Two-month status update of land-based monitoring of the Te Pēwhairangi - Bay of Islands Marine Mammal Sanctuary

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1. Introduction

Interactions between marine mammals and vessels are known to have the potential for detrimental effects on populations, including short term, such as vessel strike and changes in behaviour or vocalisations (Buckstaff 2004; Guerra et al., 2014; Pirotta et al., 2015; Peters & Stockin 2016) and long-term, such as displacement from habitats (Nishiwaki & Sasao 1977; Lusseau 2005; Rako et al., 2013). In New Zealand, 2 of the three genetically distinct populations (Tezanos-Pinto et al., 2009) of *nationally endangered* bottlenose dolphin have been shown to be affected by vessel interactions. In Fiordland, changes in dive behaviour and habitat displacement (Lusseau 2003; 2004) as a result of tour activities, as well as changes in residency patterns (Lusseau 2005) were detected. In the Bay of Islands, a decrease in resting and increase in milling in the presence of permitted vessels was initially described (Constantine 2002), followed by the detection of a population decline and high calf mortality (Tezanos-Pinto et al., 2013; 2015). These concerns were confirmed by Peters & Stockin 2016, identifying further local population decline and disruption of critical behaviour by all vessel types. In 2025, Brough et al. brought together the Bay of Islands datasets to produce a comprehensive population assessment, confirming the long-term local population decline.

In 2021, the Te Pēwhairangi (Bay of Islands) Marine Mammal Sanctuary (BOIMMS) was implemented, introducing additional local regulations, as follows:

"**(1)** Every person commits an offence who, without lawful authority or reasonable excuse, is in the water within 300m of any marine mammal in the marine mammal sanctuary, including marine mammal safe zones.

(2) Every person in charge of a vessel commits an offence who, without lawful authority or reasonable excuse, fails to ensure their vessel:

a. maintains a minimum 300m distance from any marine mammal in the marine mammal sanctuary, including marine mammal safe zones; or
b. stops if the person in charge becomes aware of any marine mammal less than 300m distance in the marine mammal sanctuary, including marine mammal safe zones; or
c. remains stopped until any marine mammal is more than 300m away in the marine mammal sanctuary, including marine mammal safe zones.

(3) Every person in charge of a vessel commits an offence who, without lawful authority or reasonable excuse, fails to ensure their vessel travels at five knots or slower while in a marine mammal safe zone."

Despite the establishment of these protected areas, the degree to which the regulations are adhered to, and the extent to which safe zones facilitate protection, both remain unclear (Brough et al., 2025)

Theodolites have been used world-wide to track free-ranging cetaceans and vessels since the 1970s (Harzen 2002; Piwetz et al., 2018). Using a theodolite from a land-based station offers the ability to collect data on marine mammal movement patterns and behaviour, as well as vessel movement and speed, with no disruption to the target species. The method has been used successfully on bottlenose dolphins, describing movement patterns in relation to tide (Gruber 1981, Felix 1994), prey diurnal cycles (Saayman et al., 1973; Würsig & Würsig 1979), or vessel traffic (Acevedo 1991, Mills et al., 2023).

By providing a detailed assessment of both dolphin behaviour and vessel activity, this study aims to fill a critical gap in the understanding of how effective the BOIMMS Marine Mammal Safe Zones are in mitigating human disturbance and supporting dolphin populations. As the first theodolite study in the Bay of Islands, this research aims to demonstrate the capability of theodolite tracking to provide accurate and actionable data for local management, and offering valuable insights into the dynamics between dolphins and vessels within protected zones.

Data was collected between January and February 2025, with the following objectives:

- Document habitat use, movement patterns and behaviour of all marine mammals
- Document vessel traffic (number of vessels, time spent, and compliance with 5 knots safe zones) within the MMS safe zones
- Document vessel compliance with the other rules of the BOIMMS and the Marine Mammal Protection Regulations (MMPR, 1992)
- Produce a summary report detailing effort, data collected, and initial data processing results, including:
  - Spatial distribution of marine mammal groups monitored
  - Spatial distribution of each behavioural state observed
  - Vessel effort (number per hour and amount of time spent) within the safe zones
  - Compliance levels with MMS rules

2. Materials and Methods

2.1 Study area

Data were collected from 2 land-based stations, in Bay of Islands waters, New Zealand (See Figure 1). The location of the 2 stations was chosen to offer a good vantage point over the marine mammal safe zones, as defined within the Te Pēwhairangi (Bay of Islands) Marine Mammal Sanctuary. The Northern-most safe zone, referred to hereafter as the Motuarohia Safe Zone, was monitored from the Motuarohia Station (-35.23094722 S, 174.16587472 E, 70m height). The southern-most safe zone referred to hereafter as the Tapeka Safe Zone, was monitored from the Tapeka Station (-35.24246944 S, 174.12034722 E, 71.5m height).

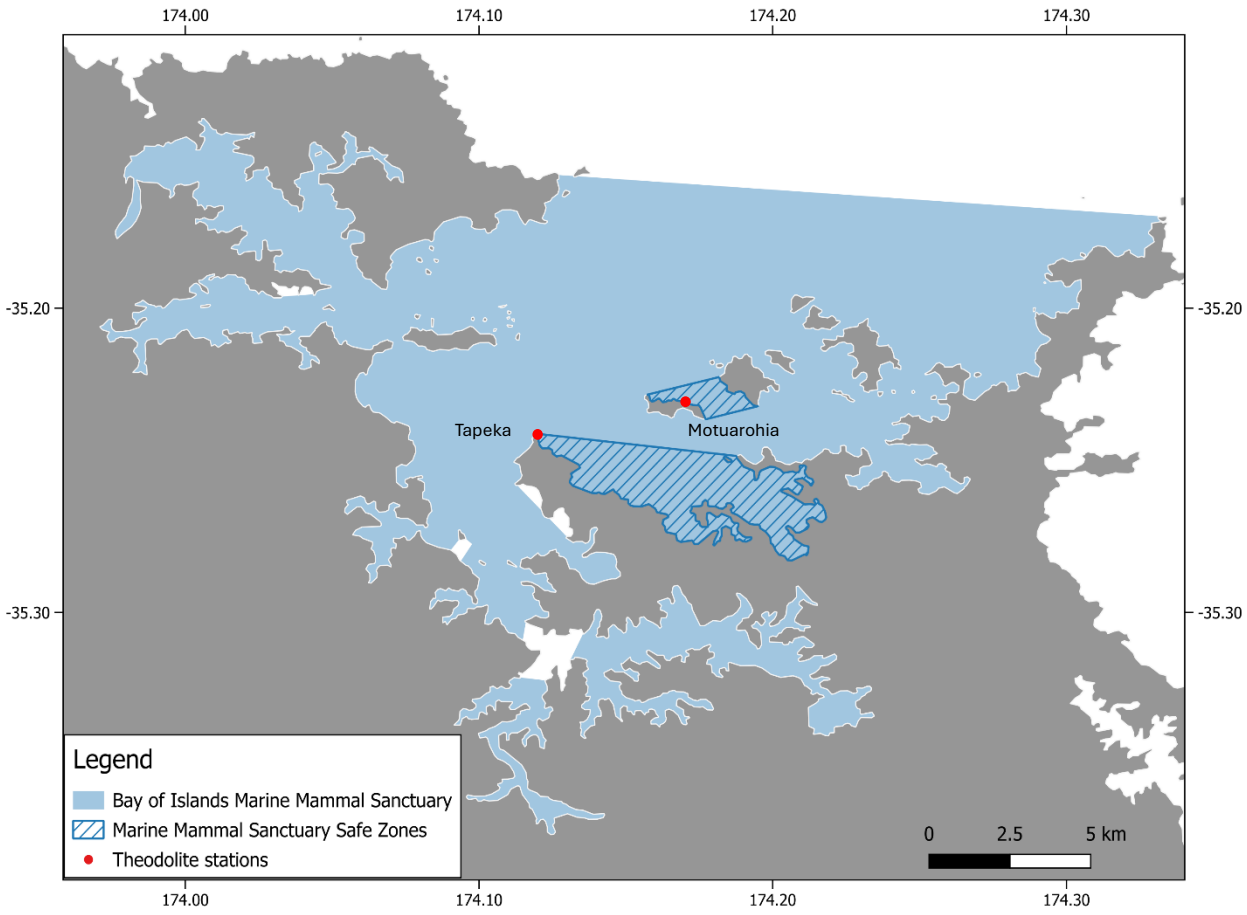

Figure 1. Study area, showing the land-based theodolite stations, as well as the Te Pēwhairangi (Bay of Islands) Marine Mammal Sanctuary and Safe Zones limits, New Zealand

2.2 Theodolite tracking technique

As first introduced by Roger Payne and colleagues in the 1970s, a theodolite (DT-102) was set-up at a pre-determined location, of known GPS location and height above sea level (Figure 2). For each target (vessel or marine mammal), data were collected by aligning the theodolite crosshairs on the point of focus (i.e., middle individual of the group and middle point of the vessel, Mills et al., 2024) to take a fix. Either the software Pythagoras (Gailey & Ortega-Ortiz, 2002) or Mysticetus (Steckler, 2011) were used to integrate the angle readings from the theodolite into latitude and longitude, for each target, through trigonometry.

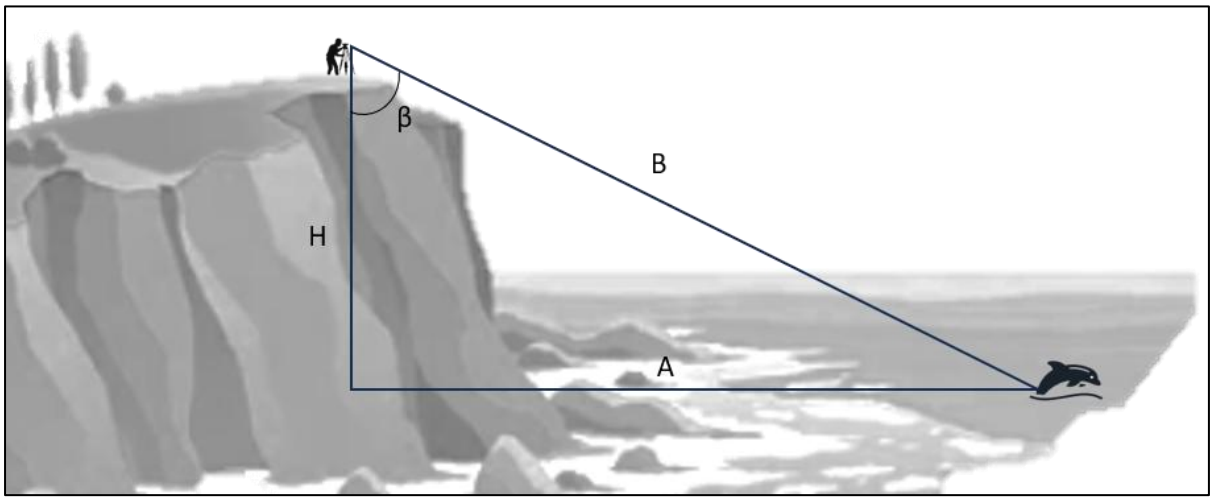

Figure 2. Theodolite tracking through trigonometry

Surveys were conducted in good weather conditions (Beaufort Sea State <3).

Additional observational data were collected using a Samsung SM-T335 tablet computer equipped with CyberTracker (CyberTracker Conservation, Version 3.505+).

2.3 Data collection

2.3.1 Marine mammal encounters

All marine mammals spotted from the land-based station were recorded, regardless of location. Groups were considered independent if separated by more than 5km, sighted more than 30min after the previous group, or where feasible as confirmed by photo-identification (Stockin et al., 2009; Peters & Stockin 2016). Group sizes were recorded using the absolute minimum, absolute maximum and best estimate for the number of individuals in the group (Dwyer et al., 2014; Peters & Stockin 2016).

Every three minutes, a fix was taken on the centre of the group of marine mammals. The predominant behaviour of the group was recorded, following mutually exclusive and cumulatively inclusive categories (Table 2). When determining the predominant behavioural state of the focal group, all dolphins were scanned from left-to-right. This ensured inclusion of all individuals in the group and avoided potential biases caused by specific individuals or behaviours (Mann 1999). In cases where not all group members behaved in a uniform manner, the 50% rule was applied (Lusseau 2003), where the behavioural state was determined as the category in which more than one-half of the group was involved. If an equal percentage of the group was engaged in different behaviours, all behavioural states were logged.

In addition to predominant behaviour, the number of vessels present within 300m, number of vessels interacting with the dolphins, and vessel traffic type (Table 3) were recorded every three minutes. The distance of 300m was chosen to follow both MMPR (1992), where all vessels must slow to idle or no

wake speed (Regulation 18(1)), and BOIMMS regulations, where all vessels must stop within 300m of marine mammals. The distance was estimated by eye by trained observers.

Table 1: Definitions of behavioural states of bottlenose dolphin groups in Far North waters, New Zealand, with abbreviations for each state given in parentheses (Neumann 2001; Constantine 2002; Lusseau 2003; Constantine et al., 2004).

Behavioural state	Definition
Travel (T)	Dolphins engaged in persistent, directional movement making noticeable headway along a specific compass bearing
Foraging (F)	Dolphins involved in any effort to pursue, capture and/or consume prey, as defined by observations of fish chasing (herding), co-ordinated deep and/or long diving and rapid circle swimming. Diving may also be performed, i.e. arching their backs at the surface to increase their speed of descent. Dolphins show repeated unsynchronised dives in different directions in a determined location. High number of non-coordinated re-entry leaps; rapid changes in direction and long dives are witnessed. Presence of prey observed.
Socialising (S)	Dolphins observed in inter-individual interaction events among members of the group such as social rub, aggressiveness, chasing, mating and/or engaged in any other physical contact with other dolphins (excluding mother-calf pairs). Aerial behavioural events such as horizontal and vertical jumps are frequent
Resting (R)	Dolphins observed in a tight group (<1 body length apart), engaged in slow manoeuvres with little evidence of forward propulsion. Surfacing appears slow and are generally more predictable (often synchronous) than those observed in other behavioural states.
Milling (M)	Dolphins exhibit non-directional movements; frequent changes in bearing prevent animals from making headway in any specific direction. Different individuals within a group can swim in different directions at a given time, but their frequent directional changes keep them together. Milling can be associated with feeding and socialising
Diving (D)	Dolphins engaged in persistent, non-directional movements; frequent periods sub-surface with short surfacings. Different individuals within a group can dive in different directions at a given time, but their frequent directional changes keep them together.

Additionally, each individual vessel was recorded upon entering within 300m of the dolphins according to vessel type: Permitted (commercial operation with dolphin-watch permit), Commercial (without dolphin-watching permit), Private (non-commercial vessels) and DOC/research. For each vessel, speed upon first entry within 300m was estimated in 5 knot increments by trained observers and recorded.

2.3.2 Vessels within the Safe Zones

For each vessel entering the BOIMMS safe zone, an “Entering” fix was recorded.

Upon entering a BOIMMS safe zone, each vessel was given a unique identifier, constituted of the vessel type and arbitrary vessel number. Vessel types included:

- **Rec power**: recreational (i.e., not carrying a commercial activity or not registered under Maritime New Zealand) power vessels. Includes all vessels using inboard, outboard or jet engines, with no sailing rig present.
- **Rec sail**: recreational (i.e., not carrying a commercial activity or not registered under Maritime New Zealand) sailing vessel. Includes all vessels with a visible sailing rig, whether or not the sail is in use at the time of the fix.
- **Commercial**: Vessels carrying out a registered commercial activity under MNZ (i.e. tourism charters, Coastguard, HarbourMaster etc), with no whale-watch permit.

- **Paddle craft**: Crafts propelled solely by paddle (i.e. kayaks, SUPs)
- **Whale-watch**: Permitted commercial whale-watch vessels

Additionally, while the vessel was transiting through the zone, additional fixes were recorded to give an accurate picture of vessel speed and behaviour (Table 2).

Table 2. Vessel behaviour categories in the Bay of Islands, New Zealand

Vessel behaviour fix categories	Definition
Slow down	Vessel noticeably slows down
Increase speed	Vessel noticeably increases speed
Stop moving	Vessel stops actively moving (no sail, engine, or paddle power). Includes anchoring. Movement through drifting may still occur
Start moving	Vessel resumes actively moving (powered by sail, engine, or paddle)
Midpoint	Vessel changes direction

For each vessel, upon leaving the zone, a “Leaving” fix was taken. Each vessel having left the zone was considered “forgotten”, and in the case it entered the zone again was given a new arbitrary number.

2.4 Data analysis

Marine mammal and vessel fix sightings were plotted using a Geographic Information System (GIS), created using QuantumGIS version 3.34.11.

Time spent in zone was calculated by comparing the time of first entry within the zone (i.e., time entering), and the time of leaving the zone, for each vessel.

Active time spent in zone was calculated by removing any bouts spent drifting or at anchor from the overall time spent in zone, for each vessel.

For each vessel, a “leg” was defined as the track between two theodolite fixes, for the same vessel. Leg speeds were calculated using Speed=Distance/Time. Leg speeds were then categorised in 5 knot increments (0 - ≤5 knots, 5 – ≤10 knots, 10 - ≤ 15 knots, and >15 knots). For each increment, the time of each leg was calculated to give an overall time spent at that speed, for each vessel type.

For each BOIMMS rule, compliance levels were calculated for each vessel type. For rule (2) (Safe Zones), compliance was assessed in 2 separate ways:

- Number of instances (i.e., number of legs) recorded
- Time spent in each speed category (i.e. length of legs for each speed category)

3. Results

3.1 Effort

Data collection between January and February 2025 comprised 19 land-based surveys, totalling 86.4hrs of survey, including 9 surveys from the Motuarohia station (39.4hrs) and 10 surveys from the Tapeka Point station (47.1hrs). Surveys ranged from 3.2hrs to 5.8hrs in length and averaged 4.6hrs. Surveys took place between 08:00AM and 16:00PM.

3.2 Marine mammals

3.2.1 Sightings

Marine mammals were spotted on 7 discrete encounters, over 5 discrete survey days (26.3% of survey days). This included 3 discrete encounters over 3 survey days from the Motuarohia Station and 4 discrete encounters over 2 survey days from the Tapeka Station. All sightings were of bottlenose dolphin groups. Group average size was 18.7 (SE=1.3).

Bottlenose dolphins were monitored for 5.9 hours (6.8% of survey hours). This included 4.9 hours outside of either safe zone (5.7% of total survey hours), and 1.0 hour within the safe zones (1.2% of total survey hours).

For the Motuarohia Station, out of 2.0 hours of encounter time, dolphins spent 34 minutes within the Safe Zone (29.1% of encounter time from this Station, and 1.2% of survey hours from this Station).

For the Tapeka Station, out of 3.9 hours of encounter time, dolphins spent 28 minutes within the Safe Zone (11% of encounter time from this Station, and 1.0% of survey hours from this Station) (Figure 2).

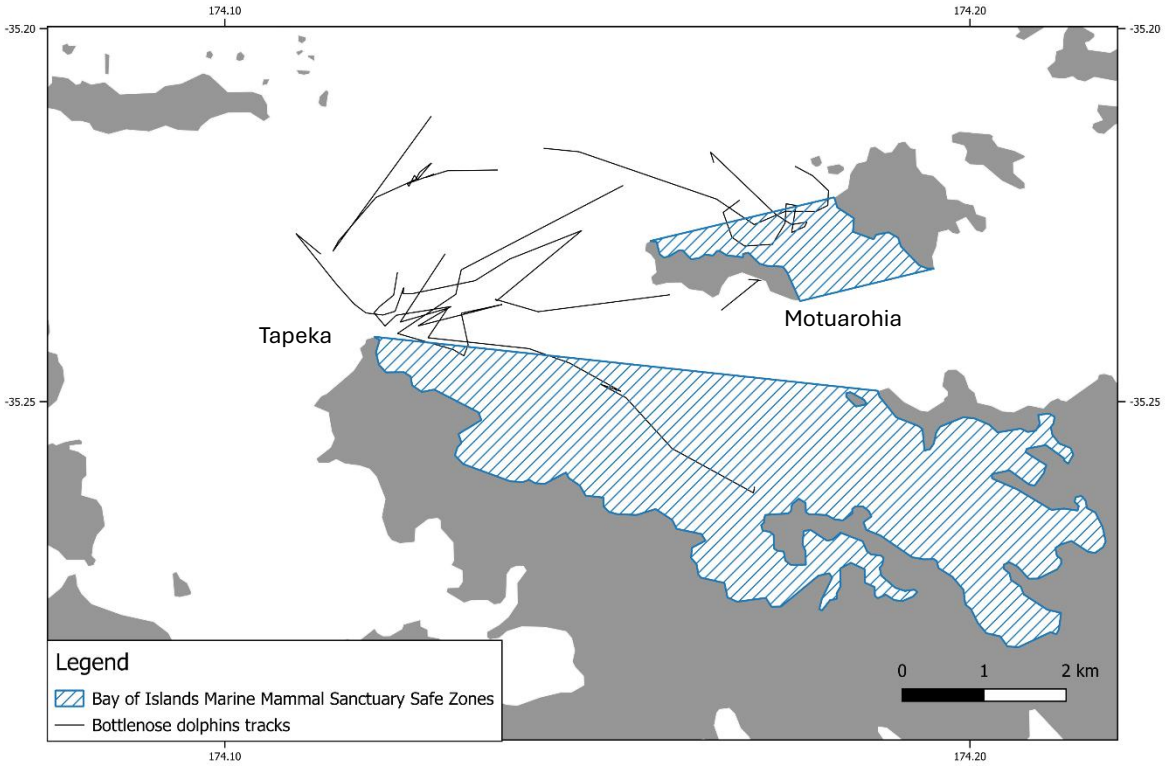

Figure 3. Bottlenose dolphin tracks between January and February 2025 in the Bay of Islands, New Zealand

3.2.2 Behavioural observations

A total of 96 behavioural observations of bottlenose dolphins were recorded, including 33 from the Motuarohia station and 63 from the Tapeka station (Table 3). Across both Stations, Traveling was the most observed behaviour (56.3%), followed by Socialising (21.2%), Foraging (11.5%), Milling and Resting (5.2% each). Diving was not observed.

Table 3. Count of behavioural observations by station and behaviour between January and February 2025 in the Bay of Islands, New Zealand

Behavioural state	Motuarohia	Tapeka	TOTAL
Traveling	21	33	54
Foraging	6	5	11
Socialising	1	20	21
Milling	1	4	5
Resting	4	1	5
Diving	0	0	0
TOTAL	**33**	**63**	**96**

No behavioural spatial pattern was observed during the study period (Figure 3).

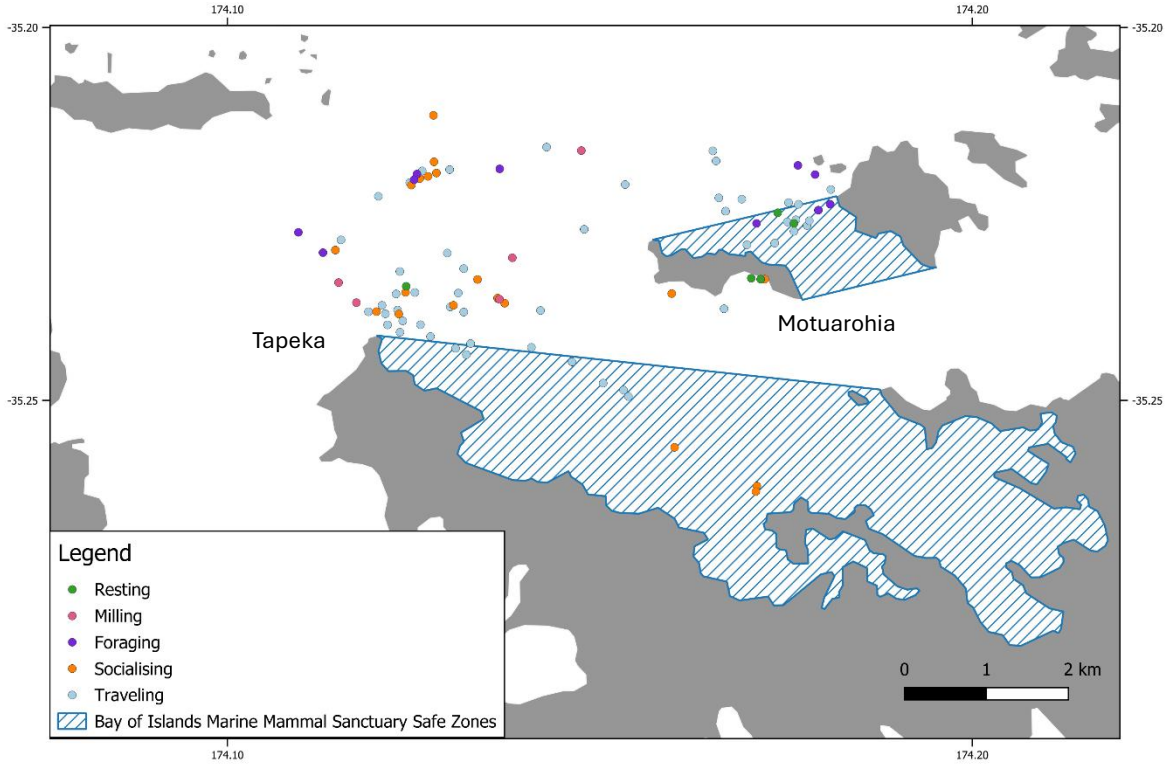

Figure 4. Bottlenose dolphin observed behaviour fixes through theodolite between January and February 2025 in the Bay of Islands, New Zealand

3.3 Vessels within the safe zones

3.3.1 Number of vessels recorded

A total of 638 vessels were recorded entering the 5-knot zones (254 at the Motuarohia Station and 384 at the Tapeka Point station). High levels of vessel traffic were recorded through the centre of the Motuarohia Safe Zone, and through the Northern part of the Tapeka Safe Zone (Figure 4).

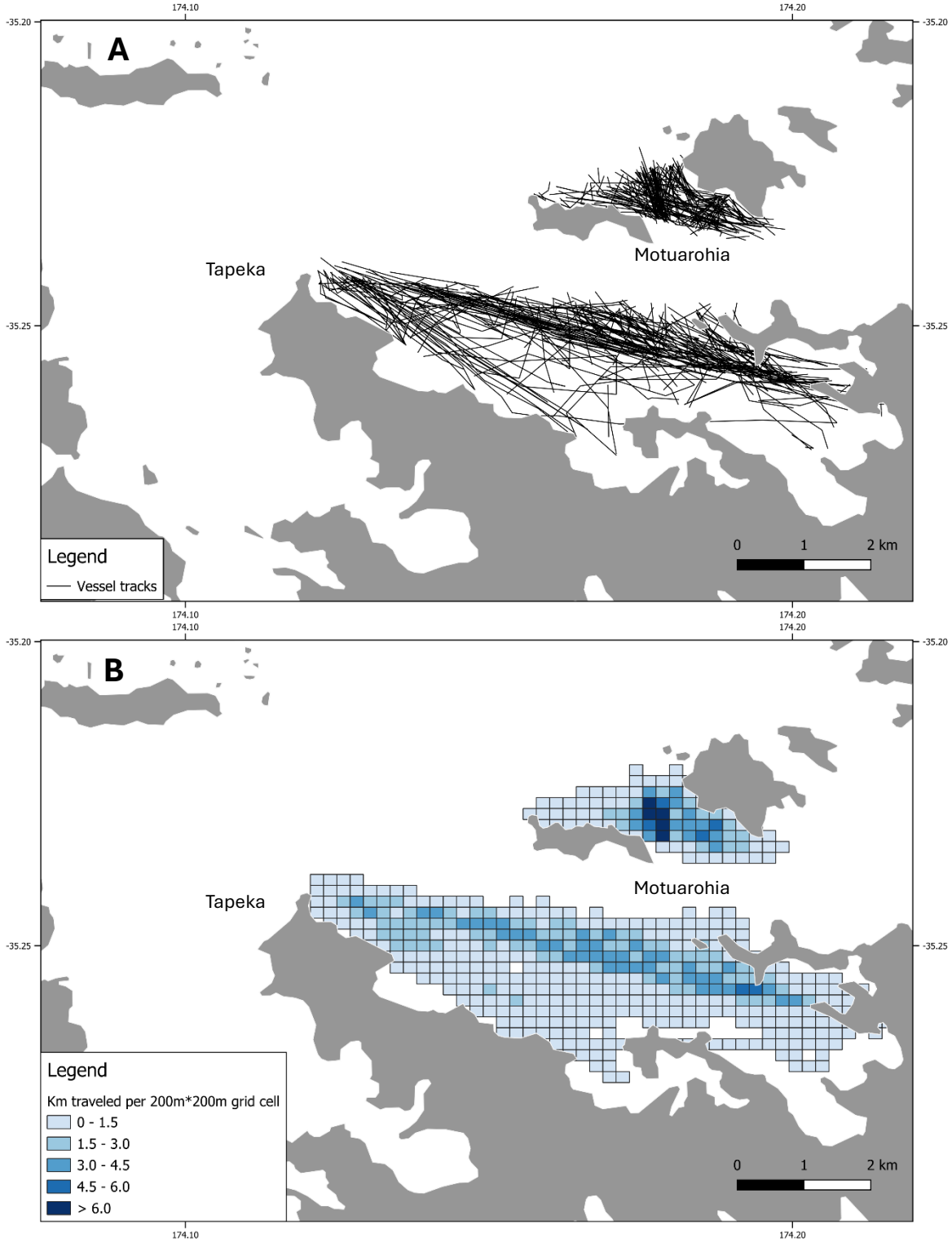

Figure 5. Vessel fixes through theodolite, with A) All tracks per vessels and B) 200m*200m grid cells coloured by kms travelled, between January and February 2025 in the Bay of Islands, New Zealand.

Recreational power vessels were recorded the most often (65.5%, n=418), followed by recreational sail vessels (26.7%, n=170), commercial vessels (5.0%, n=32), paddle crafts (2.5%, n=16) and whale-watch vessels (0.3%, n=2). This hierarchy was consistent in both zones (Table 4).

Table 4. Summary of survey efforts and vessels recorded entering each Marine Mammal Sanctuary Safe Zone between January and February 2025 in the Bay of Islands, New Zealand

	Motuarohia Safe Zone		**Tapeka Safe Zone**	
Survey effort (hours)	39.4		47.1	
Vessel types	**Number recorded**	**Number recorded/hour of survey**	**Number recorded**	**Number recorded/hour of survey**
Rec powers	166	4.21	252	5.35
Rec sails	60	1.52	110	2.34
Commercials	20	0.51	12	0.25
Paddle crafts	8	0.20	8	0.17
Whale watch	0	0.00	2	0.04
TOTAL	**254**	**6.45 (average/hour)**	**348**	**8.15 (average/hour)**

3.3.2 Vessel time spent in Safe Zones

Of the 638 vessels recorded, the time spent in zone could be recorded accurately for 544 vessels (entry and leaving time recorded accurately), with a total of 266.3 hours of vessel presence within the safe zones. For both zones, Rec power vessels were the prevalent vessel, followed by Rec sail, Commercial, Paddle craft, and Whale-watch vessels (Figure 4). No Whale-watch vessels were recorded within the Motuarohia Safe Zone.

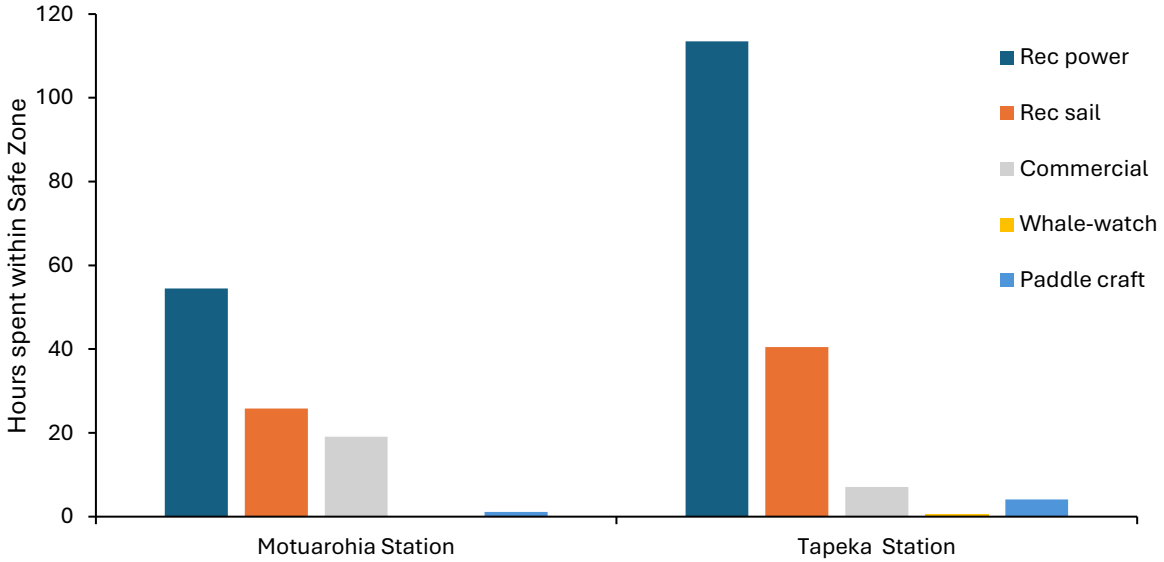

Figure 6. Overall time spent within the Safe Zones for each vessel type, between January and February 2025 in the Bay of Islands, New Zealand.

On average, Rec sails and Commercial vessels spent more time within the Motuarohia Safe Zone than the Tapeka Safe Zone. Paddle crafts spent more time on average within the Tapeka Safe Zone than the Motuarohia Safe Zone (Figure 5).

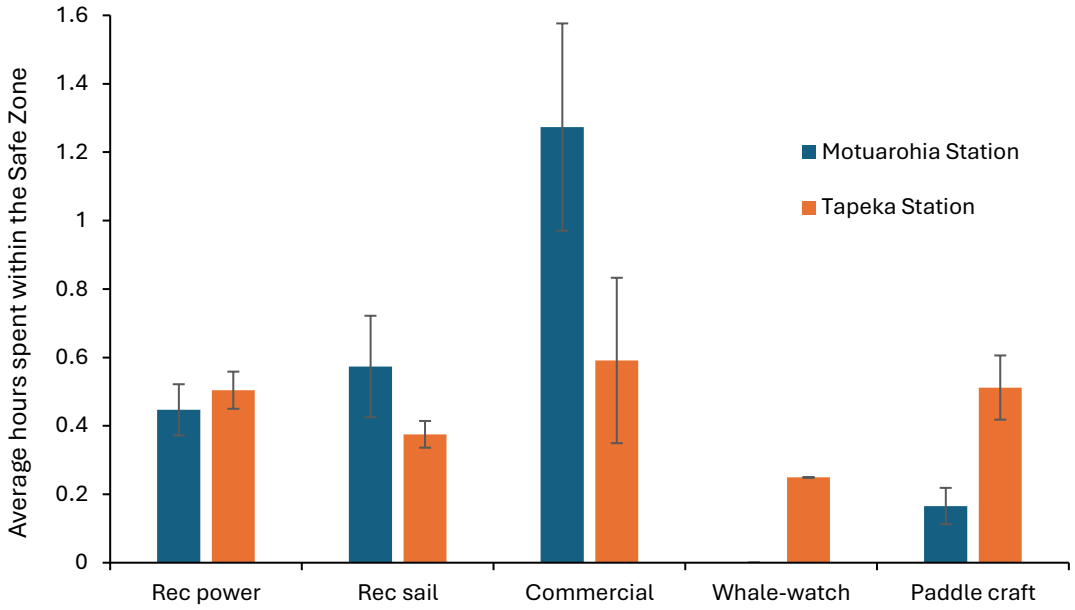

Figure 7. Average time spent within each Safe Zone, for each vessel type, between January and February 2025 in the Bay of Islands, New Zealand

Out of the 266.3 hours, 26.0 hours were spent inactive in zone (at anchor/drifting, 9.8%), including 20.0 hours by Rec power (75%), 3.1 hours by Rec sail (11.8%) and 2.9 hours by Commercial vessels (11.2%). For all vessels, time inactive in zone was not included in the speed calculations.

3.4 Compliance

3.4.1 Compliance with rule (1) (persons in the water)

No person was recorded entering the water within 300m of marine mammals, resulting in 100% compliance with this rule.

Note-worthy occurrence:
One “potential swim” event occurred, involving a group of dolphins approaching close to a popular beach on Motuarohia Island. Approximately 40 people were present on the beach, and while no one fully entered the water, several persons were observed on the water edge, not exceeding knee-deep.

3.4.2 Compliance with rule (2) (vessels within 300m of marine mammals)

Across all encounter time (both within and out of the Safe Zones), a total of 36 non-permitted vessels were recorded entering within 300m of marine mammals. 72.2% (n=26) were recorded entering at 0-5knots, 16.7% (n=6) at 6-10 knots, 5.6% (n=2) at 11-15 knots and 5.6% (n=2) at 16-20 knots. 2 of these vessels (one Rec power, one Commercial) were observed stopping once within 300m of the marine mammals, and moving again once the marine mammals were several hundred meters away, resulting in 5.6% compliance with this rule.

Note-worthy occurences:

- The DOC compliance vessel was observed monitoring an encounter on one occasion, resulting in several vessels being stopped outside of 300mm of marine mammals, then continuing without entering within 300m of marine mammals.

- Two instances of vessels actively driving/"doughnuting" over dolphins were recorded.
- Non-permitted Commercial vessels were observed actively turning towards and following dolphins on two occasions.
- Several vessels, while not stopping, were observed manoeuvring at significantly low speeds (i.e., <2 knots) while within 300m of marine mammals.

3.4.3 Compliance with rule (3) (Marine Mammal Safe Zones)

A total of 882 legs were recorded (Figure 6). Each leg speed was calculated, with an overall average of 7.5 knots (SE=0.24). No clear difference in average speed for each vessel type was observed between the two zones (Figure 6).

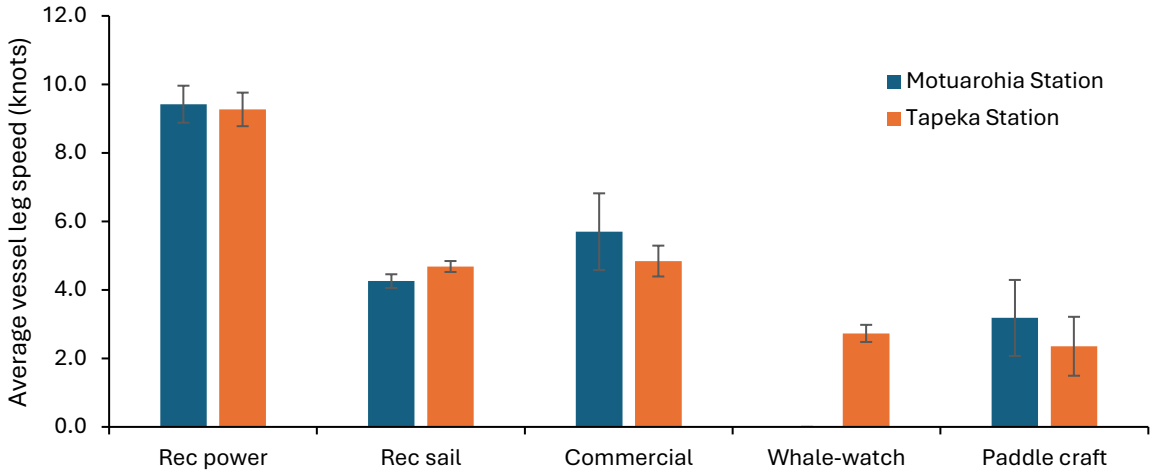

Figure 8. Average vessel leg speeds in the Motuarohia and Tapeka Safe Zones, between January and February 2025 in the Bay of Islands, New Zealand

For each vessel type, leg speeds were categorised in 5 knots increments.

Number of instances

Across all zones and all vessels, 41.9% of recorded leg speeds were compliant (below 5 knots, n=370). Leg speeds below 5 knots were divided between Rec power (42.4%, n=157), Rec sail (45%, n=168), Commercial (8.9%, n=33), Whale-watch (0.5%, n=2) and Paddle crafts (2.7%, n=10).

No clear trends were observed in speed by vessel type between the two Safe Zones (Appendix 1).

Across all Safe Zones and vessel types, 513 legs were recorded above 5 knots, resulting in 58.2% non-compliance in instances recorded.

Rec power vessels were mostly recorded at speeds of 5-10 knots (40.5% of Rec powers legs, n=220). Rec power vessels were additionally recorded at speeds of 10 – 15 knots on 68 occasions (12.5% of Rec powers legs) and at speeds over 15 knots on 98 occasions (18.1% of rec power leg speeds recorded), resulting in overall 71.1% non-compliance in instances recorded for Rec power.

Rec sail, commercial, Whale-watch and Paddle crafts were mostly recorded at speeds of 0-5 knots (Figure 7), resulting in 63.2%, 57.1% and 100% compliance levels in instances recorded, respectively.

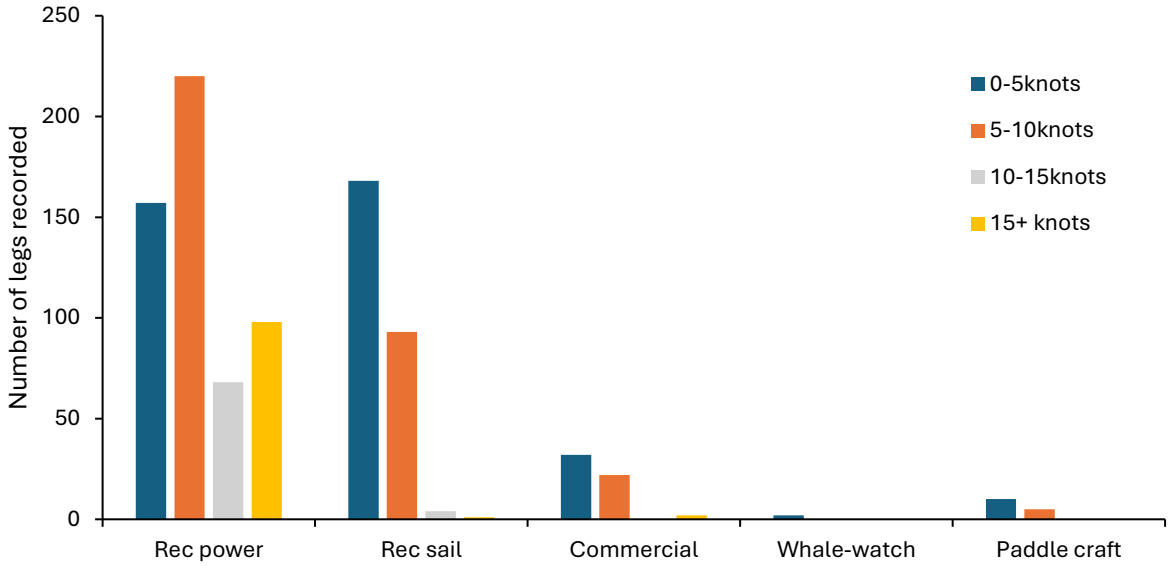

Figure 9. Number of legs recorded for each speed category within both Bay of Islands Marine Mammal Sanctuary Safe Zones between January and February 2025, New Zealand.

Time spent in each speed category

To bring a time-weighted picture, the time spent in each leg was calculated, for each vessel type and speed category (Table 5). The duration of all legs totalled 65.85 hours, and varied from 0.1 minutes to 39.7 minutes per leg. Rec power, Commercial and Rec sail vessels were the only vessel types recorded in the 15+ knots category. Whale-watch vessels and Paddle crafts were only recorded in the 0-5 knots and 5-10 knots categories.

Across all vessel types, vessels were compliant 59.3% of the time.

Table 5. Duration (hours) of legs by vessel type for each speed category between January and February 2025 in the Bay of Islands, New Zealand.

Speed categories	Rec power	Rec sail	Commercial	Whale-watch	Paddle craft	Total
0-5knots	12.42	20.40	3.88	0.12	2.25	**39.07**
5-10knots	12.66	7.17	1.58	0.12	0.26	**21.79**
10-15knots	2.55	0.13	0.00	0.00	0.00	**2.68**
15+ knots	2.22	0.00	0.09	0.00	0.00	**2.31**
TOTAL	29.86	27.71	5.54	0.24	2.50	**65.85**

Across all vessel types, vessels were compliant 59.3% of the time. Rec power vessels were non-compliant most of the time (58.4%). Rec sails were compliant 73.63% of the time, commercial vessels were compliant 67.0% of the time, and kayaks were compliant 89.8% of the time (Figure 8).

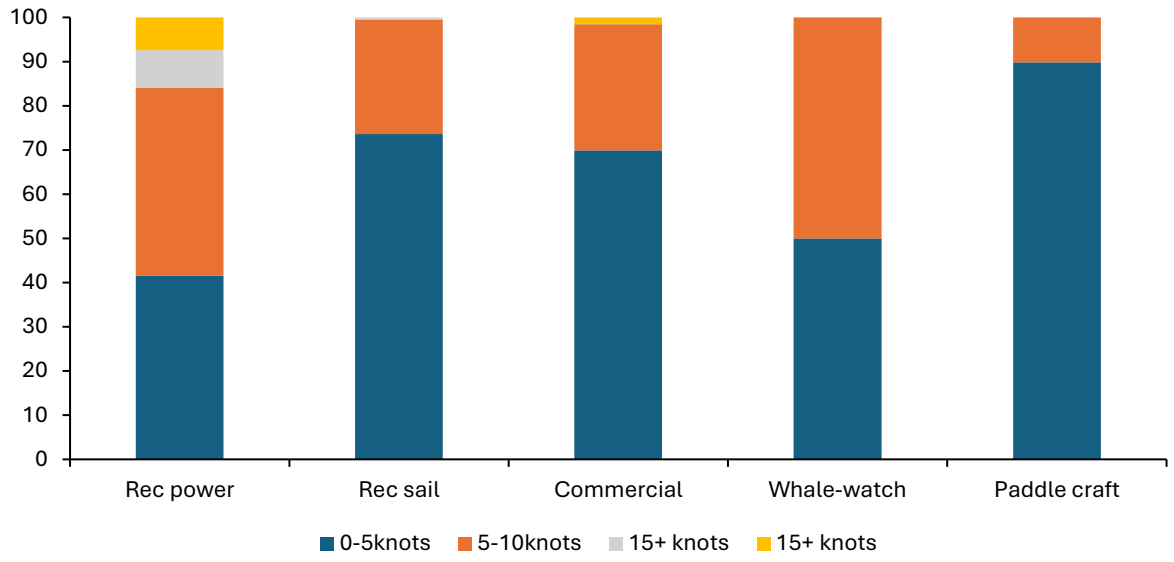

Figure 10. Percentage of time spent in each speed category for each vessel type in both Bay of Islands Marine Mammal Sanctuary Safe Zones, between January and February 2025, New Zealand.

When looking at each Safe Zones separately, the overall trends were similar. Results are presented in Appendix 2.

3.5 Educational outreach

Beyond the data collected, the land-based stations also offered an opportunity for educational outreach, thanks to the visitors coming to the stations on a daily basis.

At the Motuarohia Station, an approximate 120 visitors came to the station per survey. At the Tapeka Station, an approximate 40 visitors came to the station per survey, resulting in an overall approximate 1,480 persons witnessing the research taking place, and often taking part in active conversations with the research team, between January and February 2025. This included international and local visitors, as well as local commercial operators.

Furthermore, theodolite data collection offers the potential for internships/casual positions both from international students and local enthusiasts, including from local Hapu. During this project, 3 members of the Heteri A Nuku program, as well as two international interns, were able to participate in data collection.

4. Summary of deliverables

4.1 Habitat use, movement patterns and behaviour of all marine mammals

Bottlenose dolphins were observed and monitored for 5.9 hours out of the 86.4 hours of survey. No other marine mammal species was observed. Bottlenose dolphins were recorded within both BOIMMS Safe Zones on several occasions, for a total of 1.0 hours (1.2% of survey time, on 21% of survey days). A total of 96 behavioural observations were made, including Traveling (56.3%), Socialising (21.2%), Foraging (11.5%), Milling and Resting (5.2%). No spatial patterns between behaviours were observed.

4.2 Vessel presence within the BOIMMS safe zones

A total of 638 vessels were recorded entering the 5-knot zones (254 at the Motuarohia Station and 384 at the Tapeka Point station.), including Rec power vessels (65.5%, n=418), Rec sail vessels (26.7%, n=170), Commercial vessels (5.0%, n=32), Paddle crafts (2.5%, n=16) and Whale-watch vessels (0.3%, n=2). Vessels spent 9.8% of the time inactive (at anchor or drifting) within the zones. Vessel presence hierarchy was similar in both Safe Zones.

4.3 Vessel compliance with the MMPR and BOIMMS

Rule (1) (Person in the water): No swim-with event was recorded, resulting in 100% compliance with this rule.

Rule (2) (Vessels within 300m of marine mammals): Most vessels (72.2%) were recorded entering within 300m of bottlenose dolphins at speeds of 0-5knots. 2 out of 36 (5.6%) vessels were observed clearly stopping once they had become aware of the marine mammals' presence.

Rule (3) (Marine Mammal Safe Zones): When looking at instances (i.e. number of legs recorded), most vessels were non-compliant (41.9% compliance). Rec powers were non-compliant in 71.1% of instances. Rec sail, Commercials, Whale-watch and Paddle craft vessels were compliant on most instances resulting in 63.2%, 57.1% and 100% compliance levels, respectively.

When looking at time spent in each speed category, across all vessel types, most vessels were compliant (59.3%). Rec powers were non-compliant most of the time (58.4%). Rec sails were compliant 73.63% of the time, commercial vessels were compliant 67.0% of the time, and kayaks were compliant 89.8% of the time.

5. Conclusions and perspectives

This study highlights the effectiveness of land-based theodolite data collection in documenting marine mammal distribution and behaviour, as well as monitoring vessel compliance with regulations. In the Bay of Islands, the elevated vantage points in both zones provided accurate recordings of both mammal and vessel behaviours and speeds, eliminating potential biases that could arise from the presence of a research vessel. Theodolite data collection offers a high level of precision in an area where obtaining accurate measurements (such as speed and distances over water) can be challenging. This leads to reliable results and well-informed management recommendations.

Furthermore, there is potential to refine and enhance the methods used in this study, with future research exploring areas such as marine mammal changes in travel speed or direction in response to different boat approaches. This could lead to the creation of simulations from the collected data, offering valuable insights for the sustainable management of mammal-vessel interactions.

Data were collected over two summer months, meaning the study does not account for all seasons and is limited in its scope. As such, this work should be regarded as a pilot study, and any management decisions should consider these limitations.

Marine mammal presence in the Safe Zones

The relatively low presence of marine mammals within the Safe Zones raises questions about their effectiveness as a management tool. However, this pattern of use may change, as the zones are located near areas consistently identified as high-density habitats for bottlenose dolphins (Peters 2018, Guerin 2022, Brough et al. 2025). This potential for increased usage could be enhanced by achieving high levels of compliance within the Safe Zones, thereby improving the overall habitat quality, particularly its acoustic environment. Other factors will however also influence dolphin distribution, introducing some

uncertainty to these outcomes. According to Brough et al. (2025), for the Safe Zones to realize their full potential, efforts in education and compliance must be strengthened.

- Preliminary results suggest that, of the BOIMMS rules, the Safe Zones may offer the lowest return on investment when weighing the benefits to marine mammals against the costs of maintenance, compliance, and educational obligations.
- To improve passive education, larger buoys could be used to mark the Safe Zone, making it more visible and providing a space for on-the-water educational material.
- Increasing the number of patrols would help improve overall compliance.
- As noted during the implementation phase, cultural considerations should be integrated alongside scientific findings when making decisions about the Safe Zones.
- Year-round data collection on marine mammal presence within the Safe Zones is recommended to obtain a more accurate and comprehensive understanding of their use.

Compliance with BOIMMS

Rule (1) – Persons in the water

There was 100% compliance with BOIMMS rule (1) regarding persons in the water. Notably, even when an easy opportunity to swim with bottlenose dolphins arose (dolphins coming close to a popular beach on a warm day), no person entered the water. This could be attributed to the education conducted on board local tourism charters, most of which the present individuals had been brought on.

Rule (2) – vessels within 300m of marine mammals

Most vessels were not compliant with this rule. However, it is worth noting that many vessels were recorded traveling at low speeds (0-5 knots) within 300 meters of marine mammals, in accordance with the Marine Mammals Protection Regulations (MMPR). Only two vessels were observed actively driving over dolphins in an attempt to interact. This may indicate an effort to comply with regulations, or it could reflect a general increase in awareness of the risks of dolphin-vessel interactions, thanks to the BOIMMS compliance and education activities.

Overall, full compliance with Rule (2) is unlikely to be achieved, both due to public awareness and willingness, as well as the challenge vessels face in noticing dolphins within 300 meters. To more accurately assess the effectiveness of this rule, management should consider a broader approach than simple compliance/non-compliance. This should include evaluating the severity of breaches and the overall impact on marine mammal behaviour.

Rule (3) – Marine Mammal Safe Zones

Compliance levels with the Safe Zones varied by vessel type, with recreational power vessels showing the lowest levels of compliance. This is likely due to the fact that many of these vessels can reach higher speeds, rather than differences in skipper behaviour across vessel types. This study highlighted the importance of assessing compliance in various ways: the number of instances of non-compliance was high, but the time spent at each speed showed a majority of compliance. This discrepancy is likely because speeding vessels spend only short amounts of time within the Safe Zones, emphasizing that precise wording and methods are crucial when evaluating compliance levels.

Overall recommendations

- A “breach level” approach (i.e., minor, medium, or major breaches) may provide a more accurate way to assess BOIMMS efficiency than a strict compliance/non-compliance framework, both in compliance monitoring and scientific research efforts.
- Compliance can be assessed in different ways, yielding varying results. Management should establish clear and precise methods for assessing compliance, ideally adaptable across different regions and species.
- A post-BOIMMS implementation study, updating the results from Peters & Stockin (2016) and Guerin (2022) on the behavioural effects of vessel interactions, should be conducted to assess the effectiveness of Rule (2).

  Such a study would ideally be structured as a yearly monitoring program, stepping from the methods previously used in the Bay of Islands, with both yearly reports and a 3-yearly report to be provided to conservation management prior to each 3-yearly BOIMMS review. Objectives should include all marine mammals, with a focus on bottlenose dolphins, and include the following:

  1. **Theodolite tracking**
     - Provide updates on marine mammal use of the BOIMMS Safe Zones, including distribution and behaviour within and around the Safe Zones
     - Provide updates on compliance levels with both BOIMMS and MMPR, as outlined in this report

  2. **Vessel surveys**
     - Provide updates on marine mammal distribution and abundance through systematic surveys (i.e. distance sampling) and mark-recapture. For bottlenose dolphin, mark-recapture methods should follow previously used methods in the Bay of Islands (Constantine 2002, Tezanos-Pinto et al., 2013, Peters & Stockin 2016, Guerin 2022, Brough et al., 2025) and used to continually update the ID catalogue created by Brough et al. (2025).
     - Provide updates on vessel effects on marine mammal behaviour, following Peters & Stockin (2016).
     - Provide updates on calf survival, following Tezanos-Pinto 2009).

  3. **Passive acoustic monitoring**
     - Assess both diurnal and nocturnal marine mammal utilisation of Safe Zones using fixed hydrophones, year round.
     - Provide updates on vessel effects on marine mammal behaviour, especially whistle repertoire, following Peters (2018).

The monitoring program should additionally allow for the exploration of additional objectives, as needed, such as diet, prey movement, habitat suitability, or other.

The Bay of Islands offers a unique opportunity for an above, on, and below the water approach, informing conservation management in a holistic way. To be successful, such a program should also offer the opportunity to involve the community and stakeholders, through volunteering, short training courses, and paid Research Assistant positions. Local Hapu, permitted whale-watch, and non-permitted commercial operators should be a particular focus of the outreach part of the program.

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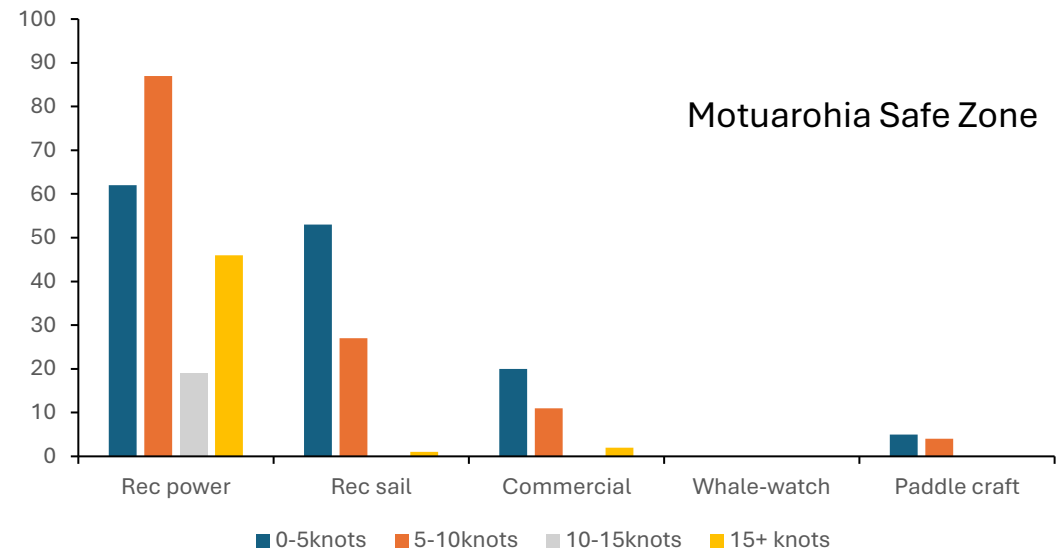
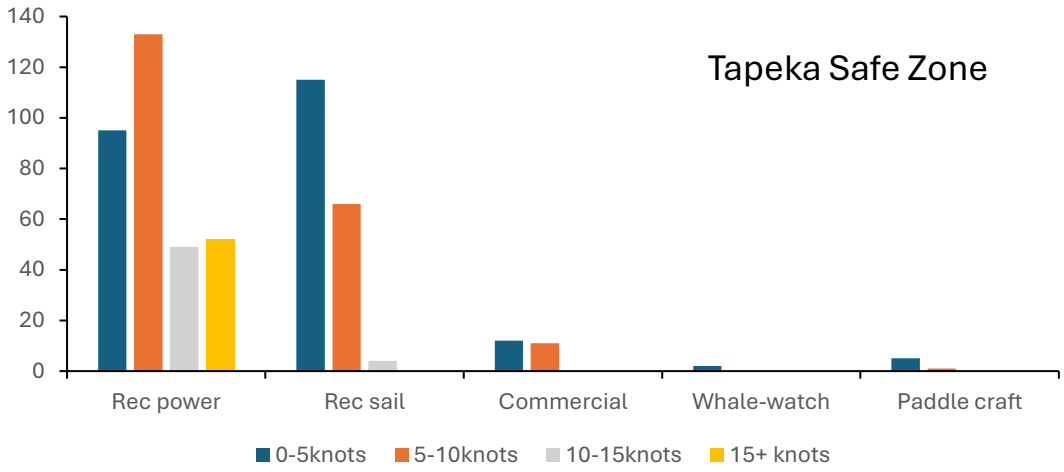
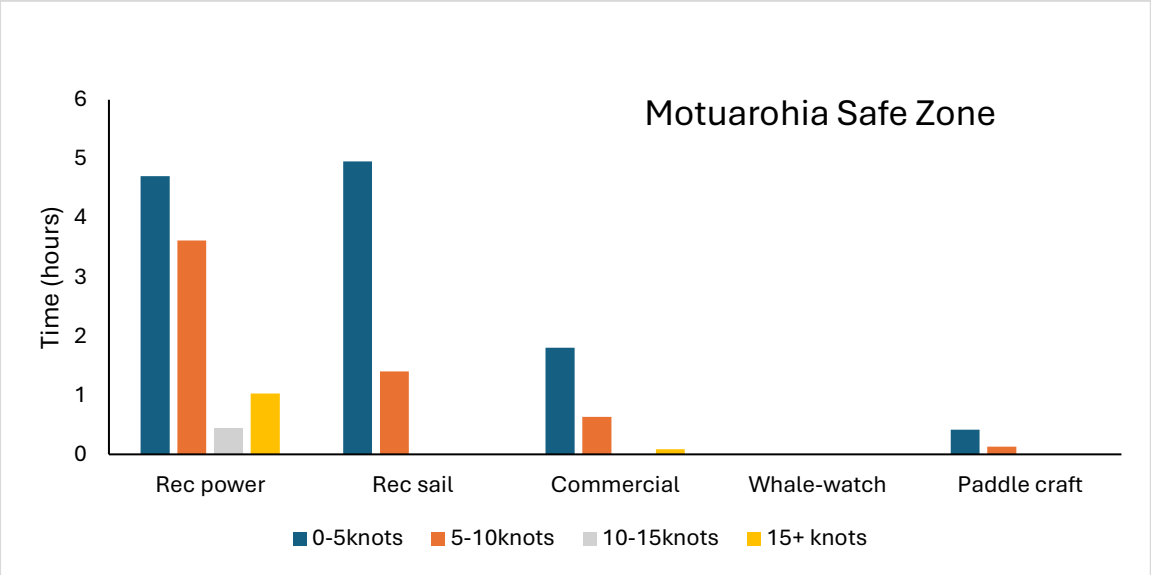
Appendix 1

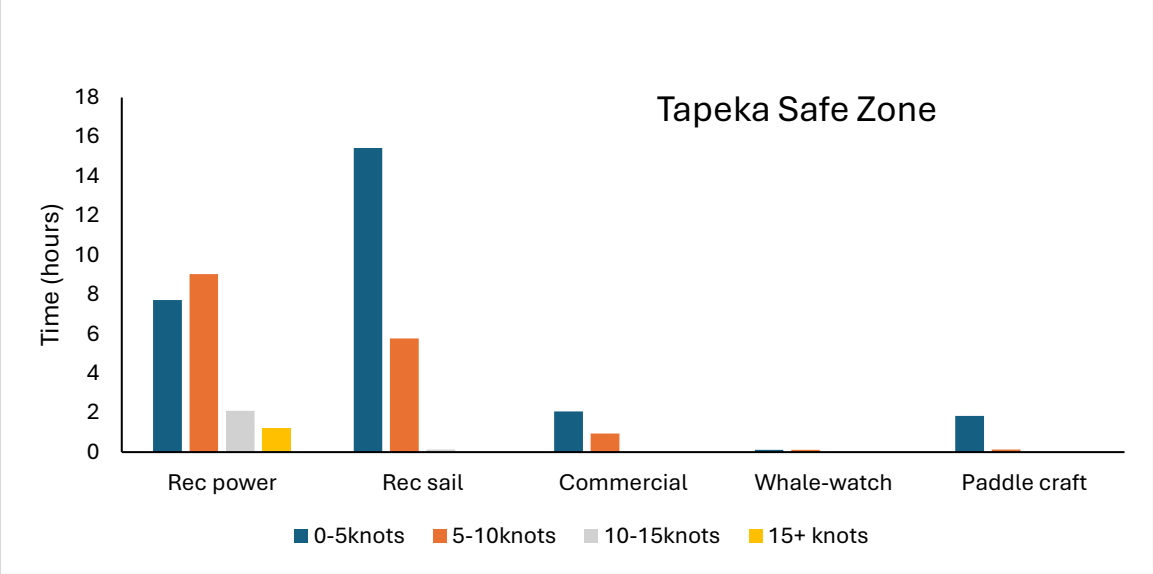




Number of legs recorded for each speed category within A) the Motuarohia Safe Zone and B) the Tapeka Safe Zone in the Bay of Islands Marine Mammal Sanctuary between January and February 2025, New Zealand.

Appendix 2





Time spent in each speed category for each vessel type in both Bay of Islands Marine Mammal Sanctuary Safe Zones, between January and February 2025, New Zealand.