai Reserve, could assist declining population numbers.
- Identify tools to assist pāua recovery.
- Investigations into when pāua spawn in Te-Moana-a-Toi would assist greater understanding of optimal spawning conditions and characteristics in both locations.
- Investigations into the state of kelp (seaweed) populations as a primary food source and the impact of climate change including warmer sea temperatures on pāua condition.
- Investigations into the impact of increasing kina presence on pāua populations and habitats
- Continue pushing the boundaries of research by deliberately prioritising mātauranga Māori alongside marine science in all future research endeavours.

6 FULFILMENT OF BROADER OUTCOMES

As required under Government Procurement rules[2], Fisheries New Zealand considered broader outcomes (secondary benefits such as environmental, social, economic or cultural benefits) that would be generated by this project.

A key purpose of this project was to produce a meaningful body of research/information at the interface of Māori knowledge and marine science. The project aimed to deliver effective and innovative solutions, services, and outcomes to assist informed decision-making, management options, and future restorative action for pāua populations in Te Moana a Toi, Bay of Plenty. This included building the capability, capacity, and networks of Māori communities to collaborate and carry out pragmatic, evidence-based research for our moana. to better access, direct, and utilise scientific endeavours that maximise its effectiveness for hapū/iwi in Te Moana a Toi.

It is understood that scientific research excellence is not identified by one measure. However, for generations, barriers to recognising, supporting and promoting mātauranga Māori at the forefront of science have impacted the ability of Aotearoa to lead the Indigenous/Science space on the international stage. A fisheries science system that develops, retains and attracts original, innovative, real-world solution generated by knowledge systems inclusive of mātauranga Māori will draw increased investment from industry, nationally and internationally.

In many areas of the world, indigenous cultural beliefs and practices have been found to be a key factor in the apparent long-term sustainable use of resources (WWF 2014). This is especially so in the case of the health and resilience of coasts and oceans, and the relevance of integrated human-nature concepts (Paul-Burke et al. 2020). In Aotearoa, there is an increasing demand to investigate mātauranga Māori to better understand degradation (e.g. declining populations, degrading ecosystems, climate change) and assist restoration initiatives (e.g. mātauranga mapping, growth rates and ecology of taonga species, tohu (environmental indicators) and mahinga kai), for the long term.

[2] https://www.procurement.govt.nz/procurement/principles-charter-and-rules/government-procurement-rules/planning-your-procurement/broader-outcomes/

For decades, the members of Mai i ngā Kuri ā Whārei ki Tihirau have voiced grave concerns regarding the state of pāua populations and access to intergenerational customary fisheries practices. The Piri Pāua project is a true representation of iwi-led direction, visioning and action for Te Moana a Toi. Western scientific research funding processes has traditionally funded projects written and led by Western scientists and academics who adhere to Western notions of research and science traditions. We have challenged that notion, which restricts research/science to pre-conceived constructs of what scientific endeavours are, who decides and who may participate. In response, this project was constructed and led by a local Māori marine ecologist/scientist who has significant experience leading successful, mātauranga Māori and marine science research, monitoring, restoration action with numerous hapū/iwi partners across Te Moana a Toi, Bay of Plenty and wider Aotearoa New Zealand.

This project celebrated mātauranga Māori alongside marine science as real, relevant and appropriate. It is an exemplar of new ways of approaching, actioning and normalising pragmatic dual knowledge systems for improved management and benefit of our moana, our kaimoana (seafood) and our collective mokopuna (grandchildren) of the future.

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