Pāua (Abalone)

Climate Change Vulnerability, Adaptation Strategies, and Identified Management Options for New Zealand Waters

Fisheries New Zealand
Tini a Tangaroa

NIWA
Taihoro Nukurangi

SPECIES DISTRIBUTION

Pāua (*Haliotis iris, H. australis*) are endemic New Zealand abalone, occupying a narrow coastal ribbon of intertidal rocky shorelines and nearshore reefs to depths of ~15 m. They are long-lived, annual broadcast spawners (1-3 week larval stage) and feed primarily on drift algae as adults. Temperature and related factors (food) are the primary drivers of adult size. Pāua have been virtually unchanged for 65 million years, making them one of the least evolved abalone species. Pāua support important commercial (export value ~NZ$55M), customary, and recreational fisheries.

VULNERABILITY TO CLIMATE CHANGE

Pāua growth and development are influenced by water temperature, wave exposure, and food availability. Pāua are vulnerable to smothering during sedimentation events. Pāua are also affected by decreasing pH both directly and indirectly (e.g., declines in coralline algae as a food source and settlement cue), and changes in suitable substrate availability due to coastal sedimentation. Terrestrial land use changes and management practices can exacerbate climate impacts due to increases in sedimentation and reduced water quality.

Fishery implications:

- Increasing temperatures and diminishing food may reduce the number of individuals that are of harvestable size
- Altered availability of food and suitable settlement substrate may reduce stock numbers (particularly in combination with elevated sediment inputs) and animal condition
- Sedimentation reduces recruitment surface availability, increases larval mortality

OVERVIEW OF PĀUA VULNERABILITY

Shellfish are vulnerable to climate change and ocean acidification, and their sessile nature makesthem susceptible to rapidly changing and/orhighly variable environmentalconditions.

Drivers of Pāua Vulnerability

- ***Climatic and climate-associated factors and disturbance regimes:*** Enhanced coastal erosion & elevated sediment inputs, increasing sea surface temperature, ocean acidification
- ***Non-climate factors:*** Management and flood control that increase nearshore sediment delivery, illegal take, nutrient pollution, conflicting management

SUMMARY OF VULNERABILITY

PROJECTED FUTURE CHANGES *(EXPOSURE)*	POTENTIAL EFFECTS ON PĀUA *(SENSITIVITY)*	FACTORS THAT INFLUENCE ABILITY TO RESPOND TO CHANGE *(ADAPTIVE CAPACITY)*
Increasing **ocean temperature** • *+0.55-3.3°C by 2100, depending on emissions scenario* • *Largest increases likely in the Tasman Sea and south of Chatham Rise* • *Increasing marine heatwaves*	• Increased rate of larval development *NZ* • Reduced size at maturity and maximum adult size *NZ* • Altered distribution and survival of macroalgal food source *NZ* • Mortality events 🌐	**Ecological factors that enhance adaptive capacity:** • Wide distribution around mainland New Zealand and offshore islands • Broad diet, long-lived (20-30 years) • High levels of genetic variation may provide opportunities for adaptation • Association with kelp beds may alleviate local acidification effects • Ability to raise larvae in hatcheries increases management potential (i.e., can avoid adverse conditions, selection of resilient strains) **Societal factors that enhance adaptive capacity:** • High economic, societal, and cultural value (taonga species) increase support for management • Fishery employs free diving for harvest
Ocean acidification • *Oceanic pH declines of 0.13-0.33 units by 2100, depending on emissions scenario* • *Lowest pH levels will occur in the south*	• Reduced juvenile growth rates *NZ* • Greater prevalence of abnormalities in larvae *NZ* • Enhanced shell surface dissolution in juveniles *NZ* • Reduced suitable recruitment habitat and/or food availability for juveniles due to pH-related declines in coralline algae ?	
Increasing frequency and severity of **storms** and **extreme precipitation events** • *Contributes to sudden decreases in salinity and increased sedimentation* • *Rubble abrasion of populations*	• Disrupted harvest pressure as storm events increase • Mortality from large or sudden decreases in salinity 🌐 • Mortality from habitat storm disturbance ** *Also see sedimentation impacts*	**Factors that reduce adaptive capacity:** • Adults are essentially sessile, increasing vulnerability to changing conditions • Extremely localised recruitment (failures reported when adult aggregation falls below 1.5 m to nearest neighbour) • Shallow habitat is more vulnerable to stressors
Increasing **coastal sedimentation** • *Deposits layers of sediment and/or elevates suspended sediment concentrations*	• Increased larval mortality due to elevated suspended sediment levels *NZ* • Settled sediments reduce availability of suitable larval settlement habitat, limiting recruitment and abundance *NZ* • Macroalgal food sources damaged by reduced light and smothering *NZ*	**Data source symbol key** 🌐 Global data *NZ* Regional data ? More information needed

EcoAdapt

POTENTIAL ADAPTATION STRATEGIES FOR PĀUA

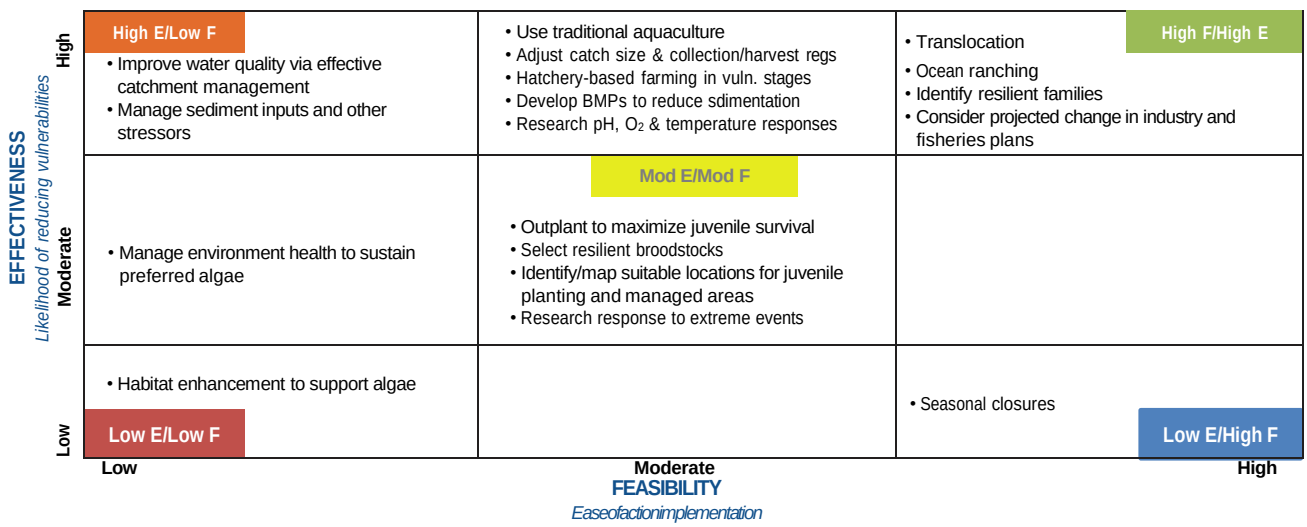
Note: Strategies evaluated for E (effectiveness) and F (feasibility)

Projected Change	Vulnerability of Fishery	Potential Adaptation Strategy & Management Options
Increasing **ocean temperature**	Reduced adult size resulting in fewer individuals that reach harvestable size each year	• Incorporate consideration of projected environmental change into plans for industry and NZ fisheries management *(High E/High F)* • Adjust catch size (where maturing smaller, recalculate sustainable harvest, if population has reset to smaller size) *(High E/Mod F)* • Change collection and harvest regulations *(High E/Mod F)* • Enhance pāua resilience to increasing ocean temperatures by reducing other stressors that are detrimental to growth (e.g., water quality) via effective catchment management *(High E/Low F)* • Continue investigation of pāua ability to acclimate or adapt to rising temperatures (growth, time to and length at maturity, mortality rates, variability by region), and incorporate knowledge into management plans *(High E/Mod F)* • Use traditional aquaculture, although cooling costs may limit economic feasibility *(High E/Mod F)* • Translocate individuals from slow-growing/depleted sites to fast-growing sites to achieve greater biomass *(High E/High F)*

	Reduced survival, especially when combined with other stressors	• Manage sediment input and other stressors where necessary *(High E/Low F)*
		  • *Create fisheries plans (Section IIA plans) for inclusion in regional plans*
		  • *Address land use and flood management*
		  • *Enforce the Resource Management Act across the whole catchment*
		• Seasonal closures of fishery or sites (determine most effective timing for closures) *(Low E/High F)*

	Reduced survival of algal food source	• Habitat enhancement to support algae *(Low E/Low F)* • Manage environment health to sustain preferred algae (reduce other stressors that are detrimental to survival) *(Mod E/Low F)*
	Potential impacts on spawning and larvae	• Increase understanding of vulnerability to marine heat waves/extreme events through existing research and translation to scale *(Mod E/Mod F)* • Research and select broodstock that is naturally more resilient to changes in temperature, pH, and disease, and incorporate these into breeding programmes *(Mod E/Mod F)*
Ocean acidification (OA)	Shells eroded, settlement habitat may be diminished	• Continue to investigate the ability of pāua to acclimate or adapt to ocean acidification *(High E/Mod F)* • Test management actions to increase OA resilience (e.g., return crushed shells to sites *unknown E/Mod F*, identify resilient families *High E/High F*) • Ocean ranching (movement to suitable habitat at each lifestage) *(High E/High F)*
	Fewer individuals that reach harvestable size each year	• Incorporate consideration of projected environmental change into plans for industry and NZ fisheries *(High E/High F)* • Change collection and harvest regulations *(High E/Mod F)* • Identify/map suitable locations for juvenile planting and managed area designation *(Mod E/Mod F)* • Hatchery-based farming, managed brood stock, spawning, and rearing through vulnerable life stages *(High E/Mod F)* • Ocean ranching (movement to suitable habitat at each lifestage) *(High E/High F)* • Use traditional aquaculture *(High E/Mod F)* • Marine aquaculture hybrid (build facility out of buffering substrate) *(Unknown E/Unknown F)*
Enhanced **coastal sedimentation** and **erosion**	Reduced availability of suitable substrate, limiting recruitment and abundance	• Develop best management practices for different land uses to reduce nearshore sedimentation *(High E/Mod F)*
Decreased O_2	Range shifts, decreased growth rates, decreased survival	• Global issue of potential importance to New Zealand. Research specific to pāua needed *(unknown E/High F)* • Identify and protect higher O_2 refugia (places of disturbance) *(unknown E/unknown F)*

Comparison of Potential Adaptation Strategy & Management Options by Effectiveness and Feasibility



For further information please contact vonda.cummings@niwa.co.nz and carolyn.lundquist@niwa.co.nz.
Citations can be found in products available online at CAKE.

EcoAdapt

Impact of Natural Hazards on Pāua 2 Fishery Access Infrastructure

Presentation by Terra Moana Ltd (for Sustainable Seas Upholding Pāua Quota Value)

Feb 2023

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INFRASTRUCTURE

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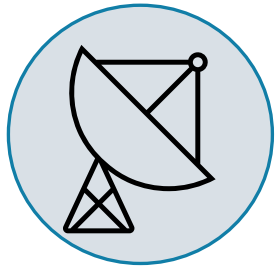
Key infrastructure

- What are lifeline utilities?
  - Facilities that provide essential infrastructure to the community
- In the Wairarapa - Wairarapa Engineering Lifeline Association (WELA) assesses risk levels from natural hazards and suggest mitigation measures to reduce risk.
- Infrastructure relevant to PAU2 fishermen to be able to go fishing.

Ports & airports

Road & rail



Radio & TV networks

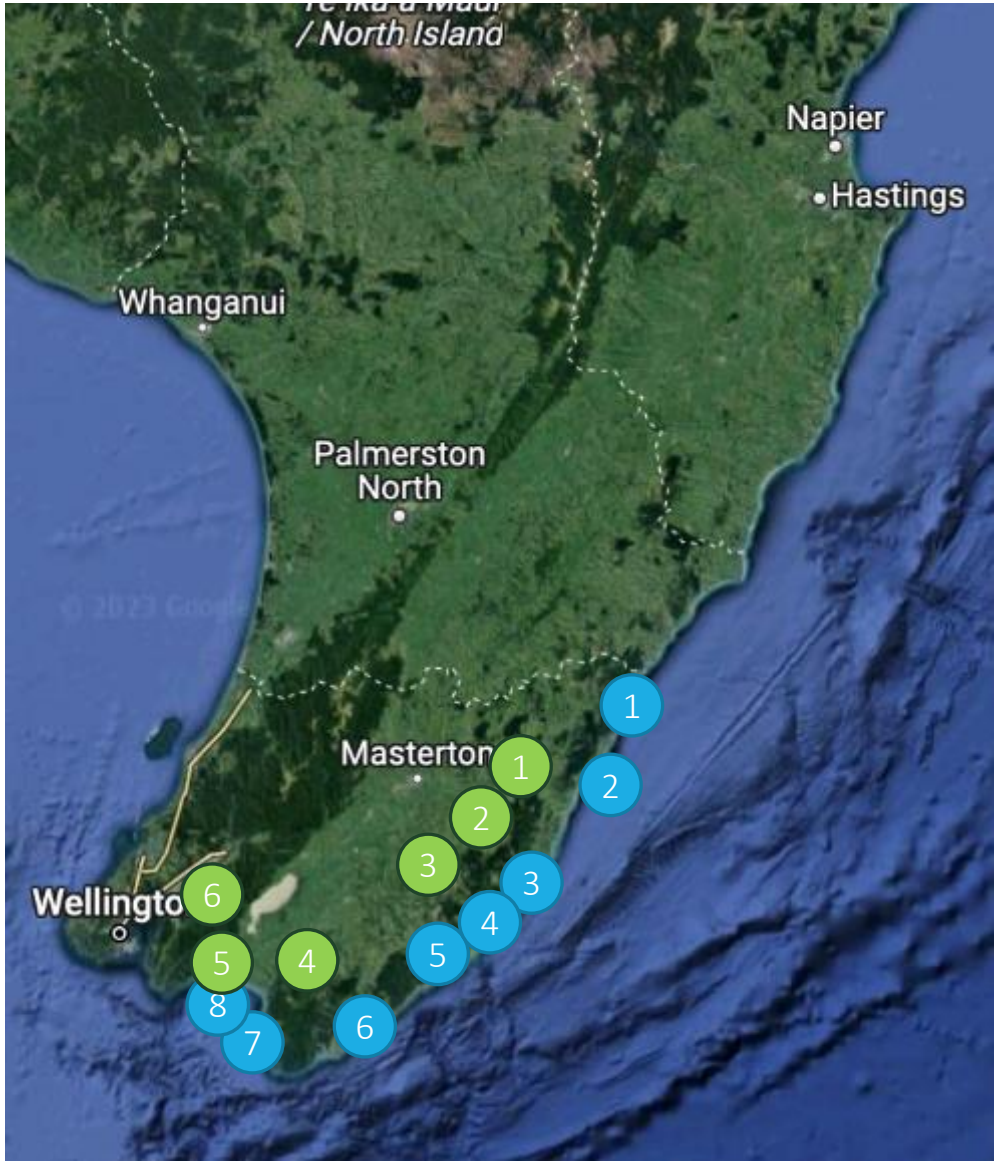
Water supply, waste & stormwater

Petrol & diesel

Electricity & gas

Telecommunications

Some Key Pāua 2 Road and Coastal Access Points



Key Roads

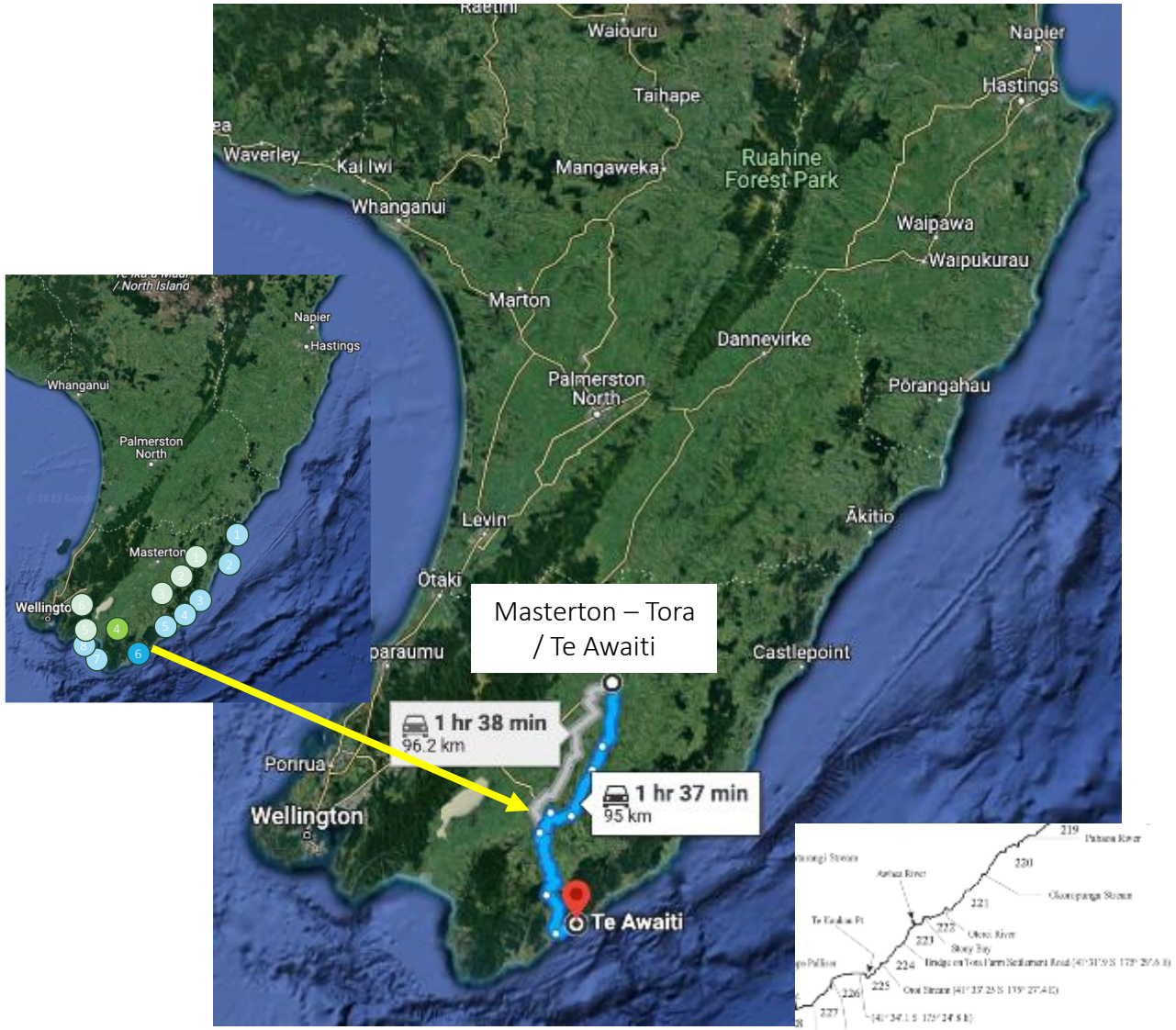
1. Castlepoint Road
2. Riversdale Road
3. Hinakura Road
4. Tora Road
5. Palliser Road
6. Western Lake Road

* Some dive teams travel from Coromandel and Northland and are affected by roads further north.

Key Coastal Access Points

1. Mataikona
2. Castlepoint
3. Riversdale
4. Flat Point
5. Pahaoa
6. Tora/ Te Awaiti
7. Ngawi
8. Ocean Beach

Tora / Te Awaiti - a key PAU2 harvest area



Tora / Te Awaiti beach

- Covers PAU2 stat area 223 and 224 either side.
- 14.5 mt (historical average used as threshold)
- 2020 -2021 average port price $24 per kg
- Estimated port price value $348,000.00

NATURAL HAZARDS

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Natural Hazards Affecting the Wairarapa

Tsunami

Flooding

Slips/ Landslide

Sea-Level Rise

Earthquake

Fire

Tsunami

1. Wairarapa is one of the most highly exposed areas to tsunami in New Zealand, primarily due to proximity to a significant local source for large earthquakes, the Hikurangi subduction zone.
2. Due to its low population density almost no detailed research has been undertaken to date regarding tsunami hazard and risk to Wairarapa.
3. A preliminary study by Evans (2020) highlights the very high tsunami risk in Wairarapa, particularly in Riversdale Beach, Castlepoint and Ngawi coastal communities (GWRC, 2004).
4. Given that the warning time for a local source tsunami could be <30 minutes (Fraser et al., 2014), evacuation modelling in Evans (2020) shows a scenario where the evacuation is unsuccessful.

The Wairarapa coast can receive tsunami from distant sources such as South America, or from local sources such as offshore faulting or trenches. Some parts of the Wairarapa can expect a large tsunami approximately once every 150 years (including both local or distant sources). By world standards, this is a high risk.

Ngawi and Castlepoint are two of the Wairarapa communities vulnerable to tsunami due to their relatively low elevation and exposure to tsunami generating sources.

Flooding

Cyclone Gabrielle (Feb 2023)

- Villages in the eastern side of Wairarapa were cut off, with major arterial routes such as Masterton Castlepoint Rd and Te Whiti Rd damaged by slips and flooding.
- Cyclone Gabrielle, people in the eastern part of Wairarapa woke up to flooded roads and fields around them.
- Multiple roads and bridges in the region were closed due to flooding.
- **Cyclone Gabrielle road closures (these are all roads that PAU2 divers use)**
  - Mataikona Rd was closed at Sandy Bay/Monument area due to flooding, as well as Mataikona Rd due to a large slip, Masterton Stronvar Rd at Brancepeth, Te Ore Ore Bideford Rd to Waterfalls Rd, Coopers Rd, Charles Street, Manawa Rd, and Masterton Castlepoint Rd.
  - Waihenga Bridge was closed, and alternative routes in and out of Martinborough were via Longbush and Kahutara.
  - Ponatahi bridge and road were both closed from Millers Rd to Nelsons Rd. Kahutara Rd was currently open but may close, and drivers were advised to be cautious while driving on Longbush Rd due to flooding.
  - White Rock Rd from Lagoon Hills was closed, and Ngakonui Rd from Summer Hill was closed. Pahutea Rd at Kahutara Rd intersection was closed, as well a Pukio West Rd. Kokotau Rd was closed from Tiffins Rd.

A flooded car on Te Whiti Rd between Gladstone and Masterton in Wairarapa.

Slips/Landslide

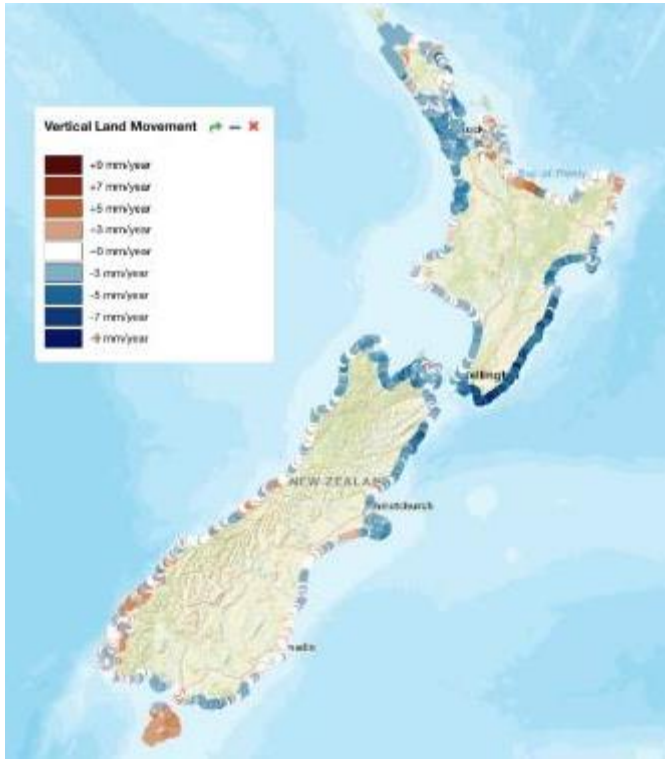
- Wairarapa could potentially be cut off from the rest of New Zealand “for a number of weeks” after a major storm or earthquake
- A major slip on a rural Martinborough road which had isolated a coastal community for weeks was a vivid example of the impact of these types of events.
- Much of the eastern and coastal Wairarapa hill country is prone to slumps and shallow soil slips. Every four to 12 years the area suffers a storm severe enough to cause widespread landslides, with smaller slips every one to three years.

A large slip has closed Hinekura Rd in Martinborough indefinitely. Residents beyond the slip have been forced to take an alternative route that adds almost an hour to their travel time.

Turners Bay Cape Palliser Source Nat Davey Diver

Sea-Level Rise

- An alarming new report by the NZ SeaRise Programme has found that the rate at which some parts of our coastline are sinking will exacerbate sea level rise. **Wairarapa will have one of the most affected coasts.**
- The **Wairarapa region's coastline** is **one of the fastest-sinking areas** in New Zealand, due to rising sea levels brought about by climate change.
- These latest projections available show that the relative sea level rise (that includes the vertical land movement) in South Wairarapa district could locally reach up to 0.72m in 2050 and 1.90m in 2100
- **Key Paua 2 fishery areas:**
  - Sea level rise is certainly expected at Cape Palliser and along the Tora coastline. Two coastal settlements that are part of Masterton District – Castlepoint and Riversdale – are among those seeing rapid sea level rise. Data from New Zealand SeaRise's website showed that Castlepoint sea level rise is 3.77mm a year, while Riversdale is at 4.67mm.
- In just eight years, parts of the Wairarapa will see 31 centimetres of sea-level rise. Two decades later, the coastline could disappear under between 57 and 61 centimetres of sea-level rise, depending on whether global emissions decline rapidly or continue to rise.



NZ SeaRise Programme

Earthquake

- The **Wairarapa Fault** is an active seismic fault
- The Wairarapa Fault continues south of Lake Wairarapa as the Wharekauhau thrust, which can be traced on the seabed in the Cook Strait
- Rupture along the Wairarapa Fault and Wharekauhau thrust was responsible for the 1855 Wairarapa earthquake with a magnitude of 8.2
- At Turakirae Head the newest raised beach was formed by an uplift of 6.4 m (21 ft) in the 1855 quake
- The earthquake generated New Zealand's largest historical locally generated tsunami, with a maximum run-up of 10–11 m (33–36 ft)
- The Mw 7.8 2016 Kaikoura earthquake ruptured the Kekerengu-Needle fault resulting in the loading of its eastern continuation, the Wairarapa fault.
- Modeling the entire offset dataset reveals 7 prior earthquakes ruptured the entire fault
- Thus, the Wairarapa fault repeatedly produced giant earthquakes and is likely able to produce a similarly strong forthcoming event

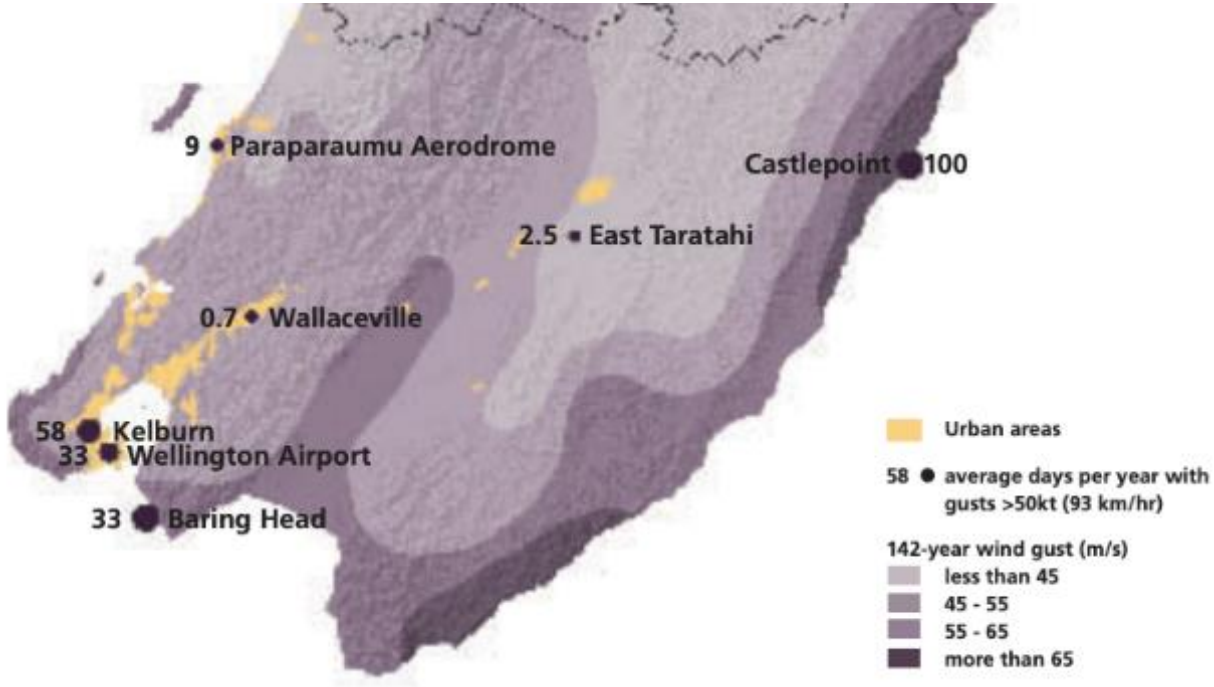
Fault	Recurrence interval (yrs)	Time since last event (yrs)	Estimated magnitude *
Awatere (South Island)	<1000 – 1300	157	7.5 – 7.8
Wairau (South Island)	1000 – 2300	>800	7.2 – 7.7
Ohariu	1500 – >5000	1060 – 1140	7.6
North Ohariu	1000 – 4000	<4000	7.3 – 7.7
Gibbs	unknown	<10,000	– 7.0
Shepherds Gully	2500 – 5000	>1000	7.6
Otaki Forks	4000 – 9000	unknown	7.3 – 7.6
Wellington	500 – 770	335 – 485	7.6
Wairarapa	1160 – 1880	150	8.0 – 8.3
Carterton	~1000	unknown	7.0
Masterton	~1000	unknown	6.7
Boo Boo (offshore)	500 – 2000?	unknown	7.2 – 7.6
Subduction interface	500 – 5000?	unknown	7.8 – 8.2

* Estimated earthquake magnitude able to be generated by that fault.

Wildfire /Severe Wind

- Winds of up to 140km/h are fanning a large forest fire in Wairarapa and are causing problems for fire crews trying to fight the blaze.
- The windiest areas are generally the eastern Wairarapa coast – particularly Castlepoint and the area around Tora – followed by the southern Wairarapa and Wellington coasts. Featherston, Mt Bruce and parts of the Rimutaka Road suffer localised wind effects. The Tararua Range creates turbulent downwind waves in such conditions, delivering very high winds to the Wairarapa.

Wind hazard varies widely across the region. The calculated 142-year return period wind gust is shown here, along with the average number of days per year with wind gusts over 50 knots (93 km/h) at selected locations. (The return interval values don't consider local topographic effects caused by features like hills, gorges and vegetation.)



Pāua Diver Survey Full Results

With the help of the Paua 2 Executive, Paua Divers in the PAUA2 Management Area were encouraged to participate in the survey. Quota owners were also contacted to encourage their divers to participate. The online survey was sent out via email on the 21st Oct with a closing date for 7th Nov (only one response was received in the first round) so the survey was extended to the 5th Dec 2022.

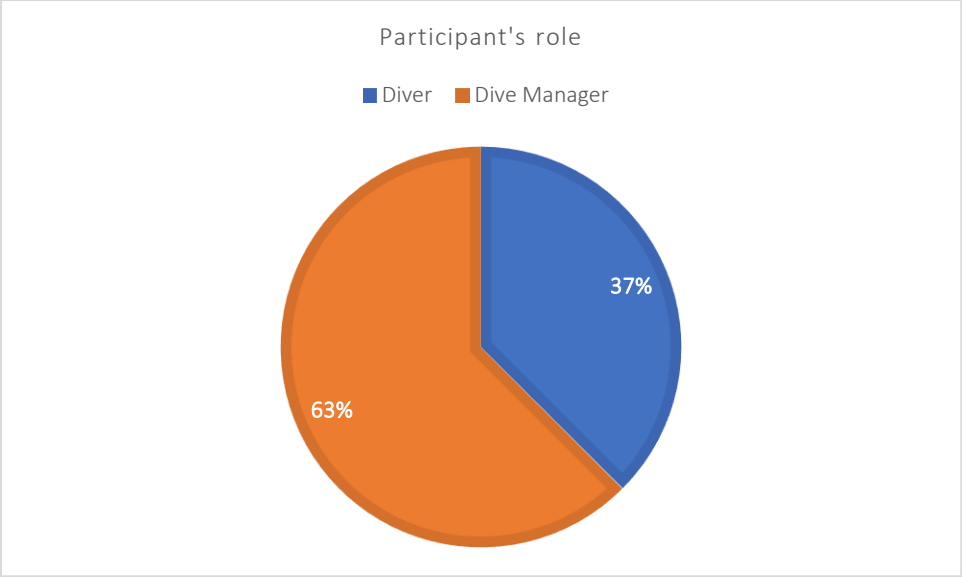
As the surveyor was well known to the divers, divers were also offered a telephone interview if preferred. In the end all responses were received online.

The Paua 2 Executive and all participating divers will receive the anonymized report of the results.

There were 8 final responses received. There are 11 dive teams and 32 divers in the fishery.

1.1 Participant Profile

- 8 participants.
- Experience in the industry varied from newcomers (2 years) to experienced (45 years).
- Most participants have more than 20 years' experience.
- Mix of divers and team managers (who also dive).



1.2 Weather observations

Weather naturally plays an important role in diver accessibility in this fishery with large parts of the coastline exposed to Easterly weather patterns (onshore) that restrict fishing versus Northwesterly patterns (offshore) that enhance diving opportunity.

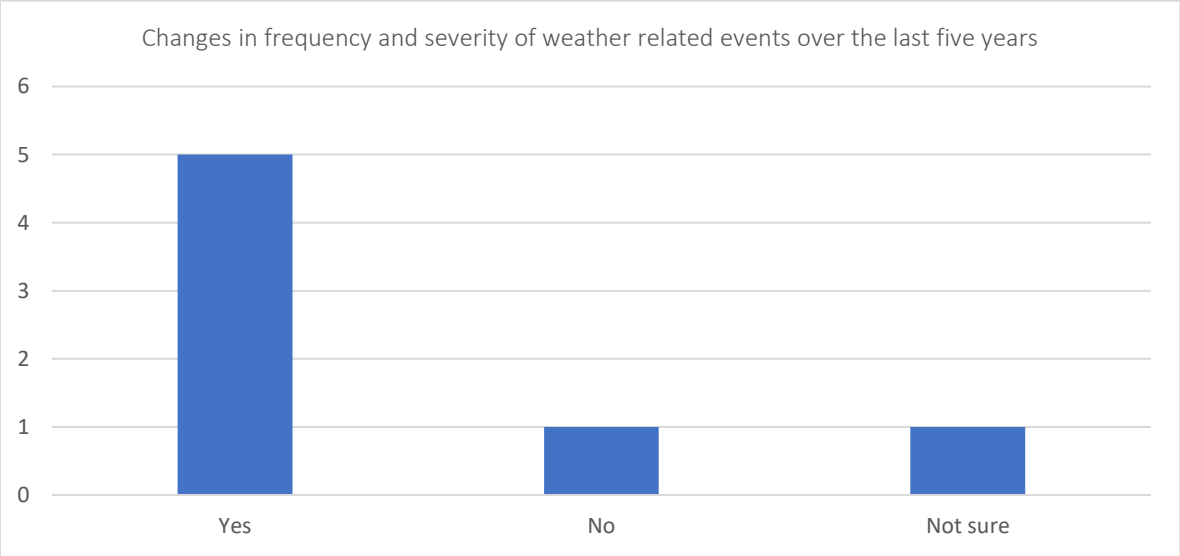
While respondents were asked to consider weather pattern changes during their time in the industry versus the last 5 years, it was difficult for respondents to recall beyond the last 5 years.

Summary of responses:

- More Easterly weather patterns observed annually.

- North Westerlies that were occurring during Spring are now not happening for a longer periods (weeks). Only one or two days.
- Very changeable weather is rare now and there seems to be more sustained weather patterns.

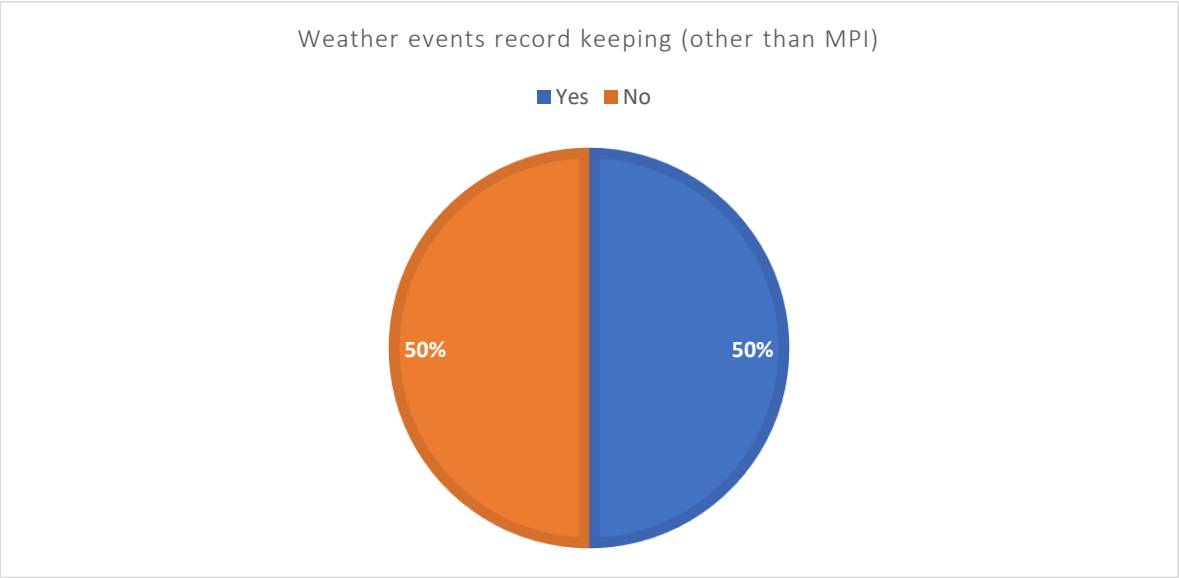
1.2.1 Has the Frequency and Severity of Weather Events Changed Over the Last 5 Years?

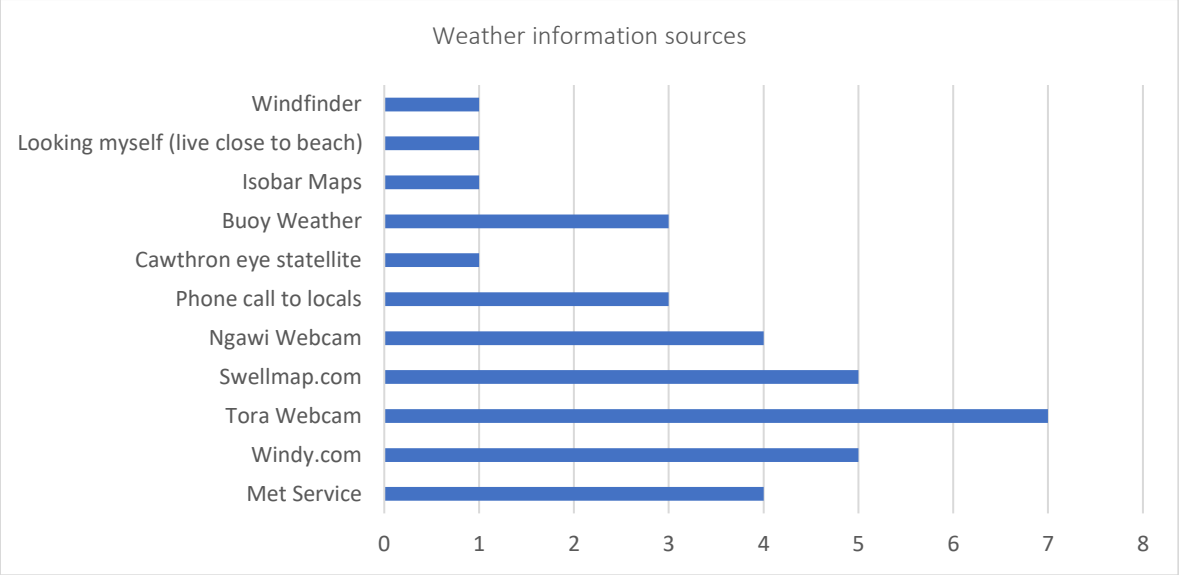


- Weather patterns are a month later than normal. NW gales (Sept/Oct) and cyclone (Feb/Mar)
- La nina effect – re more Easterlies.
- More weed loss in areas once lush.

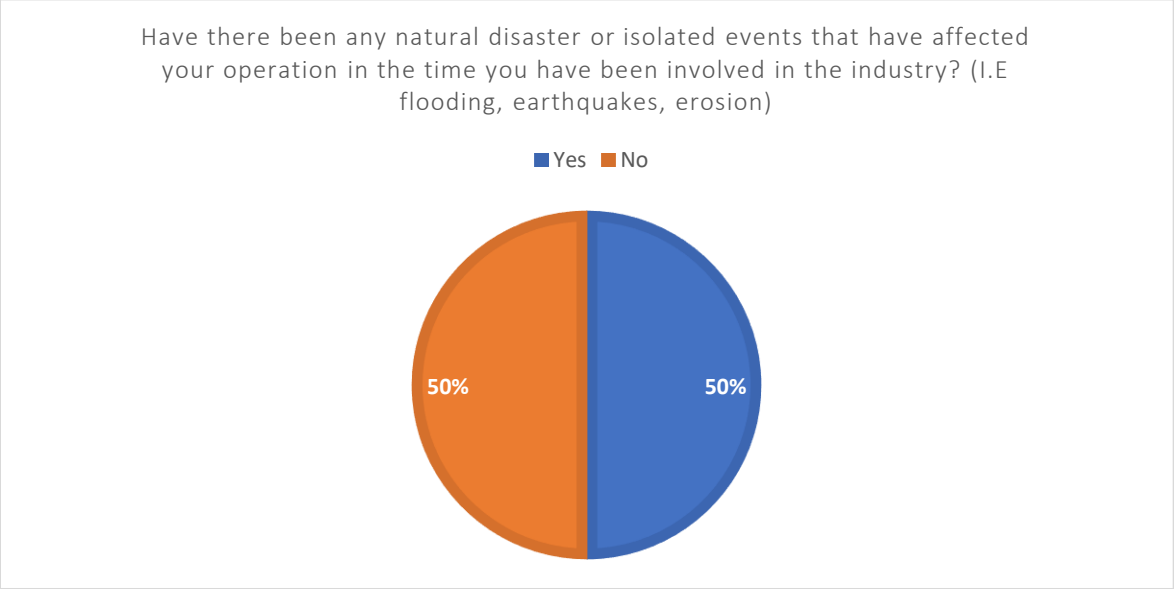
1.2.2 What of the following conditions restrict your diving or launching capabilities?

- Swell height 1-2m.
- Wind direction and swell direction varies.
- Wind levels 15knots (2 pax) 25 knots (1pax).
- Visibility limit 0.5-3m.
- 2-4 days for swell to clear up before being able to dive again.





1.3 Natural Disasters

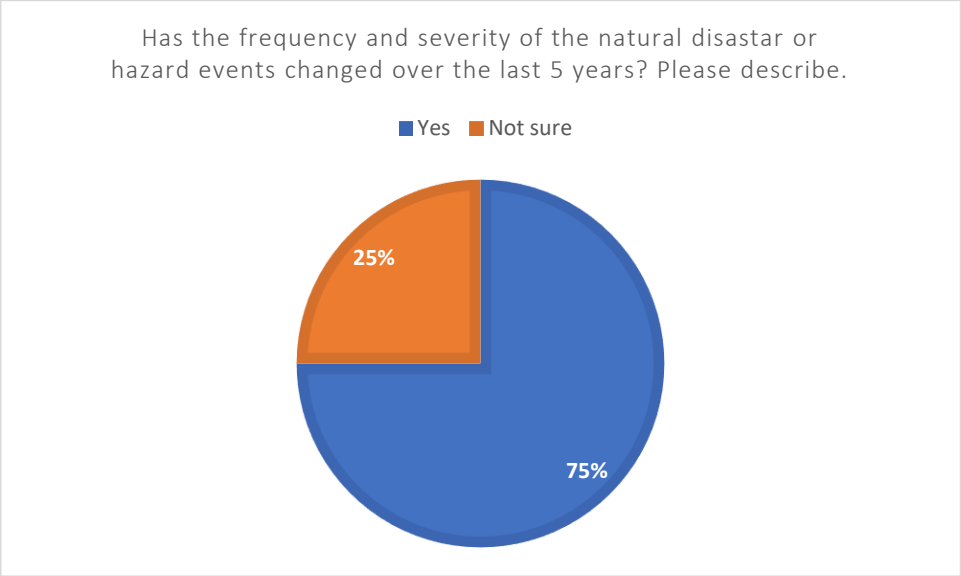


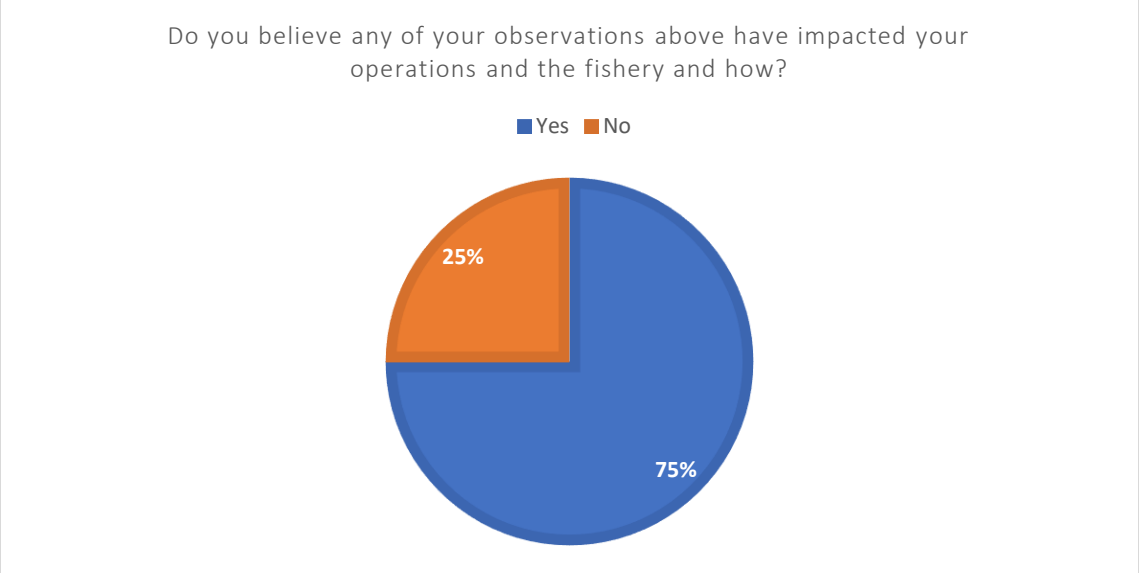
Result:

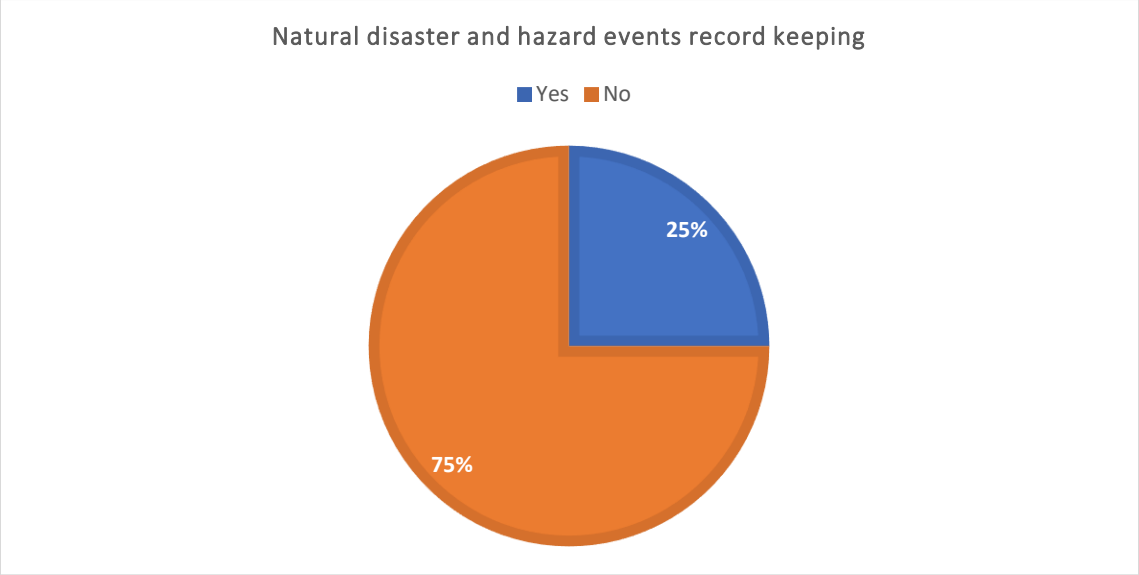
Landslides	4
Road washouts	4
Flooding	2

- Increased events of slips, landslides and flooding resulting in road washouts.
- Mostly affected by landslides and road washouts.
- Some found flooding to affect their operations too.

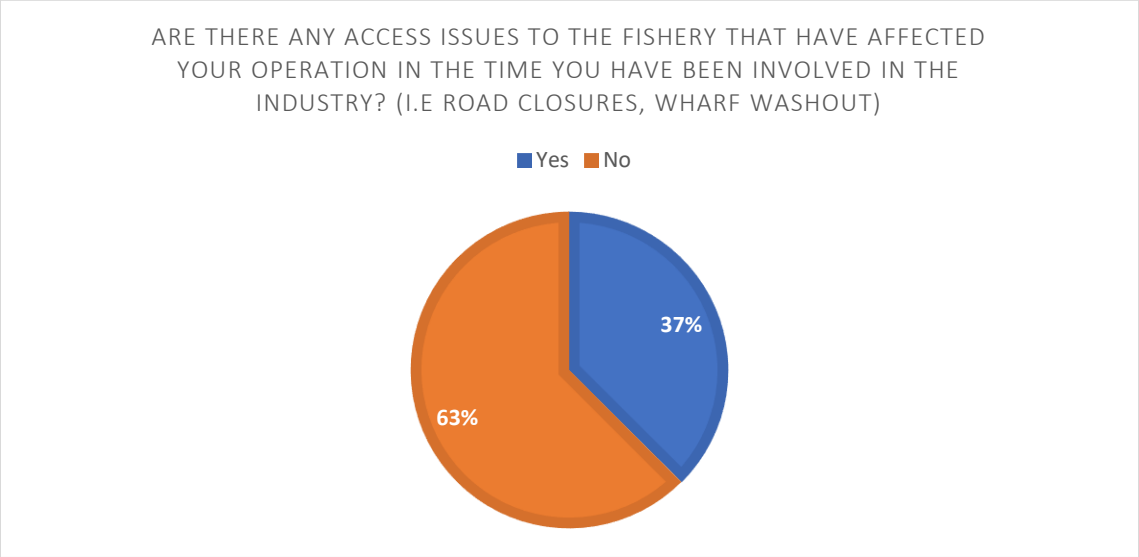
- Landslide had taken out a road (Hinakura Rd), which has closed the access to launch from the East Coast. Added an extra hour to work, currently a farmer has put a track to use until the road is fixed by council.







1.4 Access

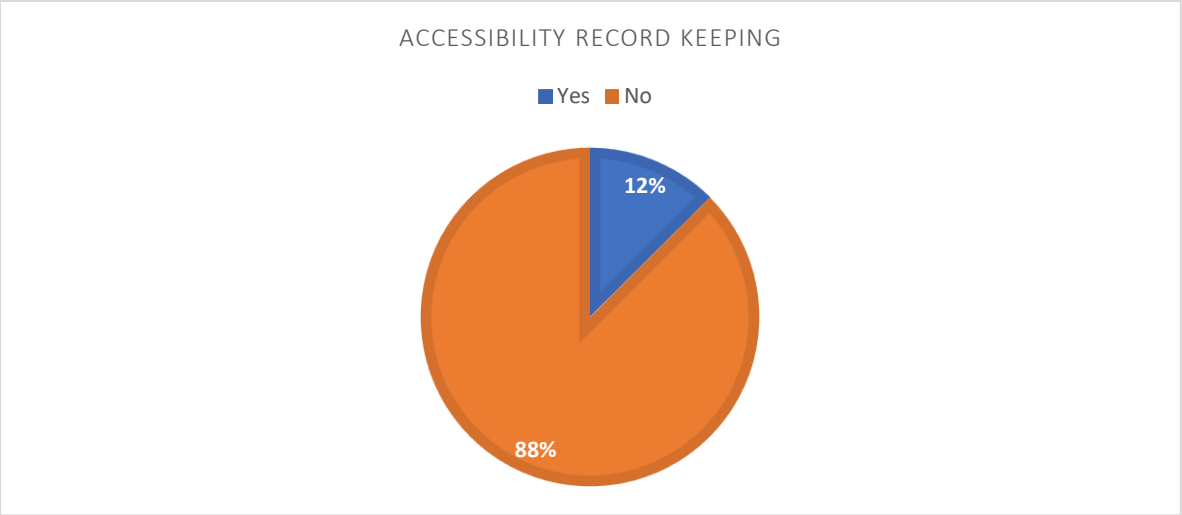


1.4.1 What are the coastal access points you use to fish?

1	Coastal Access Point	Usage Frequency	Fishing Method
2	Pahahoa Ngawi Mataikona	Monthly	Boat Launch
3	Point Howard wharf,ocean beach,ngawi,tora,castlpoint,matakona	Yearly	Boat Launch
4	Ocean beach/Ngawi/pahaoa/Riversdale/Mataikona	Weekly	Boat Launch
5	Tora beach	Weekly	Boat Launch
6	Matikona, Riversdale, Flat Point, Te Awaite/Tora and Ngawai.	Weekly	Boat Launch
7	Tora	Yearly	Boat Launch
8	Castle point	Monthly	Boat Launch
9	Tora	Monthly	Boat Launch
10	Ngawi	Monthly	Boat Launch
11	Ocean beach	Monthly	Boat Launch

1.4.2 What are the roads you use to get to the access points identified above?

1	Road Name	Usage Frequency	Road condition
2	Hinakura Rd Cape palliser Rd Csstlepoint rd	Monthly	Poor
3	Palliser rd	Yearly	Average
4	Tora rd	Yearly	Average
5	Ocean beach	Yearly	Good
6	Western lake rd/Cape Palliser rd/Hinekura rd/Riversdale rd/ Castle point rd	Weekly	Poor
7	Tora farm rd	Weekly	Poor
8	Castle Point Rd, Riversdale Rd, Tora/Te Awaite Rd, Cape Palliser Rd.	Weekly	Average
9	Tora	Yearly	Average
10	Castle point road	Monthly	Good
11	Tora settlement road	Monthly	Poor
12	Cape Palliser road	Monthly	Poor
13	Western lake road	Monthly	Good



1.5 Conclusion

1.5.1 Based on your observations, what are the environmental challenges for the fishery going forward?

- Global warming
- North Westerlies resulting in smaller fishing windows
- Sedimentation
- Landslides
- Changing weather patterns
- Run off from forestry blocks

1.5.2 Can you suggest ways to better prepare and mitigate any issues that may arise from environmental changes?

- Building new roads
- Artificial reefs seemed to be working to help with erosion from high swells
- Better forestry practices
- Allow for underwater breathing apparatus for diving

Event Logs of PAU 2 Diver Observations

Date	Notes
7/21/2016	The other day I read about the Paua problems in the upper South Island , I noted with interest that forestry was a problem with its downstream problems . > To add to this in the last few days I have heard that Lagoon Hills is to start logging again, possibly up to 30 trucks a day on the road, so the Oterie Stream around the corner from me will take the " run off " from this operation . > Also Whakapuni Station and Waipawa farm have started logging so the Awhea Stream will be the "run off" at the south end, plus today I have been told a big area in the Pahau area is to commence logging. > Been pretty rough here lately, spoke to one of the Cray Guys this morning and it's not good, heard from another at Ngawi and he told me his best day last week was 25 kg.
7/25/2016	Could be some major run off from these activities. Oterei river runs out into our launching bay, in the past we have had problems with trees etc running down into the bay due to there being no catchment gates further up the river. We have a heads up on the activities so might be timely to put something in place. As to the crays, we are in a downturn cycle which seems to happen every 8 to 10 years. This year looks to be the bottom of the trough. For reference, stat area 915 in the Northern cra4 zone experienced a major weather event approximately 12 or so years ago with large slips and run off occurring. That run off affected a very large area and so sedimentation from that wiped out Cray/ Paua habitat and is only now showing signs of regenerating. It displaced around 30 or so tonnes of Cray that was pushed into other stat areas in Cray 4. Paua wasn't so much talked about due to hardly any commercial diving done there. Obviously the forestry activities are to a far lesser extent but is worth noting.
10/15/2020	Turakirae – diving on border of Stat areas 236/235 there's a lot of dead shells, random sizes. Southern end was all right but on the northern side noticeable quite barren (near slip), lots of starfish and octopus.
15-Nov-17	Re the sediment, after the major sediment fan I observed off the Pahaoa river back in February this year, noting a lot of guts and holes on the seabed were full of a fine silt, with no crayfish to be seen in those areas. Fishing through this winter and spring, the sediment has dispersed and the crayfish are back where the silt was sitting. The question I would like to know the answer to is how do Paua deal with the fine silt buildups? Obviously crayfish can move in and out. Tom might be worth a call to answer this

Paua 2 Resilience Project

We would like you to be part of a Sustainable Seas Project looking at what Pāua fishery investors (quota owners, divers, processors etc) need to know about the fishery and industry to maintain confidence to invest?

What are the implications (good or bad) around climate change, fishery performance, management responses and the relationship between risk and quota values? In these rapidly changing times, socially, economically and environmentally, it is essential to bring all the knowledge we can to better understand rural economies and the ecosystems they depend upon.

Uniquely this project brings together recent advances in marine science sedimentation and climate change knowledge with Pāua quota owners, divers, sustainable finance, and fishery management. Alongside the marine science it is taking an initial look at the risks to the Pāua fishery from climate related sea level rise and storms to rural infrastructure such as boat ramps, wharves and roading.

With respect to the focal Wairarapa Pāua fishery (PAU2), it is imperative to uphold its value to local communities, to quota owners and to the markets that prize it as a delicacy through: i) understanding the risk to the fishery from climate change and sedimentation and using that to influence investment decisions in better caring for the fishery, and rural communities, and ii) knowing that the right management is in place and working effectively at all scales.

With a focus on sedimentation and climate change the project is characterising the fishery, building quantitative and qualitative risk analysis tools, profiling these environmental risks as they pertain to the PAU2 Fishery, and documenting key response strategies that are essential to reduce that risk.

A key part of this work is understanding the risks you face as divers through access to the resource from weather (fishing days), roading (getting to the grounds) and launching (getting on the water)

Thank you for helping us with providing your valuable knowledge of these factors!

Name

First

Last

Email

Phone

What is your role? i.e (dive manager, diver, processor)

How many years have you been in the industry?

Weather

What changes have you noticed in the weather over the time that you have been involved in the industry?

i.e increased easterly weather patterns or prolonged lack of vis periods.

Describe the event	Years	Trend	Frequency	Severity
i.e easterly weather patterns	i.e 201	select dropdowr	select dropdown	Describe the extend

+ Add event

Has the frequency and severity of the weather events changed over the last 5 years? Please describe.

Do you believe any of your observations above have impacted your operations and the fishery and how?

What of the following conditions restrict your diving or launching capabilities?

Swell height (meters)

Wind direction

Swell direction

Wind levels (knots)

Visibility Limits (meters)

Days to clear up after a swell (number)

Other than MPI reporting requirements, do you keep any other record of weather observations? (i.e diary)

- ○ Yes
- ◉ No

What are your weather information sources?(Select all relevant)

- [ ] Metservice.com
- [ ] Swellmap.com
- [ ] Windy.com
- [ ] Other website or Apps
- [ ] Tora webcam
- [ ] Ngawi webcam
- [ ] Phone call to locals
- [ ] Other

Natural Disasters or Isolated Events

Have there been any natural disaster or isolated events that have affected your operation in the time you have been involved in the industry? (i.e flooding, earthquakes, erosion)

- ○ Yes
- ◉ No

Access

Are there any access issues to the fishery that have affected your operation in the time you have been involved in the industry? (i.e road closures, wharf washout)

- ○ Yes
- ◉ No

What are the coastal access points you use to fish?

Please note all points by adding items

Coastal Access Points	Frequency of use	Fishing Method
i.e Mataikona / Ngawi	select dropdown	

+ Add Item

What are the roads you use to get to the access points identified above?

Please note all points by adding items

	Road Name	Frequency of use	What is the condition of the road?
⊗	i.e Cape Palliser Road	select dropdown	

+ Add Item

Do you keep a record of your observations of these issues? (i.e diary)

○ Yes ◉ No

Conclusion

Based on your observations, what are the environmental challenges for the fishery going forward?

Can you suggest ways to better prepare and mitigate any issues that may arise from environmental changes?

Submit

Pāua 2 Resilience Plan 2020 – 2030 (Draft Only)

A PLAN FOR THE FUTURE – UPDATED as an appendix in the Sustainable Seas Project “Upholding the Value of Pāua Quota”.

UPDATE July 2023

- PIC has continued to improve the science and knowledge base for pāua fisheries nationally, including for PAU2.
- This slide deck was developed during 2022 by Tony Craig (Terra Moana) as ex-Chair of PAU2. Tony was PAU2 Chair for 15 years.
- It was presented to the PAU2 Exec. in Oct 2022.
- The Sustainable Seas Project ‘Upholding the Value of Pāua Quota’ has added considerable depth of understanding to underpin the rationale for this Proposed Resilience Plan.

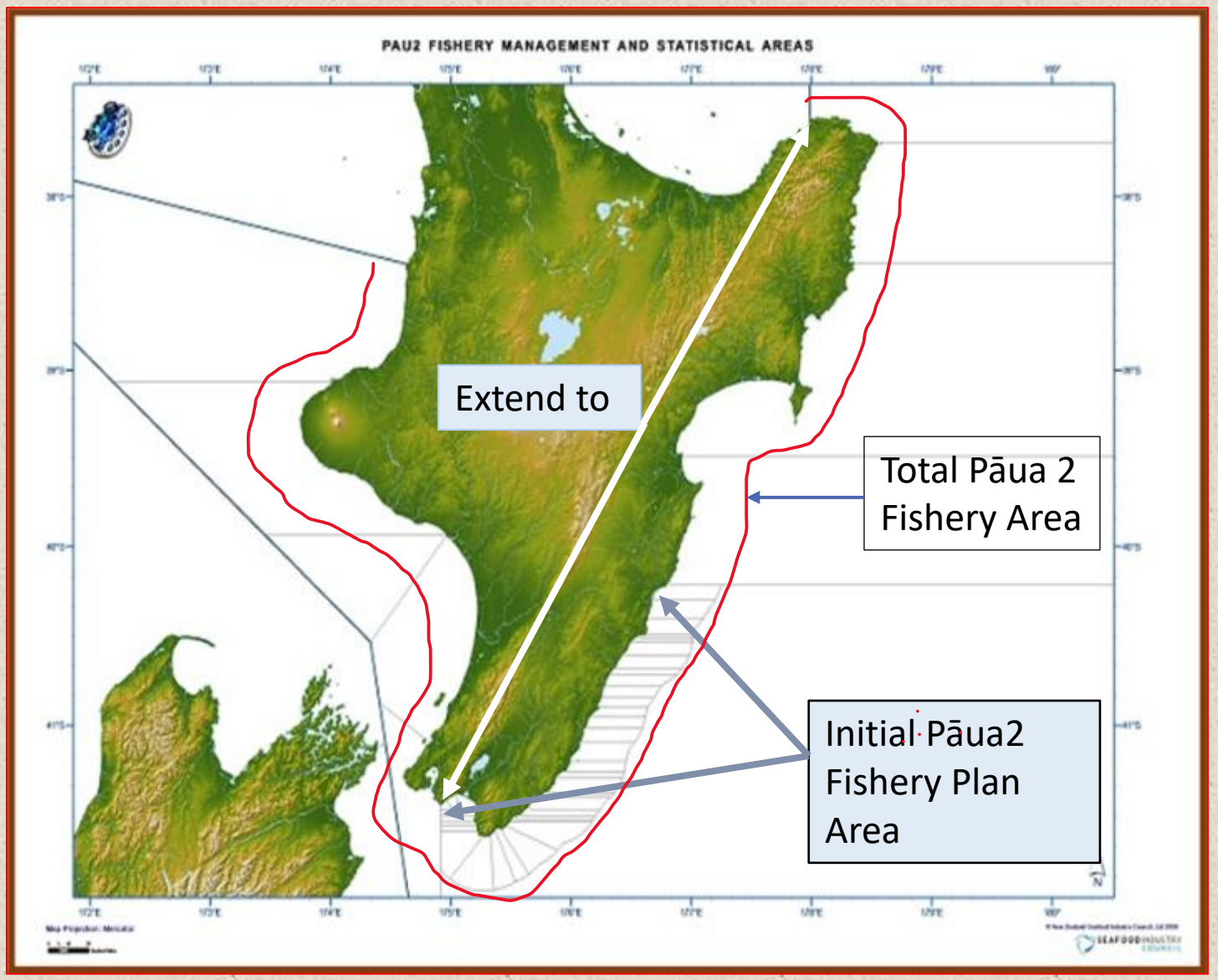
The Concept

- Develop a comprehensive Fishery Resilience Plan for the commercial section of the Pāua2 fishery. With the intention to extend to the East Coast Nth Island.
- Use an ecosystem focused/shared fishery/Mātauranga Maori/QMS approach to grow the fishery for all.
- Build resilience into the fishery by understanding and where possible mitigating external impacts
- Use a farming / paddock based model to develop fine scale management (using previous statistical reporting areas as paddocks)
- Develop a dedicated research team (3-5 years)
- Engage customary and recreational sectors in the project under “shared fishery” principles.
- Develop and agreed information based model (all sectors contributing)
- Shared and localised decision making Kanohi to Kanohi


Sector Engagement
Dedicated Research Team
Ocean ranching
(Management initiatives)
Pāua 2 App (direct diver engagement)
Environmental monitoring (sensors)
Pāua 2 Fishery Plan
PAUA 2
INDUSTRY ASSOCIATION INC.
Sustainable Fisheries Management

Initial Plan Coverage

PAUA 2 INDUSTRY ASSOCIATION INC. *Sustainable Fisheries Management*

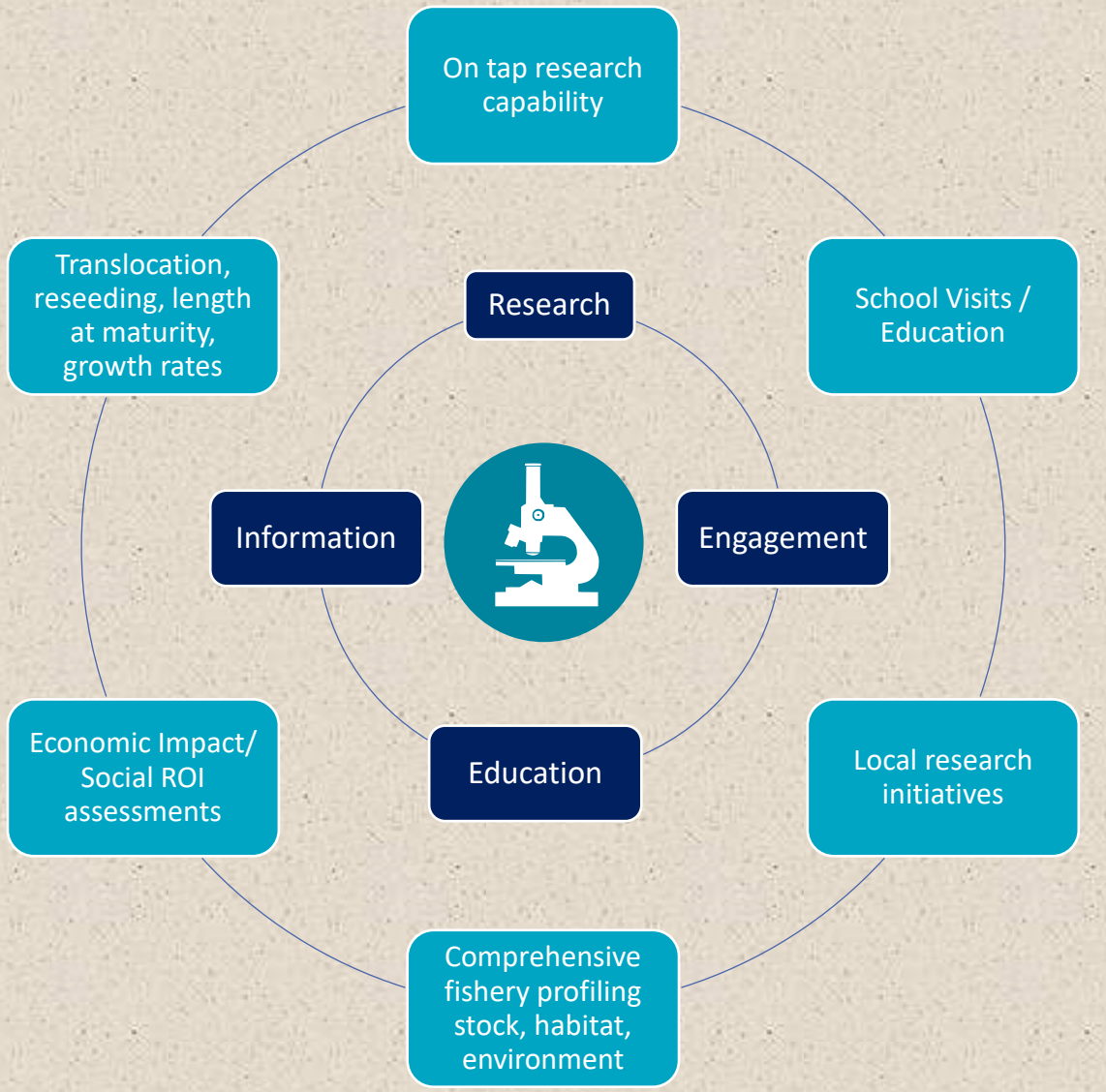


Sector Engagement (Shared Fisheries)

Key Outcomes

- Shared Fisheries Engagement – Agreed principles in place
- Wider community engage and buy–in to “enhancing the whole fishery model”
- Better sector based management inclusion
- Increased communication and understanding across sectors
- Shared gain shared pain approach
- Defined zones for commercial, recreational and customary take
- Increased support for total catch recording

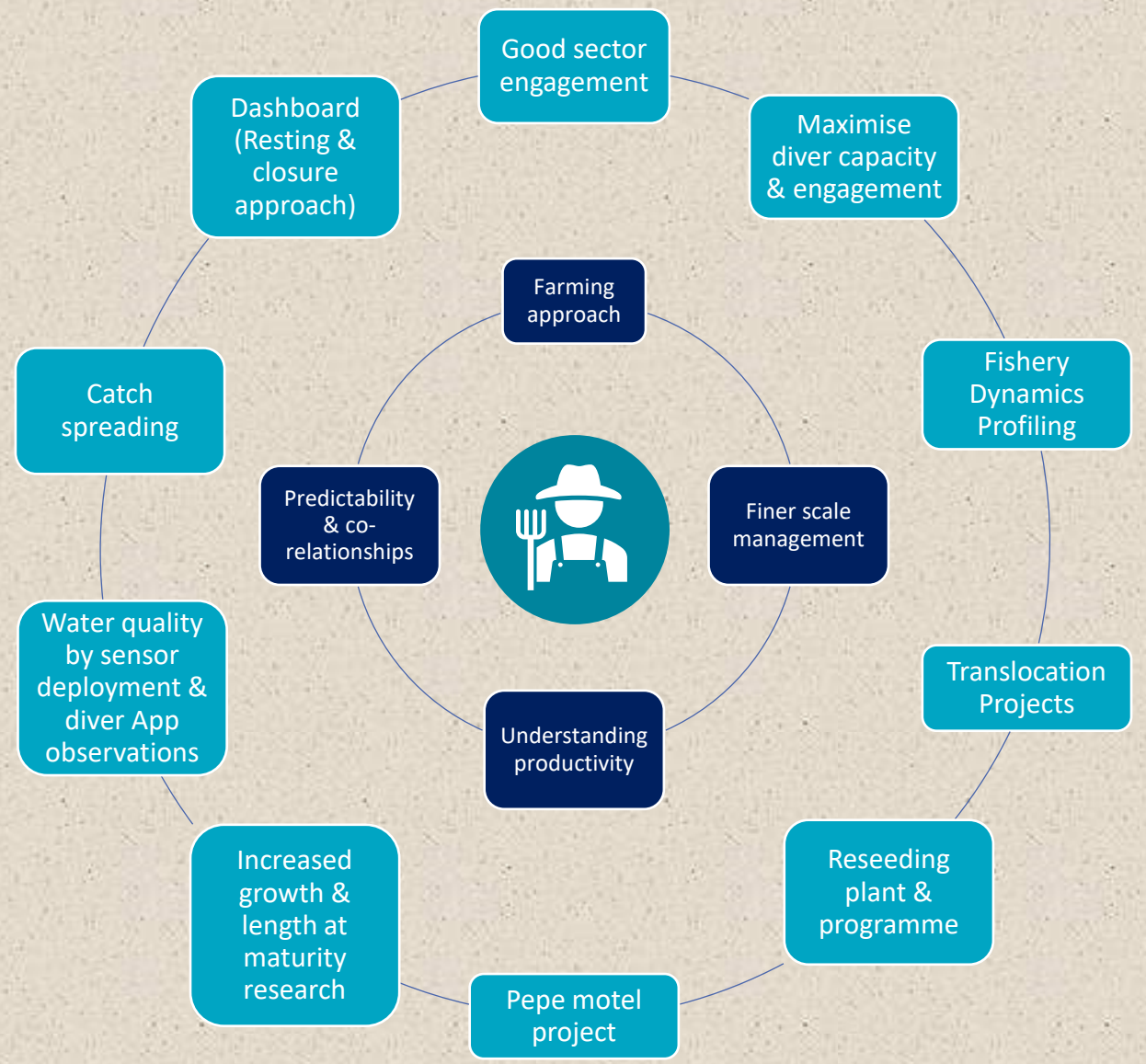
Dedicated Research & Education Team



Key Outcomes

- On tap research capability that is not reliant on current dive teams
- Mobile and able to service the wider Pāua2 fishery research needs
- Training vehicle to develop and expand local research teams
- Comprehensive fishery profiling resource
- Ongoing data analysis identifying fishery/ environmental trends and impacts for informed management decisions
- Education/communication team when not in the water (schools / marae etc)
- **Note – Auckland Museum And Ngati Kuri got $13m from the Endeavour Fund for researching the Kermadec's**

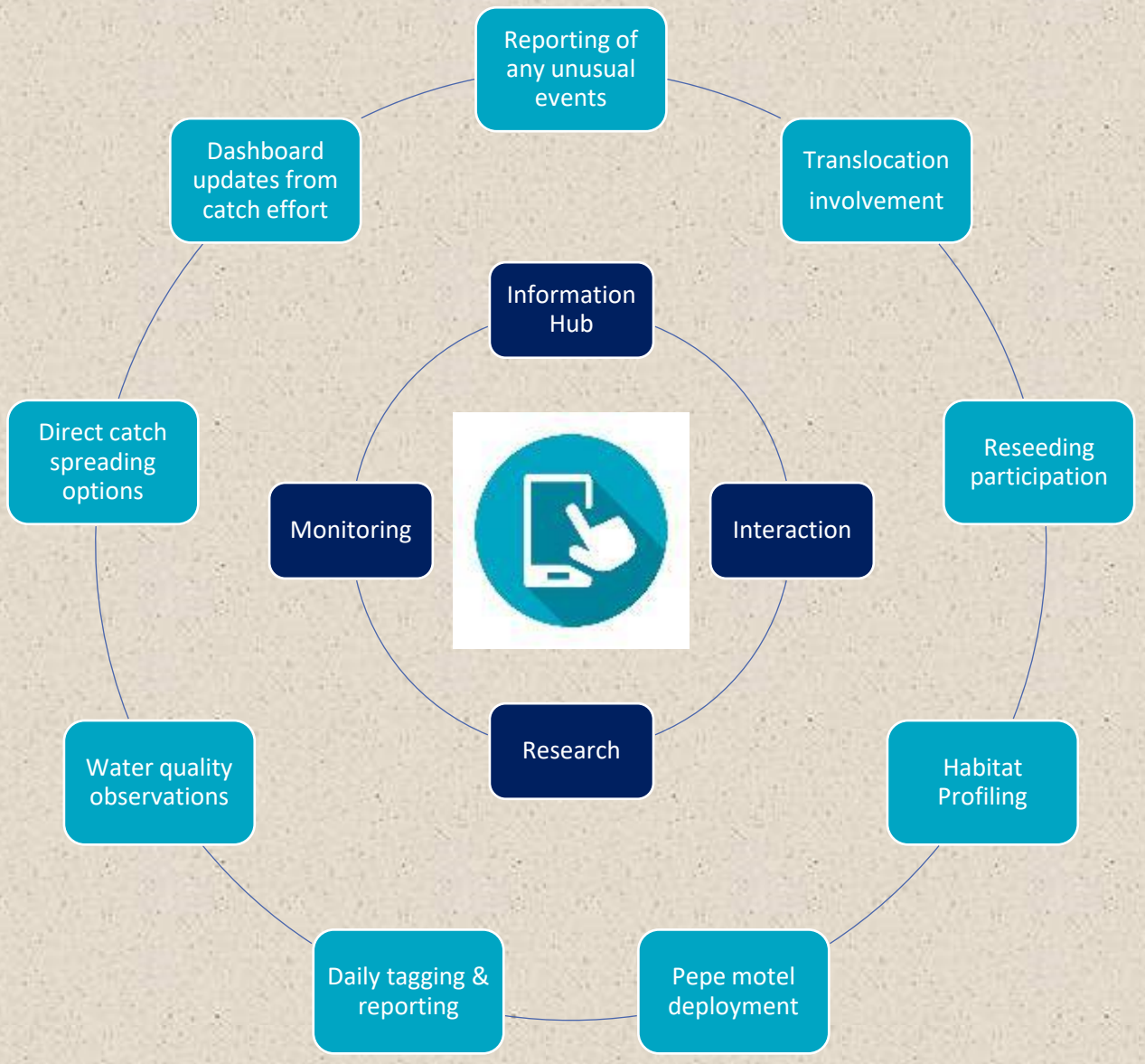
Ocean ranching (Management initiatives)



Key Outcomes

- Provides a framework that enables better long-term fishery resilience
- Better understanding of the dynamics that drive the fishery
  - Water quality
  - Habitat
  - Food
  - Recruitment
- Enable finer scale management
- Maximise productivity of the fishery
- Real-time connectivity to information & management
- Everyone sees and can understand what is happening and why
- Enable rapid responses to changes in dynamics
- Provides a transparent and comprehensive management framework
- Deliver information / data on the impacts of climate and environmental change i.e sediment impacts

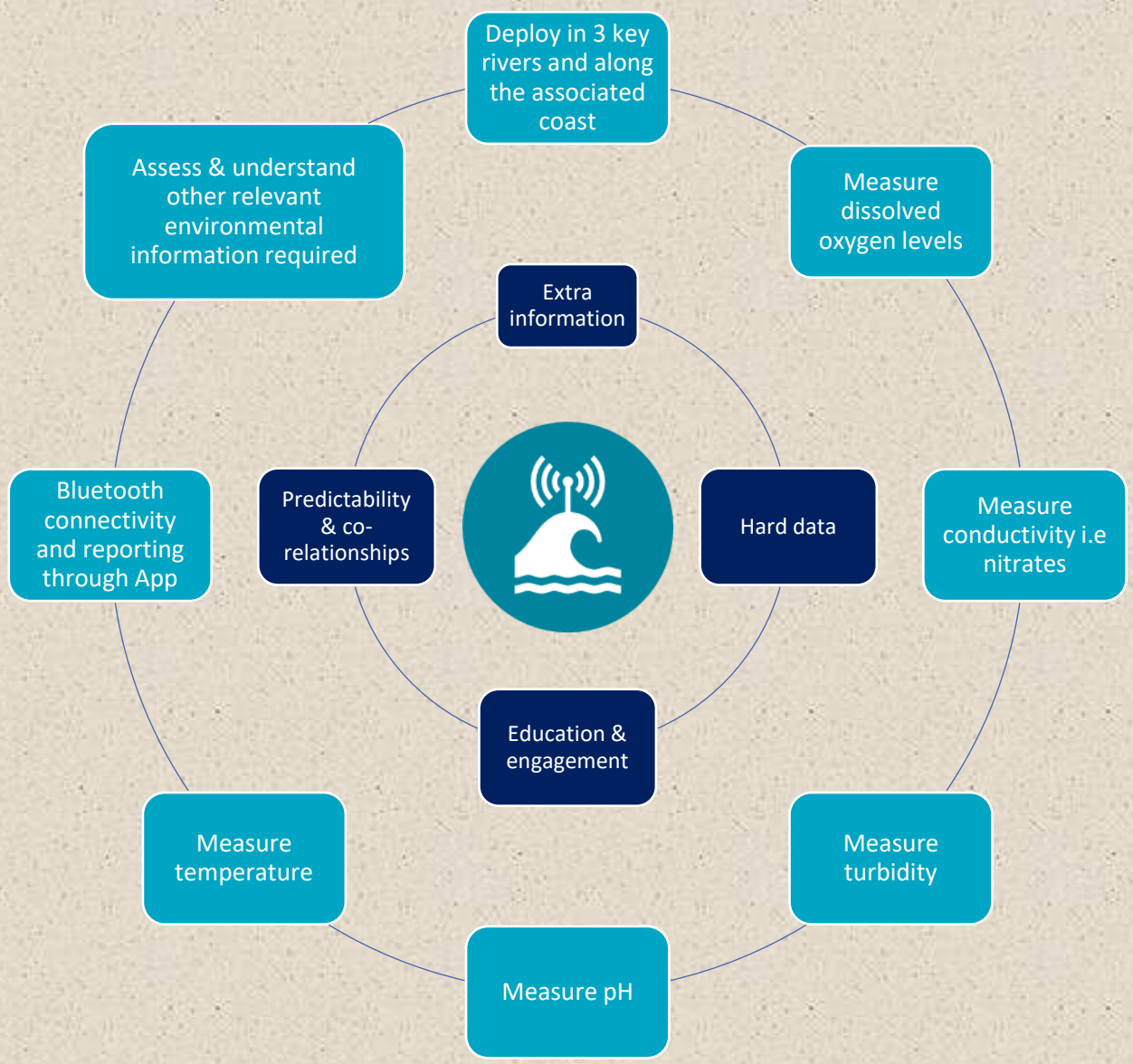
Pāua 2 App (direct diver engagement & citizen science input)



Key Outcomes

- Real-time connectivity to information & management
- Making them part of a wider team
- Increased divers collaboration and cohesion
- Increased participation in research
- Implement voluntary management initiatives with real-time information and large scale data
- Tool to enable real-time citizen science (divers) reporting.
- Sediment reporting
- Stunted stock reporting
- Habitat changes
- Tool to enable direct research involvement
- Instructions sent direct from scientist through App
- One stop shop to show how and where they contribute within the management
- Backs up anecdotal with real reporting

Environmental monitoring (sensors deployed)



Key Outcomes

- Provides clear data on the rate and levels for each key measure
- Enables distribution / spread along the coast and out to sea
- Enable comparative analysis of the impacts for 3 different options
  - Minimal terrestrial activity
  - Medium terrestrial activity
  - High terrestrial activity
- Will enable detailed and documented before and after assessments
- Will provide data for sector engagement and solutions/options going forward
- Enable the assessment of downstream impacts of medium and high terrestrial activity

Technology is happening

"We suggest that there are substantial gaps in our knowledge of how land-based stressors affect coastal fisheries both in New Zealand and globally, in particular through mechanisms of sedimentation in the New Zealand context. These stressors, and their impacts, cannot be considered in isolation from other stressors, such as fishing, which are likely to interact synergistically on harvested species populations." (M A Morrison et al "A review of land-based effects on coastal fisheries and supporting biodiversity in New Zealand 2009)

PAUA 2 INDUSTRY ASSOCIATION INC. Sustainable Fisheries Management

Challenges going forward

- Needs a joint customary, recreational and commercial partnership based on some underlying principles that do not disadvantage a sector or sectors from the beginning
- Needs a governance style that applies a “what is good for the fishery first” approach.
- Understanding that everyone working together will stand a much better chance of attracting government interest and attention.
- The current institutional framework is more comfortable with fixing “problem” fisheries rather than enhancing a good one
- Concept needs to be well resourced (funding and expertise) from the outset to achieve the desired project outcomes


PAUA 2
INDUSTRY ASSOCIATION INC.
Sustainable Fisheries Management
Shared fishery management approach
Fully researched and fine scale managed
Improved and enhanced fishery for all
Data led management approach
Resilient to environmental changes
The Pāua 2 Success Story

A strategic approach to building resilience into the fishery

Tony Craig, Chairman PAU2 Industry Association

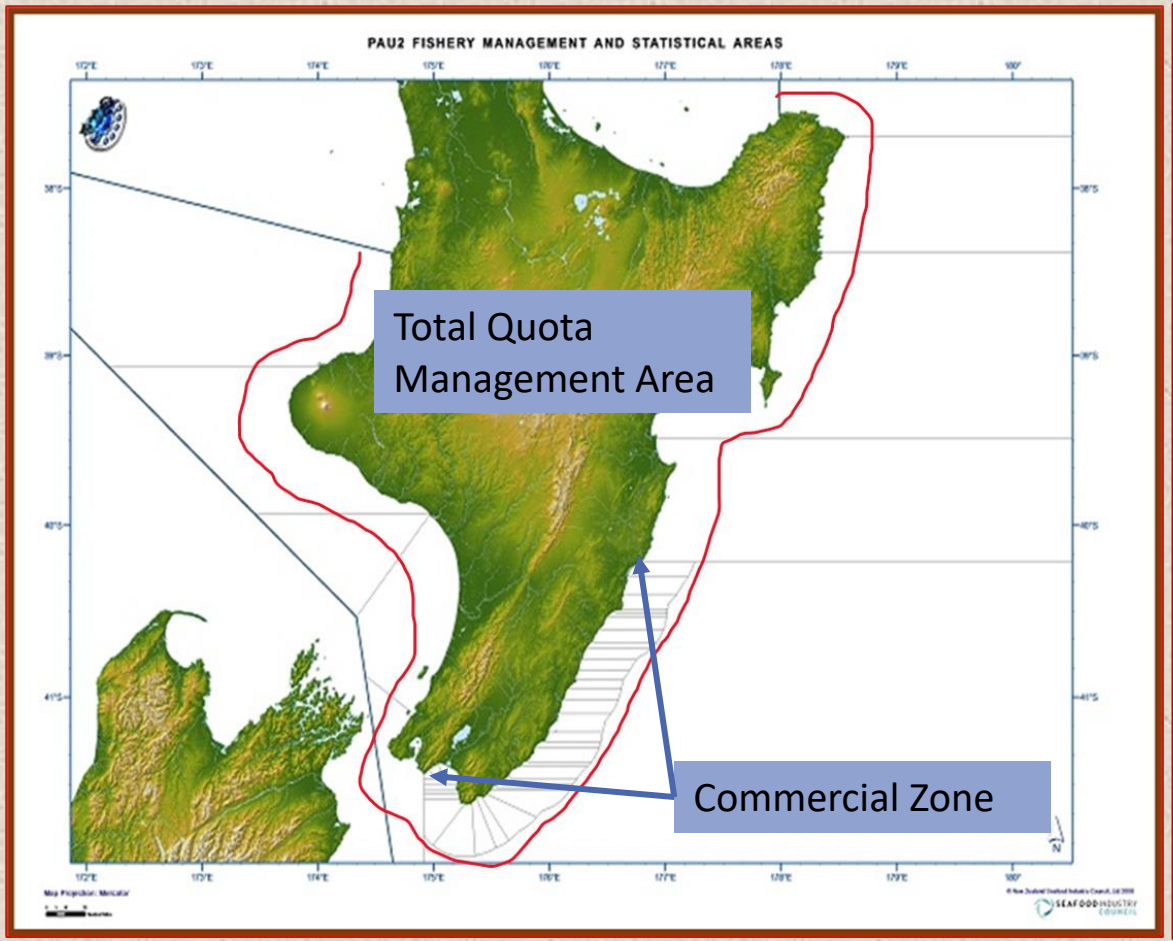
17 September 2020

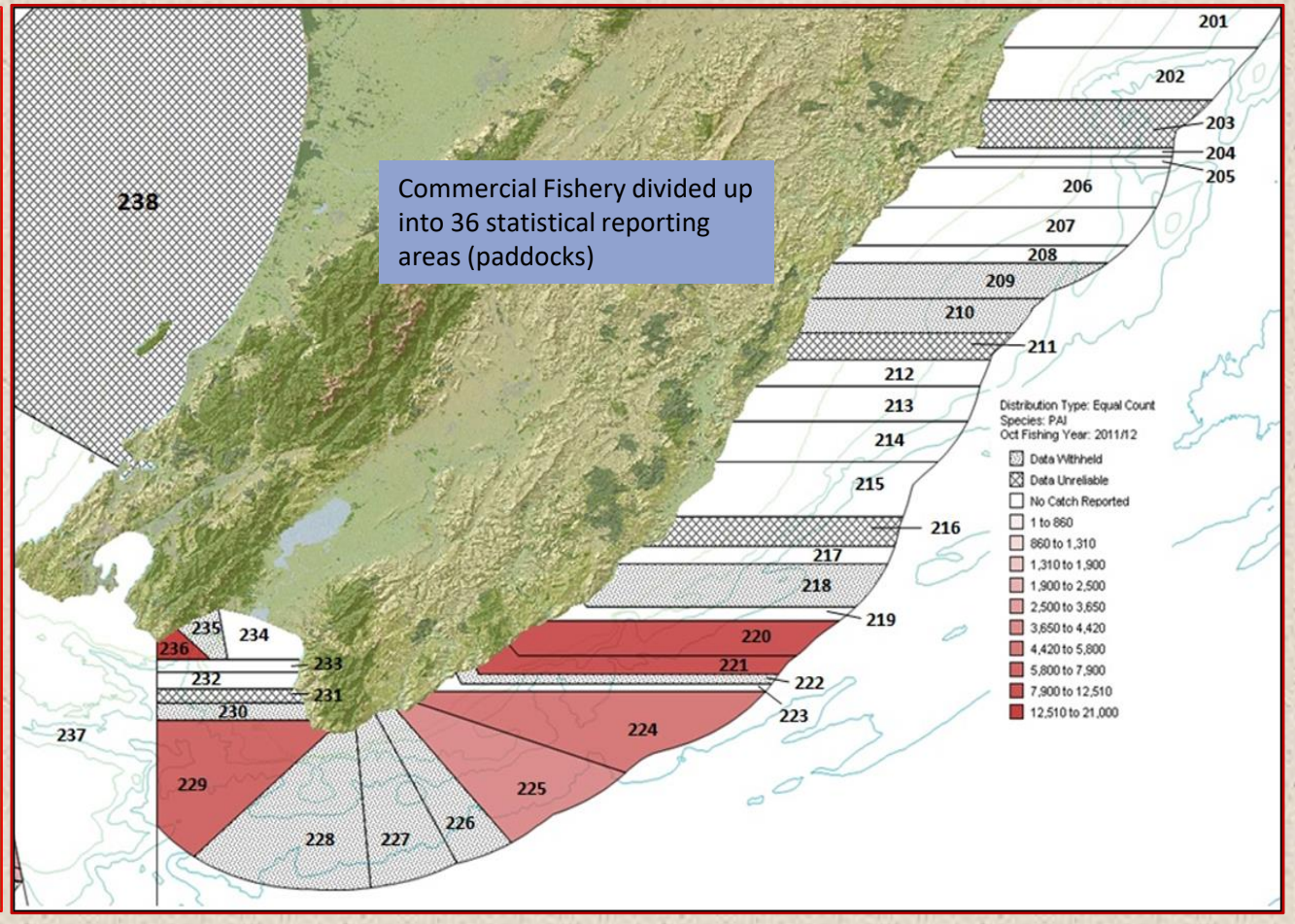
PAUA 2
INDUSTRY ASSOCIATION INC.
Sustainable Fisheries Management

Background

- The Fishery was introduced into the QMS in 1986
- There is no official total allowable catch (TAC) set (ie no specific allowance for recreational or customary)
- The total allowable commercial catch (TACC) has been set at 121mt per annum since 1986
  - There have been no cuts or shelving required
- MPI estimate recreational catch in the same period has gone from 5mt to 83.2mt (across the QMA) over the same period
- Black market poaching is estimated to be close to commercial take (120mt)
- There is no estimate of customary take

About the Fishery





Commercial Ownership

- There are 47 individual owners
- The top 11 own 84% of the fishery

Client Number	Client Name	Account type	Total shares	Estimated ACE	% Held
9791292	Aotearoa Fisheries Limited	Normal	52541506	63674	53%
9430042	Peter Thomas Herbert, Sandra Margaret Herbert, Michael John Ussher	Normal	5250520	6363	5%
9620060	Wai-Paua Company Limited	Normal	5233603	6342	5%
9640011	Owen Ray Fairbrother, Brenda Ceciel Fairbrother	Normal	3300657	4000	3%
9440072	Gavgill Nominees Limited	Normal	2954088	3580	3%
9791755	Kahungunu Asset Holding Company Limited	Settlement	2897655	3512	3%
9740210	Peter Geoffrey Borrie, Dianne Christine Millar	Normal	2888074	3500	3%
9792538	Raukawa Ki Te Tonga AHC Limited	Normal	2640526	3200	3%
8600300	Te Ohu Kai Moana Trustee Limited	Settlement	1987233	2408	2%
9900459	Greendigital Limited	Normal	1980395	2400	2%
9791668	Atiawa Nui Tonu Fisheries Limited	Normal	1840941	2231	2%

Iwi Ownership Interests

- With AFL (Moana NZ) total 68.6% and KAHC @ 2.9%

Client Number	Client Name	Account type	Total shares	Estimated ACE	% Held
9791292	Aotearoa Fisheries Limited	Normal (Iwi)	52541506	63674	52.5%
9791755	Kahungunu Asset Holding Company Limited	Settlement	2897655	3512	2.9%
9792538	Raukawa Ki Te Tonga AHC Limited	Normal (Iwi)	2640526	3200	3%
8600300	Te Ohu Kai Moana Trustee Limited	Settlement	1987233	2408	2.0%
9791668	Atiawa Nui Tonu Fisheries Limited	Normal (Iwi)	1840941	2231	2%
9792509	Te Hoiere Asset Holding Company Limited	Normal (Iwi)	1237746	1500	1%
9791656	Ngati Porou Seafoods Limited	Normal (Iwi)	825165	1000	1%
9791777	Tuhoe Fish Quota Limited	Normal (Iwi)	825164	1000	1%
9740059	Rangitane O Te Ika A Maui Limited	Settlement	579253	702	0.6%
9791783	Taranaki Iwi Fisheries Limited	Settlement	413600	501	0.4%
9791658	Ngati Ruanui Fishing Limited	Normal (Iwi)	412582	500	0%
9140091	Ika Toa Limited	Settlement	358233	434	0.4%
9791668	Atiawa Nui Tonu Fisheries Limited	Settlement	268491	325	0.3%
9792029	Te Pataka O Tangaroa Limited	Settlement	264334	320	0.3%
9791940	Te Kupenga o Maniapoto Limited	Settlement	226753	275	0.2%
9792377	Ngati Apa Developments Limited	Settlement	222128	269	0.2%
9791658	Ngati Ruanui Fishing Limited	Settlement	196816	239	0.2%
9791653	Ngai Tamanuhiri Asset Holding Company Limited	Settlement	195030	236	0.2%
9791780	Te Atiawa (Taranaki) Holdings Limited	Settlement	192659	233	0.2%
9792136	Ngaruahine Fisheries Limited	Settlement	189408	230	0.2%
9791800	Maruehi Fisheries Limited	Settlement	103217	125	0.1%
9791767	Whanganui Iwi Fisheries Limited	Normal (Iwi)	75297	91	0.1%
9791771	Ati Awa Ki Whakarongotai Holdings Limited	Normal (Iwi)	63100	76	0.1%
9792538	Raukawa Ki Te Tonga AHC Limited	Settlement	10183	12	0.0%

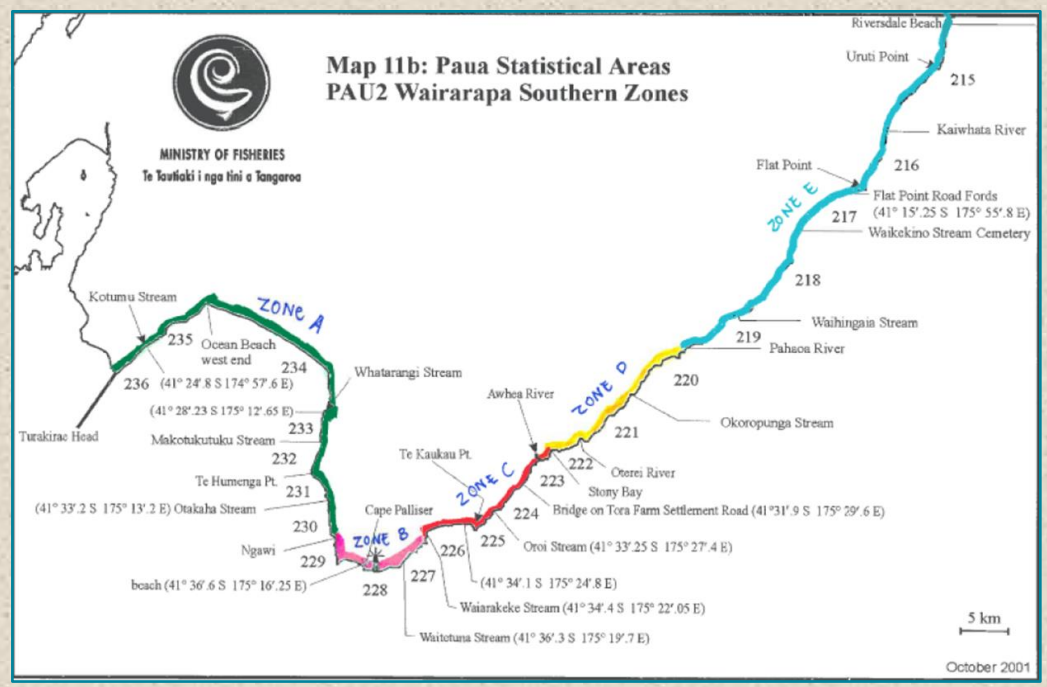
The PAU2 Association

- Established in 1999 (I became Chair in 2011)
- Purpose to represent the interests of the commercial fishing sector
  - Fisheries Management
  - Fisheries Policy
  - Stakeholder Engagement
- Membership include divers, processors and quota owners
- Has an Executive of 9 members (4 of whom have Iwi affiliations)

Each Year full Page Report in the Wairarapa Mid –Week

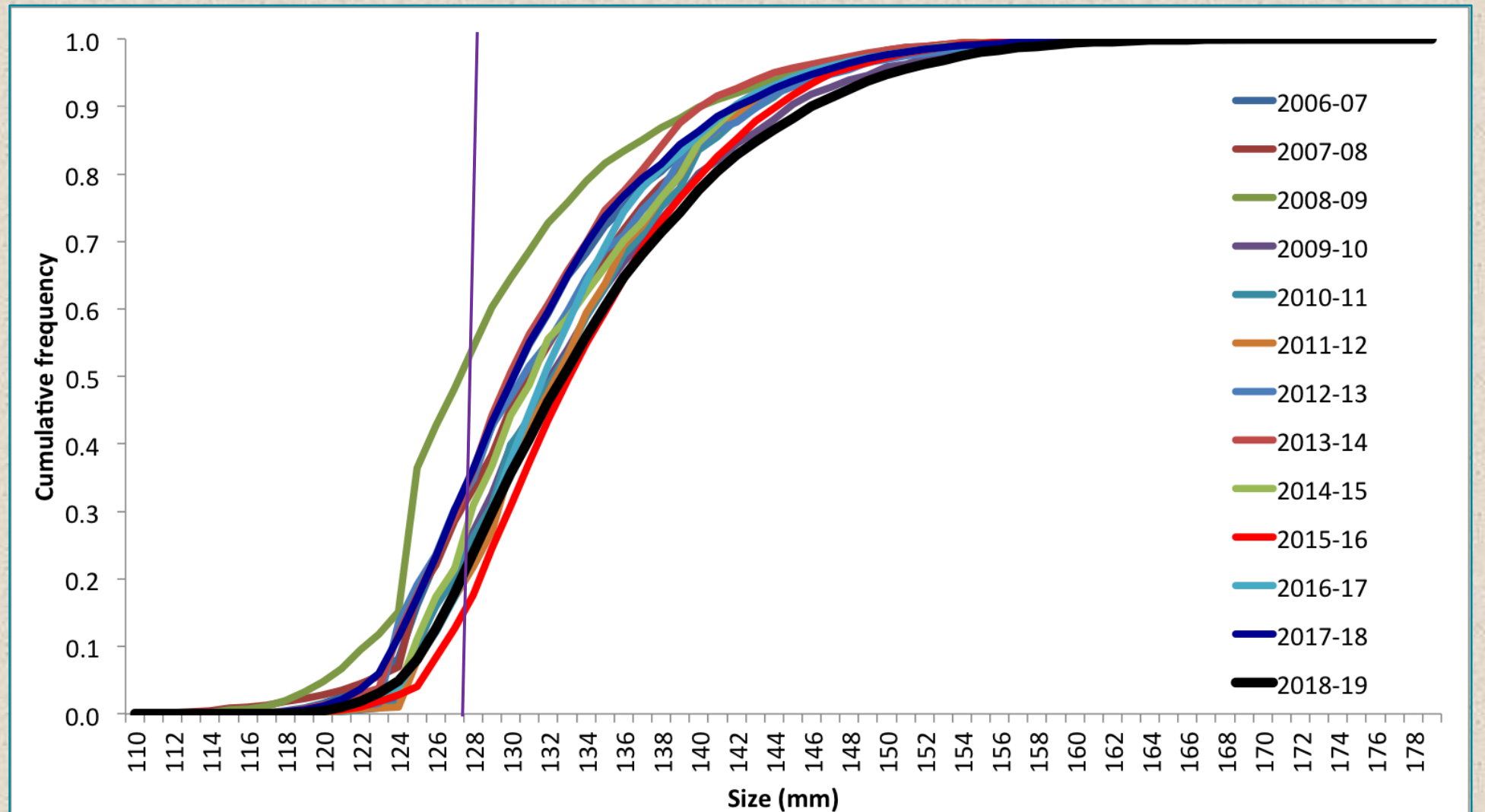
Management Initiatives that have been Introduced

Size Limit Change

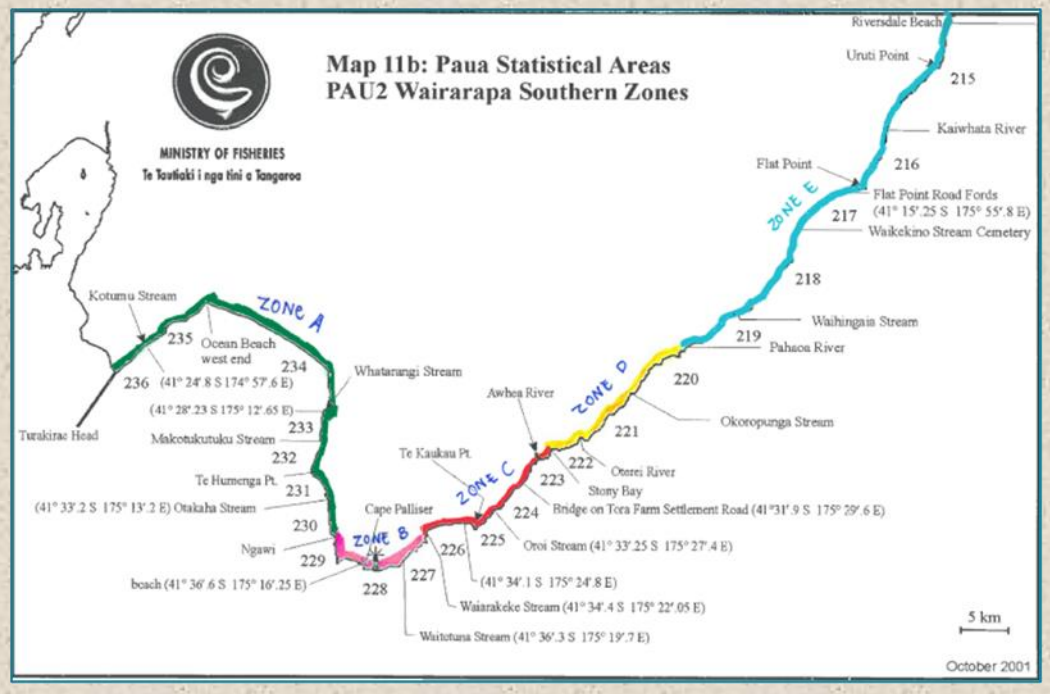


- At the 2018 AGM it was agreed to go to 127mm for zones B, C & D
- At this years AGM agreed to move zone A to 127 from 1 October 2020

Catch Sampling - Results



Catch Spreading



	Zone A	Zone B	Zone C	Zone D	Zone E
Stat Areas	235-230	229-227	226-223	222-220	219-210
Kilos	27,244	14,102	25,219	28,195	26,427
% per zone	22.48%	11.64%	20.81%	23.27%	21.81%

Statistical Area Management Threshold System

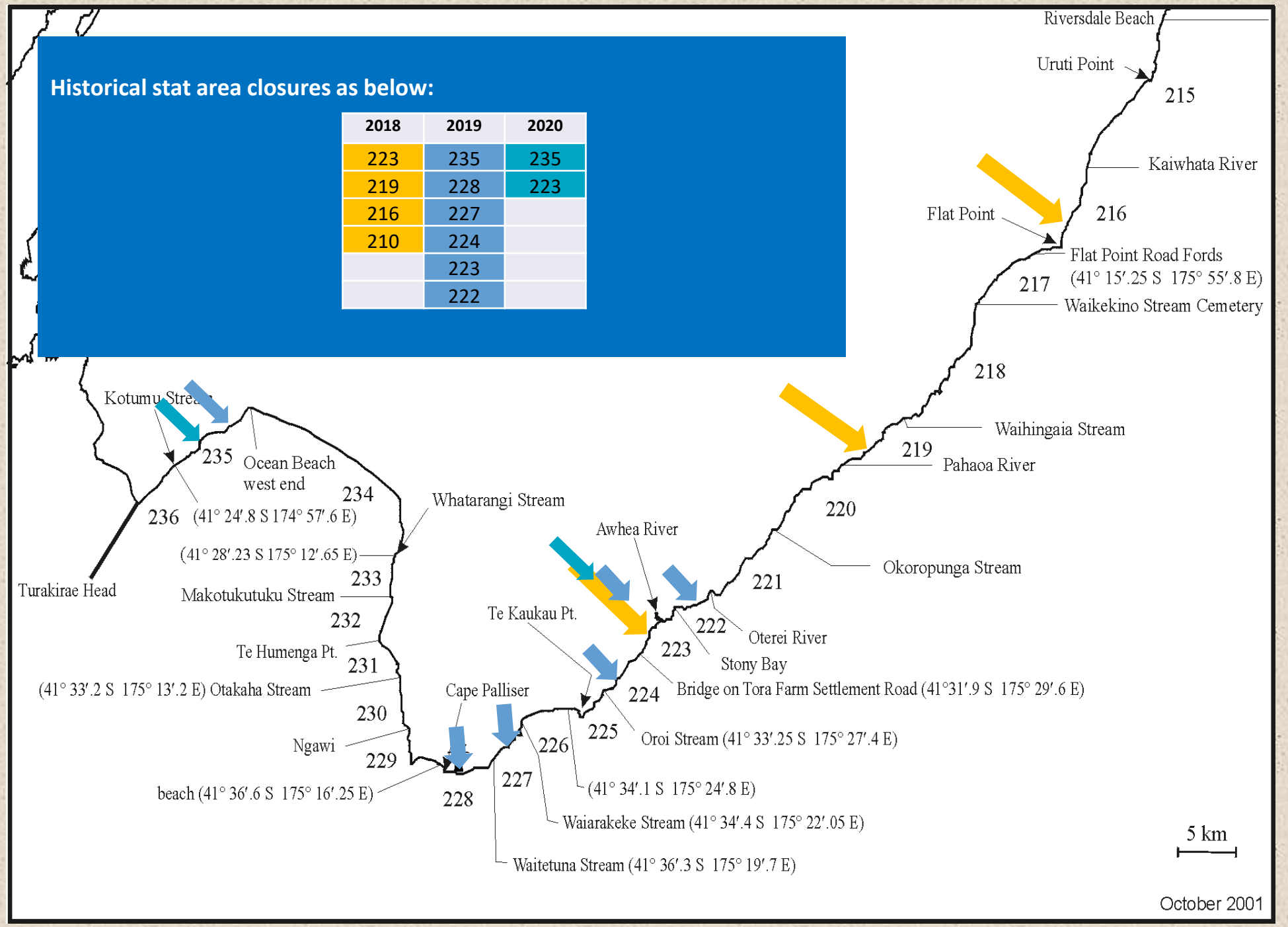
- There are two stat area threshold indicators in use
  - 8-year average catch per unit effort (CPUE) thresholds and
  - 120% of 8-year average catch limit threshold for each separate stat area.

- This is an extension of the Indicator Dashboard Project.

- The dashboard will have 4 separate colour indicators;
  - Grey = go fishing
  - Blue = under review (may be at or over a particular threshold but still open)
  - Orange = temporary closure (2 months) triggered by CPUE at or below 8-year average
  - Red = closed for the rest of the season (this will only occur where the 8 year catch average for that particular stat area is over caught by 20%)

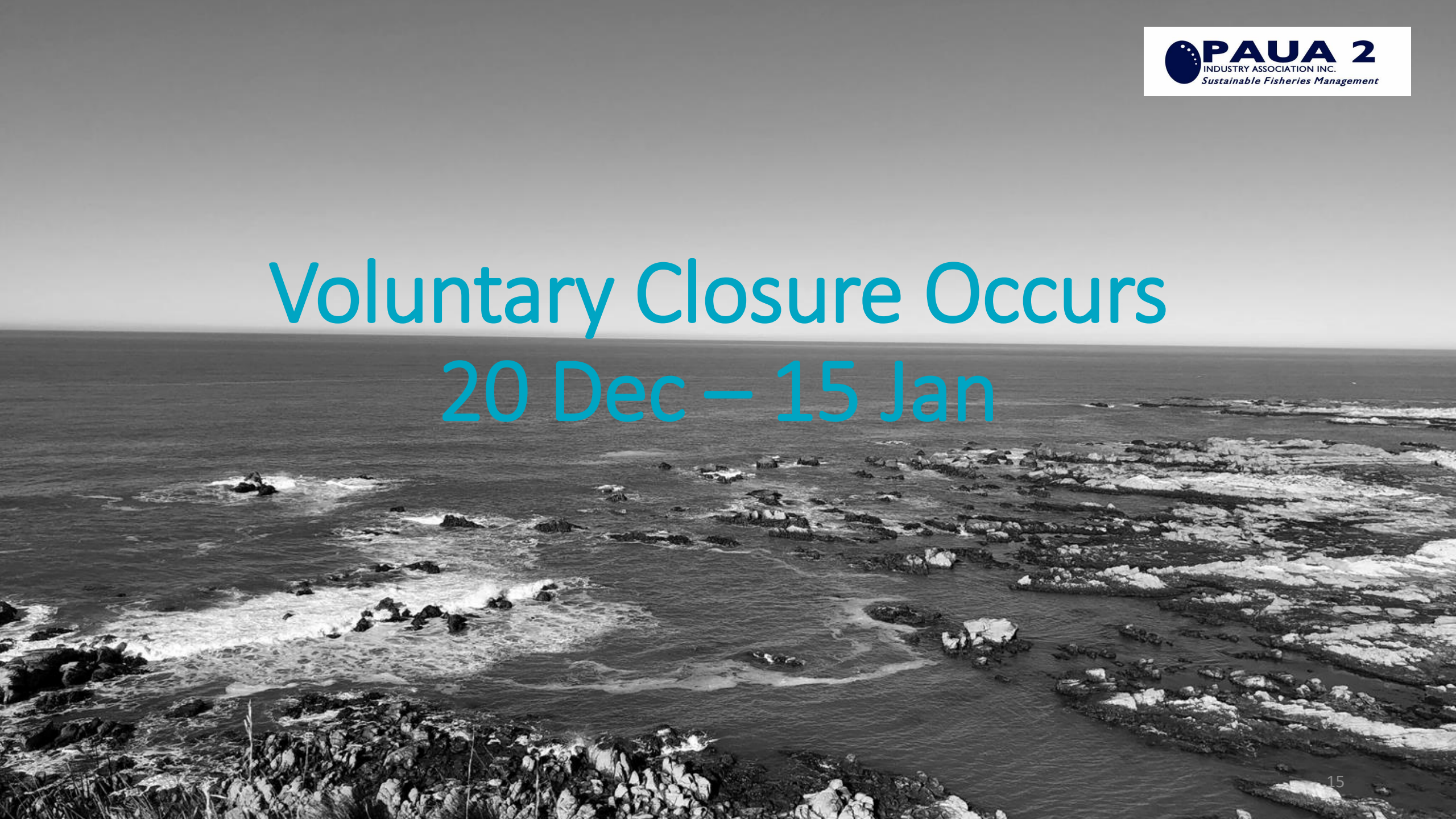
Historical stat area closures as below:

2018	2019	2020
223	235	235
219	228	223
216	227	
210	224	
	223	
	222	



Protecting our coast from poachers

- A scheme where vessels and associated vehicles belonging to members of our commercial harvesting crews are identified.
- Simple identification of the legitimate industry makes it easier to identify non-industry harvest crews that might be operating illegally, such as poachers.


PAUA 2
INDUSTRY ASSOCIATION INC.
Sustainable Fisheries Management
Voluntary Closure Occurs
20 Dec – 15 Jan

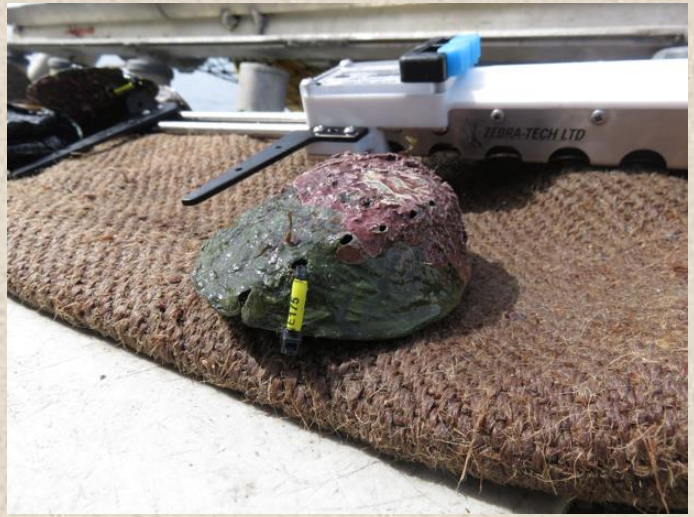
Research Projects Underway Funded by Pau2 Association

Size at maturity

Growth rates

Pepe Motel

Pāua growth and length at maturity (PAU2)



- Growth and length at maturity are both critical biological parameters required for stock assessment
  - Supports discussions around MHS

- Objectives
  - To increase the amount of growth (and length at maturity) data in each Statistical Area / QMA
  - To collect growth and (length at maturity) data in up to 2 sites per QMA per year

Growth (tag recapture)

- 800 Pāua tagged and measured at each site
- Numbered cable ties tags
- Recapture after one year

TAGGED PAUA!

The Paua 2 Harvest Management Group is undertaking research to collect data on paua growth and length at maturity in this area. This information is very important for paua stock assessment and wider management of the fishery.

To measure growth, we need to tag and measure paua, put them back to grow for a year, then recover them after a year to determine growth.

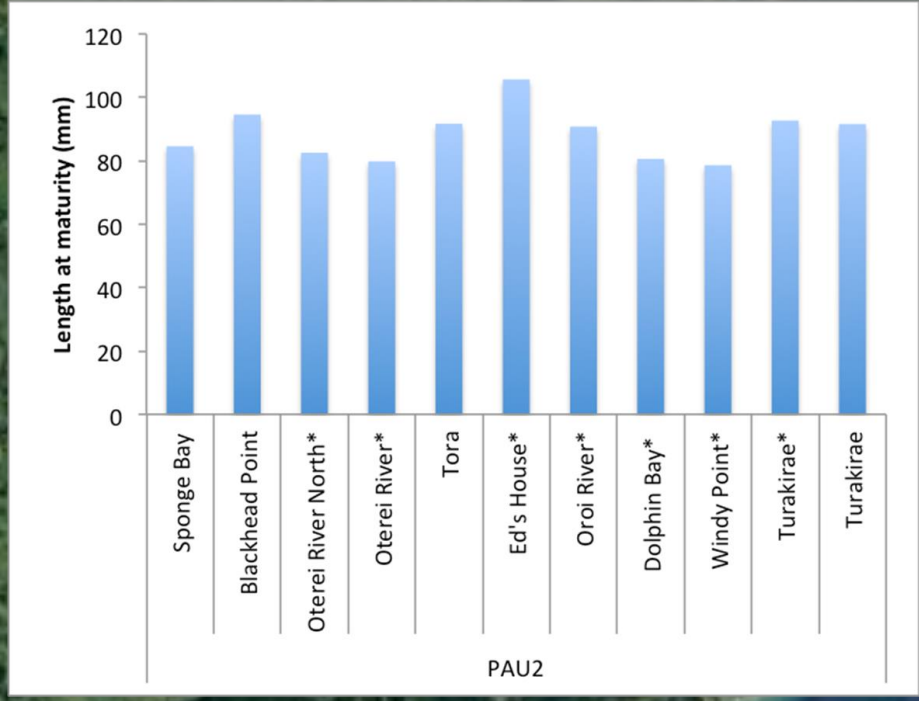
If you see a tagged paua, please leave them where they are to grow. If you accidentally end up with a tagged paua in your catch bag, please contact taggedpaua@gmail.com with the date of capture, tag number and shell measurement (mm).

Cheers and happy diving from Paua 2 Harvest Management Group!

Length at maturity

- Sampling approximately 120 Pāua ranging from 60 – 120mm per site
- Individuals are shucked
  - Shell length measured
  - Gonad scored as male, female (or just M, F) or immature
- All meat given to Iwi

PAU2 Update Tagging and length at maturity research site



Windy Point (G, LM)

Turakirae (G, LM)

Turakirae (LM)

Oterei River (LM)

Tora (LM)

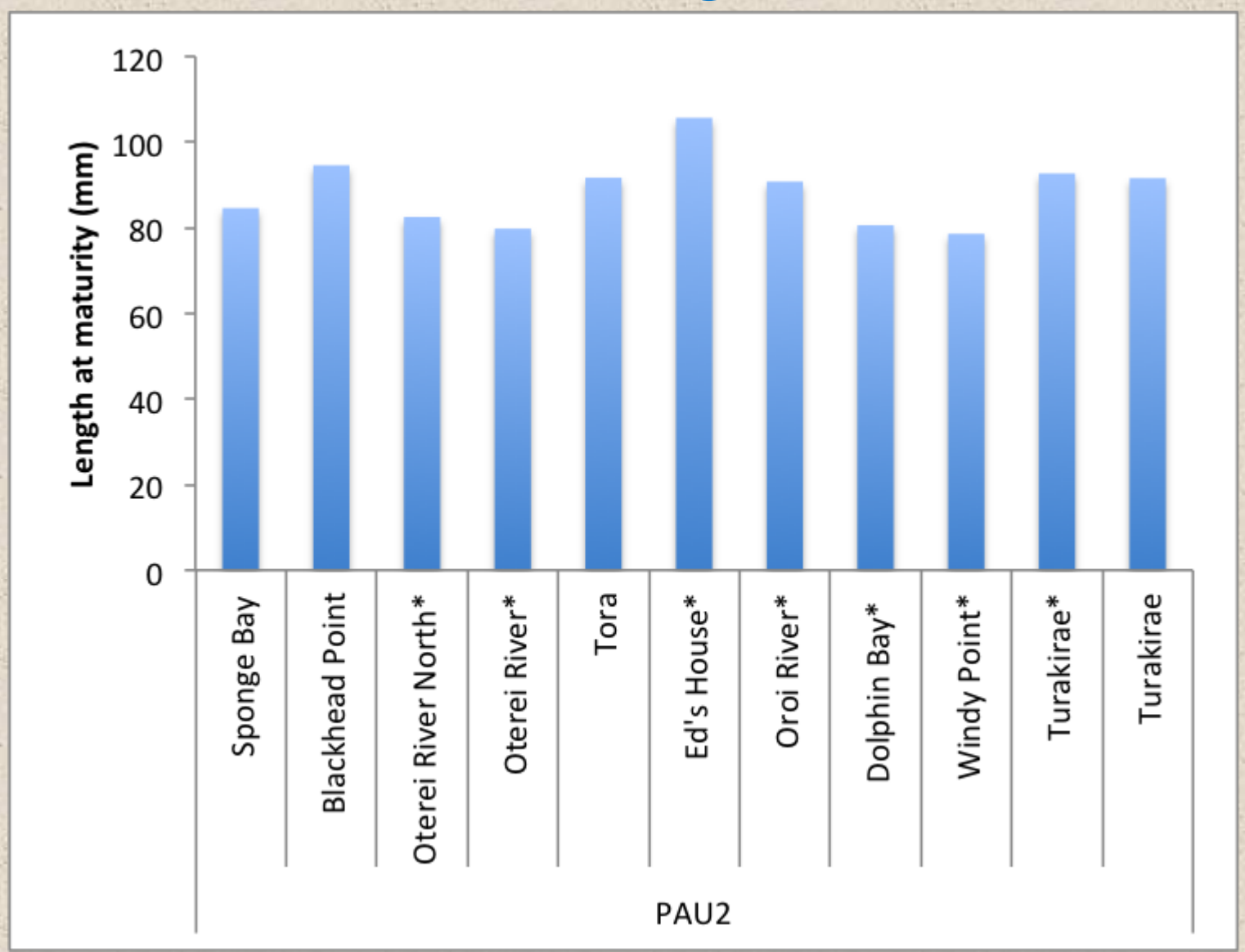
Te Awaiti (G, LM)

Oroi Stream (LM)

Deer Fence (G)

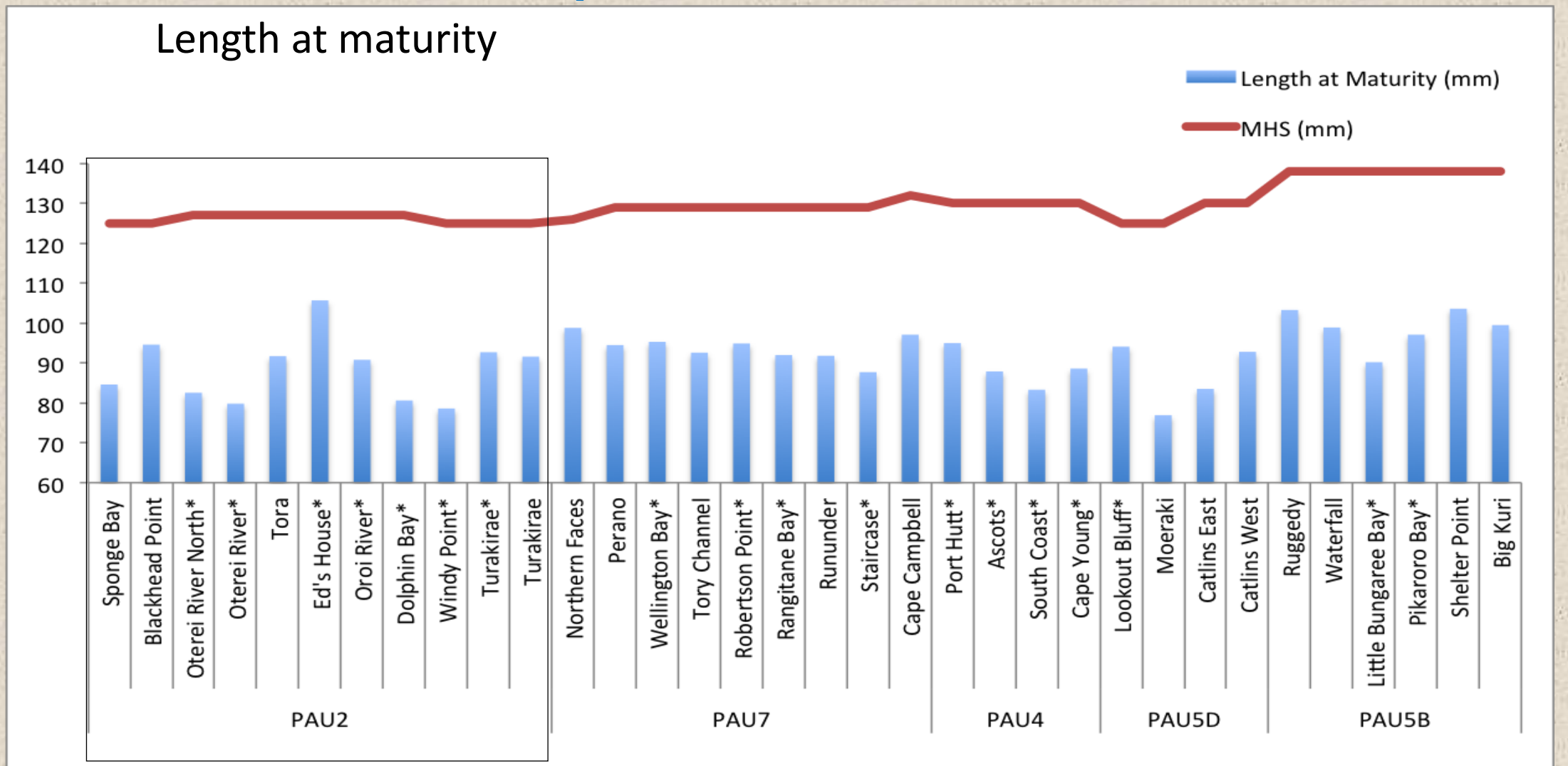
Dolphin Bay (G, LM)

Results for PAU2 Length at maturity

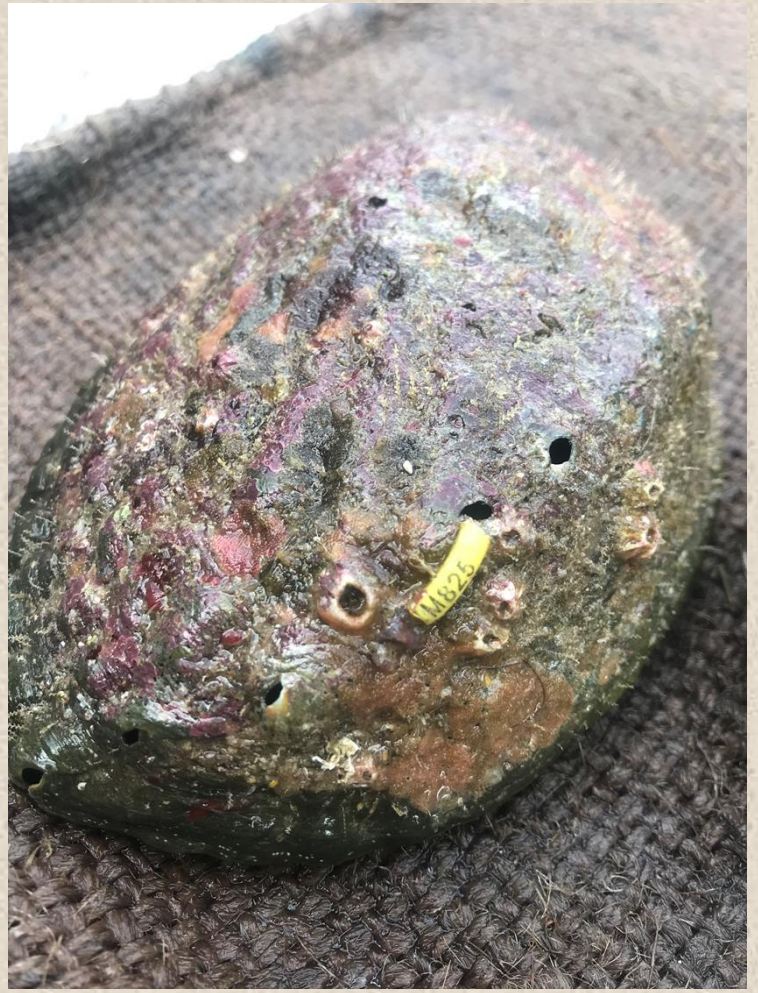


PAU QMA Comparisons

Length at maturity



Results – Te Awaiti and Dolphin Bay recapture



Pāua Pepe Motel Project

- ❑40 Pāua motels ready for deployment near Tora
- ❑Currently trialing different means for anchoring them
- ❑ Purpose = to see if we can understand recruitment

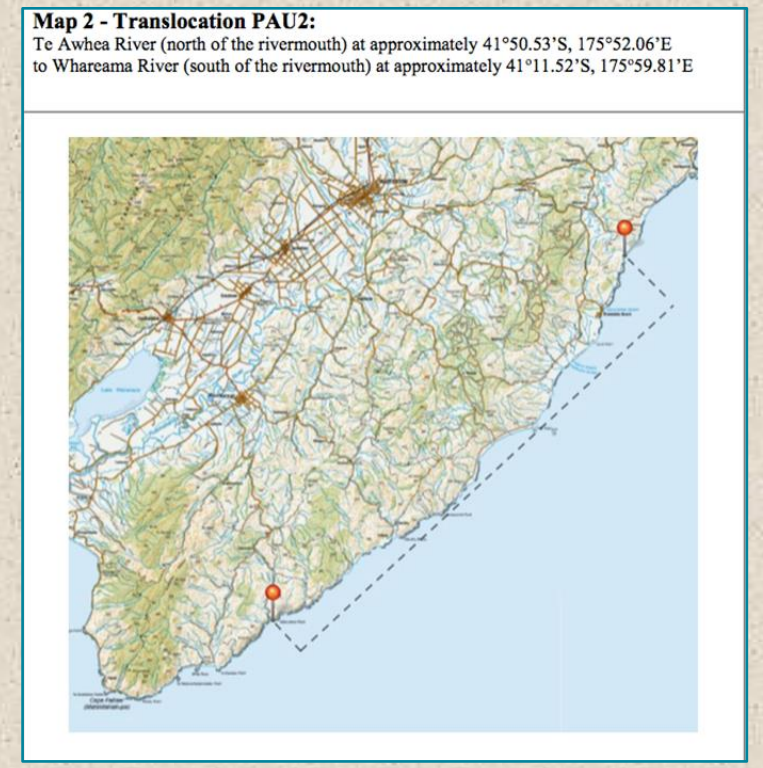
Translocation

- Moving Pāua from slow-growing “stunted” habitats to fast-growing habitats
  - Promotes growth into the fishery
  - Establishment of spawning biomass in low density populations

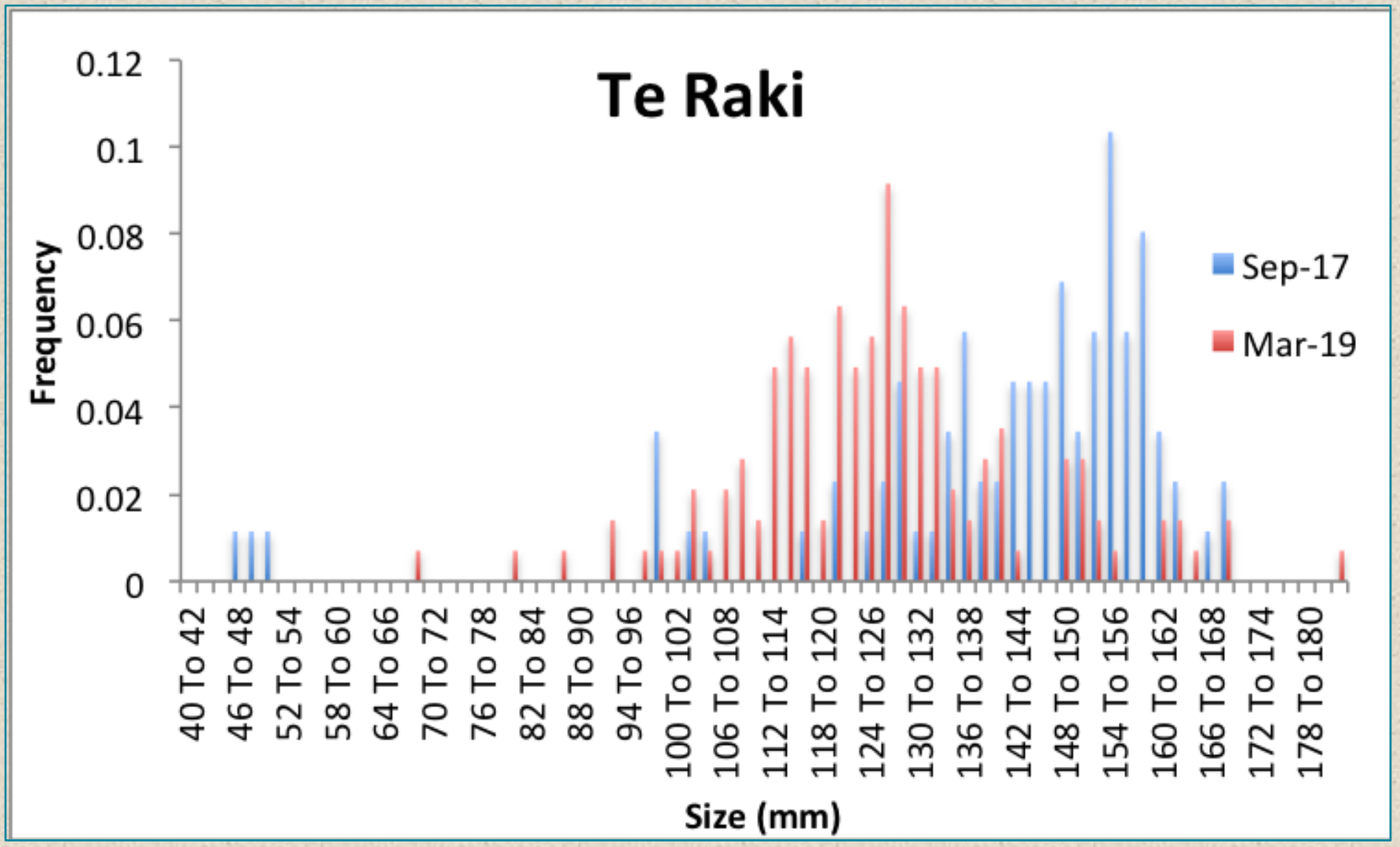
- PIC special permit covers the work

Translocation

- Project outline:
- Pau2 through PIC has a Special Permit
  - Thanks to Te Rūnanga o Ngāi Tūmapūhia ō Rangi Ki Wairarapa
- Candidate site surveys
  - Donor and receiver sites
  - Estimate length-frequency and biomass
  - Proposed translocation
- Translocation (agreed amount from donor to receiver site)
  - Tagging to measure differences in growth rates
- Follow-up surveys
  - Monitor changes in Pāua density at donor and recipient sites
  - Detect differences in growth rates



Length-Frequency



Pāua 2 Resilience Plan 2020 – 2030 (Draft Only)

A PLAN FOR THE FUTURE

The Concept

PAUA 2 INDUSTRY ASSOCIATION INC. *Sustainable Fisheries Management*

- Develop a comprehensive Fishery Resilience Plan for the section of the Pāua2 fishery currently open to commercial fishing. With the intension to extend to the East Coast Nth Island
- Use an ecosystem focused/shared fishery/Mātauranga Maori/QMS approach to grow the fishery for all.
- Build resilience into the fishery by understanding and where possible mitigating external impacts
- Use a farming / paddock based model to develop fine scale management (using previous statistical reporting areas as paddocks)
- Develop a dedicated research team (3-5 years)
  - to develop base-line assessment of the farms components along the coast and undertake core research programmes
- Engage customary and recreational sectors in the project under “shared fishery” principles.
  - ie exclusion of any sector (other than voluntary) not an option
  - Understanding, respecting, recognising and providing for respective needs
- Develop and agreed information based model (all sectors contributing)
- Shared and localised decision making Kanohi to Kanohi

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Sustainable Fisheries Management

Initial Plan Coverage

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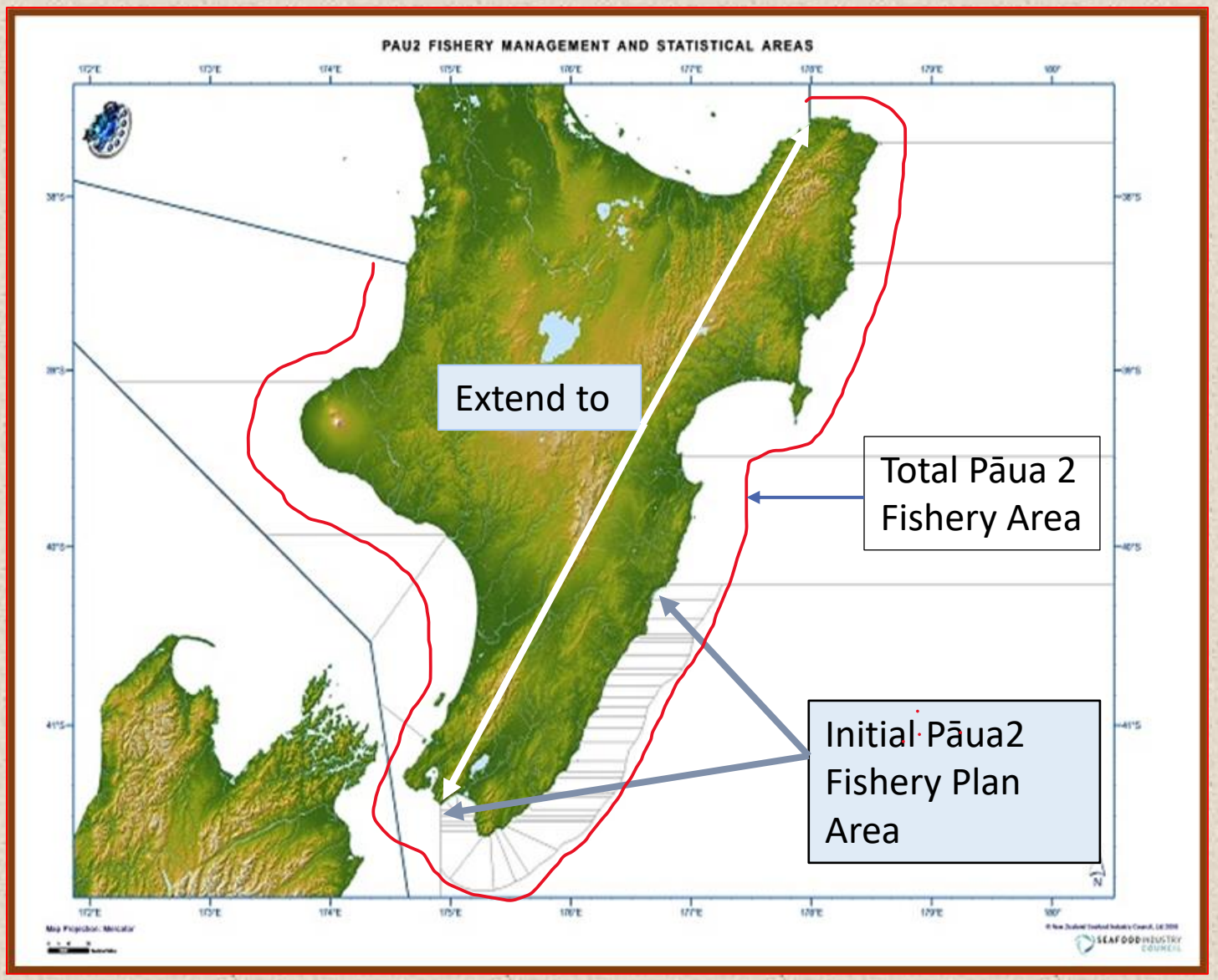
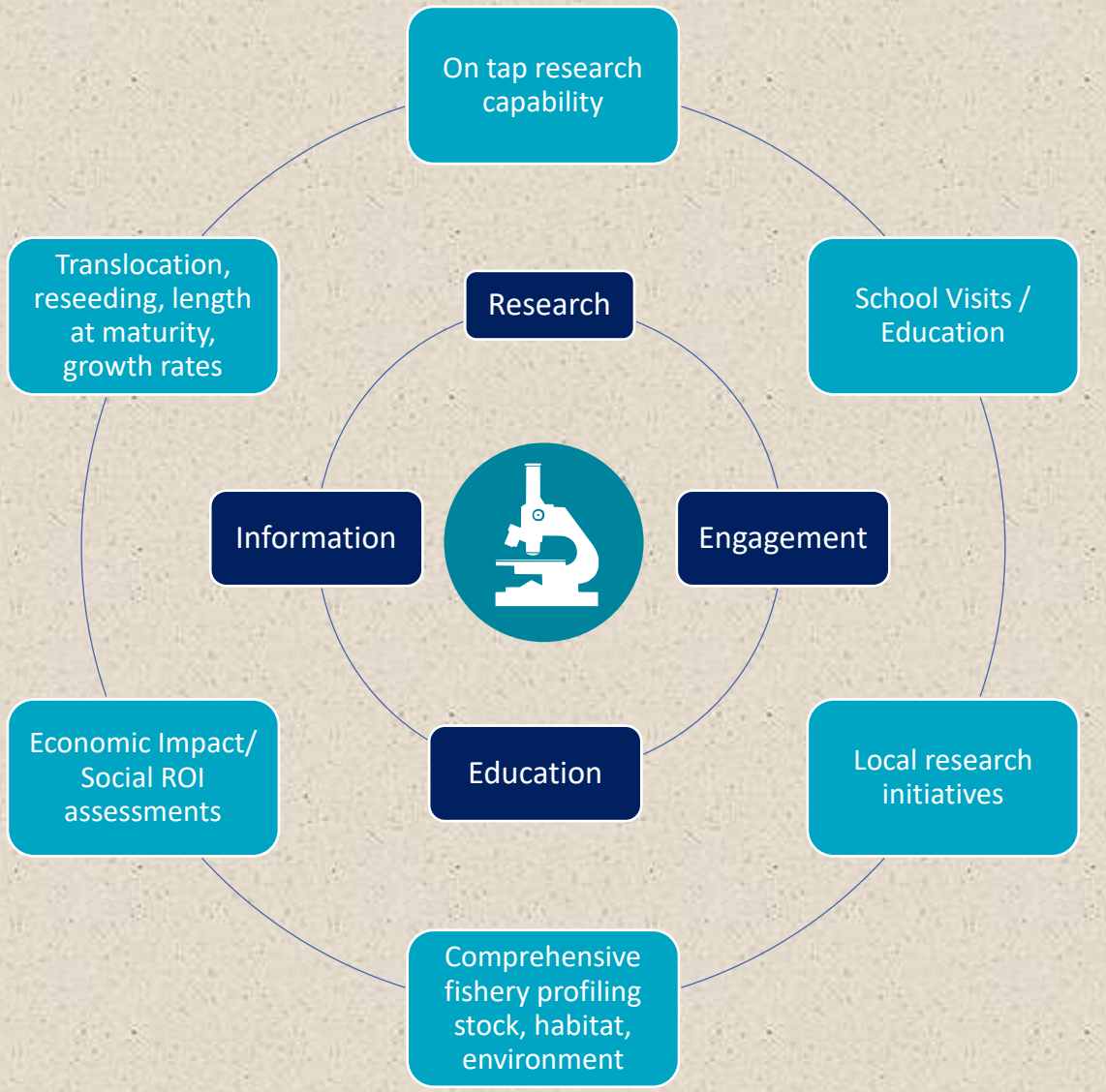


Sector Engagement (Shared Fisheries)

Key Outcomes

- Shared Fisheries Engagement – Agreed principles in place
- Wider community engage and buy–in to “enhancing the whole fishery model”
- Better sector based management inclusion
- Increased communication and understanding across sectors
- Shared gain shared pain approach
- Defined zones for commercial, recreational and customary take
- Increased support for total catch recording

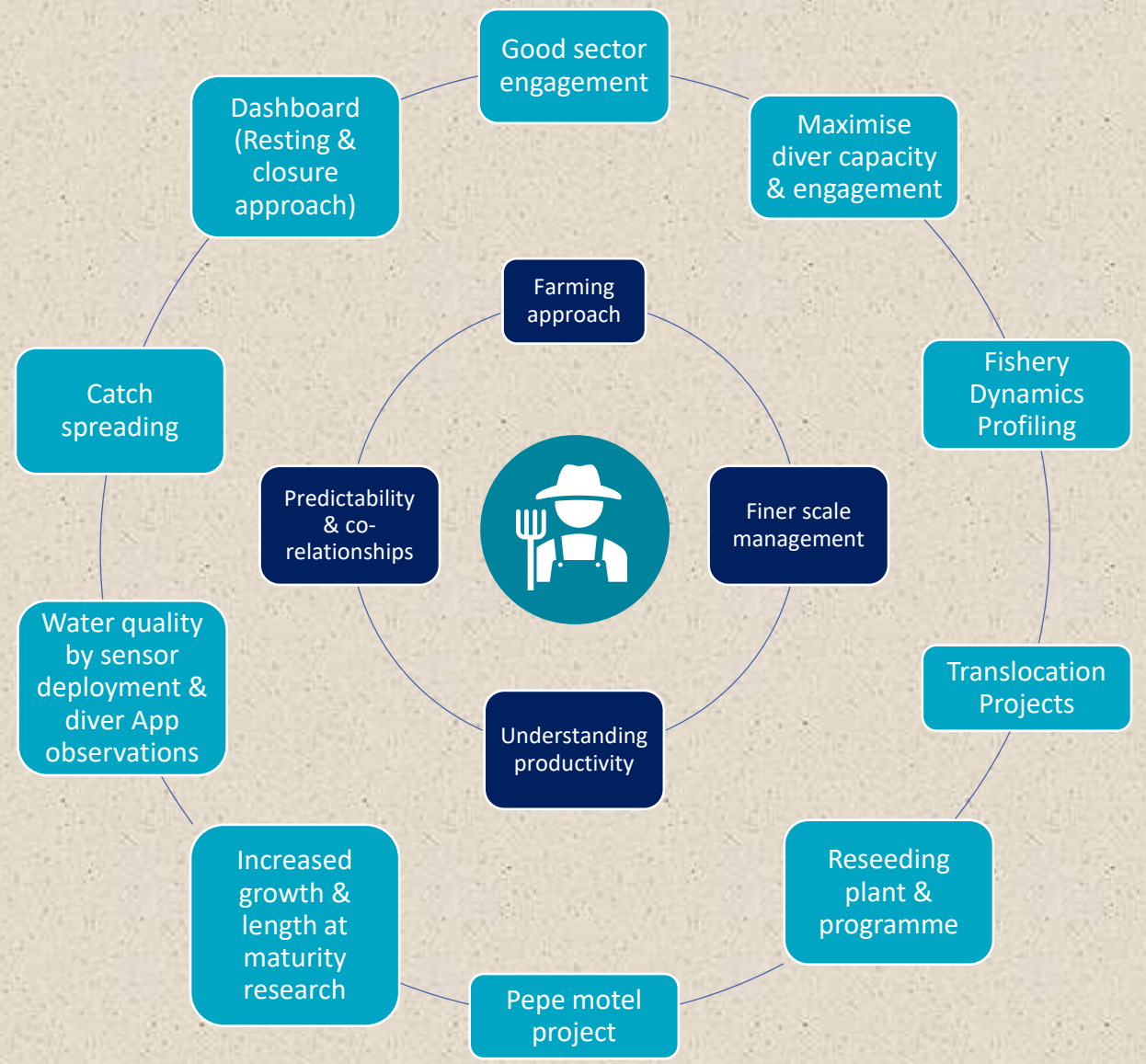
Dedicated Research & Education Team



Key Outcomes

- On tap research capability that is not reliant on current dive teams
- Mobile and able to service the wider Pāua2 fishery research needs
- Training vehicle to develop and expand local research teams
- Comprehensive fishery profiling resource
- Ongoing data analysis identifying fishery/ environmental trends and impacts for informed management decisions
- Education/communication team when not in the water (schools / marae etc)
- **Note – Auckland Museum And Ngati Kuri just got $13m from the Endeavour Fund for researching the Kermadeck's**

Ocean ranching (Management initiatives)



Key Outcomes

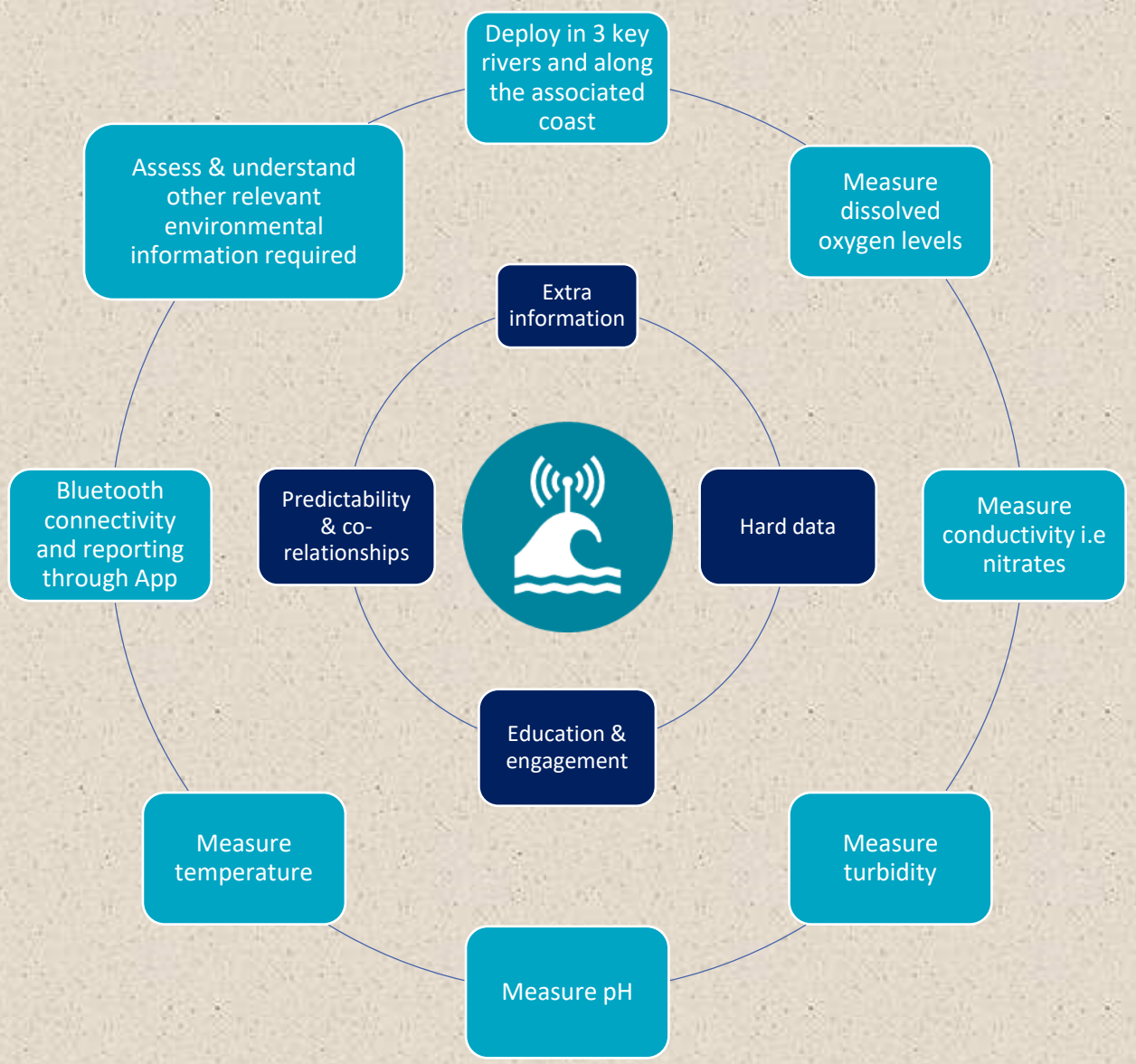
- Provides a framework that enables better long-term fishery resilience
- Better understanding of the dynamics that drive the fishery
  - Water quality
  - Habitat
  - Food
  - Recruitment
- Enable finer scale management
- Maximise productivity of the fishery
- Real-time connectivity to information & management
- Everyone sees and can understand what is happening and why
- Enable rapid responses to changes in dynamics
- Provides a transparent and comprehensive management framework
- Deliver information / data on the impacts of climate and environmental change i.e sediment impacts

Pāua 2 App (direct diver engagement & citizen science input)

Key Outcomes

- Real-time connectivity to information & management
- Making them part of a wider team
- Increased divers collaboration and cohesion
- Increased participation in research
- Implement voluntary management initiatives with real-time information and large scale data
- Tool to enable real-time citizen science (divers) reporting.
- Sediment reporting
- Stunted stock reporting
- Habitat changes
- Tool to enable direct research involvement
- Instructions sent direct from scientist through App
- One stop shop to show how and where they contribute within the management
- Backs up anecdotal with real reporting

Environmental monitoring (sensors deployed)



Key Outcomes

- Provides clear data on the rate and levels for each key measure
- Enables distribution / spread along the coast and out to sea
- Enable comparative analysis of the impacts for 3 different options
  - Minimal terrestrial activity
  - Medium terrestrial activity
  - High terrestrial activity
- Will enable detailed and documented before and after assessments
- Will provide data for sector engagement and solutions/options going forward
- Enable the assessment of downstream impacts of medium and high terrestrial activity

Technology is happening

"We suggest that there are substantial gaps in our knowledge of how land-based stressors affect coastal fisheries both in New Zealand and globally, in particular through mechanisms of sedimentation in the New Zealand context. These stressors, and their impacts, cannot be considered in isolation from other stressors, such as fishing, which are likely to interact synergistically on harvested species populations." (M A Morrison et al "A review of land-based effects on coastal fisheries and supporting biodiversity in New Zealand 2009)

RiverWatch is the only water quality monitoring system that provides intelligent data interpretation

Challenges going forward

- Needs a joint customary, recreational and commercial partnership based on some underlying principles that do not disadvantage a sector or sectors from the beginning
- Needs a governance style that applies a “what is good for the fishery first” approach.
- Understanding that everyone working together will stand a much better chance of attracting government interest and attention.
- The current institutional framework is more comfortable with fixing “problem” fisheries rather than enhancing a good one
- Concept needs to be well resourced (funding and expertise) from the outset to achieve the desired project outcomes


Shared fishery management approach
Fully researched and fine scale managed
Improved and enhanced fishery for all
Data led management approach
Resilient to environmental changes
Pāua 2 Success Story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Patai ?