Final progress report for the Department of Conservation, Northland
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Responses of bottlenose dolphin (*Tursiops truncatus*) to vessel activity in Northland, New Zealand

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Note from the authors

This report meets a requirement of a tendered research contract between the Department of Conservation and Massey University. The department initiated this research in direct response to concerns over sustainability of the tourism industry in the Bay of Islands, New Zealand. As part of the consultation for this study, operators were engaged by both the department and Massey University and kept informed of the proposed research.

In the framework of this study and in agreement with the associated Department of Conservation contract, some of the data presented here were collected aboard tour vessels operating in the Bay of Islands. Access to the tour vessels for the specific purpose of the pre-determined research remit was agreed between all stakeholders including but not limited to the Department of Conservation and the tour operators at the outset of research project. Operators invited the Principle Investigator (Catherine Peters) and associated research assistants to board their platforms with the express intent of collecting data with respect to the predetermined research remit. On a daily basis, permission to board each tour vessel was further discussed between the observers (Catherine Peters and/or the research assistants) and the tour operators. Furthermore, an introduction of the on-board researchers to the patrons was undertaken along with a brief dialogue about the data collection being undertaken and the overarching purpose of the study.

Disclaimer: Data presented herein represents only data collected within the BoI between December 2012 to April 2015 and is in accordance with the specific contract objectives outlined by the Department of Conservation. Extended data collected both temporally and spatially outside these objectives are the focus of a PhD underway to be fulfilled by Miss Peters. Material presented in this report should not be cited in any format without the written consent of the authors and the Department of Conservation.

1. *Executive summary*

Presently, three commercial marine mammal tourism operators are permitted to view and swim with bottlenose dolphins (*Tursiops truncatus*) in the Bay of Islands (BoI), New Zealand. Concerns over the local decline of the species (Tezanos-Pinto 2013; Tezanos-Pinto et al. 2013) and developments in the industry following previous research findings have resulted in the need for a comprehensive review of the current management regime using updated empirical data on habitat use, site fidelity, and behavioural responses, including vessel interactions. The present report describes the results of a dedicated continuous study between December 2012 and April 2015 and provides management recommendations to ensure adequate protection of this local population of *nationally endangered* bottlenose dolphins (Baker et al., 2010).

Data collection between December 2012 and April 2015 comprised a total of 81,892 km of track surveyed whilst on effort (4,027 hrs). Coastal bottlenose dolphins (referred to hereafter as bottlenose dolphins) were the most encountered species within the study area with 0.05 bottlenose dolphin sightings/hour (88.0%, n=2,015).

Season-specific extent of bottlenose dolphin range use within BoI waters indicated a variable resight rate, with a total of 96 uniquely identifiable individuals documented. The current estimate is less than previously reported, with a 65.5% decline since 1999 (278 identified in 1997-1999 (Constantine 2002)) and a 39.6% decline since 2005 alone (159 in 2003-2005 (Tezanos-Pinto et al., 2009)). All 19 core frequent users (≥ 8 sighting/lunar month) were observed year round. The majority (60.4%, n=58) were defined as infrequent users (≤ 1 sighting/lunar month). Frequent users and occasional visitors (2-7 sighting/lunar month) represented a further 19.8% (n=19) each. While broad scale distribution is consistent with previous studies (Hartel et al., 2014), fine-scale habitat use has shifted to a small area around Tapeka Point and the eastern end of Roberton Island, resulting in minimal use of current designated rest areas (7.0%, n=16). A mean of 2.8 bottlenose dolphin groups encountered per day was observed across the study period (range 0-5, SE=0.03, n=692 days). The largest number of sightings occurred in summer and autumn, with 0.03 sightings/km effort (31.0%, n=626 and 30.9%, n=624 of all sightings, respectively) and least in winter with 0.01 sightings/km effort (12.8%, n=259). Groups containing immature dolphins were also more frequent in summer, including 55.2% (n=466) of all calves and neonate sightings, suggesting reproductive seasonality in the BoI. A total of 10 identifiable adult females were observed with 12 young of the year calves. Only three (25.0%) are suspected to have survived their first two years to perceived independence, representing an increase in mortality in the first two years of life, as compared to 1994-2006 (Tezanos-Pinto 2009 and Tezanos-Pinto et al., 2015).

This study indicates sensitisation to vessel interactions with disruption to critical behaviours, representing further sensitisation compared to Constantine et al. (2003). Whilst behavioural budget comparisons can be drawn with previous studies in the BoI, until now it was not possible to determine the broader extent of vessel disturbance to dolphin groups. The current study addresses this via the analysis of behavioural transitions, time to return to behavioural state and behavioural bout length. Dolphins in the BoI spend on average 85.7% of daylight hours with at least one vessel, with a cumulative diurnal behavioural budget (control + impact) that varies significantly from the control behavioural budget (goodness-of-fit test, $G^2_{adj.}$=0.37, df=1, p<0.001).

The current level of effort correlated with significant effects on all behaviours by time of day/season, vessel presence, vessel number, vessel type and vessel activity. Overall, dolphins spent more time traveling, resting and foraging in absence of vessels within 300 m of the dolphin group, which in the

presence of vessels decreased by 69.7%, 133.3% and 160.0% respectively. In addition, dolphins generally spent more time socialising, diving and milling in presence of vessels, which increased by 126.3%, 300.0% and 247.6%, respectively.

Key biologically important behaviours decreased significantly in the presence of vessels with resting (z=1.060, p<0.001) and foraging (z=1.560, p=0.036) bouts shorter by 22.9% and 13.3%, respectively. As the number of vessels present with dolphins increased up to two vessels, the behavioural budget decreased for resting (95%) and foraging (57.1%). As the number of vessels present within 300 m of the focal dolphin group increased from ≥ 2 to ≥ 4, the magnitude of change increased with particularly strong effects noted during the presence of ≥ 4 vessels on the behavioural budget of foraging (64.3%). Un-permitted vessels had the strongest effect on foraging (87.5% decline). Resting didn't occur in the presence of un-permitted vessels. Overall, private vessel presence resulted in a decrease in foraging (62.5%) and resting (95.0%), as well as permitted vessel presence (68.8% and 100.0%, respectively). Permitted vessels had the largest magnitude change on resting. The likelihood to stay in a given state in the presence of vessels was reduced for foraging and resting by 11.5% and 21.2%, respectively. No resting bouts were initiated when a vessel was already interacting with dolphins. Time required to return to a given behavioural state was significantly affected by the presence of vessels for all 6 behaviours (Table 16). Primarily when foraging (z=4.732, p=0.004) or resting (z=4.447, p<0.001), bottlenose dolphins took significantly longer to return to these states in the presence of vessels, with time increasing by 262.0% and 725.6%, respectively.

Poor compliance with MMPR (1992) was observed across all vessel types. Beyond this, non-compliance was also observed for permitted vessel conditions resulting in 63.2% (n=12) violation of mandatory conditions, at varying levels, across operators. Results indicate current mitigation efforts have not been successful. Clear and/or easy to follow regulations are more likely to be respected. Private vessels were the most prevalent type of vessels recorded in the BoI (36.0%, n=6,274). However, both permitted and un-permitted vessels also demonstrated a strong presence, accounting for 33.0% (n=5,752) and 31.0% (n=5,403) of the vessels observed in the bay, respectively. All vessel types exerted significantly more cumulative viewing effort in spring/summer than autumn/winter. Cumulatively, permitted vessels spent significantly more time viewing dolphin groups (range=0-138, median=62.5, n=5,752) than un-permitted vessels (range=0-48, median=29, n=5,403) (Kruskal-Wallis: h=39.63, df=2, p<0.001). Private vessels spent significantly less time with dolphin groups (range=0-45, median=16, n=6,274) than permitted (Kruskal-Wallis: h=29.43, df=2, p=0.013) and un-permitted vessels (Kruskal-Wallis: h=27.04, df=2, p=0.018).

The local BoI bottlenose dolphin population is at high risk of a continued decline to localised extinction unless critical action is taken. Management in the BoI must address all vessels utilising the area to address the trend of continued decline. Protection measures should be adaptive, extend beyond permit conditions and need to be supplemented with educational and enforcement programs (Keane et al., 2008) to promote compliance with regulations. Cumulative existing effort with dolphins needs to be down regulated. Clearly defined legislation which allows significant authority, including that of revoking operator permits (Bejder et al., 2006b; Higham & Bejder, 2008) and penalising any non-compliance, regardless of vessel type, in a way that is fair and reasonable is required. This study demonstrated that 88.0% of all encounters between permitted vessels and marine mammals are with bottlenose dolphins. The localised loss of this species from the BoI would result in the local marine mammal tourism industry losing its economic core and long-term viability in the region.

2. Introduction

Worldwide, the marine environment and our use of it is changing. One such way is the ever-adapting cetacean focused tourism industry. This type of tourism can present a potentially sustainable use of cetaceans and an economically viable alternative to whaling (Hoyt 1995). Cetacean watching may improve public attitude towards the marine environment (Orams 1997) and promote support for conservation issues (Bejder et al., 1999; Dwyer et al., 2014), while simultaneously benefiting local economies (Berggren et al., 2008; Hoyt 2001). However, during the last decade cetacean watching has become more interactive than the traditional passive vessel viewing (Spradlin et al., 2001). This can place cetaceans at higher risk of being harassed and/or injured by an unknown number of unpredictable effects associated with cetacean watching/swimming (Bejder et al., 2006; Frohoff & Dudzinski 2001; Parsons 2012). As long-term data on the possible effects of tourism is increasing, it is becoming apparent such activity may be having effects not only at the behavioural level but also at the population level (Bejder et al., 1999; Lusseau 2004). The inter- and intra-species response to watching/swimming has been shown as variable and the need to carefully manage each population separately at a local level has become apparent. This is difficult to achieve in wide ranging cetaceans but more achievable in dolphin populations repeatedly frequenting an area with tourism activity.

New Zealand (NZ) has more than matched the rapid worldwide growth in cetacean focused tourism (O' Connor et al., 2009). Changes in dolphin behaviour in response to tour activity have also been noted in a range of other dolphin species in New Zealand waters including Hector's (*Cephalorhynchus hectori*) (Bejder et al., 1999; Martinez et al., 2011), dusky (*Lagenorhynchus obscurus*) (Lundquist at al., 2012; Markowitz et al., 2009), and common dolphins (*Delphinus* sp.) (Meissner et al., 2015; Neumann & Orams 2005; Neumann & Orams 2006; Stockin et al., 2008).

In New Zealand, previous research focusing on the *nationally endangered* bottlenose dolphins (*Tursiops truncatus*) in Doubtful and Milford Sounds indicate a number of effects of tour activities ranging from changes in dive behaviour (Lusseau 2003), displacement from areas by tour activities (Lusseau 2004), and changes in residency patterns (Lusseau 2005). Motor noise appears to be a key element in these interactions, with effects less pronounced if vessels were driven carefully, in accordance with MMPR's (Lusseau 2006). Research in Fiordland demonstrated a decline in population abundance, as well as in the reproduction rates of the local population of bottlenose dolphins (Lusseau 2006; Lusseau et al., 2006), though tourism may only be one of many factors driving these trends (Currey at al., 2011) and population management options have been presented.

Within NZ waters, coastal bottlenose dolphin inhabit three discontinuous coastal regions (Figure 1), with little mixing between genetically distinct populations (Tezanos-Pinto et al., 2009). Such a population structure (little or no inward or outward genetic migration) means any effects on the North Eastern population would not be mitigated by populations further north and/or south (Baker et al. 2010).

In the Bay of Islands, NZ (referred to hereafter as BoI), dolphin tourism focuses specifically on viewing and swimming with the bottlenose dolphin (Constantine 2002). Indeed, the BoI has a comparably high level of commercial swimming-with-dolphin activities targeting this species. Presently, there are three operators (Fullers Great Sights, Explore NZ and Carino Sailing and Dolphin Adventures) that hold permits under the MMPR (1992) to commercially interact with marine mammals and swim with bottlenose dolphins. These operators cumulatively offer up to ten trips per day that are permitted to view and/or swim with bottlenose or common dolphins in BoI waters. During the course of this study only one swim with common dolphins was observed. In addition, a fourth operator in Tutukaka (Dive Tutukaka) is running a dive operation and is permitted to view marine mammals that they mainly encounter en route to the dive sites, and to swim with common or bottlenose dolphins. Collectively, these operators may exert a high human disturbance levels on dolphin populations in the region.

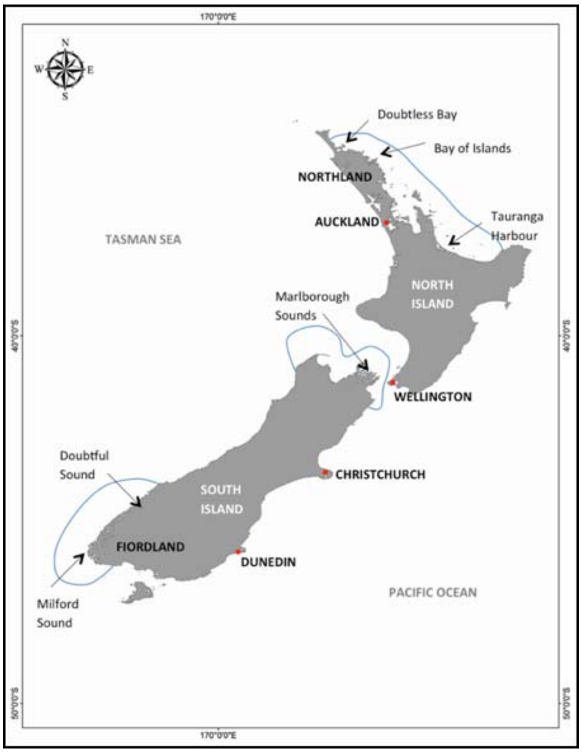


Figure 1: Discontinuous coastal regions of New Zealand inhabited by coastal bottlenose dolphin

Within the BoI, Constantine (2002) documented 278 unique bottlenose dolphins with 59 core users and demonstrated dolphin behaviour differed by vessel number; in particular, bottlenose dolphins rested less and engaged more in milling behaviour when the permitted vessels were present. Furthermore, Constantine et al. (2004) noted that an increase from 49 to 70 permitted trips per week and a subsequent change in trip departure times, resulted in a further decrease in resting behaviour. Successful swims have also been reported to decrease from 48% in 1994-1995 to 34% in 1997-1998, while evidence of sensitization to vessels has also been demonstrated (Constantine et al., 2004). Dolphin response varied according to swimmer placement from the vessels, with only *line abreast* placement resulting in a decrease in avoidance, while *in path* exhibited the highest level of avoidance. If a swim attempt was successful, it involved a mean of 19% of the group, with juveniles more likely to interact with swimmers than adults (Constantine 2002). Observations regarding juveniles and recent studies in the area are notable given the high calf mortality detected in bottlenose dolphins in the BoI (Tezanos-Pinto et al., 2009; 2014).

Abundance trends and developments in the industry have resulted in the need for a comprehensive review of the current management regime (Tezanos-Pinto 2013). The apparent decline of bottlenose dolphin abundance in the BoI (Tezanos-Pinto 2009; 2013) is of particular note. A detailed re-evaluation of tourism effects was undertaken to assess the immediate and potential cumulative effects of current tourism activities on dolphin behaviour. While basic activity budgets served to replicate analyses presented in Constantine (2002) and Constantine et al. (2004) for comparative purposes, more comprehensive analyses were applied to assess behavioural transitions and to model increases in tourism pressure accordingly. Further to this behavioural analysis included un-permitted and private vessel covariates not previously assessed independently. The current research did not focus on staggered vs discrete departure times or changes in the number of permitted vessels as both remained stable throughout unlike in previous research. When historical research began in late 1996, a maximum of 36 swimmers were allowed in the water per vessel/trip. This changed part way through the previous research to 18 swimmers per vessel/trip and three swim drops per operator per trip. The permitted operators adopted the change in swimmer number at various times and, as a result, the assessment of such change was challenging and, thus, could not be examined. Swimmer number was assessed in the current study. This project presents an opportunity to further assess and review the effects of swimmers on the behaviour of bottlenose dolphins.

The Department of Conservation (DOC) contracted this research to obtain a scientific evidence base for management decisions. Results and sound scientific analysis presented herein form the basis of management advice to the department based on the current status quo of bottlenose dolphins in the BoI.

3. Objectives

The DOC is tasked with the management protection and conservation of marine mammals under the MMPA (1978), primarily achieved through the MMPR (1992). This is achieved through the regulation of behaviour of persons coming into contact with marine mammals, for example commercial operators which are required to hold a permit under the regulations. Whilst the department had knowledge of a decline in the local bottlenose population, given the complexity of tourism pressures in the BoI it was unable to determine which aspects of current management needed to be improved. The Department of Conservation commissioned this study to obtain sound scientific advice on how to improve management of the threatened local bottlenose population by better mitigating the tourism impacts it is exposed to. Specifically, this present study aims:

1. Examining season-specific extent of bottlenose dolphin range use within BoI waters.
2. Examining inter-seasonal use of regional waters of bottlenose dolphin within BoI waters.
3. Quantifying and documenting the type, level and operational effort of existing bottlenose dolphin tourism activity within BoI waters.
4. Determining the potential effects of interacting with bottlenose dolphins as currently permitted (viewing and swimming). This includes describing behavioural responses of dolphin groups, and determining if such responses have population level consequences for seasonal and inter-seasonal range use.
5. Integrating the recommendations of former historical research. Specific questions were addressed in order to better understand the effects of vessel traffic on bottlenose dolphins and develop clear measures and guidance. This includes describing behavioural responses of groups and specified age groups. This will be used to determine if such responses have population level consequences for seasonal and inter-seasonal range use. This is based on 1-3 above to i) avoid or minimise human impacts, and ii) measure impacts that quantify thresholds over which further impacts must not occur.
6. Producing statements and recommendations based on 1-4 above regarding existing and future tourism activity particularly in the BoI waters, but also in the wider regions generally.

More explicitly:

1. What is the current level of effort (i.e. swimming and viewing, private and commercial, permitted and non-permitted)? Does the actual current level of effort of swimming and viewing

trips correlate with any significant effects on dolphin behaviour? What implications could this have on the level of effort permitted in the BoI for each activity? Note: this answer needs to take into account the actual level of effort per day in the BoI for each activity, and the current maximum number of permitted trips for each activity.
2. What are the short-term behavioural responses of dolphins in relation to commercial and non-commercial viewing and swimming vessels? Are these activities significant for the population of the BoI? Should these activities be reduced, remain at current levels, or could the level of activity be increased? Do behavioural responses vary between individuals, groups, and specified age groups, if so how? Do behavioural responses vary between what is currently and what was previously reported?
3. What further conditions (if any) could be considered in order to minimise any determined effects? These conditions should address the following questions:
   a) What is the occupancy patterns of bottlenose dolphins? Do the occupancy patterns of bottlenose dolphins in the BoI indicate some areas should be excluded from the commercial operators' permit areas and / or tourism pressure in general, year round or season-specifically?
   b) What is the mean time each permitted operator spends with the dolphins? What is the amount of time permitted operators cumulatively spend with dolphins? What period/s during the day do permitted operators activities exert the greatest effort? In what season do permitted operators activities exert the greatest effort?
   c) What is the mean time each non-permitted vessel spends with dolphins? What is the cumulative amount of time non-permitted vessels spend with dolphins? What period/s during the day does non-permitted vessel activity exert the greatest effort?
   d) Are there any conditions that need review since previous studies? Is the limit on the length of time each permitted operator spends with the dolphins for viewing and swimming, once an interaction is established, still appropriate? Are departure times of permitted vessels appropriate and do they have an effect? Is the current number of swimmers appropriate? Are the current conditions on swimming or swim approaches mitigating any observed effect on bottlenose dolphins, i.e. such as line abreast method for swimming approaches, etc.?
   e) What are the operators' levels of compliance with permit conditions and regulations?
4. What is the potential long-term significance of the current level of tourism activities on bottlenose dolphins in the BoI?
5. Once questions 1,2,3 and 4 have been answered, what are the implications of the current tourism effects in the BoI and how can these findings be used to inform on the wider area? What recommendations could be suggested for managing permitted operations in these areas?

4. Materials and methods
4.1. Study area

Data were collected in BoI waters, Takou Bay to Whangamumu (Latitude 34°51 to 35°05'S, Longitude 173°16 to 174°28'E), on the north east coast of North Island, New Zealand (Figure 2). The bay itself is an irregularly shaped 16km-wide, 260km^2 drowned valley system and a natural sheltered harbour (Hartel et al., 2014), containing 144 islands in addition to numerous peninsulas and inlets. The survey area was particularly selected as it includes the current and potential future areas (including marine mammal tour permit exclusion areas) utilised by dolphin tour operators.

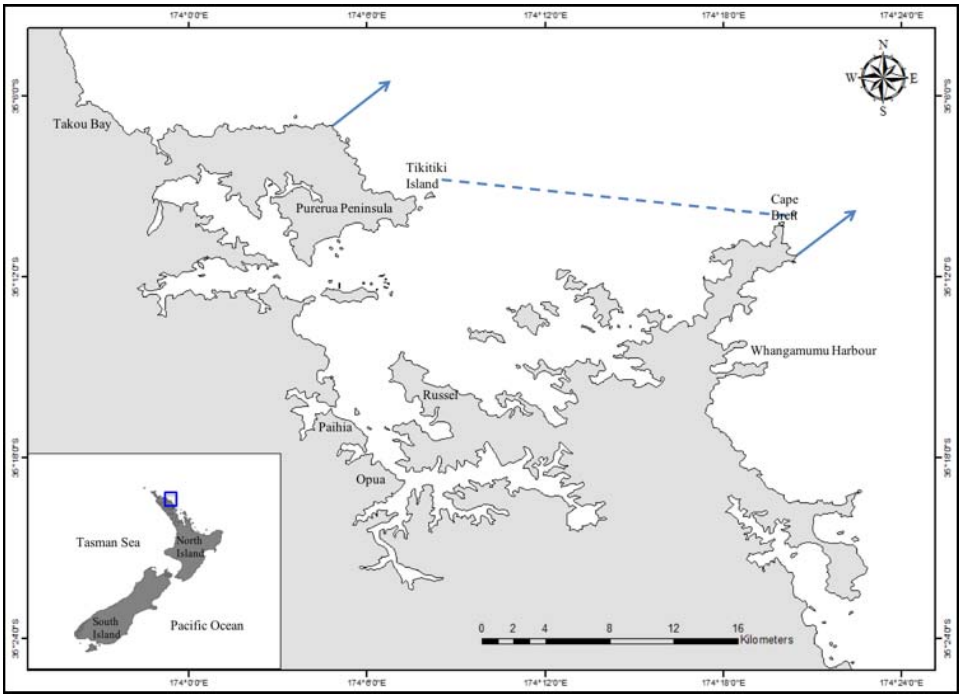


Figure 2: Bay of Islands study area, New Zealand. The dashed line indicates operational limits for Carino sailing and dolphin adventures. All other permitted vessels operational limits are depicted as the area between the arrows.

4.2. Survey platforms

Surveys were conducted year round from December 2012 to April 2015, between sunrise and sunset, and therefore included the peak tourism season (December-March) in the BoI. Data were collected from two primary platforms: 1) Research vessel *Te Epiwhania*, a 5.8 m Stabicraft vessel powered by a 100 hp four-stroke engine; and 2) seven platforms of opportunity (permitted vessels) based in BoI (Figure 3). Both types of platforms have proven utility in tourism effects studies, although each has its own limitations (refer to Bejder & Samuels 2003 for review). Both platforms were used concurrently in order to collect complementary data, and methods standardised, thereby overcoming some of the analytical and logistical limitations of using only one research platform and allowing for cross referencing of data.

All platforms were used to quantify and document 1) the type and number of vessels within 300 m relative to the focal dolphin group, 2) vessel movements, 3) swimmer deployment and swim approach parameters, 4) number and identity (where possible) of dolphins interacting with permitted vessels via photo-id and 6) general occurrence in relation to abiotic parameters. Further to this, the research vessel was also used to collect data on dolphin occurrence, behaviour in relation to presence and absence of vessels via *focal dolphin group* observations and conduct whole group photo-ID (Neumann 2005). Opportunistic platforms were used to perform *focal permitted vessel* observations of changes in dolphin behavioural state and frequency during an encounter (Lundquist 2012; Markowitz et al., 2009; Martinez 2010).

4.3. Surveys

As platform height is known to affect the detectability of cetaceans at sea, survey conditions were assessed in relation to the observational platform used (Hammond et al., 2002). Owing to the lower eye height of *Te Epiwhania*, and consequently reduced detectability of dolphins, surveys were conducted in good weather conditions (Beaufort sea state, BSS, ≤3) and in good visibility (≥1 km) (Dwyer et al., 2015). Surveys on board the permitted vessels were conducted in good to moderate weather conditions (BSS ≤4) and in good visibility (≥ 1 km). Surveys were discontinued in precipitation, fog or if the BSS exceeded the acceptable limit.

4.4. Research vessel methodology

Survey transects were selected on the beginning of the day based on prevailing weather, sea conditions and on the extent any particular area had been previously surveyed within that month (the overall intention being to cover most areas, where possible, within any given month, Figure 4, Dwyer et al., 2015). Direction of travel was based upon sea state and wind direction; with vessel speed maintained at approximately 11 knots (knts) in accordance with published methods (Cañadas & Hammond 2008; Dwyer et al., 2015; Stockin et al., 2008a).

At the onset of each survey, start time on the water, observer ID, observer assignments, tides and environmental conditions (*e.g.*, visibility, swell height and BSS) were recorded. Once the initial data had been collected, the vessel was operated at survey speed and *on survey* mode commenced. Subsequently, the following variables were logged at 15 min intervals: BBS, swell height, observer field of view and glare (de Boer et al., 2008). Observational and environmental data were collected using either a HTC Touch Pro2 Windows Mobile device or Acer Iconia B1 tablet computer with associated Garmin GLO GPS device. CyberTracker (CyberTracker Conservation, Version 3.296+) software was programmed to record continuous GPS tracks (with GPS recordings every 30s).

Figure 3: Massey University research vessel *Te Epiwhania* (A) and Bay of Islands permitted vessels: Explore NZ *DV* (B), Explore NZ *DIV* (C), Explore NZ *DIII* (D), Fullers Great Sights *Dolphin Seeker* (E), Fullers Great Sights *Tangaroa* (F), Fullers Great Sights *Tutunui* (G) *and Carino Sailing and Dolphin Adventures* (H). (Photographs: A. Coleing, M. Quintin, C. Peters).

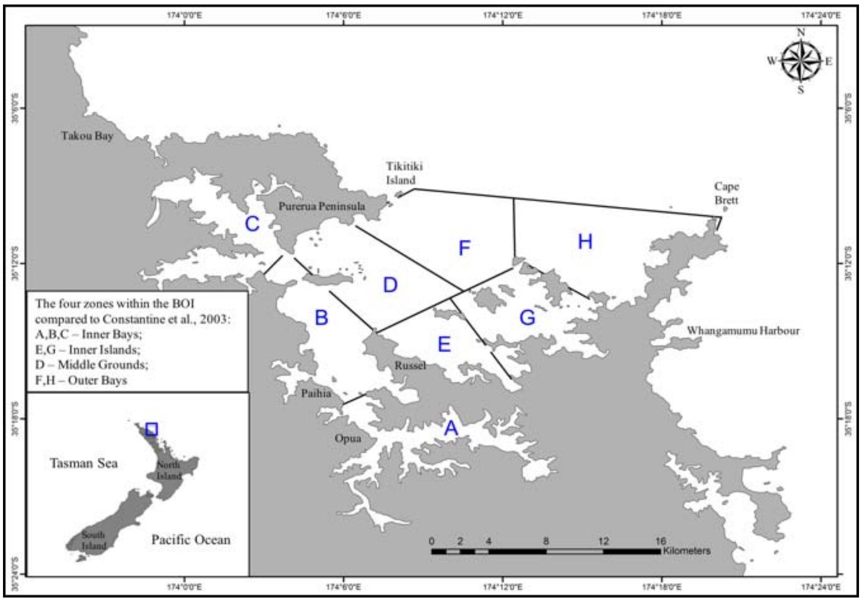


Figure 4: Designated survey zones (modified from Constantine et al., 2003) utilised between December 2012 and April 2015, in Bay of Islands waters, NZ.

During *on survey* mode, dolphins were detected by naked eye and/or binoculars using a scanning methodology (Mann 1999). At the start of each observation period, a systematic scan began. Three experienced observers continuously scanned to the horizon (Lusseau 2006), with one observer scanning from 055 to 175°, a second searching from 175 to 315° and a final observer scanning from 055 to 315°. Observers started in opposite directions to ensure an approximate equal time interval between successive scans for any point within the field of view. To prevent fatigue, observers rotated their positions every hour or at each *on survey* point. Standard sighting cues including splashing, fins breaking surface waters, vessel behaviour and presence of birds were used to detect dolphin groups (Constantine 2002; Lusseau 2006).

Once a group was located, all observers were focused on data collection pertaining to the focal group encountered (Mann 1999; Stockin et al., 2008a; b). As such, no further search effort was undertaken for new groups during this time. In accordance with the Marine Mammal Protection Regulations (MMPR) 1992 (Part 3), the research vessel was operated so as not to disrupt the normal movement or behaviour of any marine mammal. When the research vessel was within 300 m of any marine mammal, it was manoeuvred at a constant idle or *no wake* speed in such a way that no animal was separated from the focal group. This involved approaching groups from the side or behind and moving in the same direction as the group as far as possible (Stockin et al., 2008b).

Once within 300 m of the group, environmental parameters including water depth (± 0.1 m) and SST (sea surface temperature) (± 0.1°C) were recorded using an on board depth sounder and a hand-held digital thermometer, respectively (Stockin et al., 2009a). Biotic parameters pertaining to group size and composition, group behaviour and associated species were logged respective to time and GPS coordinates (as above). Species and ecotype were confirmed at the onset on data collection. External morphological separation of the 2 ecotypes was deemed an appropriate criterion for classification (Zaeschmar 2015; Visser et al. 2010). The oceanic form is comparatively more robust and typically exhibit wounds and scars, presumed to be inflicted by the cookie cutter shark (*Isistius* spp.) (Constantine 2002, Dwyer and Visser 2011). In contrast, the New Zealand coastal form does not usually exhibit cookie cutter shark scarring (Constantine 2002), is smaller in body size and paler in colour.

A group was defined as any number of individuals observed in apparent association, moving in the same direction and often but not always, engaged in the same activity >5 body length apart (Constantine 2002; Constantine et al., 2004; Shane 1990). Groups were considered independent if they were encountered at a spatial or temporal scale that prevented the same individuals becoming resampled (Stockin et al., 2009a). For this study, subsequent groups were considered independent if separated by >5 km or sighted >30 min after the previous group. Where feasible, this was additionally confirmed via photo-identification. Photo-identification of individual bottlenose dolphins was conducted during encounters using a Nikon D90 camera fitted with a AF-S VR ZOOM-NIKKOR 70-300MM F4-5.6G IF- ED lens, following previously outlined methods (Dwyer et al, 2015; Tezanos-Pinto et al., 2009; 2013) and at times when the dolphin behaviour and the sea state were conducive to undertaking photo-identification. Images of the dorsal fin of each identified individual was compared across encounters in order to assess the minimum number of individuals using BoI waters, site fidelity and any possible individuals exhibiting continued attraction to vessels.

Group sizes were logged according to three categories; the absolute *minimum* number of dolphins counted, the absolute *maximum* number of individuals believed to be in the group and the *best estimate* for the most likely number of dolphins in the group (Dwyer et al., 2015). Group size estimates were recorded for mixed (any combination of adults accompanied by juvenile and/or calf and/or neonate) and adult only groups (Table 1).

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).

Table 1: Age class definitions of bottlenose dolphins based on Constantine et al., (2003) for the Bay of Islands waters, New Zealand.

Age class	**Definition**
Neonate	Classified by the presence of white dorso-ventral foetal folds down their sides (Cockcroft & Ross 1990b, Kastelein et al., 1990). Typically displayed poor motor skills and were often uncoordinated upon surfacing to breathe (Mann & Smuts 1999). The neonate stage usually lasts up to 3 months of age.
Calf	Defined as dolphins that were approximately one-half or less the size of an adult and were closely associated with an adult, often swimming in ‘infant position’ (i.e., in contact under the mother) (Mann & Smuts 1999).
Juvenile	Approximately two-thirds the size of an adult and were frequently observed swimming in association with their mothers but were never observed swimming in 'infant position' (i.e., in contact under the mother; Mann & Smuts 1999), suggesting they had been weaned (Mann et al., 2000).
Adult	All dolphins (including assumed mothers) that were fully-grown, i.e., equal or greater than 3m in total body length.

Every three minutes, in addition to the predominant behaviour, the following variables were also recorded: group dispersal, group heading, and number of vessels. Group dispersal was defined as:

- State 1: dolphins 0 – 2 dolphin body lengths apart
- State 2: dolphins 3– 6 dolphin body lengths apart
- State 3: dolphins 7 – 10 dolphin body lengths apart
- State 4: dolphins >11 dolphin body lengths apart

Predominant behaviour protocol assumes the behaviour observed at the surface is representative of the behaviour occurring under the surface (Baird & Dill 1996). States were defined so as to be mutually exclusive and cumulatively inclusive to describe the behavioural budget of the bottlenose dolphins. Behavioural states definitions are based on previous studies to maintain consistency (Table 2).

Table 2: Definitions of behavioural states of bottlenose dolphin groups in Bay of Islands waters, New Zealand, with abbreviations for each state given in parentheses (Constantine 2002; Constantine et al., 2004; Lusseau 2003; Neumann 2001a).

Behavioural state	Definition
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.
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.
Rest (R)	Dolphins observed in a tight group (<1 body length apart), engaged in slow manoeuvres with little evidence of forward propulsion. Surfacing appear slow and are generally more predictable (often synchronous) than those observed in other behavioural states.
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.
Travel (T)	Dolphins engaged in persistent, directional movement making noticeable headway along a specific compass bearing at a speeds of >3 knts but not involving porpoising.
Fast Travel (FT)	Dolphins engaged in persistent, directional movement making noticeable headway along a specific compass bearing at speeds of >3 knts involving porpoising. Group spacing varies and individuals swim with short, relatively constant dive intervals.
Slow Travel (ST)	Dolphins engaged in persistent, directional movement making noticeable headway along a specific compass bearing at speeds of <3knts often-involving periods of other behaviours (foraging/socialising/milling).
Diving (D)	Dolphins engaged in persistent, non-directional movements; frequent periods sub-surface with short surfacing's. Different individuals within a group can dive in different directions at a given time, but their frequent directional changes keep them together.

In order to minimise the potential bias when not all group members behave in a uniform manner, the 50% rule was applied (Lusseau 2003). The behavioural state was determined as the category in which >50% of individuals were involved in, with all represented behaviours logged when an equal percentage of the group were engaged in different behaviours (Stockin et al., 2009). Dolphin group behavioural state was therefore recorded every three minutes as well as the response of the dolphin to vessels/swimmers. Responses were defined relative to the movement direction of the dolphins in relation to vessels/swimmers (see table 3 and section 4.6).

Behavioural events were defined as recognisable instantaneous behaviours (see appendix 1 for full definitions), and were additionally recorded using all occurrence sampling.

The effect of vessel traffic was categorised as follows in order to standardise assessment;

- *Research vessel present with all other vessel types absent (absence)*: absence of vessels anywhere within 300m other than research platform (verified by reticular binoculars).
- *Research vessel present with other vessel types present (presence)*: considered initiated whenever at least one vessel of any type is within 300m of a focal group additional to the research vessel. The distance of 300m (verified by reticular binoculars) was chosen because under the MMPR (1992), all vessels must slow to idle or no wake speed when there is an intention to view a marine mammal (Regulation 18(l)) and pilot assessment indicated vessels within 300m could be accurately assessed.

Vessel types were categorised in four independent groups: *permitted* (permitted swim or view dolphin vessels), *un-permitted* (commercially operated vessels not holding a permit to swim or view dolphin, i.e. all commercially operated kayaks, jet skis, yachts etc.) *research* (any vessel involved with research activity) and *private* (all vessels not included in the other categories, i.e. privately owned kayaks, jet skis, yachts etc.). All categories were further assessed by engine type (e.g. inboard, outboard, jet, paddle). Vessels present were also classified according to time of day, weekend or weekdays as well as month. Public holidays (e.g. Waitangi Day) were considered as weekend because traffic was deemed to be similar to that of weekends (as per Martinez 2010). Vessel speed when in encounter was estimated by assessing distance travelled in 20 seconds and categorised by 7 different speeds (0-5, 6-10, 11-15, 16-20, 21-25, 26-30, 30+).

After observational data were logged and photo-identification completed, the research vessel returned to the original track line, returning to *on survey* effort mode in order to search for further independent groups. Identical protocols were applied over consecutive months and years to allow for inter-seasonal and inter-annual comparisons.

Table 3: Definitions of behavioural responses to vessels and swimmers of *Tursiops* in Bay of Islands waters, New Zealand (Constantine 2002).

Behavioural response	**Definitions**
Attraction	At least one dolphin changed its direction of travel and actively moved towards a vessel or swimmer(s) reducing the distance between them to ≤4 dolphin body lengths.
Avoidance	At least one dolphin changed direction/path and actively swam away from vessel or swimmer(s) more than 3 times in succession, increasing the distance between them. Also, dolphins dived and surfaced away from the swimmers.
Neutral	No apparent change in behaviour, despite an initial approach within 5 m of vessel or swimmer(s), continued swimming and did not appear to be attracted towards them in any way. Also when dolphins are present within more than 5 m of a vessel or swimmer(s) but not actively swimming away from them (i.e. swimming away no more than 3 times in succession).

4.5. Opportunistic vessel-based platforms methodology

A second vessel-based platform was utilised for opportunistic data collection. Commercial vessels (here on board both wildlife cruises/dolphin-watching and swim-with dolphin permitted vessels) were appropriate platforms for the following reasons:

1. Such platforms allow documenting dolphin group behaviours during close vessel/swimmers interactions at a finer scale than from research-vessel platforms alone.
2. Such platforms are ideal to conduct photo-identification in order to identify individuals engaging in interactions with vessels and/or swimmers.

Observations were undertaken whenever possible (if space was available and weather conditions were favourable). Methodology used at start of survey was the same as the research vessel. Once a group was encountered, dolphin behaviour, group dispersion and responses to swimmers were recorded every three minutes (where possible), following the same protocol as research-vessel observations in order to assess the frequency and type of behavioural changes. All observations were made using the same CyberTracker system as the research vessel on Motorola Defy Mini handheld mobile phones.

Photo-identification was also undertaken to identify any known individuals repeatedly interacting with dolphin-watching and swim-with-dolphin vessels. Photo-identification methods followed those used on bottlenose dolphins in the BoI (Constantine 2002; Tezanos-Pinto et al., 2013) and other regions (Silva et al., 2009; Wilson et al., 1999). For each sighting, effort was made to photograph randomly all individuals present in a group. Photos were taken of the dorsal fin as primary identifiers and flanks and/or any other areas with identifiable marks as secondary identifiers. A digital SLR Nikon D100 with a 70-300mm lens was used.

4.6. Swimming with dolphins

A total of 7 commercial vessels in the BoI are permitted to view and swim with bottlenose dolphins (though only five vessels can swim under the authority of the permits at any one time). Skippers and companies used different swim techniques (e.g. free swimming/snorkelling and boom netting, Figure 5). In this study, a swim encounter consisted of one or several swim attempts. These attempts were judged to have commenced when the first swimmer entered the water and ended when the last swimmer got back on board the vessel. When more than one swim attempt took place, it was noted whether it occurred with the same swimmers. The end of a swim encounter was when all swim attempts ceased and the vessel had moved over 300m away from the focal dolphins. Swim attempts were monitored from both the research vessel and permitted vessel platforms, when possible, and included all vessels observed putting swimmers in the water, i.e. permitted, non-permitted and private vessels. The number of water entries (swim attempts) and length of time that swimmers spent in the water per swim attempt were the primary variables used for analysis of swim-with-dolphin tours.

Swimmer placement was documented and categorised for every swim attempt as:

- Line abreast: swimmers placed ahead or to the side of dolphins' path of travel,
- In path: swimmers placed directly in dolphins' path of travel,
- Around vessel: vessel stationary and dolphins perform non-directional behaviour, i.e., milling, around the vessel when swimmers enter the water.
- Other: none of the above definitions are applicable.

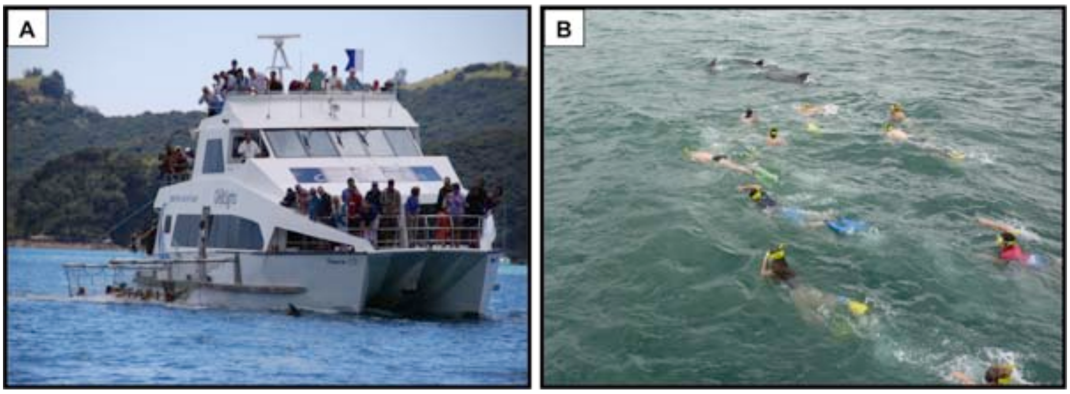


Figure 5: Swim techniques used with bottlenose dolphin in the Bay of Islands waters, New Zealand: A) boom netting; and B) free swimming/snorkelling. Photo credit: C. Peters and T. Guerin.

Dolphin response to swimmers was adapted from Constantine (2002) and Martinez et al. (2011) as follows:

- Neutral presence: no apparent change in dolphin behaviour. At least one dolphin remained within 5 m of the swimmers for at least 10 seconds. Presence was recorded when at least one dolphin was within 5 m of the swimmers,
- Neutral absence: no apparent change in dolphin behaviour. Dolphins were >5 m away from the swimmers and did not approach within 5m of the swimmers,
- Avoidance: change in dolphin behaviour. Dolphins were within 5 m of vessel prior to swim start and departed when swimmers entered the water,
- Interaction: change in dolphin behaviour. Dolphins were >5 m away from the swimmers and at least one dolphin approached the swimmers at least once and for at least 10 seconds.

The different reasons for ending a swim encounter were as follows:

- Unsuccessful swim encounter, i.e. the skipper decided not to pursue the dolphin group,
- Loss of sight of dolphins, i.e. the dolphin group could not be viewed again from the surface after initial sighting,
- Skipper's decision, due to time restrictions, i.e. the maximum time allowed for encounter was reached, or because swimmers were no longer interested in swimming,
- Presence of juveniles/calves/neonates during the swim attempt,
- Environmental conditions deteriorating.

Data collected during a swim encounter can be summarised as:

1) Total number of swimmers,
2) Swimmer placement,
3) Number of swim attempts,
4) Entry and exit time for each swim attempt,
5) Number of other permitted vessels interacting with the same dolphin pod.

Eighteen swimmers were the maximum number permitted per vessel in the water at any time, with up to three separate swim drops permitted. The permitted vessels would occasionally take additional swimmers on board and use one of two strategies to provide the opportunity to swim. The first was as a swap of swimmers, wherein they would be allowed to enter the water once a primary swimmer became tired, or otherwise concluded their swim session. The second was when the trip was booked as a double load: that is, two or more separate groups of swimmers on the same trip. The first group would engage in a normal swim tour while the second group watched, and then the two groups would switch and the second load of swimmers would enter the water. The number of swimmers per encounter was used to classify each tour as follows:

- Light – ≤9 swimmers
- Normal – 10-18 swimmers
- Swap – 19-22 swimmers
- Double-load – ≥22 swimmers

4.7. Data analysis

A multi-scale approach was applied to all analyses, building on this foundation and replicating key methodologies from previously published work (particularly that of Constantine et al., 2003; 2004; Tezanos-Pinto et al., 2013). The latest tools, techniques, and analytical approaches were applied to further investigate bottlenose dolphin interactions with vessel activity in the BoI.

Statistical analyses were conducted using R i386 (Version 3.2.0, R Development Core Team, 2013) with the significance threshold set at 0.05 unless stated otherwise. Data were initially tested for normality and heterogeneity of variance and subsequently analysed using the Shapiro-wilk and Bartlett tests, respectively. All data was also tested for significant variation between platform used and annual variation, if significant variation was not detected data were combined for subsequent analysis. If significant variation was indicated results were analysed independently and/or only one vessel data was utilised where appropriate. Results of first tests determined whether parametric or non-parametric statistics applied, as appropriate. In order to avoid pseudo-replication, only mutually exclusive data (not overlapping temporally) were used in analysis, determined via random selection on a day-by-day basis. Only data collected from one platform of opportunity were included per day however multiple encounters within the day were included.

4.7.1. Season-specific and inter-seasonal use of BoI waters by bottlenose dolphin
4.7.1.1. User type and site fidelity

Digital photo-identification photographs were renamed with information on region (BoI), species, photographer, camera, year (last two digits), month, date, frame number, vessel, survey number and encounter number (i.e. BoI_TT_CHP_D90_130419_0169_RB_62_90). Analysis of identification data began with grading all photos according to a quality scale (as per Tezanos-Pinto et al., 2013), with only excellent and good quality photographs included in the analyses. All photos of the same individual were grouped in each encounter and matched to a temporary BoI catalogue. Individual dolphins were primarily identified and matched based on long term markings, nicks and notches on the dorsal fin, with secondary features such as scarring (including rake marks due to the short length of study relative to mark loss rate) and additionally fin shape (Dwyer et al., 2015; Würsig & Jefferson 1990). Dolphins were considered marked if there was at least one primary and two secondary features. Before adding a new individual or resighting of a previously identified individual in the catalogue all images were independently checked by three researchers (Cat Peters, Manue Martinez and Thibaud Guerin) (Tezanos-Pinto 2009). When there were doubts about the identity of the individual, a fourth experienced researcher was consulted. Further final consultation on the catalogue and matching to previous catalogues will be performed before full population analysis. After a confirmed match (or new individual identification number was assigned), the data were entered into a database. A ‘sighting’ refers to an individual identification photograph obtained during an encounter with a unique individual (ID) and the associated data collected during each encounter (Dwyer et al., 2014).

Site fidelity in the BoI was investigated using lunar month (a month measured between successive new moons) to give biological relevance through tidal association. Seasonal sighting rates were additionally included as a function of number of encounters, as per Constantine (2002) and Tezanos-Pinto (2009), and defined by Parra et al. (2006). Between December 2012 and April 2015, a total of 31 consecutive lunar months occurred, However, one month (beginning 20th April 2015) was deleted from the database. This month was removed as it was not a complete. A total of 30 'effective' lunar months were included in analysis. Individual site fidelity was calculated by expressing the number of lunar months and times within a lunar month a dolphin was identified as a proportion of the total number of months in which at least one survey was conducted; and the number of seasons a dolphin was identified as a proportion of the total seasons surveyed (Cagnazzi et al., 2011; Dwyer 2009; Dwyer et al., 2014; Parra et al., 2006). To minimise the chance of dependence in the data, only one sighting record per individual per day was used (Cagnazzi et al., 2011; Dwyer 2009; Dwyer et al., 2014; Parra et al., 2006b).

User type was based on sighting frequency and grouped into three categories: frequent users, occasional visitors and infrequent users of the BoI following Constantine (2002) and Tezanos-Pinto (2009). This was achieved by fitting a Poisson distribution to test the null hypothesis that individuals were sighted randomly with regards to frequency. This distribution was selected given that it expresses the probability of a number of events occurring in a period of time (e.g., lunar months) with a known average rate (e.g., frequency of sightings). The point at which the frequency of observed sightings exceeds the expected frequency of the Poisson distribution was considered to indicate 'frequent users'. To assess relative changes by season a weighted ratio of the total number of sighting records per unique individual was calculated for each category.

4.7.1.2. Calf survival and identification

All analysis was designed to allow comparison with Tezanos-Pinto (2009).

An approximate indication of *date of birth* was based on the first sighting of a female accompanied by a neonate. As female dolphins were only observed giving birth on one occasion exact birth time and date could not be utilised. A neonate could have been born 1-3months prior to the date of first sighting (see table 1 for neonate definition, Tezanos-Pinto 2009). As per Tezanos-Pinto 2009, other methods for estimating calf age were deemed inappropriate.

If a mother-calf pair were resighted after 12 months from the date of the first pair sighting a young of the year (neonate or calf <1 year old) was assumed to have survived its first year of life. Only data from dolphins known to be neonates or very young calves on a given year were used to avoid potential errors caused by uncertainties regarding a calf's year of birth or age. Given that the minimum weaning age in the bottlenose dolphin has been estimated at 18-20 months (Smolker et al., 1992; Wells and Scott 1999) an older calf (1-3 years old) was assumed to have survived its second year of life if the pair were resighted 24 months after the first pair sighting. A calf was assumed to have died if the mother was resighted in two consecutive encounters without the calf (Steiner and Bossley 2008) and the calf was <18 month of age. The interval between the first sighting of the mother-calf pair to the last sighting of the pair was used to estimate the minimum approximate age a calf survived (Tezanos-Pinto 2009).

As calves usually lack markings, individual identity was inferred from the close association with the identified mother. A mother-calf pair that was observed in frequent association for 3 years after parturition was assumed to be the same calf, as long as estimated age correlates, due to calves staying in frequent association with mothers for up to three years (Smolker et al., 1992). Conversely, if the mother was sighted with an old calf (1-3 years old) and subsequently with a neonate, those were considered different calves. If the mother was not sighted during the next year but was resighted on the third year with an older calf, the calf sighted during the first year was assumed to be the same calf and therefore to have survived. When a mother-calf pair was not resighted in the BoI in consecutive years, the data were excluded for estimation of calving rate or mortality (Tezanos-Pinto 2009). Calf mortality was calculated as the proportion of young of the year (<1 year old) that were assumed to have died, divided by the total number of young of the year assigned to individually identified mothers and with a documented fate during that year (Tezanos-Pinto 2009). Second year calf mortality was calculated as the proportion of calves that were assumed to have died before reaching 24 months of life, divided the total proportion of calves assigned to individually identified mothers with a documented fate during their second year of life.

4.7.1.3. Group size and composition

For analytical purpose, group composition was analysed according to the presence or absence of immature individuals (i.e. adult only *versus* adults and juveniles *versus* mixed groups). On a broad scale, group size was classified as ≤20 or >20 animals. Fine scale analysis classified dolphin group size into nine categories (1-5, 6-10, 11-15, 16-20, 21-25, 26-30, 31-35, 36-40 and >40). Mean group sizes were calculated to assess whether the following factors had an effect on dolphin group size: month (and season), time of day and behaviour.

4.7.1.4. Distribution

Interaction data collected from both research and opportunistic platforms were examined at various spatial (e.g. proximity to vessel, regional distribution) and temporal (e.g. diurnal, seasonal and annual) scales. If significant variation was found within each test group data were tested separately.

Survey effort and dolphin group encounters were plotted using a Geographic Information System (GIS), created using ArcGIS version 10.3 (©ESRI Inc.). GPS location of each independent dolphin group encountered was plotted taking into consideration the following variables: size, composition and the distance observed from shore. All effort and sighting data was gridded as effort per km covered / km^2 and sightings per km^2 respectively using the planar method to allow trends in sightings to be analysed in the context of unevenly distributed effort. Kernel density of sightings was calculated using the Kernel density tool present in ArcToolbox of ArcGIS as per previous studies (Hartel et al., 2014). Distance from nearest shore was calculated using the Calculate Geometry Tool in ArcMap. Austral seasons used were summer (December, January, February), autumn (March, April, May), winter (June, July, August) and spring (September, October, November). Diurnal categories were created to account for varying length of daylight across the year. To that effect, a time of day index was calculated. The difference between the time of the sample and sunrise was divided by the length of daylight (time of sunset – time of sunrise). This index represented a percentile of daylight hours where sunrise equals 0, midday=0.5 and sunset=1.0. This index was used to classify each sample as morning (<0.33), midday (0.33-0.66), or afternoon (>0.66) (Lundquist 2011).

4.7.1.5. Behaviour

The behavioural state in which ≥ 50% of the animals were involved was examined, therefore excluding any group where two behavioural states were recorded simultaneously. Group size patterns in behaviour were investigated by comparing group behaviour and group size at the onset of encounter. Behavioural distribution was calculated quantifying proportion of all observations of a behavioural state within each 1km x 1km grid cell surveyed. Kruskal-Wallis analysis defined where trends seen in the data were significant.

4.7.2. Type, level and operational effort of bottlenose dolphin tourism
4.7.2.1. Variable analysis

AIC model analysis was utilised to determine variables of importance in the behavioural budget of dolphins for further analysis. The behavioural counts underwent a full analysis with models tested for appropriateness based on season, time of day, and vessel presence on behavioural transitions. Results showed the most appropriate analysis for data collected and indicated whether dolphin behaviour changes are due to natural (time of day, season) and/or anthropogenic (vessel presence) factors. Markov chains were included in this model analysis (Lundquist 2012; Lusseau 2003b; Martinez 2010; Stockin et al., 2008a). Results of model analysis revealed important parameters for further investigation.

4.7.2.2. Development of transition probability matrices

Assumptions described in Lusseau (2003), including 1) the probability that a transition will occur remains the same over time and 2) annual variation had no effect on the outcome were met here. Two 1st-order behavioural chains were constructed, one for the absence of vessels except for the research vessel and one for the presence of vessel(s) within 300 m (research vessel plus at least one more vessel, following the methodology used by Lundquist et al., 2012).

Whilst no assumption is made that the research vessel had no effect on dolphin behaviour, the vessel was consistently driven in accordance with best practice in order to allow it to act as a reliable control. The research vessel was always operated by the same skipper to aid consistency. When no vessel was present with the dolphins other than the research platform between two behavioural samples, the transition between these two samples in the *absence* chain were tallied. Following the same principle, a transition was considered to be part of the *presence* chain if at least one vessel (in addition to the research vessel) was found interacting with the dolphins. As a result, the transition between two succeeding events when the situation changed (i.e. presence to absence, and absence to presence) was discarded once the sequence was selected (≥ 15 min as determined appropriate by Meissner et al., 2015).

In order to assess whether the presence of vessels had an effect on the behavioural transitions, transition probabilities from preceding to succeeding behavioural state were determined for both absence and presence chains by:

$$P_{ij} = \frac{a_{ij}}{\sum_{j=1}^{5} a_{ij}} ; \sum_{j=1}^{5} P_{ij} = 1 \qquad (1)$$

where *i* and *j* refer respectively to the preceding and succeeding behavioural state with *i* and *j* ranging from 1 to 5 (five behavioural states), a_{ij} is the number of transition recorded from the behaviour *i* to *j* and p_{ij} corresponds to the transition probability between behaviour *i* and *j* in the chain. Therefore, each calculated transition corresponds to the proportion of time the specific succession was observed in the chain. Pairs (each absence transition to its presence counterpart) were tested for the effects of vessel presence on the behavioural transitions by the mean of a Z-test for proportions (Fleiss, 2003).

A Z-test for proportions was used to assess whether two groups differ significantly on a single categorical characteristic. The assumptions for using a Z-test are: 1) Samples must be independent; and 2) Sample sizes must be large enough to run the test. Alpha was set to 0.05 corresponding to the critical values of Z=±1.96. Therefore, if the Z-value found is greater or lower than ±1.96, the null hypothesis (proportion 1=proportion 2) is refuted, and the two proportions are different.

$$Z = \frac{(\widehat{P_1} - \hat{P}_2)}{\sqrt{\hat{P}(1-\hat{P})}\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}} \tag{2}$$

With

$$\widehat{P_1} = \frac{x_1}{n_1};\ \hat{P}_2 = \frac{x_2}{n_2} \tag{3}$$

And

$$\hat{P} = \frac{x_1 + x_2}{n_1 + n_2} \tag{4}$$

With x_1 and x_2 representing the proportions for the group 1 and 2, n_1 and n_2 standing for the total number of the group 1 and 2 respectively.

Using a Z-test to calculate probabilities between different chains allowed for proportions, combined with a Holm-Bonferroni sequential correction, to account for multiple comparisons (Holm 1979). This made it possible to test whether interactions with vessels had a significant effect on the behaviour of dolphins.

The mean time (i.e. number of transitions) it took to the dolphins to return to each behavioural state after disturbance for both chains was also assessed:

$$E(T_j) = \frac{1}{\pi_j} \tag{5}$$

with T_j the number of time (i.e. number of transitions) it takes the dolphins to return to a behaviour *j* given that they are currently in this state and π_j the probability to be in the behavioural state *j* in the chain. The number of transitions obtained was multiplied by the length of the transition unit (three minutes, since each sample was collected every three minutes) in order to convert the results in minutes and estimate the mean time it took the dolphins to return to a specific state. Each mean absence time was compared to its presence counterpart to assess a potential effect of vessel presence. In addition, the mean length of behavioural bouts for each chain was calculated. Bout length represents the mean length of time dolphin groups spend in a particular behavioural state before changing to a different state (Lundquist et al., 2012). This was calculated following Lusseau (2003):

$$\overline{t_{ii}} = \frac{1}{1 - p_{ii}} \tag{6}$$

With p_{ii} the probability of transitioning from state *i* to state *i*. Standard errors for bout lengths were calculated as:

$$SE = \sqrt{\frac{p_{ii} * (1 - p_{ii})}{n_i}} \tag{7}$$

With n_i representing the number of times the behavioural state *i* was counted as the preceding behaviour. Each mean bout length was compared between the two chains with a Z-test. Bottlenose dolphin cumulative diurnal behavioural budget (control + impact behavioural budget) variation from control chain was tested with a goodness-of-fit test (Lusseau 2003).

4.7.3. *Determine the potential effects of interacting with bottlenose dolphins*

Focal group data collected from the research vessel were used to compare the behavioural parameters of dolphin groups relative to the number of vessels present, vessel approach and departure, time of day, and season. Parameters examined included activity states and their transition probabilities. *Focal tour* data collected from permitted vessels were used in conjunction with data collected from the research vessel (if not significant difference between vessel types was found) to assess dolphin responses to specific tour activities (e.g. reversing, deployment of swimmers). Behavioural states of dolphins interacting with another vessel prior to approach were excluded from the analysis.

4.7.3.1. Behaviour and vessels

Each consecutive 3-min behavioural observation was classified according to the season, daylight index and number and type of vessels present.

To evaluate how bottlenose dolphin behaviour varied relative to the number (i.e., 0 to ≥ 4) and type (i.e., commercial permitted, commercial un-permitted and private vessels) of vessels present within 300 m, it was necessary to account for natural variation by time of year and time of day (i.e. day light index). All vessels within 300m were included in analysis of vessel presence, but only included as interacting if positioned to view.

Log-linear analysis was conducted using *R's* AIC function utilizing LogLik package. The presence of vessels likelihood to alter dolphins moving from one behavioural state to another, called transition, was tested. This was accomplished by using count data from transition matrices. Models were tested in *R* for all combinations of parameters and interactions between parameters. The goodness of fit for each model was compared to the goodness-of-fit for the fully saturated model in order to calculate the maximum likelihood for the model being tested. This takes into account the effect of the missing parameters (Lusseau 2003). Degrees of freedom were the difference in degrees of freedom between the two models. Evaluating the significance of this difference determined which parameters were significant and degrees of freedom were the difference between the two models degrees of freedom (Lusseau 2003; Lundquist et al., 2012).

Akaike Information Criteria (AIC) values (Akaike 1974) were calculated to choose the best-fitting model. AIC assists in selecting the most parsimonious model. Each model is strengthened for providing information and reduced for each using extra parameter to do so (Anderson et al., 2000; Caswell 2001). Due to sample size limitations, it was not possible to include different numbers and types of vessels in the log-linear analysis. Annual effects were not tested for in AIC as no significant annual variation in behaviour was found in previous analyses. Therefore, a simple presence/absence analysis was performed to determine whether vessels had a significant effect on behavioural transitions of bottlenose dolphins. Following this, separate analyses were conducted on behavioural budget and bout lengths for different numbers and types of vessels.

4.7.3.2. Quantify and document the type, level and operational effort of existing bottlenose dolphin tourism activity within BoI waters

To evaluate levels of vessel traffic in BoI waters and quantify operational effort, each count of a vessel interacting with dolphins during a focal follow was considered an independent sampling unit. Vessel traffic analysis sought to examine the presence (min), number and type of vessels (permitted, Un-Permitted and Private) interacting with dolphins. Further to this, the overall number of vessels that interacted with a single group and interacted simultaneously with a group were assessed and compared using Kruskal-Wallis analysis and further defined by location. The number of approaches made by each vessel category was defined by vessel type and the type of approach examined.

The cumulative time that a focal group spent in the presence of vessels was defined as the total time the group spent with or without vessels per day. The continuous time that a focal group spent in the absence of vessels was defined as the mean length of time (minutes) dolphins were without vessels uninterrupted (no vessels additional to the research vessel) per day. When a vessel interacted with a focal group more than once, successive encounters were cumulated and interaction time was summed. The duration of encounters was examined with regards to vessel type and the maximum time of 90 mins (50 mins allowed with adults and/or 30 mins with calves/juveniles) allowed in the permits.

The speed and direction of each vessel approach and departure was collected for every vessel within 300m, analysis was categorised by vessel type for comparison. Approach methods were categorised as: non-invasive (no approach; parallel), invasive (J; in-path/head-on) and unspecified (direct; reverse; drift). To ensure independence across all encounters, if a vessel encountered a focal dolphin group and attempted to interact more than once with that same group, the second attempt was excluded from the speed analysis (Martinez 2010).

4.7.3.3. *Swimmers*

Swim data were examined according to the platform of observation used, due to differences observed in regulation compliance. For analytical purpose, group composition was analysed according to the presence or absence of immature individuals (i.e. adult only *versus* adults and juveniles *versus* mixed groups). Fine scale analysis classified dolphin group size into nine categories (1-5, 6-10, 11-15, 16-20, 21-25, 26-30, 31-35, 36-40 and >40). Mean group sizes were calculated to assess whether the following factors had an effect on dolphin group size: month (and season), time of day and behaviour. This aligned with group size and composition for all encounters.

Distance of all swim attempts from nearest shore was calculated using the Calculate Geometry Tool in ArcMap (ArcGIS version 10.3 (©ESRI Inc.). Behaviour of bottlenose dolphins in the presence of swimmers was analysed for all swim attempts; these were analysed in three categories (approach, neutral and avoid).

Each swim tour was classified based on season, number of permitted tour boats present, and number of swimmers (light: ≤ 9, normal: 10-18, swap: 19-22 or double-load: ≥ 22). Number of tour boats present ranged from one (only the boat from which the observation was made was present) to four (all four permitted dolphin-swim boats were present, only 4 of 6 were permitted for swimming on any one day). The presence of other vessels (those which were not permitted) was not included in this analysis.

Four response variables were calculated with data obtained from opportunistic platforms: number of swim attempts, mean length of swim drops, swimmer placement at start of each swim drop, and length of swim period (from time of entry on first swim drop to time of exit on last swim drop). Histograms were examined and response variables were transformed as necessary to achieve a normal, homogeneous distribution. Analysis of variance (ANOVA) was performed for each of the three response variables to determine if there were significant differences by season, number of tour boats, or tour type. The Tukey HSD statistic was used in post-hoc comparisons to evaluate significant differences between the various classifications. Of particular interest was the variation in the orientation of a bottlenose dolphin focal group with respect to swimmers and/or vessel in relation to time into an encounter, recorded at three-minute intervals from the start of an encounter.

To allow intra-species comparisons, previously utilised methods were used (Bejder et al., 1999; Martinez 2010). In order to account for the effect of a continued interaction with the dolphins, data during swim encounters were scored cumulatively. For example, if swimmers entered the water at 21 minutes that swimmer scored in the >21-24min as opposed to the >18-21 minutes' interval. Such scoring was deemed necessary since swimmers did not always enter the water immediately after a group had been detected. Additionally, the presence of vessels cannot be dissociated from a swim encounter because swimmers are launched from a vessel-platform.

Following Bejder et al. (1999), the observed proportions of responses in each time interval were analysed with logistic regression (LR). LR provides a tool for modelling such changes in proportions in the binomial form (Harraway 1995). Here, LR models predicted the probability of a dolphin group heading towards or away from the vessel and/or swimmers, based on the observed proportion of orientations classified as towards or away in each time interval. LR models were then fitted to the observed proportion of responses in each time interval to evaluate the effect of time into encounter on group orientation (Harraway 1995). These were in the form:

$$\pi = \frac{\exp\,(ß_0 + ß_1 T + ß_P T^P)}{1 + \exp\,(ß_0 + ß_1 T + ß_P T^P)}$$

where π was the probability of movement towards or away from a vessel and/or swimmer. LR models involved either a constant only ($ß_0, Model$ 1) or a constant with higher powers of T (time into an encounter) up to a cubic (P=3: Models 2 to 4). These models were as follows:

Model 1: Constant $ß_0$

Model 2: Constant ß plus linear term in T.

Model 3: Constant ß plus linear and quadratic terms in T.

Model 4: Constant ß plus linear, quadratic, and cubic terms in T.

Models were further tested for goodness-of-fit using the deviance statistic for each model and the deviance differences (both of which followed a chi-squared distribution). A significant deviance difference indicated that the predictive value of the model was significantly improved by the addition of the new factor. Analysis of residuals between observed and the corresponding predicted proportions (probabilities) confirmed whether a model was a good predictor of the probability of a dolphin group heading towards or away from swimmers and/or vessel(s) as a function of time into an encounter.

Here, modelling of dolphin responses was based on the assumption that if dolphin movements relative to vessels and/or swimmers were random, the expected proportion of each response (towards, away, or neutral) would be expected to be 0.33. If the 95% confidence intervals for the predicted probabilities are above and exclude the expected value, dolphin groups exhibit significant response to a vessel.

5. Results
5.1. Overall effort

Data collection between December 2012 and April 2015 comprised 1,472 vessel-based surveys (Table 4), with the majority (85.9%, n=1,265) being conducted from the different opportunistic platforms, while the remaining (14.1%, n=207) were from the independent research vessel (Table 4).

A total of 81,892 km of track were surveyed whilst on effort (4,027 hrs), including 8,550 km (476 hrs) and 73,342 km (3,596 hrs) from the research vessel (Figure 6, 7) and the other opportunistic platforms (Figure 8, 9), respectively. Surveys undertaken on the tourism vessels were not exhaustive but representative of the trips tour operators may have undertaken during that period.

Table 4: Seasonal summary of surveys by platform, between December 2012 and April 2015, in Bay of Islands waters, New Zealand. NOTE: one survey per day was conducted on Te Epiwhania and a combination of a maximum of two per day on all various permitted vessels due to a return to Paihia and possible change of crew.

	Te Epiwhania	***DIII***	***DIV***	***DV***	***Tutunui***	***Tangaroa***	***Dolphin Seeker***	***Carino***	**Total**	**Seasonal effort (km)**	**Seasonal effort (hrs)**
Spring	36	66	62	0	59	4	76	61	364	18,089	1,008
Summer	81	144	0	0	105	0	0	79	409	22,545	1,085
Autumn	53	102	34	22	87	2	55	56	411	21,832	1,143
Winter	37	0	88	0	0	46	117	0	288	19,426	791
Total	207	312	184	22	251	52	248	196	1,472	81,892	4,027

5.1.1. Research vessel effort

Between December 2012 and April 2015, bottlenose dolphin groups were followed for a total of 812 hrs (4,597 km), of which 248 hrs (30.6%) were spent in the absence of other vessels. Total survey effort for the research boat is detailed in Figure 8 & 9.

5.1.2. Permitted vessel effort

During the same time period, dolphin groups were followed from the various opportunistic platforms for a total of 604 hours (3,562km). Total survey effort for permitted vessels is detailed in Figure 6 & 7. Surveys on board opportunistic vessels favoured zones D, E, G and H (Figure 6 & 7). Permitted vessels spent a mean of 103 min in the presence of marine mammals per trip (range=0-127, n=2,290) with a mean trip length of 248 min (range=129-271, n=2,290).

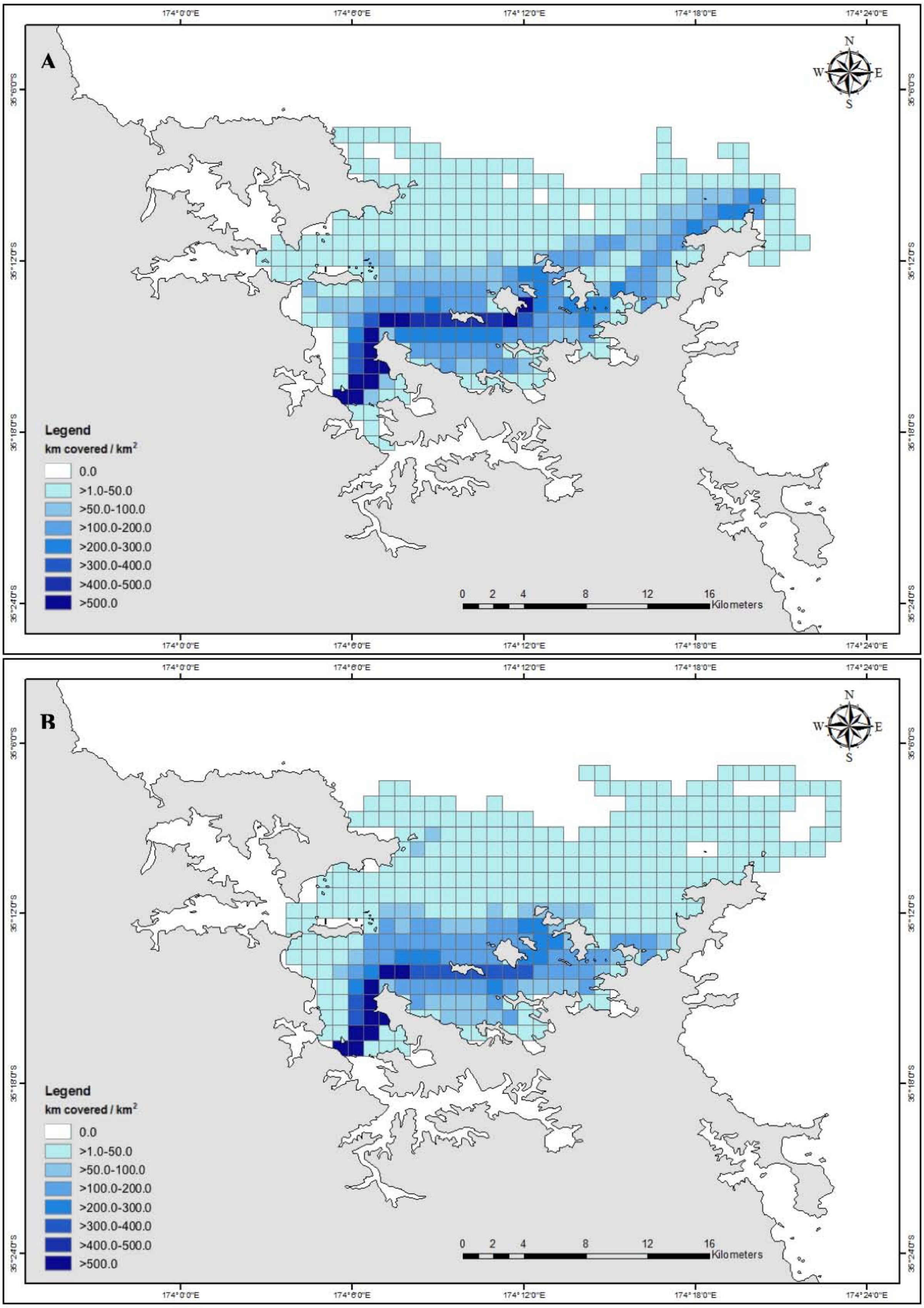


Figure 6: Permitted vessel effort per km (mutually exclusive) between December 2012 and April 2015, in Bay of Islands waters, New Zealand with A) Spring and B) Summer gridded measures of effort, coloured according to the proportion of kilometres (km) travelled within each grid cell (1km x 1km).

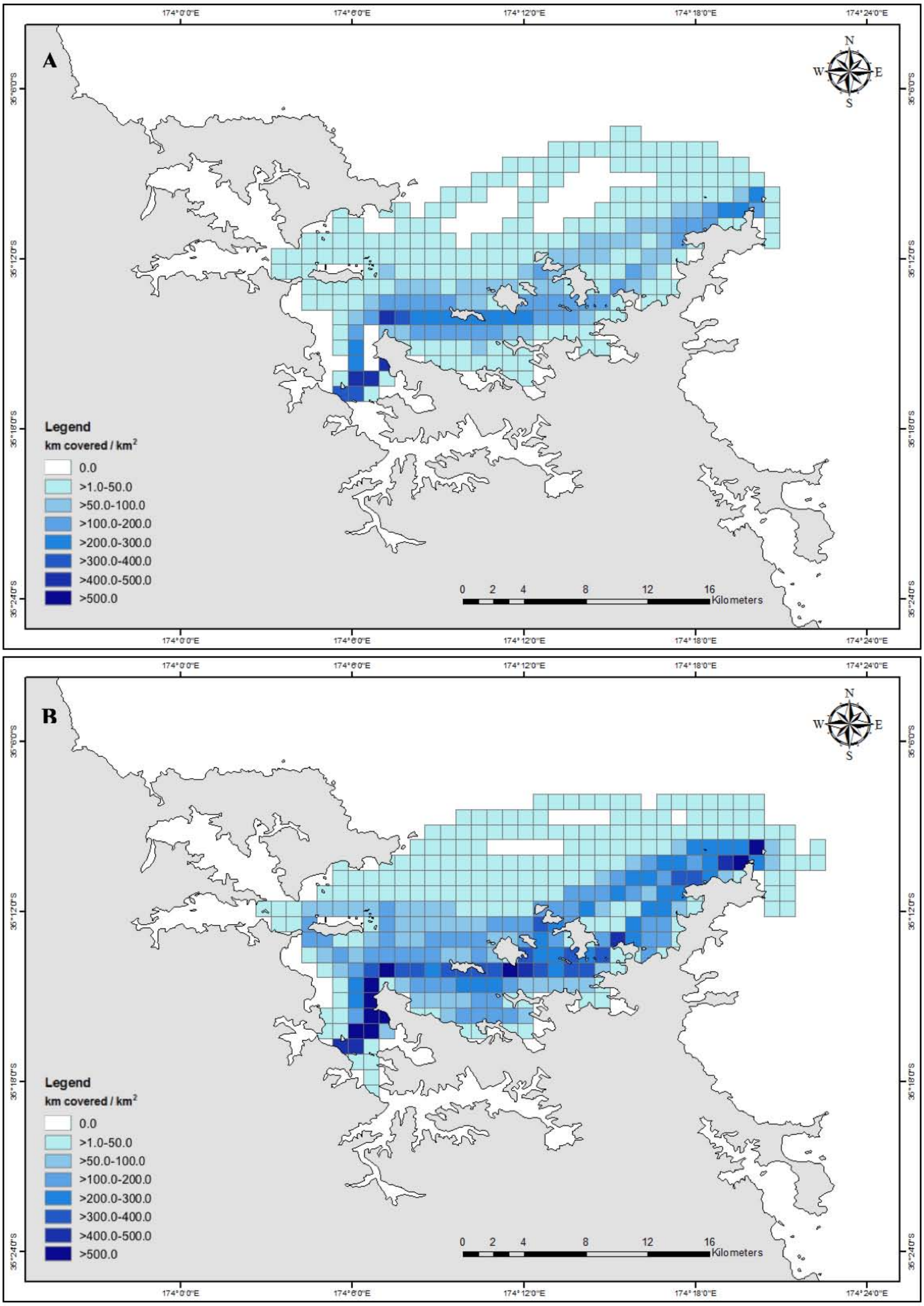


Figure 7: Permitted vessel effort per km (mutually exclusive) between December 2012 and April 2015, in Bay of Islands waters, New Zealand with A) Autumn and B) Winter gridded measures of effort, coloured according to the proportion of kilometres (km) travelled within each grid cell (1km x 1km)

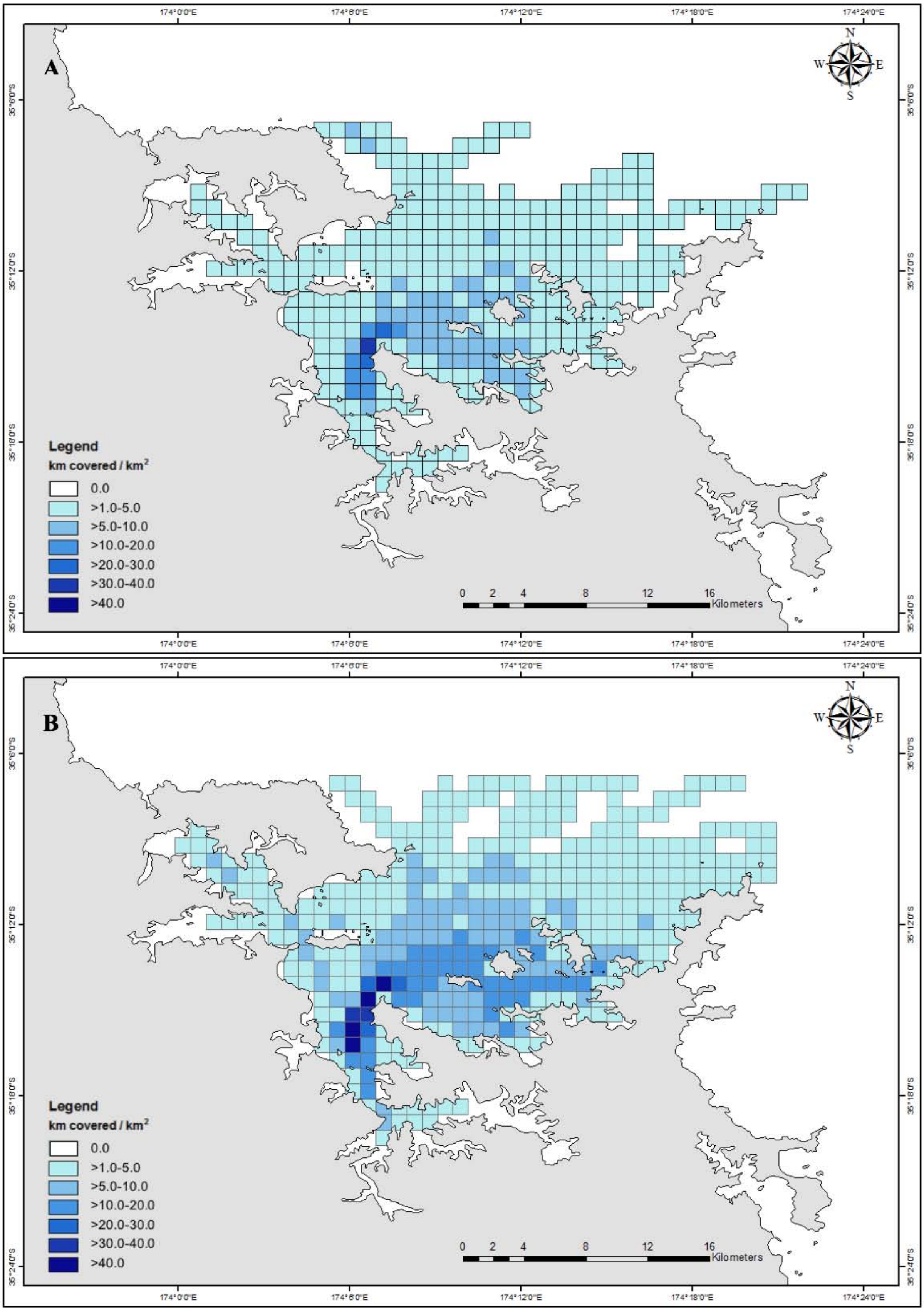


Figure 8: Research vessel effort per km between December 2012 and April 2015, in Bay of Islands waters, New Zealand with A) Spring and B) Summer gridded measures of effort, coloured according to the proportion of kilometres (km) travelled within each grid cell (1km x 1km).

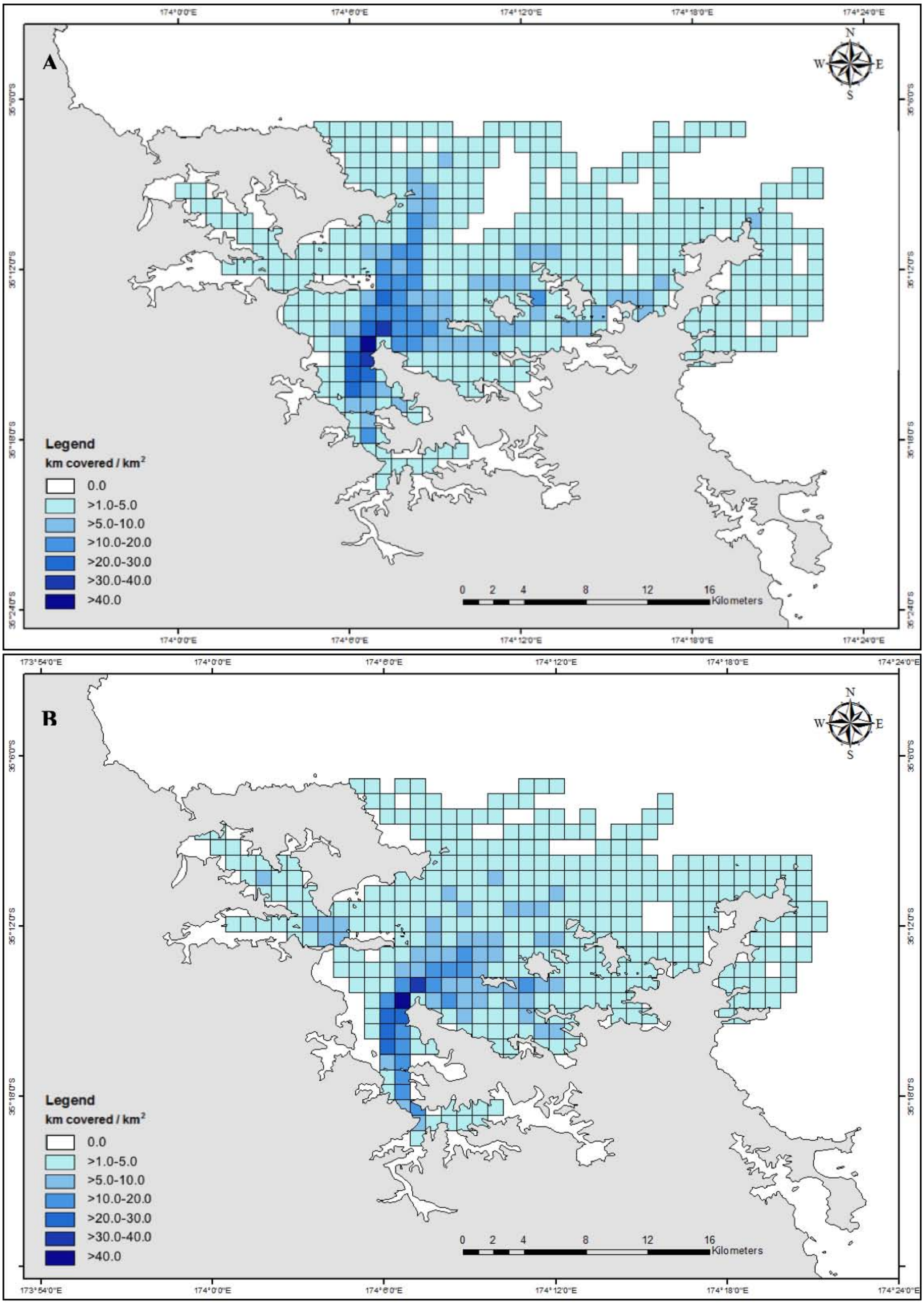


Figure 9: Research vessel effort per km between December 2012 and April 2015, in Bay of Islands waters, New Zealand with A) Autumn and B) Winter gridded measures of effort, coloured according to the proportion of kilometres (km) travelled within each grid cell (1km x 1km).

5.2. Overall sightings from combined platforms types

Out of a total of 2,290 marine mammal encounters, bottlenose dolphins were the most recorded marine mammal species within the study area (88.2%, n=2,019, Table 5), with almost all sightings being of the coastal ecotype (99.8%, n=2,015) and the remaining 0.2% (n=4) being oceanic *Tursiops*.

Other marine mammals observed occasionally in the BoI included common dolphins (*Delphinus sp.*) (6.4%, n=146), killer whales (*Orcinus orca*) (2.7%, n=62), and Bryde's whales (*Balaenoptera edeni*) (1.6%, n=37). Five other cetacean species were sighted less than 1% of the time: humpback whale (*Megaptera novaeangliae*) (0.5%, n=12), false killer whale (*Pseudorca crassidens*) (0.1%, n=3), pilot whales (*Globicephala* spp) (0.1%, n=2), blue whales (*Balaenoptera musculus*) (0.2%, n=5) and fin whales (0.2%, n=4) (Table 5). New Zealand fur seals (*Arctocephalus forsteri*) were additionally observed on 389 occasions.

Table 5: Seasonal summary of marine mammal encounters, between December 2012 and April 2015, in Bay of Islands waters, New Zealand. NOTE: False killer whales have only been observed in association with bottlenose dolphins and on one occasion with both pilot whales and bottlenose dolphins. Those encounters are referred to collectively as *TtPc*, *TtPcGm* and *TtGm* respectively.

	bottlenose dolphins	**common dolphins**	**killer whales**	**Bryde's whales**	**humpback whales**	**blue whales**	**fin whales**	**false killer whales**	**pilot whales**	**Total**
Spring	510	56	19	25	6	1	4	0	0	621
Summer	626	27	16	2	0	1	0	0	0	672
Autumn	620	6	24	1	2	1	0	2TtPc	1TtPcGm 1TtGm	663
Winter	259	57	3	9	4	2	0	0	0	334
Total	2,015 (+4)	146	62	37	12	5	4	2	2	2,290

5.3.Bottlenose dolphin sightings from combined platform types

Of the 2,019 independent bottlenose dolphin encounters recorded, 88.9% (n=1,795) were made from the other platforms and 11.1% (n=224) were made from the research vessel (Table 6-7).

A mean of 2.82 bottlenose dolphin groups encountered per day were observed across the study period (range 0-5, SE=0.03, n=2,015, 692 days). Bottlenose dolphin distribution occurred throughout the study area, though initial spatial mapping infers higher density use areas in BoI zones D and E (Figures 11-14).

Permit conditions dictate that vessels must maintain a minimum distance of 60m from the shore when interacting with marine mammals. Sightings were recorded with an overall mean distance of 997.9m (range=3.8m-6913.7, SE=56.24, n=2,019). Throughout the study period, 2.1% (n=42) of observations occurred within 60m of the shore, with dolphins located between the vessel and shore. In total, 78.6% (n=33) of such encounters involved permitted vessels.

Seasonal variation was noted; the greatest distance from shore was observed in summer and autumn (Mean=1,098.9), and closest to shore in winter and spring (Mean=865.2).

Table 6: Seasonal summary of bottlenose dolphin encounters, between December 2012 and April 2015, in Bay of Islands waters, New Zealand. Numbers are inclusive of all *Tursiops* sightings; the number of confirmed pelagic ecotype sightings within this total is shown in parentheses.

	Te Epiwhania	**DIII**	**DIV**	**DV**	**Tutunui**	**Tangaroa**	**Dolphin Seeker**	**Carino**	**Total**
Spring	30 (1)	103	78	0	100	3	95	101	510 (1)
Summer	104	243	0	0	163	0	0	116	626
Autumn	66 (1)	174	51	30 (1)	140 (1)	7	59	99	624 (3)
Winter	24	0	85	0	0	32	118	0	259
Total	224 (2)	520	214	30 (1)	403 (1)	42	272	314	2,019 (4)

Table 7: Seasonal summary of bottlenose dolphin encounters as a function of effort (km and hours), between December 2012 and April 2015, in Bay of Islands waters, New Zealand. Numbers are inclusive of all *Tursiops* sightings.

	Te Epiwhania (sightings/km)	**Te Epiwhania (sightings/hrs)**	**Permitted vessels (sightings/km)**	**Permitted vessels (sightings/hrs)**	**Combined vessels (sightings/km)**	**Combined vessels (sightings/hrs)**
Spring	0.02	0.03	0.03	0.10	0.03	0.08
Summer	0.03	0.10	0.03	0.22	0.03	0.00
Autumn	0.02	0.06	0.02	0.15	0.02	0.04
Winter	0.02	0.03	0.01	0.00	0.01	0.11
All seasons	0.03	0.06	0.02	0.13	0.02	0.05

5.4. Bottlenose dolphin sightings from research vessel only

All sightings were recorded within a SST range of 14.2-22.8^{o}C (mean=17.9, Table 8). Sightings were made within a depth range of 2.3-140m (mean=41.1, Table 9). However, most sightings for bottlenose dolphins occurred closer inshore at depths below 20m (88.4%, n=198).

Table 8: Mean sea surface temperature (SST) of bottlenose dolphin encounters, between December 2012 and April 2015, in Bay of Islands waters, New Zealand. (SE=Standard Error)

Species	Mean SST(°c)	SE	Range	N
Both ecotypes	18.9	0.2	14.2-22.8	224
coastal ecotype	18.9	0.2	14.2-22.8	222
pelagic ecotype	21.1	0.1	21.1-21.1	2

Table 9: Mean water depth (m) of bottlenose dolphin encounters, between December 2012 and April 2015, in Bay of Islands waters, New Zealand. (SE=Standard Error)

Species	Mean depth (m)	SE	Range	N
both ecotypes	21.7	0.9	2.3-140	224
coastal ecotype	20.9	0.7	2.3-56.3	222
pelagic ecotype	70.8	9.1	34-140	2

5.5. Spatial distribution

Between December 2012 and April 2015, broad-scale distribution patterns of dolphins remained constant across seasons and years relative to seasonal movements (Figure 10-13), as did the finer scale habitat-use patterns. Dolphins were observed by all platform types in high densities areas (50% contour) near Tapeka Point and Roberton Island (Figure 14).

In only 7% of sightings recorded from the research vessel were dolphins observed in previously designated permitted exclusion zones (n=16, 13% effort, 0.01 sightings/km, figure 10-11).

The largest number of sightings occurred in summer and autumn with 0.03 sightings/km effort (31.0%, n=626 and 30.9%, n=624 of all sightings respectively) and least in spring and winter with 0.02 sightings/km effort (25.3%, n=510) and 0.01 sightings/km effort (12.8%, n=259) respectively (10-13).

Seasonal preference Kernel densities of dolphins was consistent across vessel types and therefore combined. Dolphins showed a strong fine-scale seasonal preference for the Inner Islands (Zone E) in Winter (58.4%, n=151) and Spring (59.6%, n=304) (Mantel r=0.167, P=0.001). In Summer and Autumn, sightings were more distributed utilising the Inner Islands (48.6%, n=304 and 44.2%, n=276, respectively) and Middle Grounds (42.8%, n=268 and 35.2%, n=220 respectively) (Mantel r=0.092, P=0.001).

Tapeka Point and Roberton Island were high density areas year round across all years (figure 10-14) (Mantel r=0.112, P=0.001).

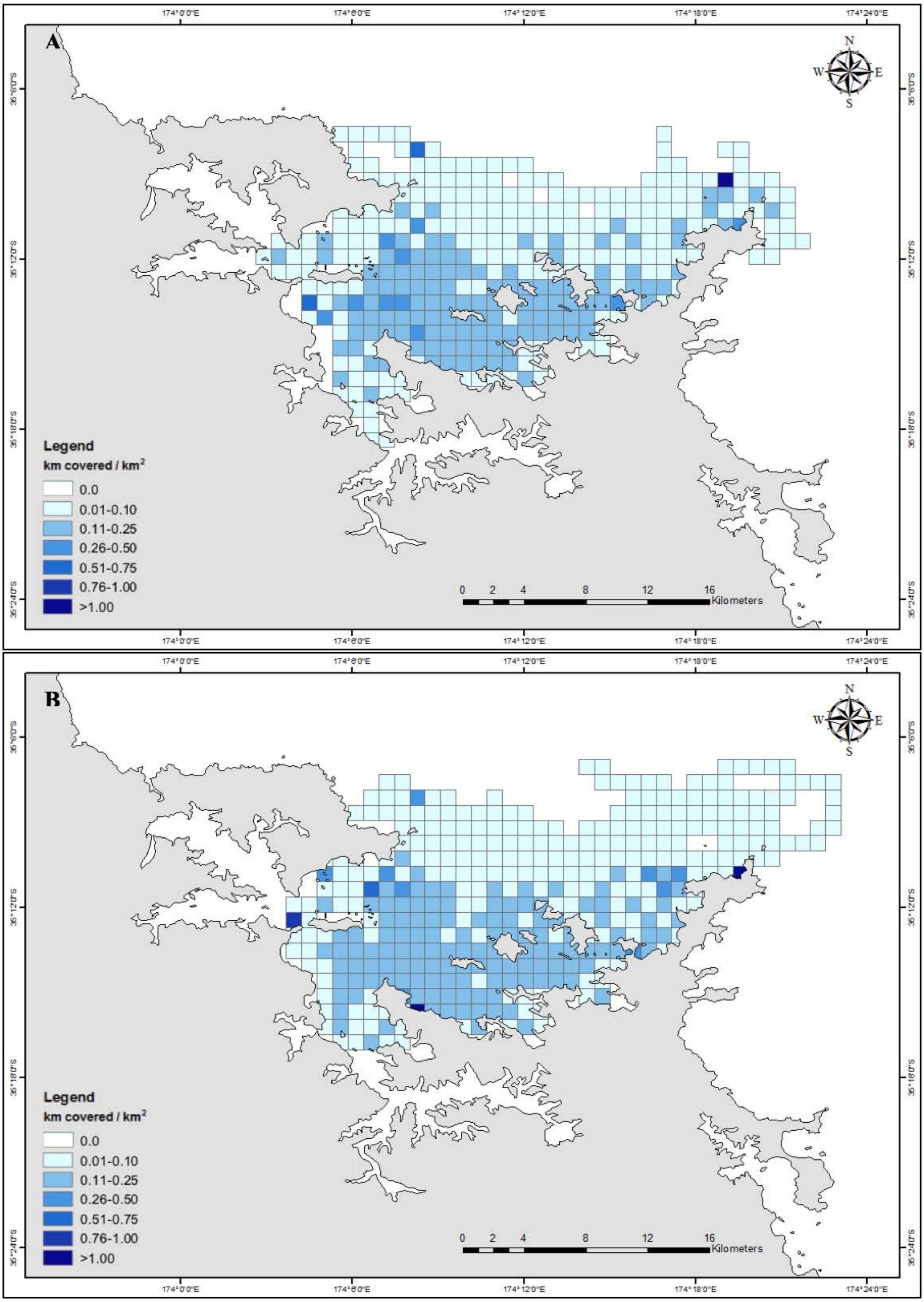


Figure 10: Permitted vessel sightings per km (mutually exclusive with only one vessel per day) effort between December 2012 and April 2015, in Bay of Islands waters, New Zealand with A) Spring and B) Summer gridded measures of effort (1km x 1km).

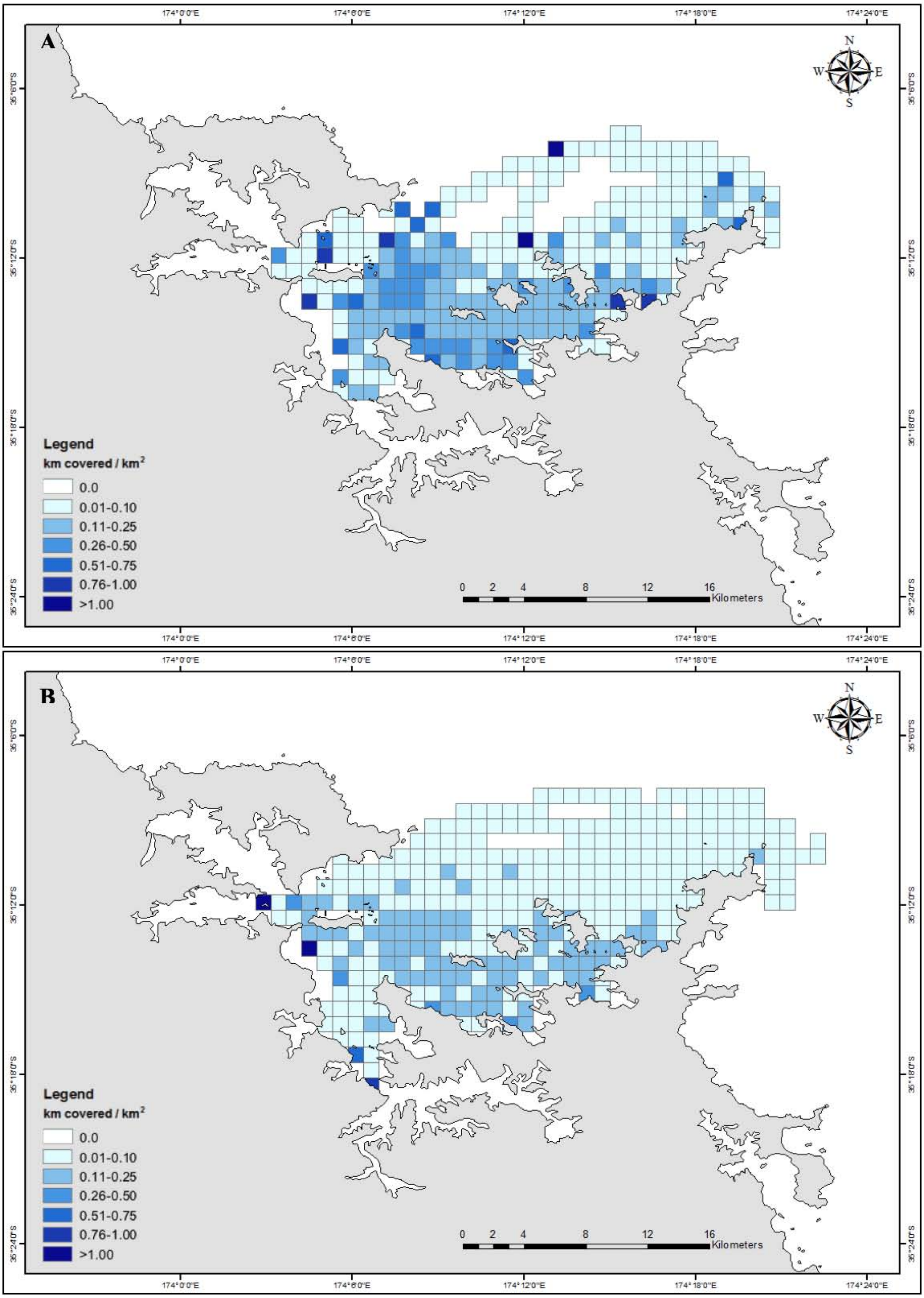


Figure 11: Permitted vessel sightings per km (mutually exclusive with only one vessel per day) effort between December 2012 and April 2015, in Bay of Islands waters, New Zealand with A) Autumn, and B) Winter gridded measures of effort (1km x 1km).

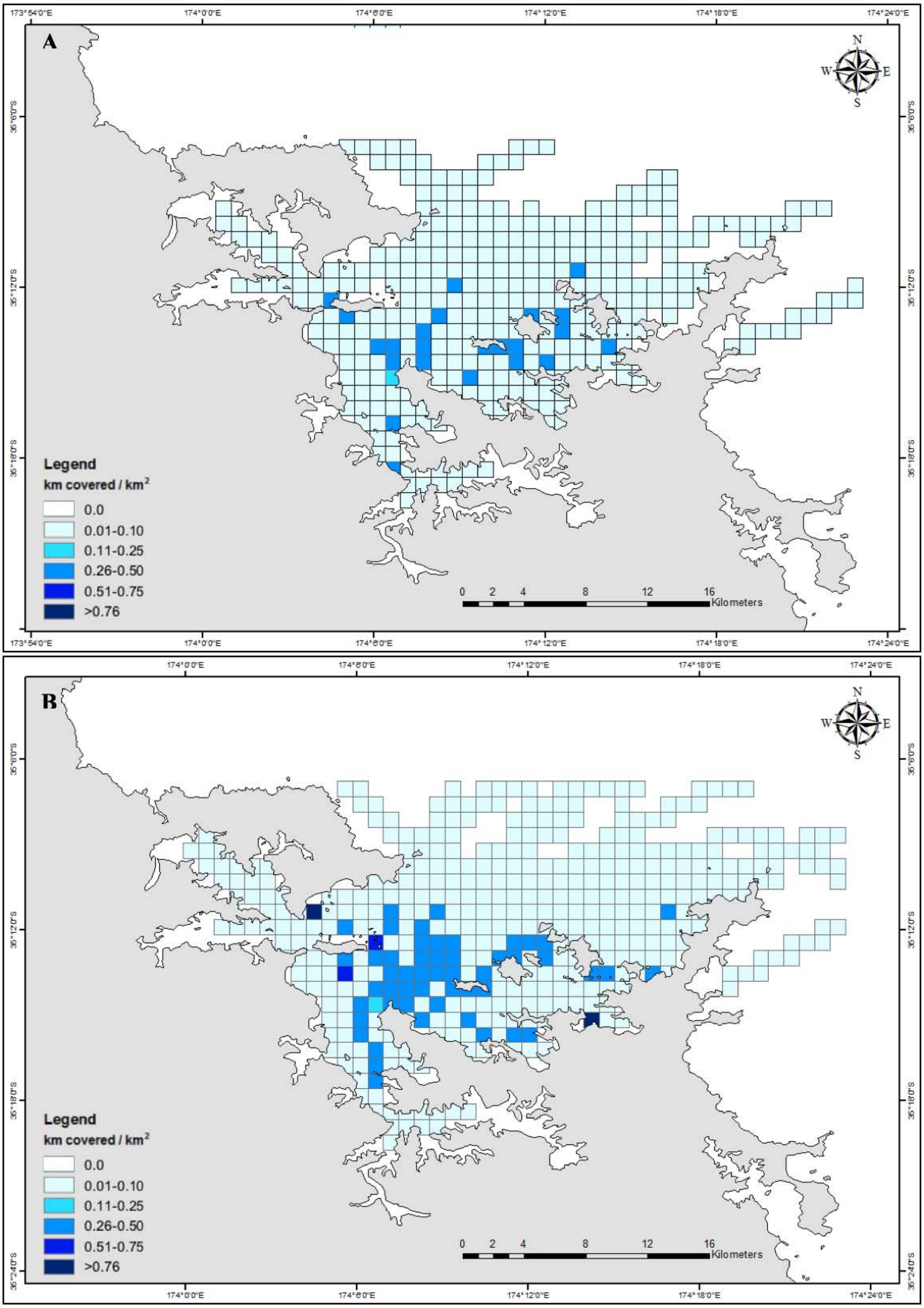


Figure 12: Research vessel sightings per km effort between December 2012 and April 2015, in Bay of Islands waters, New Zealand with A) Spring and B) Summer gridded measures of effort (1km x 1km).

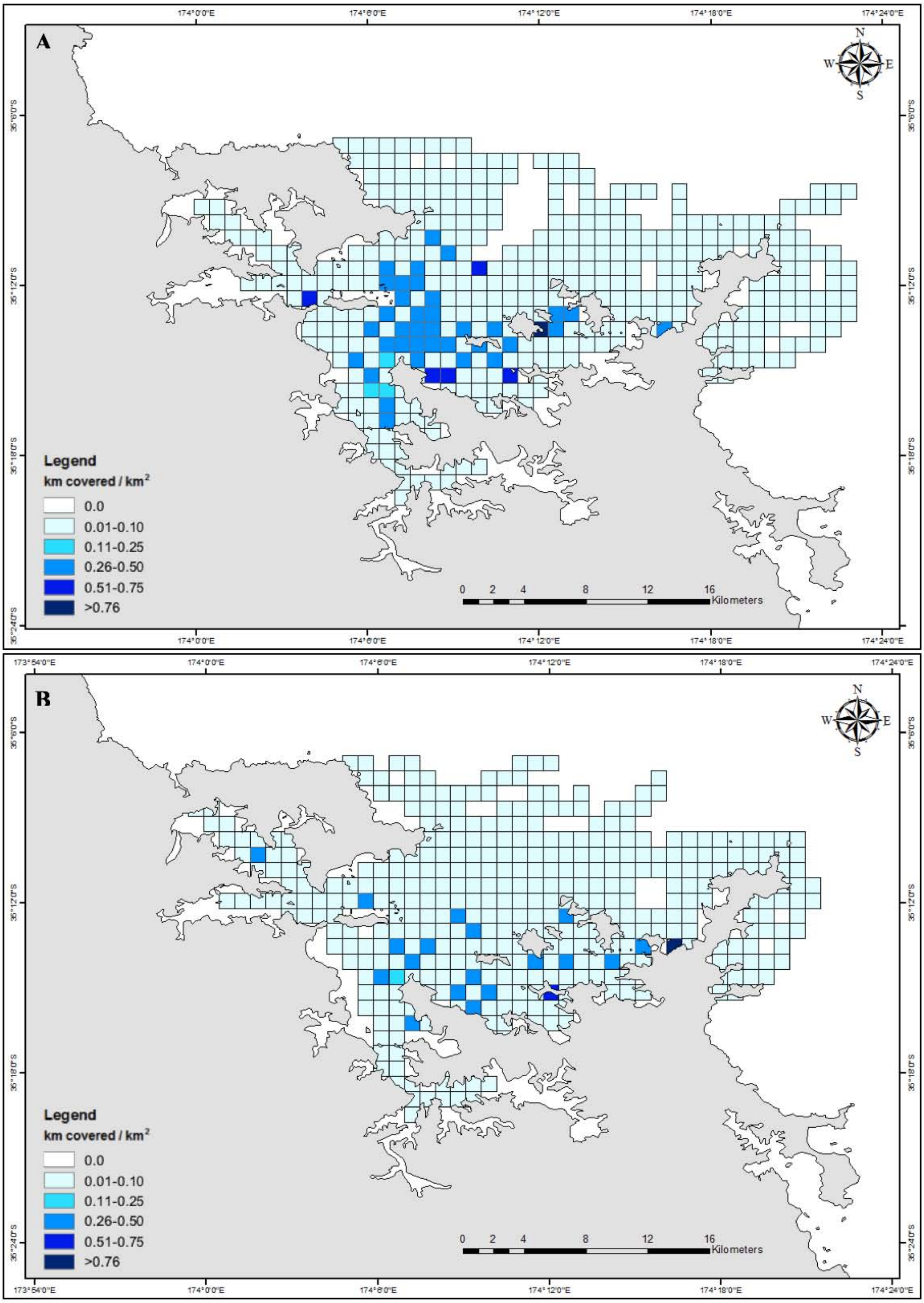


Figure 13: Research vessel sightings per km effort between December 2012 and April 2015, in Bay of Islands waters, New Zealand NZ with A) Autumn, and B) Winter gridded measures of effort (1km x 1km).

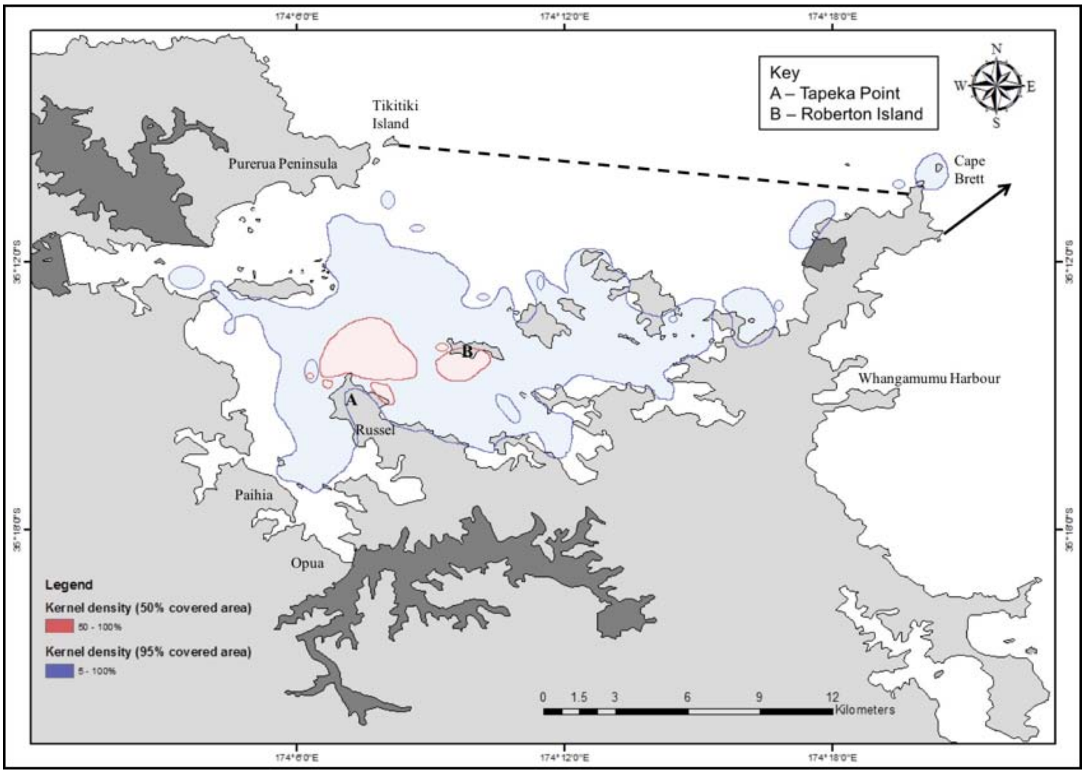


Figure 14: Bottlenose dolphin range between December 2012 and April 2015, in Bay of Islands waters, New Zealand with 95% and 50% volume contours realised by generating effort corrected kernel densities of the dataset. Black dotted line represents harbour boundaries and permitted vessel exclusion zones are indicated as dark grey for the Bay of Islands.

5.6. Group size

Groups ranged in size from singletons to 48 individuals (mean=14.8 ± 3.6 SE, n=2,015). No significant annual, observation vessel or group size variation in distribution was observed. The frequency distribution of group size was skewed towards smaller groups, yet more than 68.0% (n=1,370) of groups were larger than 10 individuals, explaining the discrepancy between the mean and the mode group size. Mean group size between 2012 and 2015 was smaller than that reported from previous studies (Table 10).

Table 10: Mean best group size and range of bottlenose dolphins across New Zealand (SE=Standard error, S.D.=Standard deviation).

Location	Range	Group Size	SE	Reference
BoI	3-40	15.3	8.3	1996-1997 (Constantine & Baker 1997)
BoI	2-50	17.1	1.24	1999 (Constantine 2002)
BoI	2-50	16.7	12.62	1997-99 (Tezanos-Pinto 2009)
BoI	2-45	19.1	10.7	2003-2005 (Tezanos-Pinto 2009)
BoI	2-50	17.9	11.72	1997-05 (Tezanos-Pinto 2009)
BoI	1-48	14.8	3.6	This study
Hauraki Gulf	1-82	35	23.36 S.D	Dwyer et al., 2014
Marlborough Sounds	3-172	12	38 S.D	Merriman et al., 2009
Doubtful Sound	1-65	17.2	N/A	Lusseau et al., 2003

Small groups (<20, 69%, n=1,390) were more commonly observed than larger groups (>20, 31%, n=625). When examining smaller group size categories, 11-15 individuals (24%, n=484) and 6-10 individuals (21%, n=423) were the most prevalent (Figure 15). Each category above 20 individuals represented 10% or less of the observations (e.g. 21-25: 8%, 26-30: 8%, 31-35: 5% and 36-40: 4%, (Figure 16)). Forty-eight instances of solitary dolphins were also recorded (overall 2%, 3% of group 1-5).

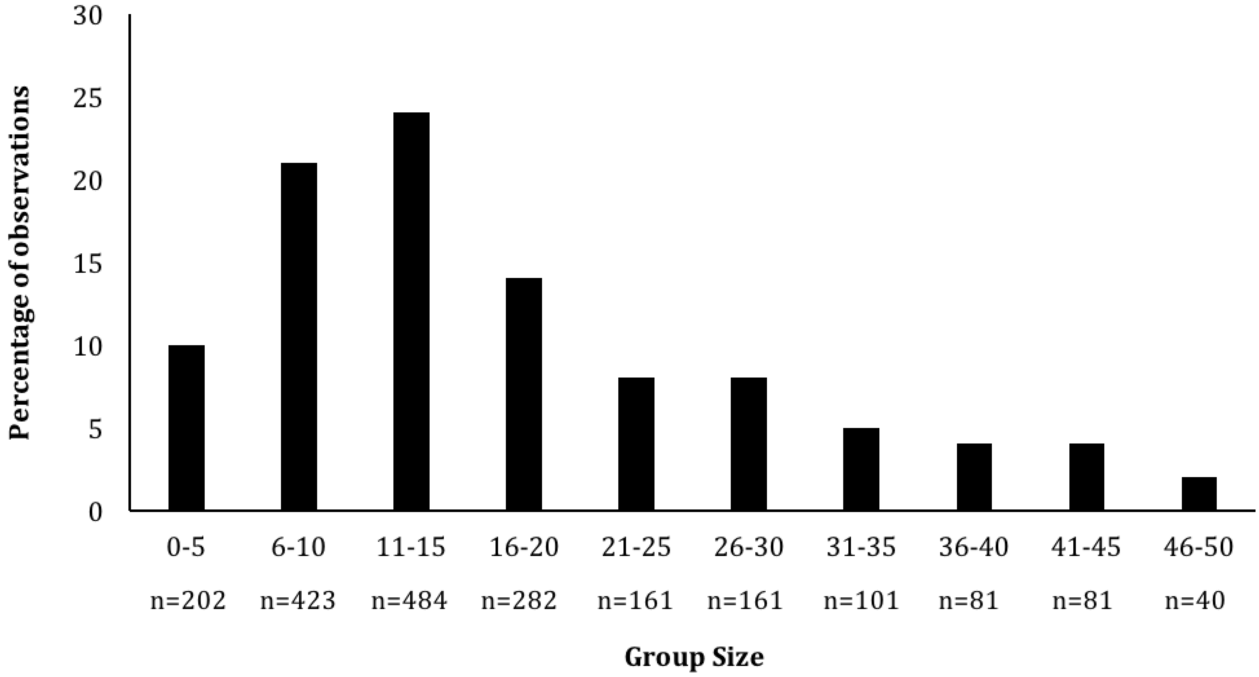


Figure 15: Mean group size of bottlenose dolphins categorised by percentage of observations between December 2012 and April 2015 within Bay of Islands waters, New Zealand.

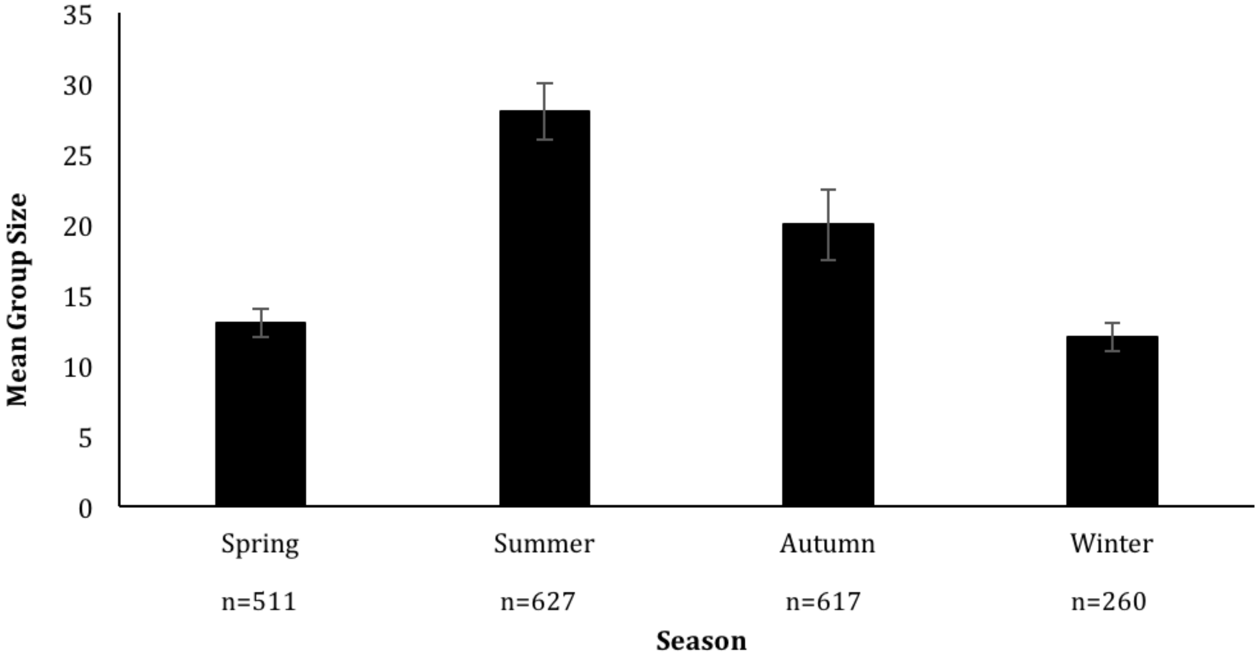


Figure 16: Mean group size of bottlenose dolphins categorised by season between December 2012 and April 2015 within Bay of Islands waters, New Zealand. Bars represent the standard error of the mean.

Groups were larger in summer and autumn than spring and winter (Kruskal-Wallis: h=37.14, df=3, p=0.005, Figure 16) and larger at midday (Kruskal-Wallis: h=41.11, df=2, p<0.001, Figure 17). Finally, groups generally were larger when socialising, foraging and travelling, (Figure 18) and the smallest when diving (Kruskal-Wallis: h=31.82, df=5, p=0.031).

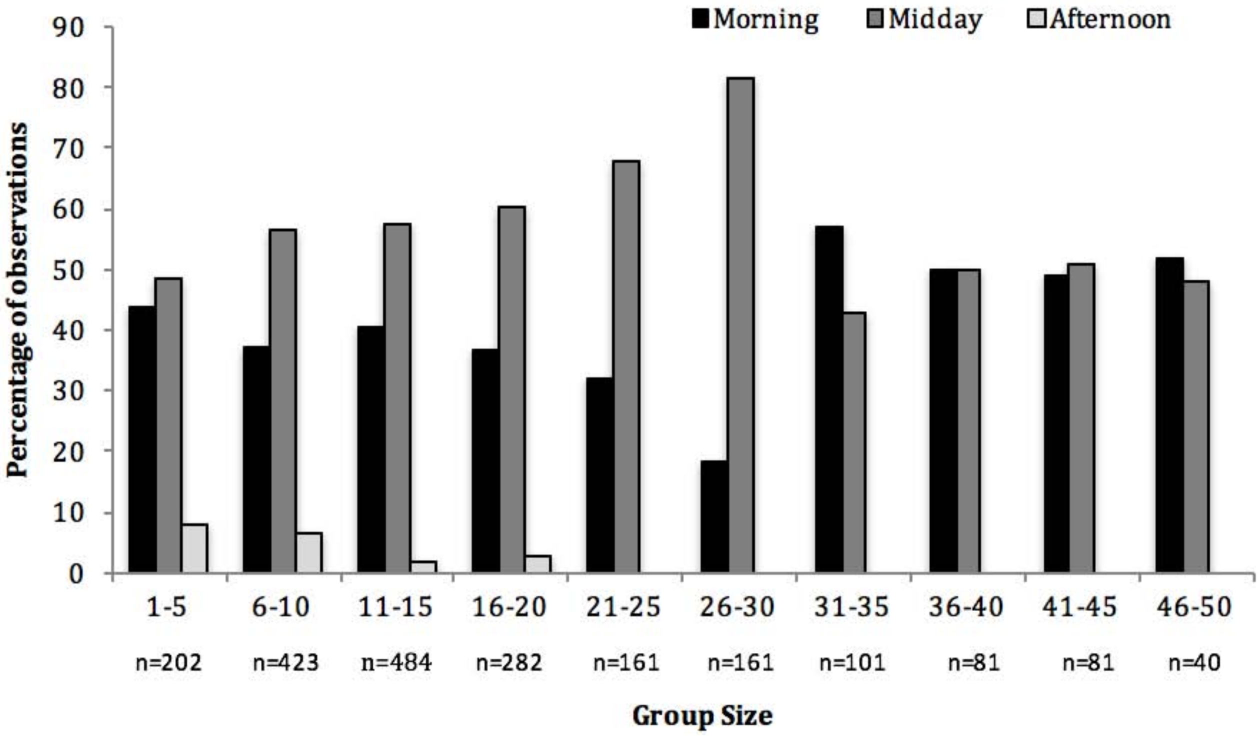


Figure 17: Group size of bottlenose dolphins during different time periods between December 2012 and April 2015 within Bay of Islands waters, New Zealand. Bars represent the standard error of the mean.

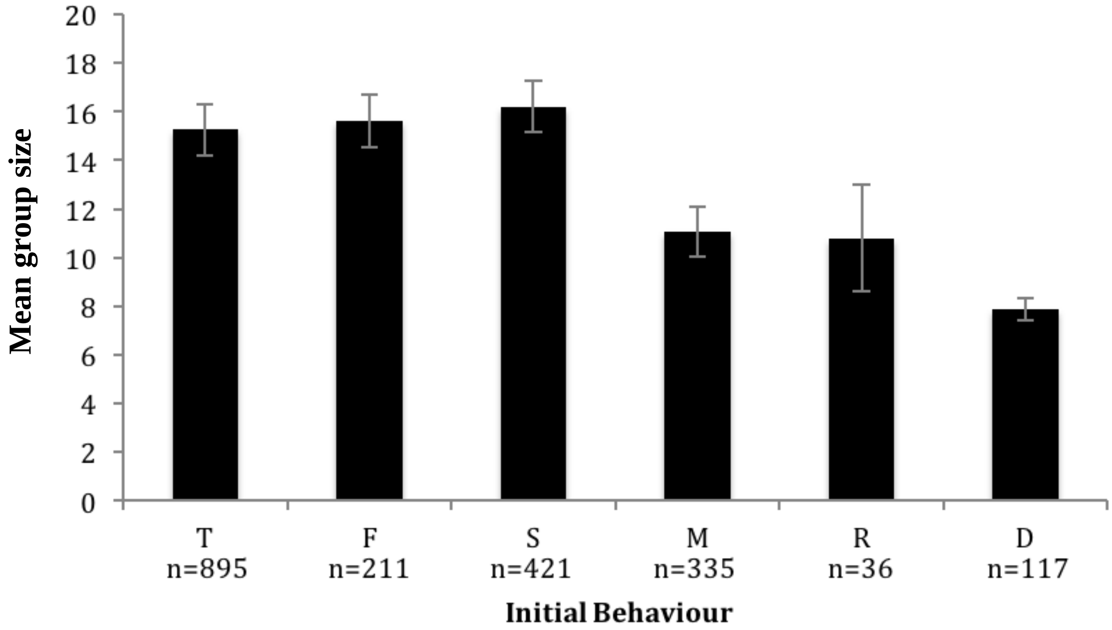


Figure 18: Mean group size of bottlenose dolphins engaging in different behavioural activities on first sighting by observation vessels between December 2012 and April 2015 within Bay of Islands waters, New Zealand. Bars represent the standard error of the mean.

5.7. Site fidelity

Bottlenose dolphin were encountered in every survey season (Table 11, Figure 19) and month between December 2012 and April 2015 by all platform types.

The discovery curve (Figure 20) indicated a steep ascent during early surveys before reaching a plateau in February 2014, with only two new individuals identified for the remainder of the study.

Out of a total of 134 identifiable individuals, a large proportion (71.6%, n=96) were sighted on more than three occasions. The remaining thirty-eight dolphins (28.4% of total) were recorded on less than three occasions, and were therefore excluded from analysis. Almost all resighted individuals (97.9%, n=94) were observed over at least two different years and 54.2% (n=52) across all years.

Table 11: Summary of the number of surveys conducted and individual bottlenose dolphins identified per season between December 2012 and April 2015, within Bay of Islands waters, New Zealand.

	Spring	Summer	Autumn	Winter
Number of surveys	364	409	411	288
Km on survey effort	18,089	22,545	21,832	19,426
Number of hours on encounter effort	370	545	461	157
Number of encounters	511	627	617	260
Number of individually identifiable dolphins	85	83	77	87

5.7.1. User type

Between December 2012 and April 2015, the 96 individuals categorised as distinctive and sighted on more than three occasions were added to a temporary BoI catalogue. The highest number of individually identified dolphins per encounter for December 2012-April 2015 was 41 dolphins (range=1-41; mean=14; SE=8.89).

The resighting rate of those 96 individuals varied considerably during the study period. To examine patterns of use, sightings were categorised into lunar months and seasons to avoid bias due to pseudo-replication (refer to methods section 4.7.0) (Figure 19-22).

Resight rate ranged from 0 - 12 sightings per lunar month (median=3.50, interquartile range=1-3.8). A Poisson distribution was calculated to test the null hypothesis that individuals were sighted randomly (Zar 1996) (Figure 21), which was rejected (x^2=38.37, df=6, p<0.001). The point at which the frequency of observed sightings exceeded expectation (i.e., ≥ 8 sightings/lunar month) was considered to indicate frequent users of the BoI. Infrequent and occasional visitors were arbitrarily defined as the individuals with ≤ 1 and 2-7 sightings/lunar month, respectively.

Infrequent visitors formed the majority group (60.4%, n=58), while occasional visitors represented another 19.8% (n=19). The remaining 19.8% (n=19) of dolphins may be considered core frequent users, where the BoI represent an integral part of their home range. Finally, an unexpectedly large number of individuals were observed only once per lunar month (n=58, x^2=25.27, df=1, p<0.001).

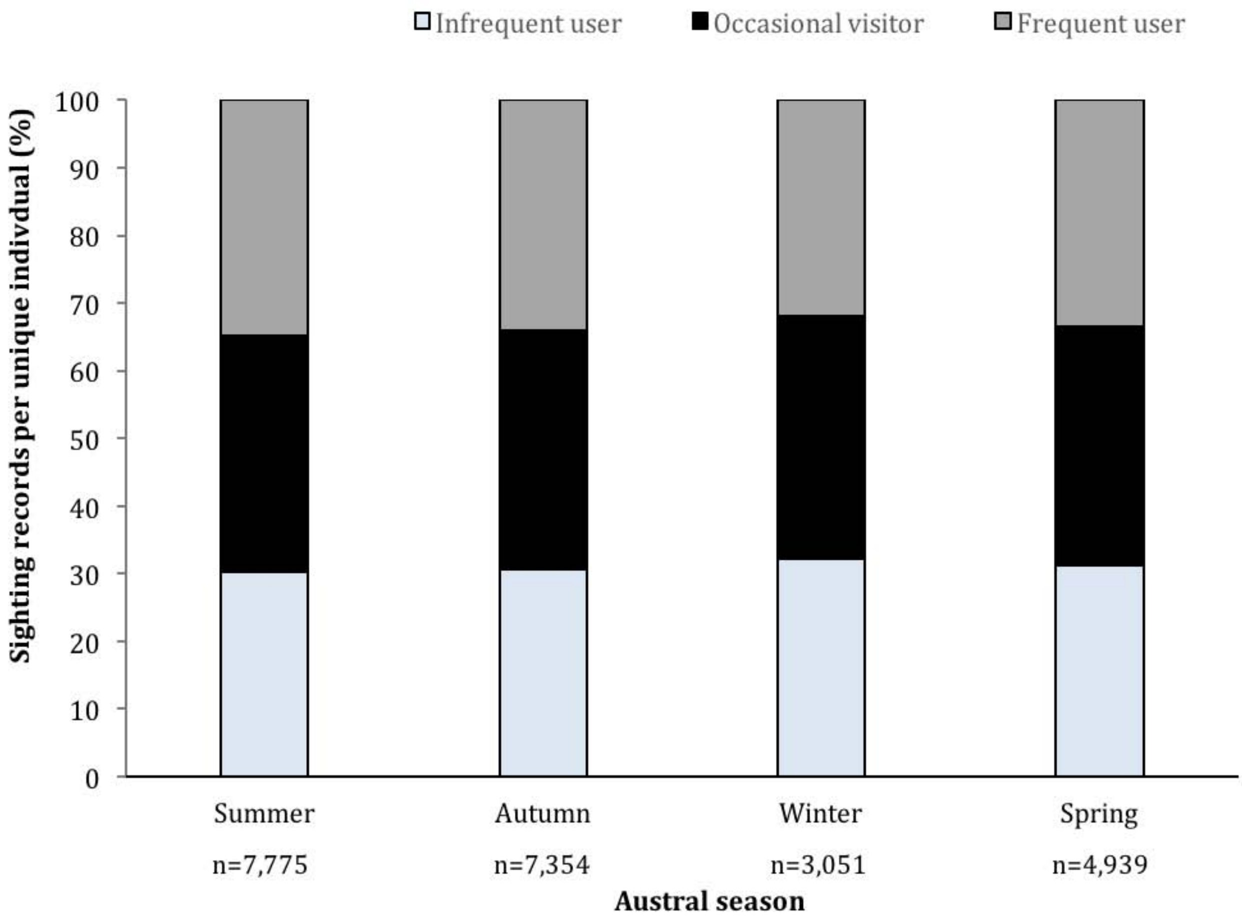


Figure 19: Seasonal effort (km) weighted ratio (expressed as a percentage) of the total number of sighting records per unique identified individual bottlenose dolphin between December 2012 and April 2015 within Bay of Islands waters, New Zealand. The proportion of different user types (infrequent, occasional, and frequent) are also indicated.

All 19 core users were observed in all four seasons. Further to this, 68.4% (n=13) of these core users were sighted in every lunar month while the remaining 31.6% (n=6) in half or more of all lunar months. Occasional visitors were observed on an average of 4.8 months/year (range=2-7, n=19) and infrequent users on an average of 1 months/year (range=0-1, n=58).

At least one frequent user was present in 86.7% of encounters (n=1,747 encounters) and the maximum interaction occurred with two identified individuals whom were each present in 55.3% of encounters (n=1,114 encounters).

No significant difference in seasonality was detected (x^2=13.81, df=3, p=2.610) between user types, when a weighted ratio of the total number of sighting records per individual was analysed (Figures 19 & 22).

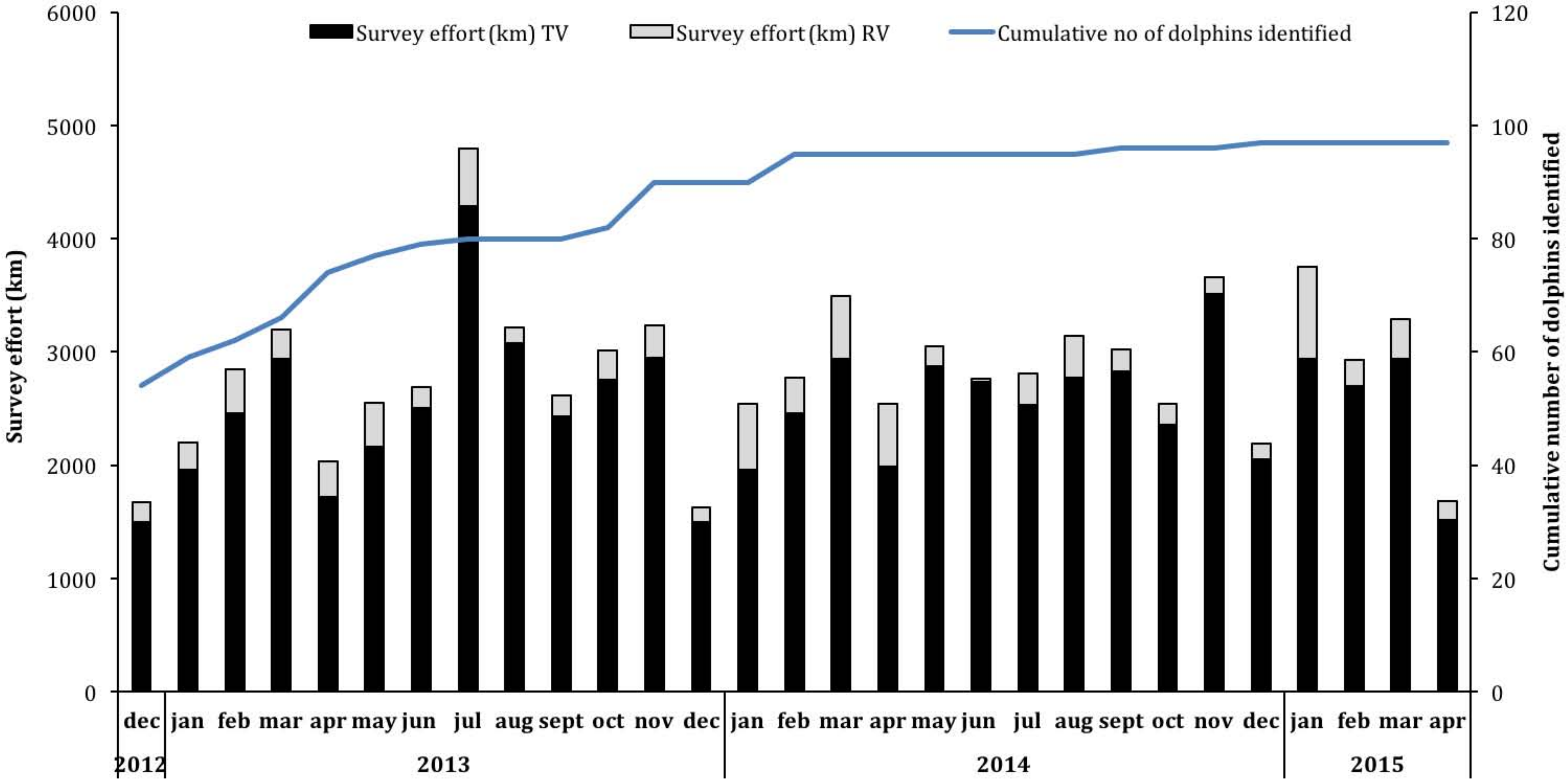


Figure 20: Discovery curve of bottlenose dolphins between December 2012 and April 2015 within Bay of Islands waters, New Zealand, with cumulative number of individuals' photo-identified per survey month. Bars represent the number of kilometres (km) spent *on effort*.

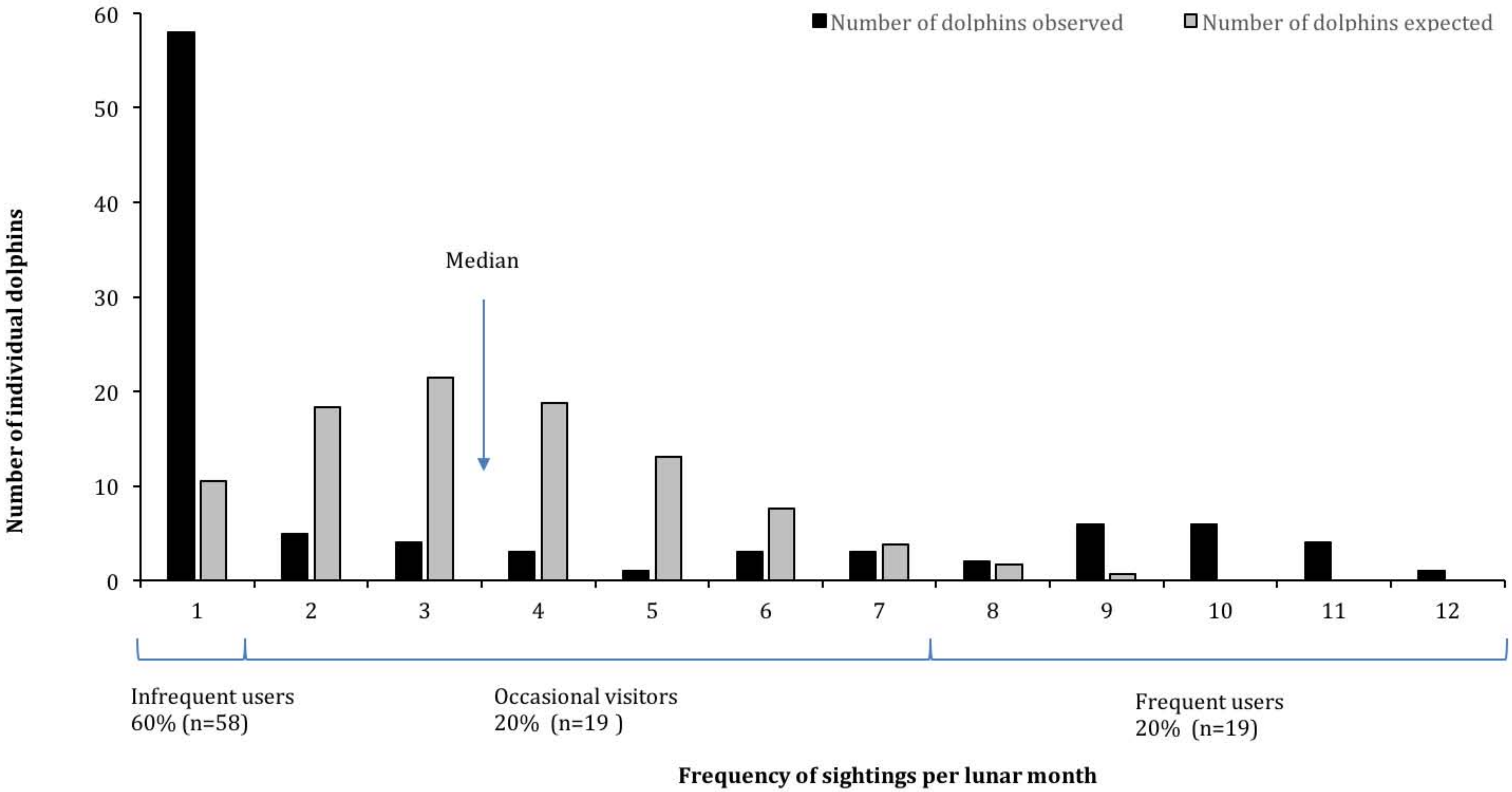


Figure 21: Observed (black) vs. expected (grey) Poisson distribution of number of times individual bottlenose dolphins were identified by lunar months between December 2012 and April 2015 within Bay of Islands waters, New Zealand. The proportion of different user types (infrequent, occasional, and frequent) are also indicated.

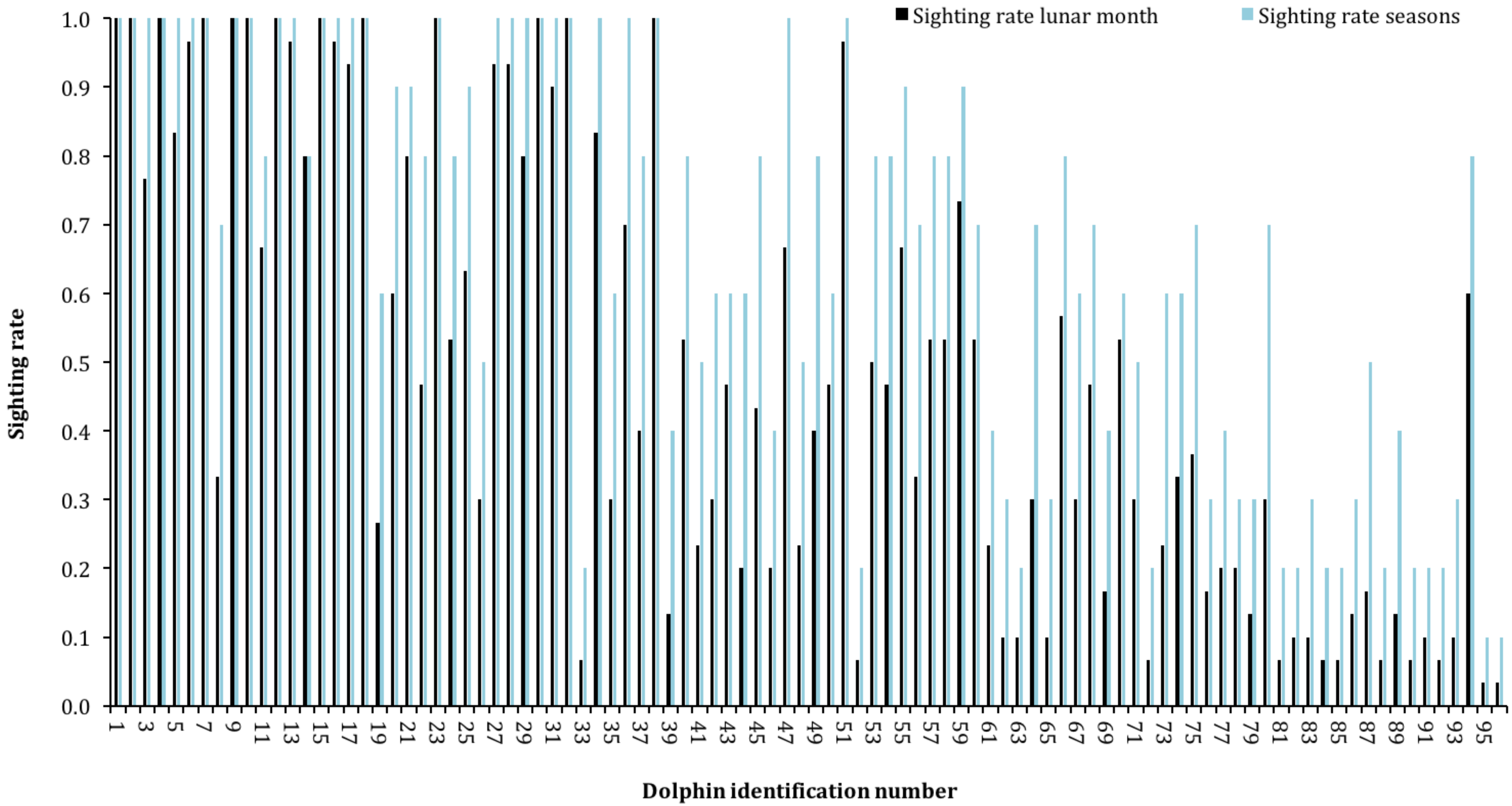


Figure 22: Monthly and seasonal sighting rates of identifiable bottlenose dolphins between December 2012 and April 2015, within Bay of Islands waters, New Zealand.

5.8. Group composition
5.8.1. Adult-calf groups and mixed groups

Out of the 2,015 initial sightings of dolphin groups, 46.0% (n=926) involved adult-only groups, while 41.9% (n=845) comprised at least one calf (nursery group). The remaining 12.1% occurred with lone animals (n=244).

A total of 10 identifiable adult females were observed with 12 young of the year calves whose fate could be documented over 1 or 2 years. Suspected 1st year mortality was observed for 0.67 (CI=0.48-0.71, n=8). Of the surviving 33% of calves (n=4) a further 0.25 of calves did not survive to over 2 years of age (CI=0.11-0.49, n=1). Only 3 individual survived to over 2 years of age (75.0% mortality, CI=0.57-0.89).

The income breeder nature of dolphins dictates that a short temporal scale of investment prior to conception/birth needs to be considered in conjunction with confounding variables, thus further analysis of these data is required to provide full calf mortality assessment.

Mean group size of nursery groups was 18.0 (±0.9 SE, n=845), with no apparent distribution variation by group size (Appendices 1 and 2). Calves were observed in every summer month, with 55.2% (n=466) of all calves sighted during December-February (a further 23.6%, n=199, in Spring) (Figure 23).

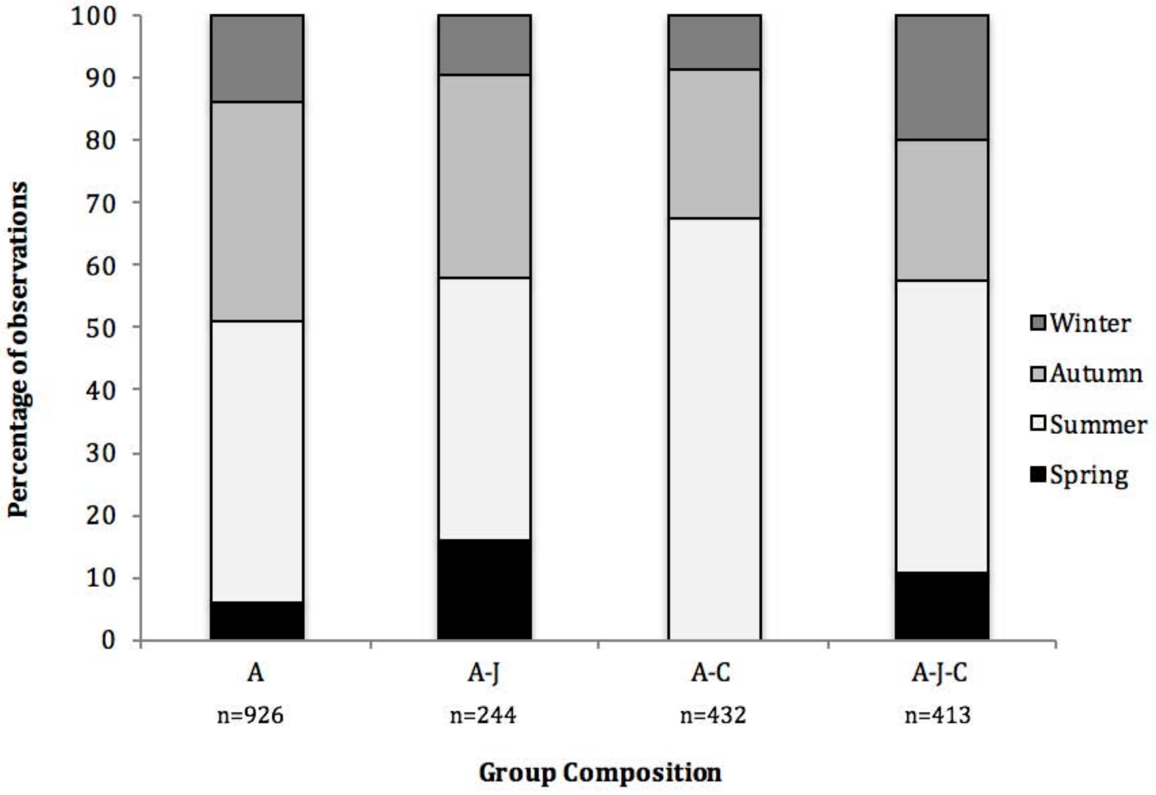


Figure 23: Percentage of observations of each group composition in different seasons, between December 2012 and April 2015, within Bay of Islands waters, New Zealand. A represents adults, A-J represents adults and juveniles, A-C represents adults and calves and A-J-C represents adults, juveniles and calves.

Mixed group mean size (including groups with calves) was the largest with a mean of 35.6 (±0.06 SE, n=845) and varied between three and forty individuals. In contrast, adult-only groups were smaller with a mean of 11.3 (±0.09 SE, n=926). The majority of mixed groups ranged between thirty-one and thirty-five individuals (86.6%, n=732, Figure 24).

5.8.2. Adult only groups

Bottlenose dolphin adults only groups (46.0%), had a mean group size of 7.8 (±0.20 SE, n=926), below the overall mean size of 14.8 (±0.35 SE, n=2,015). No significant annual variation was observed. Groups ranged from singletons up to forty-eight individuals (Figure 24).

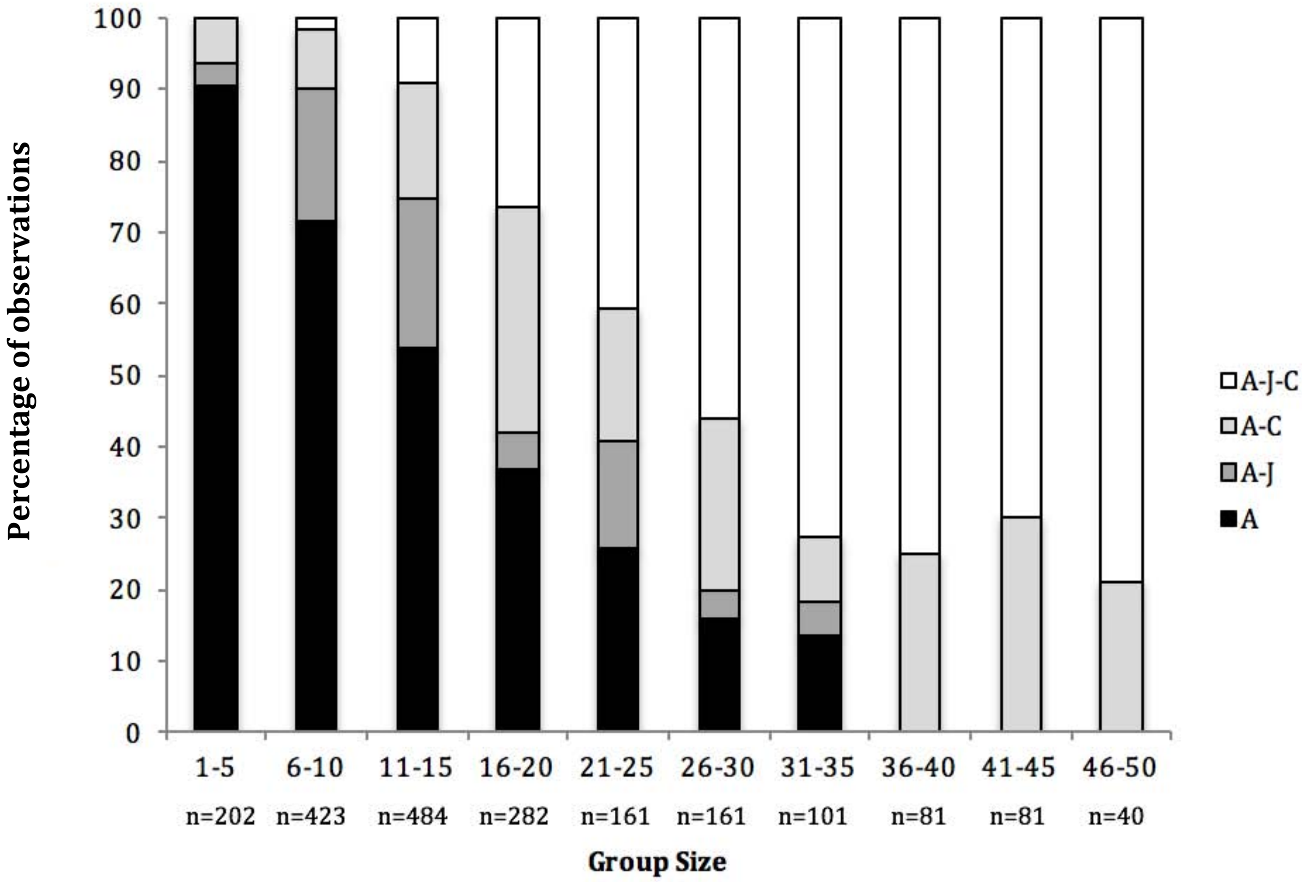


Figure 24: Percentage of observations of each group size *vs* group composition, between December 2012 and April 2015, within Bay of Islands waters, New Zealand. A represents adults, A-J represents adults and juveniles, A-C represents adults and calves and A-J-C represents adults, juveniles and calves.

5.9. Spatial distribution of behaviour

Overall, a clear pattern in the distribution of behaviours was detected for resting and travelling (Figure 25-27) but not other behaviours (foraging, socialising and milling).

Resting primarily occurred in significantly shallower waters (mean=17.3, 67% >20m, n=36) (Kruskal-Wallis: h=11.76, df=4, p<0.001) and closer to land (Mean=98.3, range=3.8-394.7m, SE=56.24, n=2,019) (Kruskal-Wallis: h=12.39, df=4, p=0.008) than other behaviours. Dolphins selected inner islands zones for resting (Figure 25). Contrary to this, travelling was the primarily observed behaviour in significantly deeper waters (mean=69.3, 58% <20m, n=895) (Kruskal-Wallis: h=14.43, df=4, p<0.001) and in outer bays areas further from land (mean=3482.4m, range=112.1-6913.7m, SE=1.3m, n=895) (Kruskal-Wallis: h=17.12, df=4, p=0.003).

Dolphins were rarely observed travelling in inner bays and inner islands when compared to outer bays (Kruskal-Wallis: h=9.64, df=2, p<0.001) (Figure 27B).

Foraging, socialising and milling exhibited more even distribution across the BoI with no significant differences observed in depth (Kruskal-Wallis: h=31.82, df=4, p>0.05; Kruskal-Wallis: h=22.31, df=4, p>0.05; Kruskal-Wallis: h=25.08, df=4, p>0.05) (Figure 26, 27A).

Similarly, distance to coast (range=6.7-5381.2m, SE=72.19, n=967) did not vary according to behavioural state of foraging (Kruskal-Wallis: h=9.14, df=4 p>0.05), socialising (Kruskal-Wallis: h=17.21, df=4, p>0.05) or milling (Kruskal-Wallis: h=12.05, df=4, p>0.05).

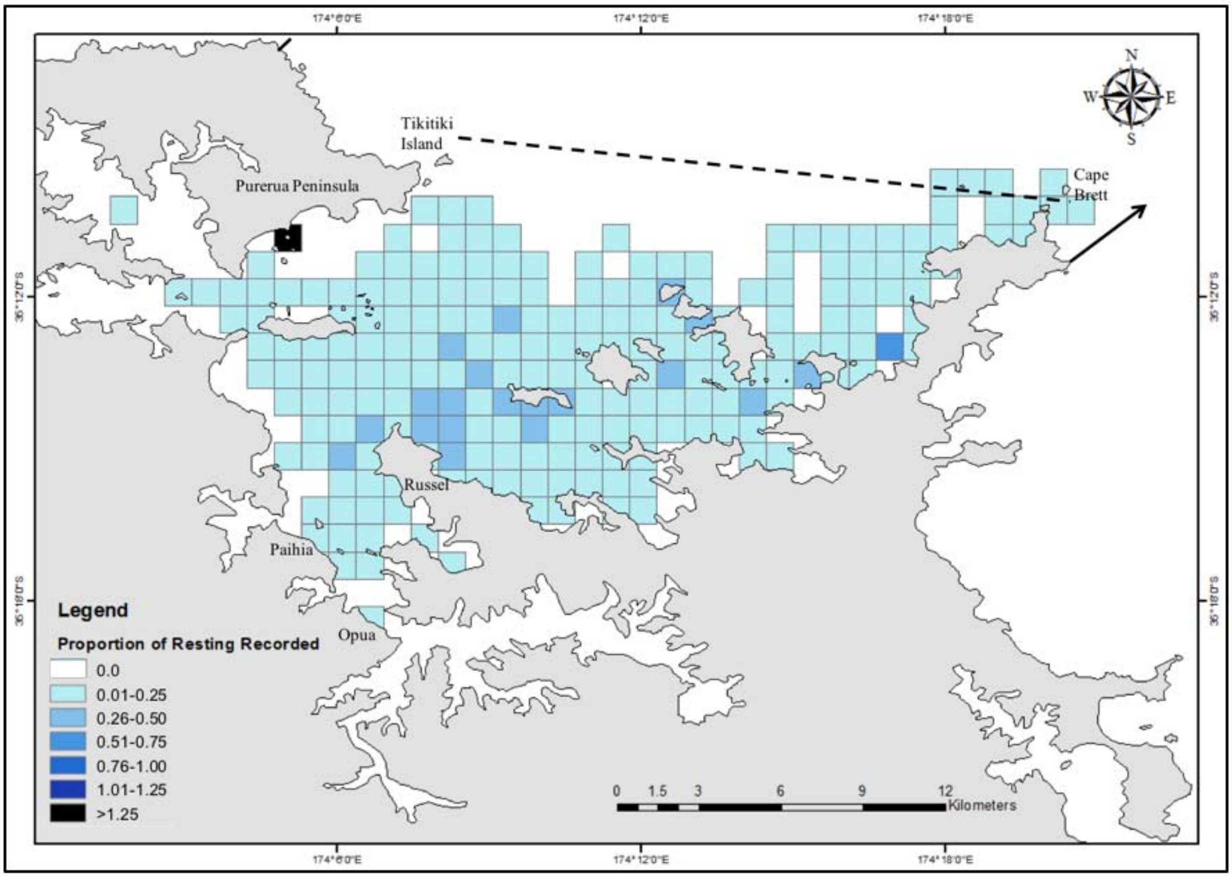


Figure 25: Combined platform initial sighting (mutually exclusive with one vessel per day) categorised by behaviour between December 2012 and April 2015, in Bay of Islands waters, New Zealand, with resting behaviour gridded as proportion of all behaviours, coloured according to the proportion per kilometre (km) within each grid cell (1km x 1km)

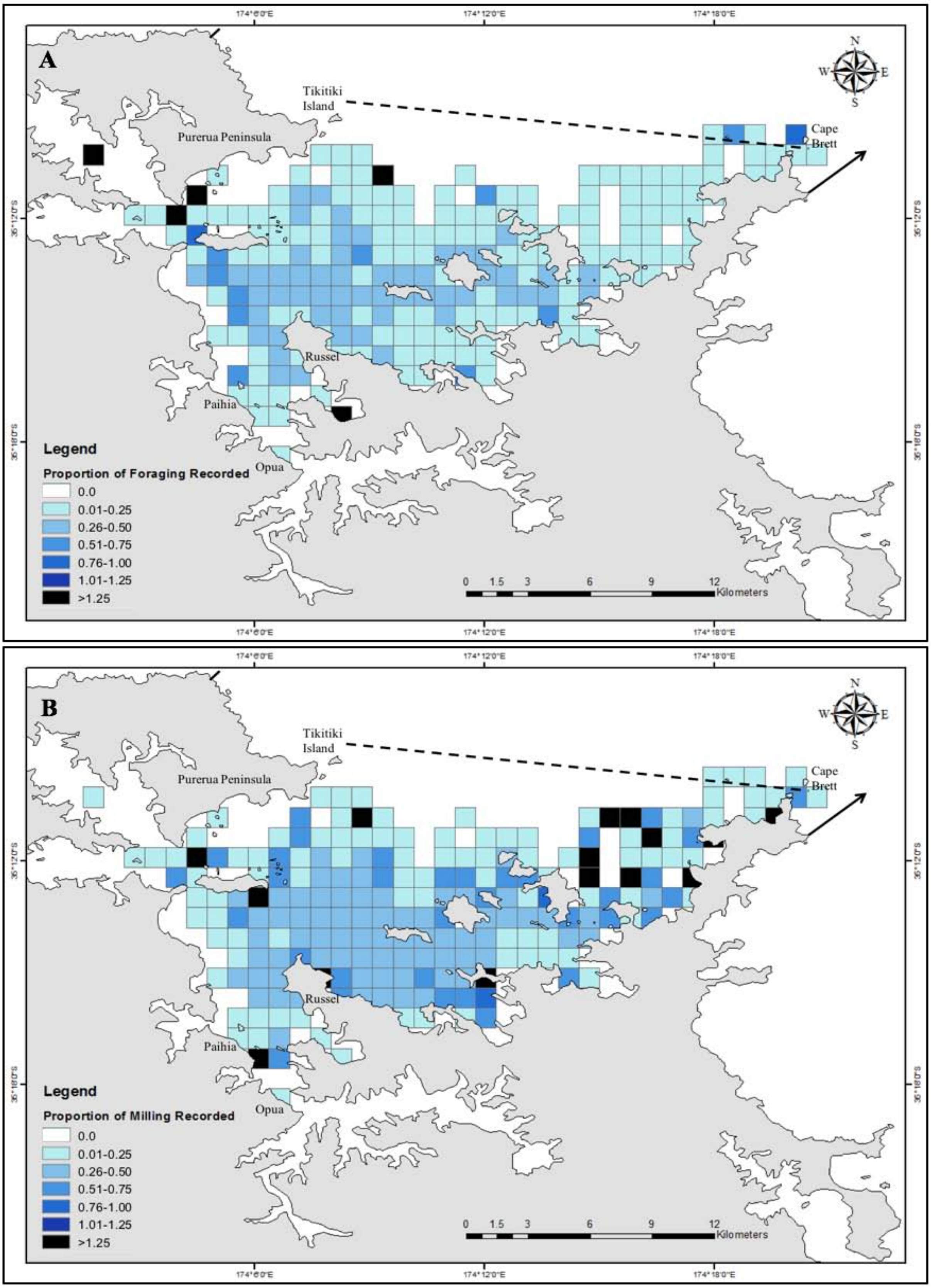


Figure 26: Combined platform initial sighting (mutually exclusive with one vessel per day) categorised by behaviour between December 2012 and April 2015, in Bay of Islands waters, New Zealand, with A) foraging and B) milling behaviour gridded as proportion of all behaviours, coloured according to the proportion per kilometre (km) within each grid cell (1km x 1km).

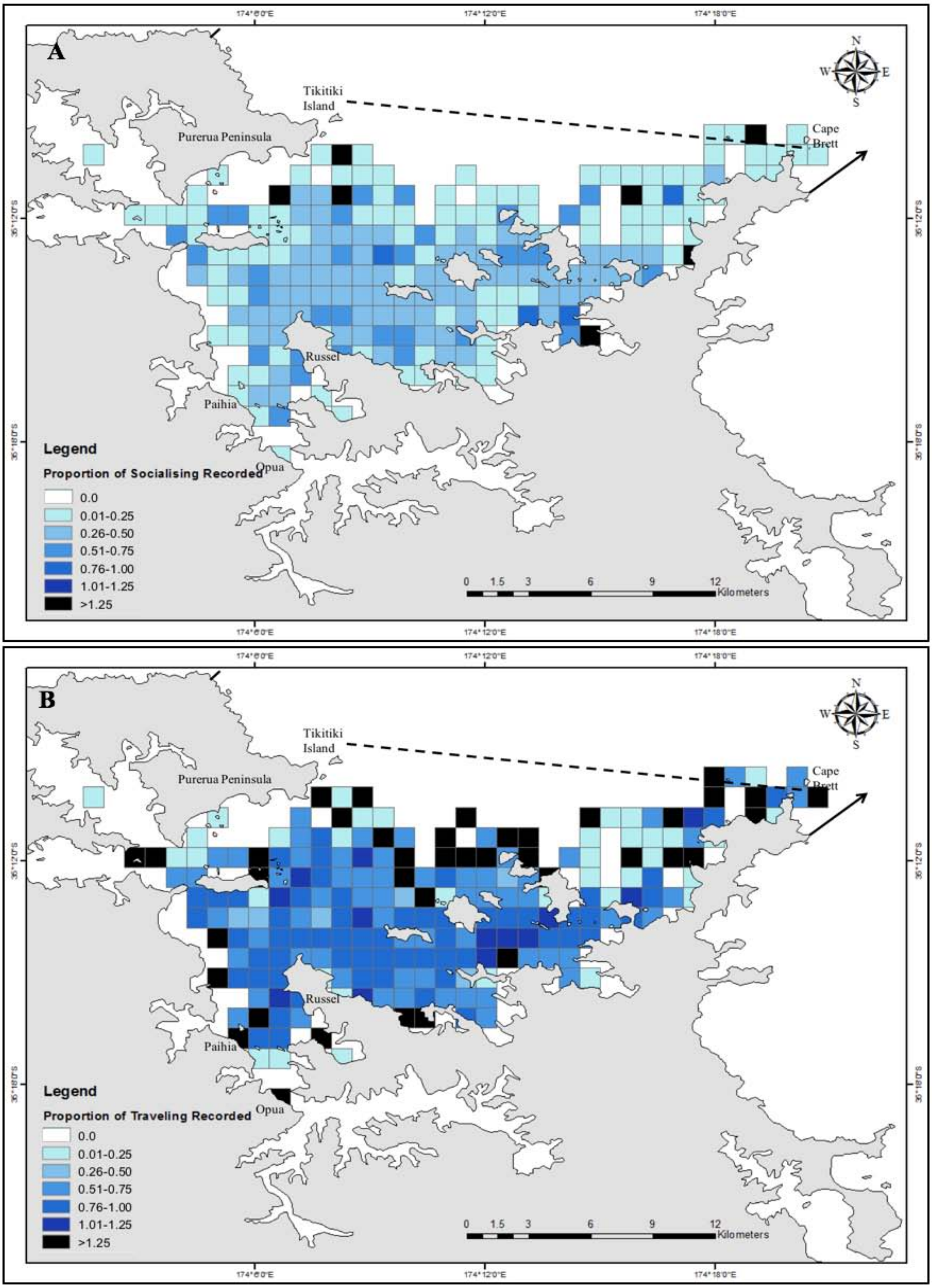


Figure 27: Combined platform initial sighting (mutually exclusive with one vessel per day) categorised by behaviour between December 2012 and April 2015, in Bay of Islands waters, New Zealand, with A) socialising and B) travelling behaviour gridded as proportion of all behaviours, coloured according to the proportion per kilometre (km) within each grid cell (1km x 1km).

5.10. Behavioural transitions

A total of 4,062 (62.1%) observations of behaviour with vessels were recorded from the research vessel within BoI harbour limits between December 2012 and April 2015, which equates to 17,429 new vessels within 300m observations. A total of 2,416 behavioural transition counts were observed from the RV. The summary by time of day, season and vessel presence is detailed in Table 12.

Table 12: Count of observed behavioural state transitions for bottlenose dolphins by season, time of day and vessel presence between December 2012 and April 2015 within Bay of Islands waters, New Zealand.

	Morning		**Midday**		**Afternoon**		
	Present	**Absent**	**Present**	**Absent**	**Present**	**Absent**	**Total**
Spring	165	88	36	53	7	8	357
Summer	812	248	112	31	3	6	1,212
Autumn	292	91	90	56	12	8	549
Winter	78	126	35	61	12	7	319
Total	1,347	553	273	201	34	29	2,437

The number of counts were sufficient to conduct a full 5-way log-linear analysis of the effects of factors such as season, time of day and vessel presence on behavioural transitions (Table 13, Figure 28).

Table 13: Akaike Information Criterion values for the effects of time of day, season and vessel presence on the behavioural state transitions of bottlenose dolphins between December 2012 and April 2015, in Bay of Islands waters, New Zealand. Likelihood for a model given the data are approximated by $^{(-0.5*\Delta AIC_i)}$, and the weight of evidence provided by each model is calculated by normalising the likelihoods to 1.

Model	**AIC**	**ΔAIC**	**Likelihood**	**Weight**
Vessel Presence + (Season x Time of Day)	2196.33	0	1.000	0.346
Vessel Presence + Time of Day + Season	3103.61	1.033	0.632	0.206
Vessel Presence x Season	3104.19	1.663	0.052	0.155
Season + Vessel Presence	3107.27	2.816	0.009	0.085
Season + (Vessel Presence x Time of Day)	3107.68	3.732	3.765E-08	0.053
Season x Time of Day	3108.23	4.067	5.095E-08	0.045
Time of Day + (Vessel Presence x Season)	3128.25	4.691	6.218E-09	0.033
Time of Day + Season	3179.89	4.921	1.901E-10	0.029
Vessel Presence	3210.05	5.097	7.67E-11	0.027
Season	3210.38	5.701	1.539E-12	0.017
Vessel Presence x Season x Time of Day	3217.01	10.567	6.195E-21	0.002
Time of Day + Vessel Presence	3315.51	10.687	1.061E-28	0.002
Vessel Presence x Time of Day	3327.76	12.079	1.04E-40	<0.001
Time of Day	3418.23	12.349	5.595E-52	<0.001
Null model	3429.39	14.015	2.21E-56	<0.001

The null model (no effects due to the three factors) is listed first, with each subsequent branch adding an effect from factor(s) or/and interaction between factors. Significant differences were detected when each of the factors was added to the null model (Figure 28), indicating dolphin behaviour changes in relation to natural (time of day, season) and anthropogenic (vessel presence) factors. Analysis of AIC values revealed that three models provide more information than the others (Table 13). All included effects due to time of day, season and vessel presence. The model with the greatest likelihood also included the interaction between time of day and season (Table 13).

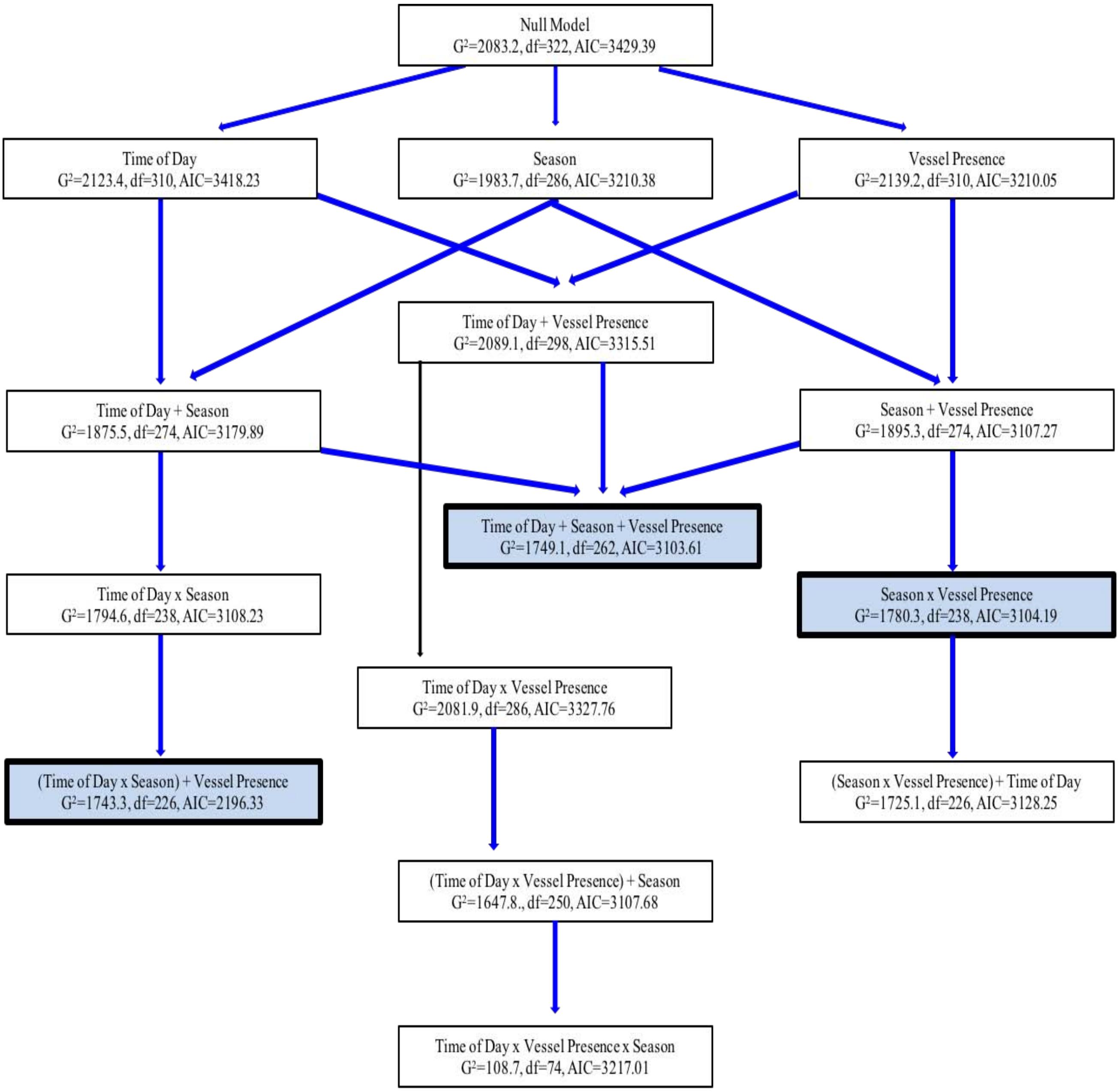


Figure 28: Effects of time of day, season and vessel presence on the behavioural state transitions of bottlenose dolphins between December 2012 and April 2015, in Bay of Islands waters, New Zealand.

Boxes represent the model, which was tested, with G^2, degrees of freedom, and AIC values listed. An 'x' between two terms indicates that the interaction is included. Arrows in blue indicate significant terms added (p<0.05). Boxes with blue background indicate the best fitting models determined by AIC values.

5.11. Seasonal and diurnal variation in behaviour

5.11.1. Mean behavioural bout length

Behavioural bout length was shortest for foraging in summer (z=9.144, p=0.041) (Figure 29A). Bout length also significantly increased (z=10.279.144, p=0.012) for travelling throughout the day while milling decreased (z=3.832, p=0.033) (Figure 29B). No resting was observed in the afternoon.

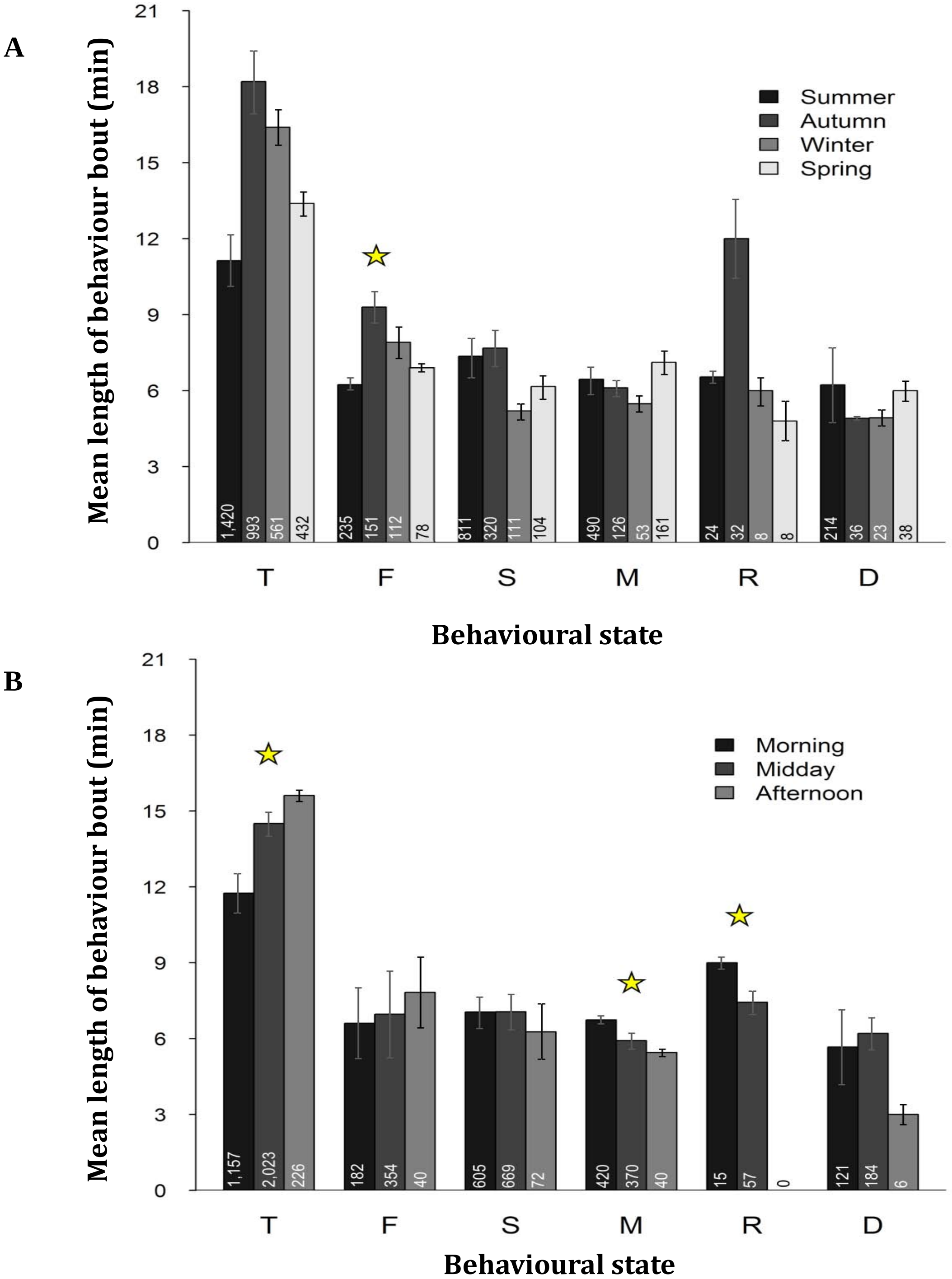


Figure 29: Mean bout length of each behavioural state for bottlenose dolphins observed from research vessel between December 2012 and April 2015 in Bay of Islands waters, New Zealand, by A) season, and B) time of day. Note: T=Travelling, F=Foraging, S=Socialising, M=Milling, R=Resting and D=Diving. Significant bout length difference (z-test $p<0.05$) is marked with a yellow star. Bars represent standard error. N values for each category are displayed on the bars.

5.11.2. Behavioural budget

Both season (Figure 30A) and time of day (Figure 30B) had a significant effect (z-test $p<0.05$) on the behavioural budget of bottlenose dolphins. Milling varied across all seasons. The highest proportion of milling was observed in Summer, with a 33.5% decrease in Autumn, 40.0% in Winter and 66.7% in Spring. Travelling and foraging varied consistently by time of day, with the highest proportion of travelling and foraging observed in the afternoon (28.3% and 71.4% increase from morning to afternoon, respectively).

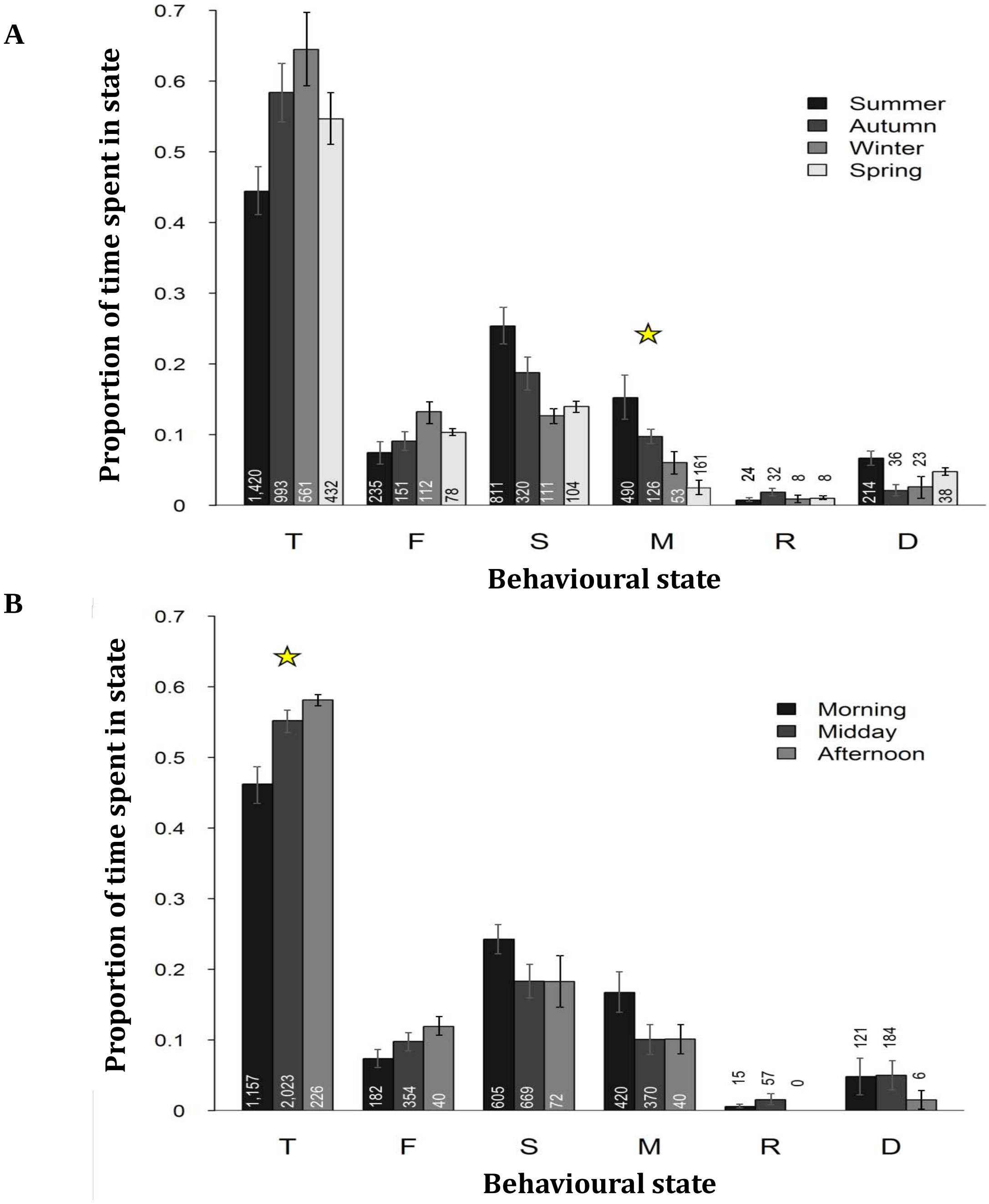


Figure 30: Overall behavioural budget of each behavioural state for bottlenose dolphins observed from research vessel between December 2012 and April 2015 in Bay of Islands waters, New Zealand, by A) season and B) time of day. Note: T=travelling, F=foraging, S=socialising, M=milling, R=resting and D=diving. Significant bout length difference between all time categories (z-test $p<0.05$) is marked with a yellow star. Bars represent standard error. N values for each category are displayed on the bars.

5.12. Effects of vessel presence on behaviour
5.12.1. Mean behavioural bout length

The mean behavioural bout length varied significantly in presence of vessels for five states (Figure 31). In the absence of vessels, travelling (z=6.820, p<0.001), resting (z=1.060, p<0.001) and foraging (z=1.560, p=0.036) bouts were longer, while socialising (z=-2.060 p=0.039), and diving (z=-17.740, p<0.001) bouts were shorter. Milling bouts did not significantly change in the presence of vessels (z=-0.550, p=0.119). When vessels were present within 300m traveling decreased by 35.7%, resting by 22.9%, and foraging by 13.3%, whilst socialising and diving increased by 21.1% and 118.3% respectively.

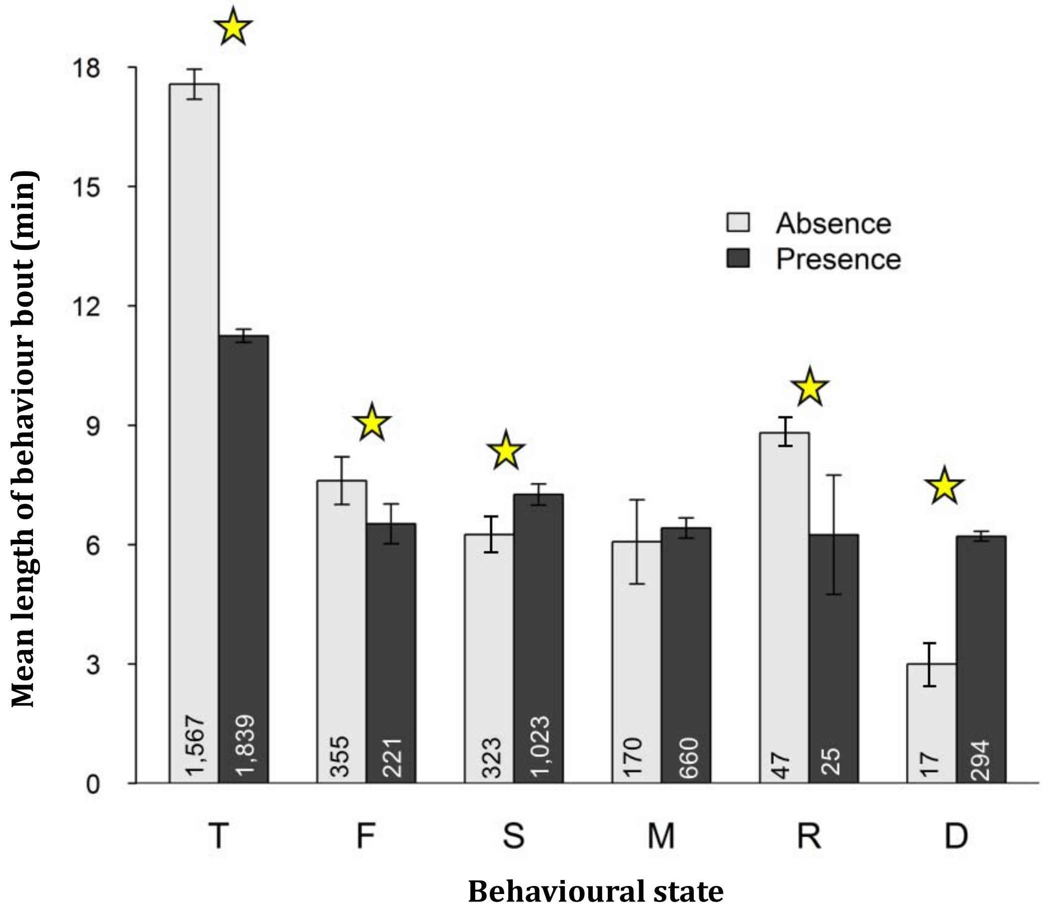


Figure 31: Mean bout length (min) of each behavioural state for bottlenose dolphins observed from research vessel in absence and presence of vessels between December 2012 and April 2015 in Bay of Islands waters, New Zealand. Note: T=travelling, F=foraging, S=socialising, M=milling, R=resting and D=diving. Significant bout length difference between the presence and absence of vessels (z-test p<0.05) are marked with a yellow star. Bars represent standard error. N values for each category are displayed on the bars.

The number of vessels present had a significant effect on mean behavioural bout length (Figure 32). Travelling bout length differed significantly in the absence and presence of vessels (z=7.820, p<0.001) Figure 32); as the number of vessels increased from ≥ 2 to ≥ 4, bout length decreased significantly further (z=9.311, p=0.017).

A similar significant but reversed trend was detected for diving bout length (z=-7.442, p=0.032). As vessel numbers increased, resting bout length showed a further decrease in length in the presence of

≥ 2 vessels (z=-3.984, p=0.021), and a subsequent increase in the presence of ≥ 4. Though the increase was significant (z=-6.220, p=0.049), resting bout length was still significantly lower than in the absence of vessels (z=-2.157, p=0.026).

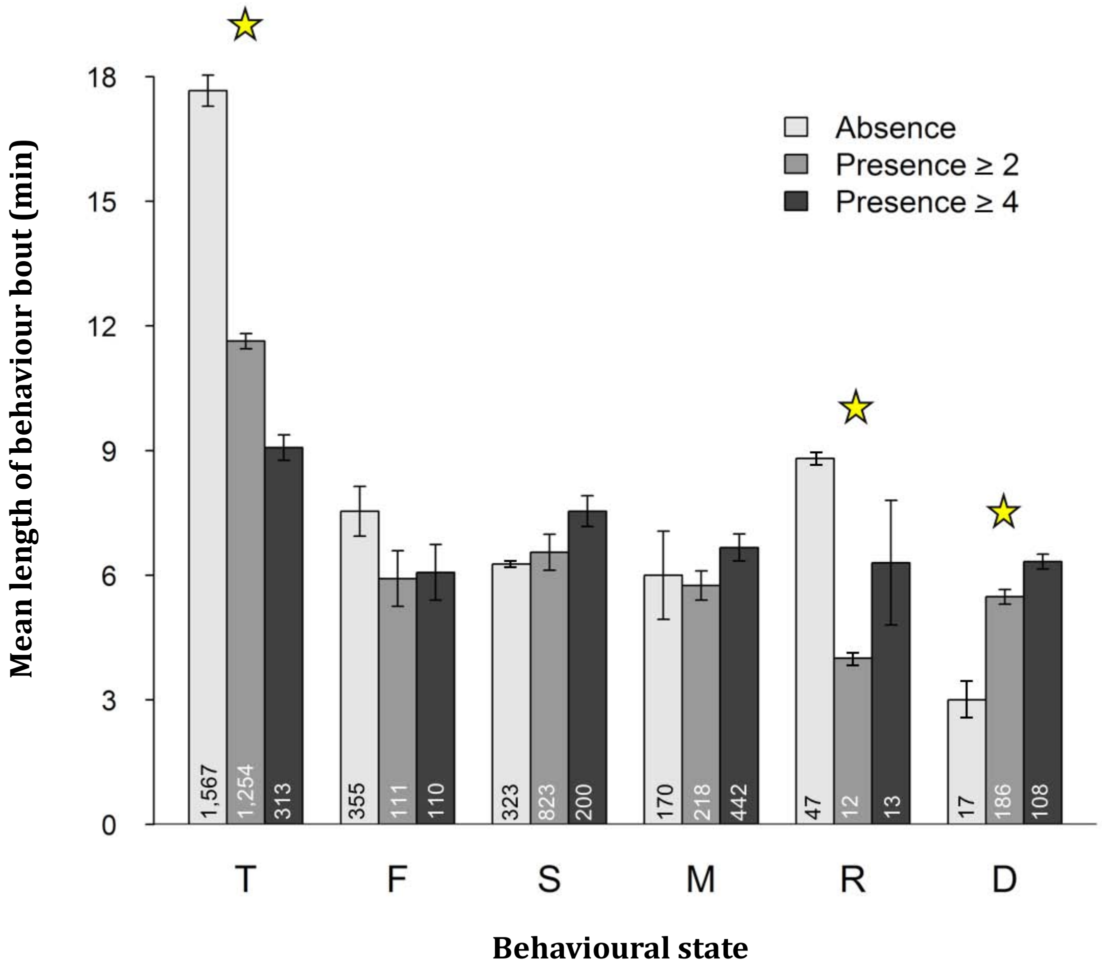


Figure 32: Mean bout length (min) of each behavioural state for bottlenose dolphins observed from research vessel in absence, presence of up to three vessels plus research vessel and presence of four and more vessels between December 2012 and April 2015 in Bay of Islands waters, New Zealand, Note: T=travelling, F=foraging, S=socialising, M=milling, R=resting and D=diving. Significant bout length difference between all vessel categories (z-test p<0.05) is marked with a yellow star. Error bars represent standard error. N values for each category are displayed on the bars.

The mean behavioural bout length varied in the presence of different vessel types when up to three vessels were present (Figure 33). Data were restricted to only three vessels in order to allow direct comparison between vessel types and control for vessel numbers.

Mixed vessels presence had the largest effect on behavioural bout length (z test p<0.05) apart from in milling (z=-7.306, p=0.051) and foraging (z=-4.192, p=0.054) situations when un-permitted vessels had the largest effect. Private and permitted vessels had a similar effect in contrast to un-permitted and mixed. For example, when compared to the absence of vessels, the mean milling bout length increased significantly in the presence of un-permitted (z=6.772, p=0.024) and mixed vessels (z=6.825, p=0.019) but decreased when private (z=-3.298, p=0.057) or permitted vessels (z=-3.282, p=0.063) were present.

Significant differences were also observed between vessel categories with the largest decrease in behavioural bout of foraging in the presence of un-permitted vessels when compared to absence situations (z=-9.120, p=0.032).

In the presence of un-permitted vessels, milling bout length significantly increased when compared to all other vessel categories (z=12.143, p=0.038). Overall, the presence of un-permitted vessels resulted in a decrease in travelling (z=-1.170, p=0.042) and foraging (z=-6.192, p=0.032) and an increase in socialising (z=6.334, p=0.014) and milling (z=9.120, p=0.021). Diving and resting were not observed in the presence of un-permitted vessels.

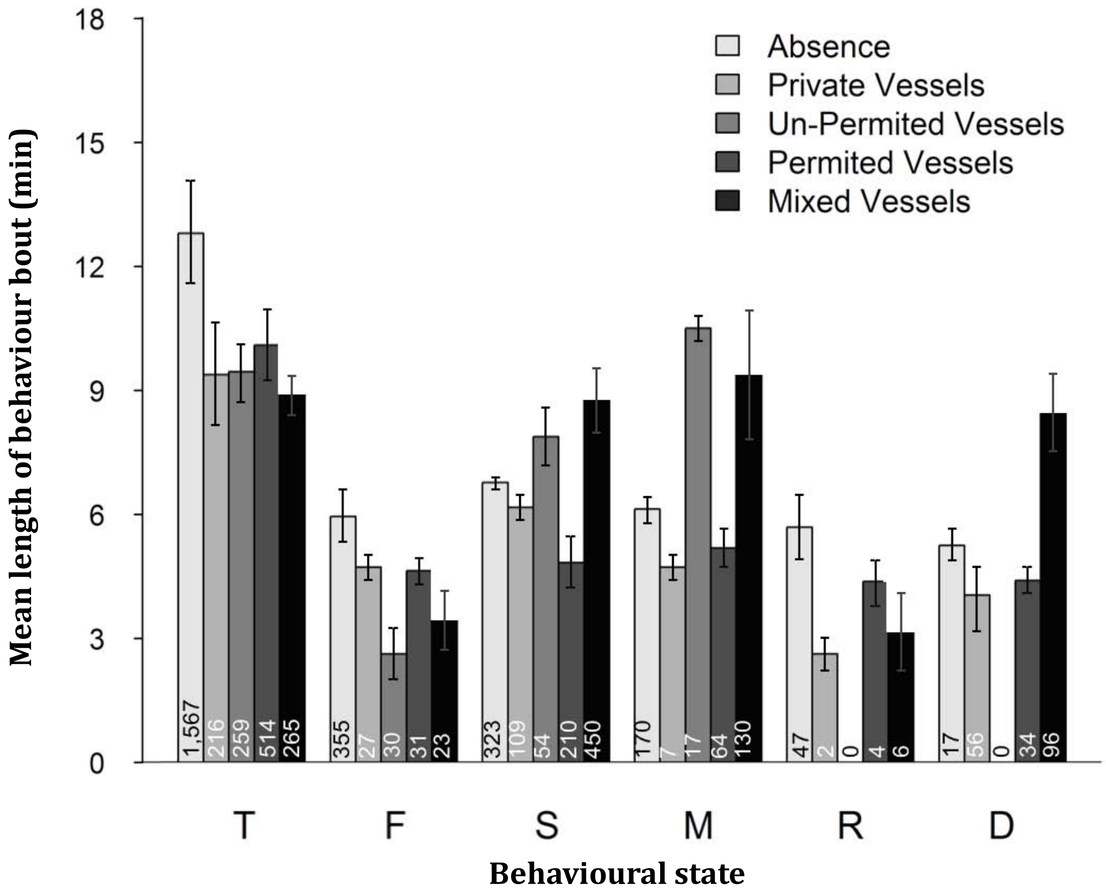


Figure 33: Mean bout length (min) of each behavioural state for bottlenose dolphins observed from research vessel in absence, presence of private vessels, un-permitted vessels, permitted and mixed up to three vessels between December 2012 and April 2015 in Bay of Islands waters, New Zealand. Note: T=travelling, F=foraging, S=socialising, M=milling, R=resting and D=diving. Error bars represent standard error. N values for each category are displayed on the bars.

5.12.2. Behavioural budget

Bottlenose dolphin behavioural budgets were significantly affected by the presence of vessels (Figure 34).

Overall, dolphins spent more time travelling, resting and foraging in absence of vessels within 300 m of the dolphin group, which in the presence of vessels decreased by 69.7%, 133.3% and 160.0%, respectively. However, dolphins generally spent more time socialising, diving and milling in presence of vessels, which increased by 126.3%, 300.0% and 247.6%, respectively.

Bottlenose dolphin cumulative diurnal behavioural budget (control + impact) did vary significantly from the control behavioural budget (goodness-of-fit test, $G^2_{adj.}$=0.37, df=1, p<0.001)

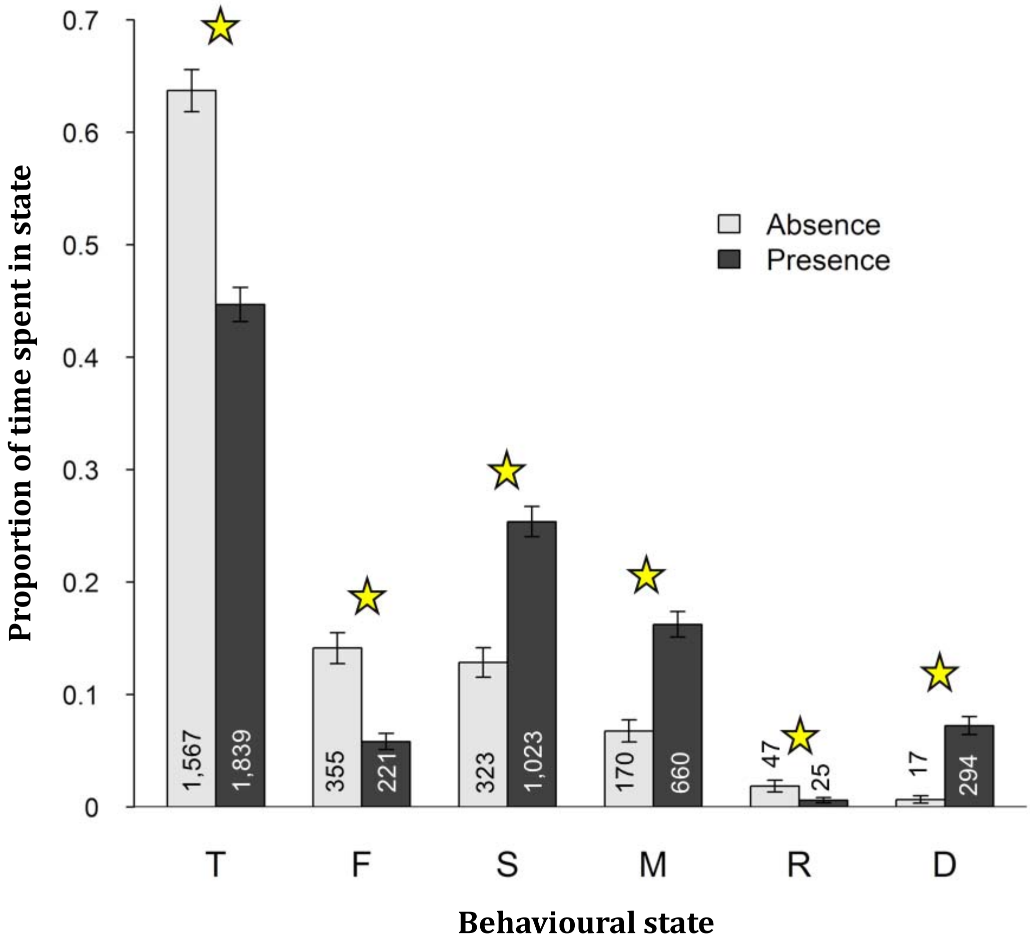


Figure 34: Overall behavioural budget of bottlenose dolphins observed from research vessel in absence and presence of vessels between December 2012 and April 2015 in Bay of Islands waters, New Zealand. Note: T=travelling, F=foraging, S=socialising, M=milling, R=resting and D=diving. Significant behaviour budget differences between categories (z-test p<0.05) is marked with a yellow star. Error bars represent standard error. N values for each category are displayed on the bars.

As the number of vessels present with dolphins increased up to two vessels, the behavioural budget decreased for travelling (23.4%), resting (95%), foraging (57.1%) and increased for socialising (84.6%), milling (54.6%) and diving (1,100%) (figure 35).

As the number of vessels present within 300 m of the focal dolphin group increased from ≥ 2 to ≥ 4, the magnitude of change increased. Particularly strong effects were noted during the presence of ≥ 4 vessels: the behavioural budget of travelling (40.6%) and foraging (64.3%) decreased whilst socialising (107.7%), milling (233.3%) and diving (93.8%) increased (figure 35).

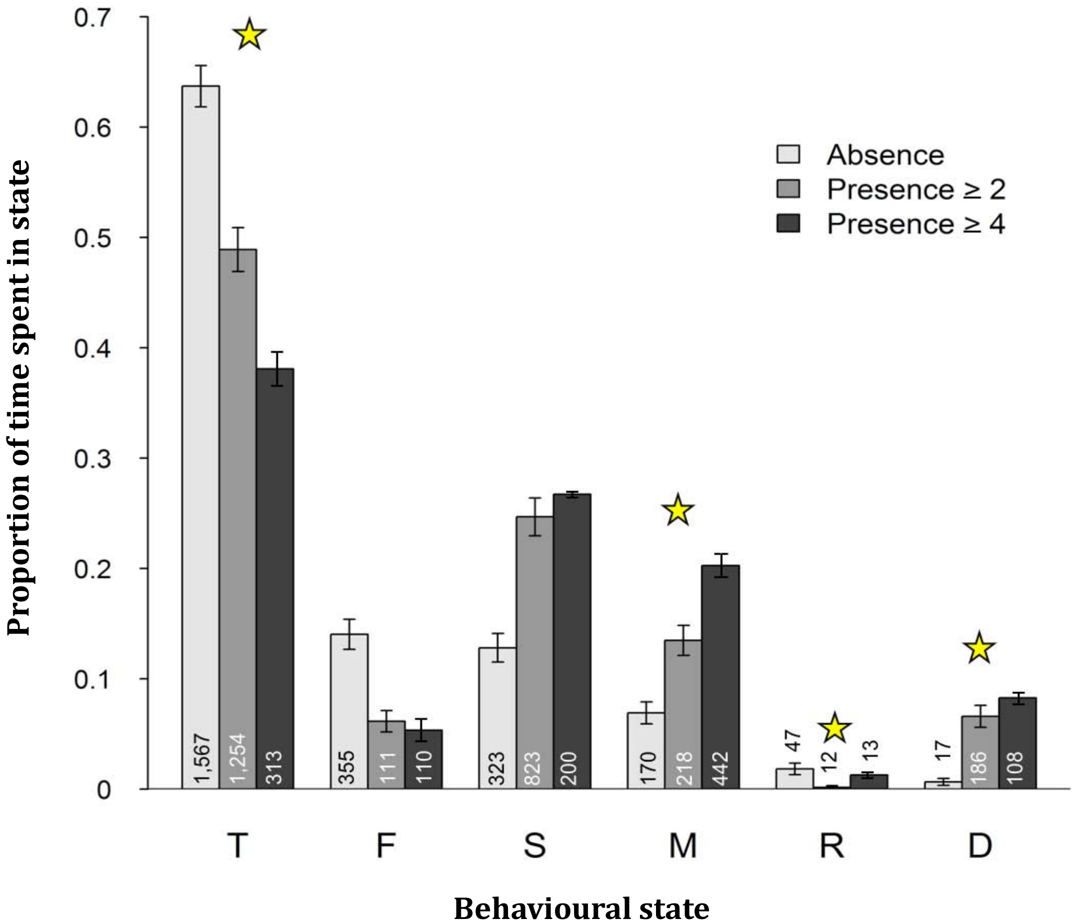


Figure 35: Overall behavioural budget of bottlenose dolphins observed from research vessel in absence of vessels, presence of up to three vessels plus research vessel and presence of four or more vessels between December 2012 and April 2015 in Bay of Islands waters, New Zealand. Note: T=travelling, F=foraging, S=socialising, M=milling, R=resting and D=diving. Significant behaviour budget differences between categories (z-test $p<0.05$) is marked with a yellow star. Error bars represent standard error. N values for each category are displayed on the bars.

Dolphins also responded differently depending on the type of vessel present.

The behavioural budget of all behavioural states was affected between absence and presence of various vessel types (Figure 36).

Mixed vessels had the strongest effect on both diving (500.0%) and milling (111.1%). Un-permitted vessels had the strongest effects on socialising (192.3%) and foraging (87.5%). Resting and diving didn’t occur in the presence of Un-permitted vessels.

Overall, private vessel presence resulted in a decrease in travelling (8.9%), foraging (62.5%), milling (18.2%) and resting (95.0%), while an increase in socialising (100.0%) and diving (500.0%).

Overall, permitted vessel presence resulted in a decrease in travelling (7.1%), foraging (68.8%), milling (27.3%) and resting (100.0%), while an increase in socialising (61.5%) and diving (300.0%). Permitted vessels had the largest magnitude change on resting and lowest on traveling, socialising and diving.

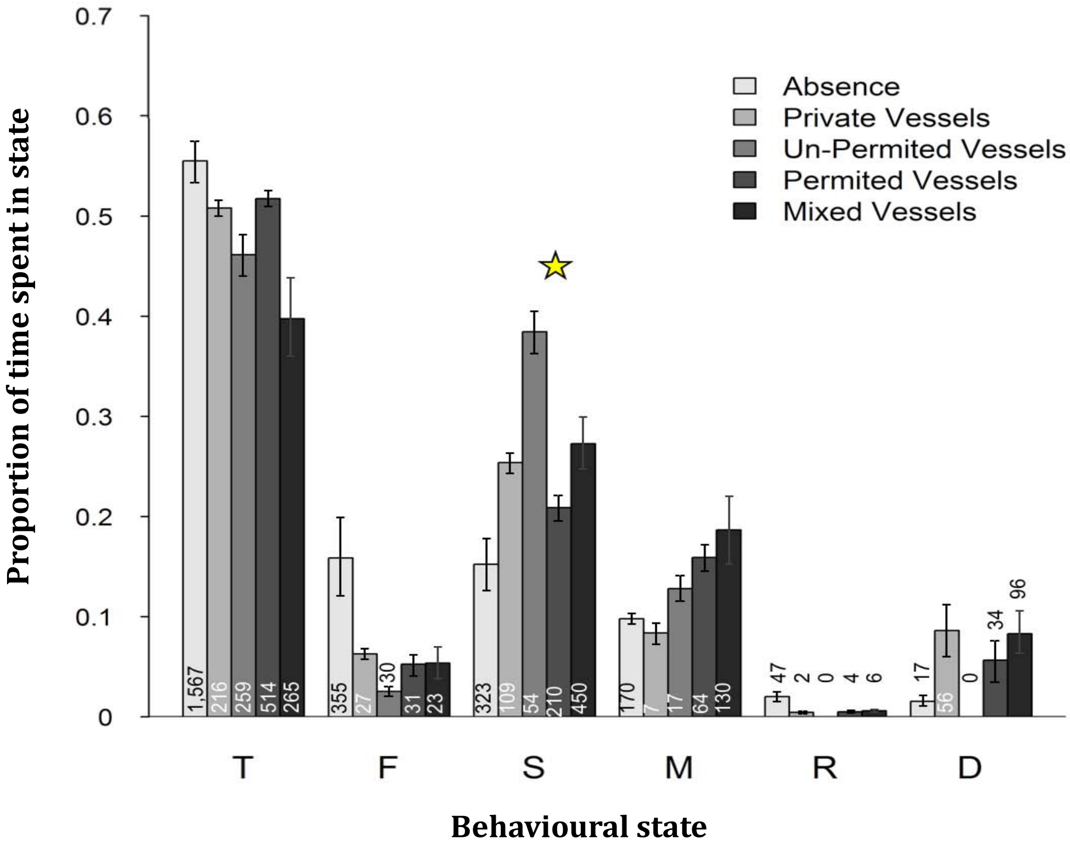


Figure 36: Overall behavioural budget of bottlenose dolphins observed from research vessel in absence of vessels, presence of private, un-permitted, permitted and mixed up to three vessels between December 2012 and April 2015 in Bay of Islands waters, New Zealand. Note: T=travelling, F=foraging, S=socialising, M=milling, R=resting and D=diving. Significant behavioural budget difference between all vessel categories (z-test $p<0.05$) is marked with a yellow star. Error bars represent standard error. N values for each category are displayed on the bars.

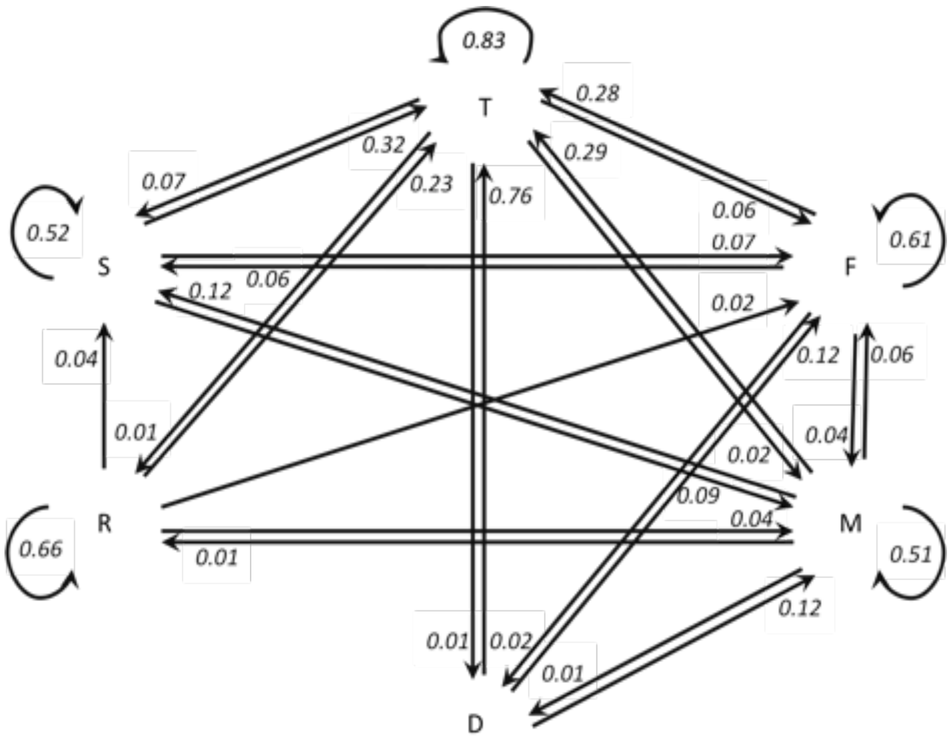
5.12.3. Transition probabilities

The summary of behaviour count values recorded and probabilities to shift from one state to another in presence and absence of vessels are shown in Table 14 and Figure 37, respectively.

Table 14: Count of each behavioural state of bottlenose dolphins observed from research vessel in absence and presence of vessels between December 2012 and April 2015 in Bay of Islands waters, New Zealand.

Behavioural state	Absence	Presence
Travelling	1,599	1,815
Foraging	355	237
Socialising	323	1,031
Milling	170	659
Resting	47	25
Diving	17	294
Total	**2,511**	**4,061**

A



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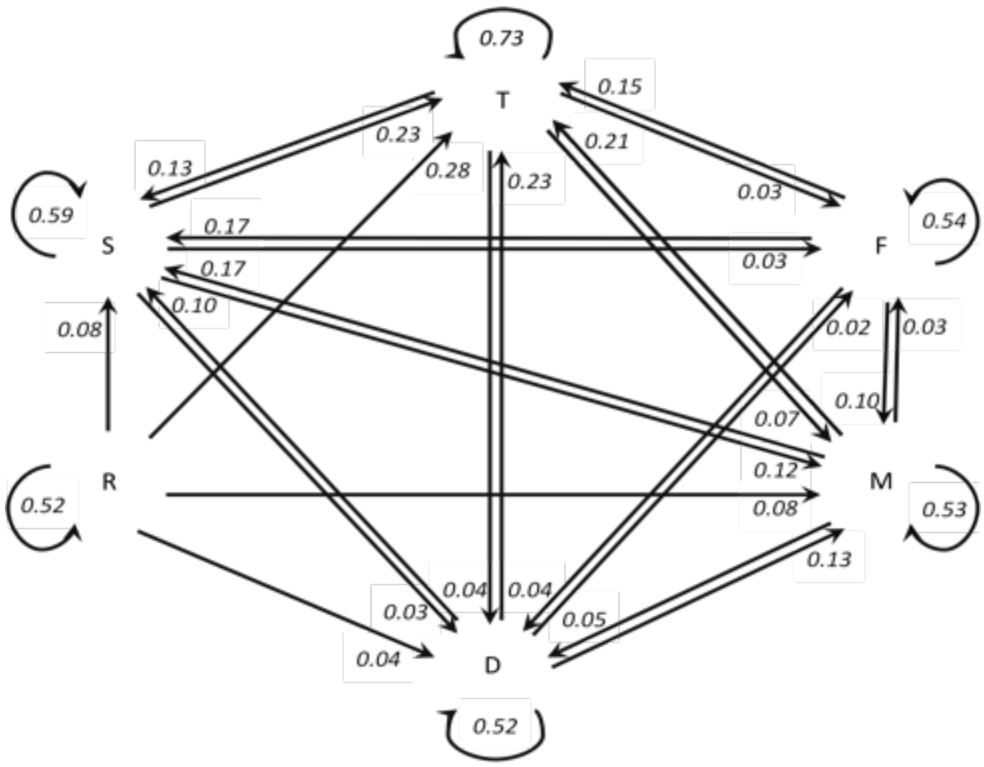


Figure 37: Probabilities of bottlenose dolphins observed from research vessel to shift from one behavioural state to another between December 2012 and April 2015 in Bay of Islands waters, New Zealand in A) absence, and B) presence of vessels. The absence of arrow between two states means there was no transition recorded between the two states. Note: T=travelling, F=foraging, S=socialising, M=milling, R=resting and D=diving.

Fifty-eight percent of transitions were significantly affected by the presence of vessels (Figure 38).

The likelihood to stay in a given state in the presence of vessels was reduced for foraging and resting by 11.5% and 21.2%, respectively. In contrast, the probability to remain socialising and milling was significantly increased by 13.5% and 3.9%, respectively. Furthermore, a diving-diving transition was only observed in the presence of vessels. Therefore, the limited sample size of observation and transitions of this behavioural state in an absence situation (i.e. only research vessel present), may have affected the statistical power of analyses of these results. No resting bouts were initiated when a vessel was already interacting with dolphins.

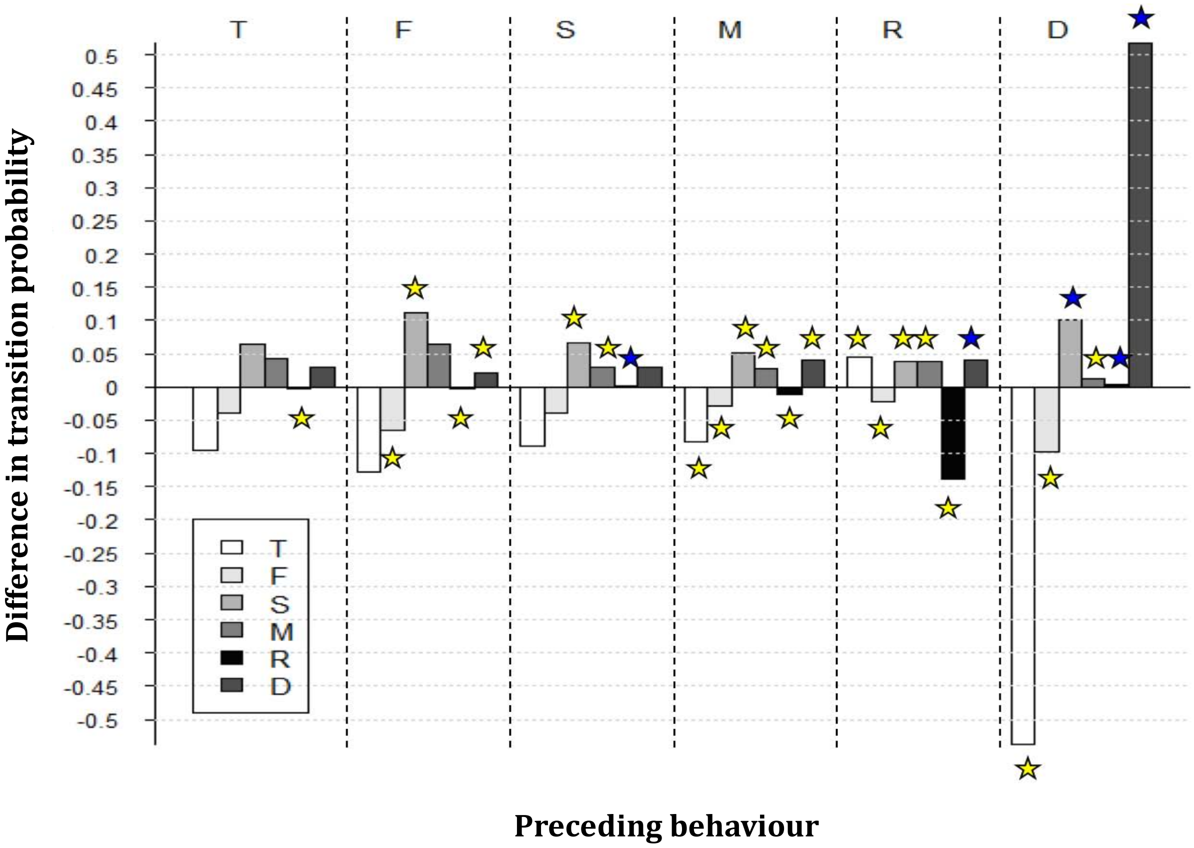


Figure 38: Effect of vessel presence on transitions in behavioural states of bottlenose dolphins between December 2012 and April 2015 in Bay of Islands waters, New Zealand, based on differences in transition probabilities p_{ij}(presence) - p_{ij}(absence). A negative value on the Y-axis means that the probability of a behavioural transition in the presence chain is lower than the one in the absence chain. The five sections correspond to the five preceding behavioural states. Each bar represents a succeeding state. Note: T=travelling, F=foraging, S=socialising, M=milling, R=resting and D=diving. Transitions showing a significant difference (z-test $p<0.05$) are marked with a) a yellow star when data were sufficient to assess the presence, and b) a blue star indicates significance but compromised statistical accuracy based on small sample size.

In most cases where an increase in transition probability was detected, socialising was the succeeding behavioural state.

Overall, milling, resting and diving were the behavioural states primarily affected in presence of vessels, with all transitions to other states significantly affected (Figure 38). The probability of transitioning from milling to travelling and foraging decreased by 27.6% and 50.0%, respectively. In contrast, the probability of transitioning from milling to socialising and diving increased by 41.7% and 400.0%, respectively.

The probability to transition from socialising to milling, foraging to diving and foraging to socialising increased by 33.3%, 100.0% and 183.3%, respectively in the presence of vessels. Diving to travelling and diving to foraging significantly decreased by 69.7% and 83.3%, respectively in the presence of vessels.

The transition from foraging to resting did not occur. Resting to foraging, diving to resting, traveling to resting and diving to socialising were not observed in the presence of vessels. In addition, the transition from resting to diving did not occur in the absence of interacting vessels.

5.12.4. Time to resume state

Time required to return to a given behavioural state prior to being disturbed was significantly affected by the presence of vessels for all 6 behaviours (Table 15). Primarily when travelling ($z=5.00$, $p<0.001$), foraging ($z=4.732$, $p=0.004$) or resting ($z=4.447$, $p<0.001$), bottlenose dolphins took significantly longer to return to these states in the presence of vessels, with time increasing by 132.3%, 262.0% and 725.6%, respectively. In contrast, the time required to return to socialising ($z=-2.85$, $p=0.004$) or milling ($z=-4.95$, $p<0.001$) decreased by 36.8% and 58.7%, respectively. Due to a small sample size, the 95.6% decrease in time needed to return to diving ($z=-3.04$, $p<0.001$) should be interpreted with caution (table 12).

Table 15: Probability of staying in a given state π_j, mean number of transitions T_j it took for bottlenose dolphins to return to that state, and time (min) required to return to the state when interrupted in absence of vessels (absence, exception of the research boat), and in presence of vessels in Bay of Islands waters, New Zealand, between December 2012 and April 2015. Note: sample size for diving is limited.

Behavioural state	π_j	$E(T_j)$	**Behavioural state resumed (min)**
Absence			
Travelling	0.6	1.0	3.1
Foraging	0.1	3.1	9.2
Socialising	0.1	8.2	24.7
Milling	0.1	11.5	34.4
Resting	<0.1	14.4	43.3
Diving	<0.1	43.2	129.6
Presence			
Travelling	0.5	2.4	7.2
Foraging	0.1	11.1	33.3
Socialising	0.3	5.2	15.6
Milling	0.2	4.7	14.2
Resting	<0.1	119.2	357.5
Diving	0.1	1.9	5.7

5.12.5. Dolphin behavioural events

In addition to behavioural states, specific behavioural events were also documented (n=9,935). However, not all behavioural events could be recorded due to a large majority being subsurface, therefore this analysis is not exhaustive of all events during encounters. All occurrence sampling was effective for bow riding, jumps and copulation associated events.

The predominant behavioural event observed was bow riding (81.1%, n=8,057), followed by horizontal jump (6.3%, n=626), vertical jump (5.0%, n=497) and belly present (4.9%, n=487). All other events made up the rest of observations (2.7%, n=268) and were significantly effected by vessel type.

Bow riding events were predominantly observed with un-permitted vessels (56%, n=4,512, Kruskal-Wallis: h=17.43, df=2, p=0.014), 27.0% with private vessels (n=2,175, Kruskal-Wallis: h=11.27, df=2, p<0.001) and 15.0% with permitted vessels (n=1,246, Kruskal-Wallis: h=24.16, df=2, p=0.027). Bow riding was observed with just the research vessel (absence) in 2.0% of observations (n=124, Kruskal-Wallis: h=24.16, df=2, p=0.027).

The converse was observed for jump behaviour (horizontal and vertical combined, n=1,123). Jump events were predominantly recorded with permitted vessels (57.0% n=640, Kruskal-Wallis: h=38.21, df=2, p<0.001), 20.2% with private vessels (n=228, Kruskal-Wallis: h=22.91, df=2, p<0.001) and 12.0% with un-permitted vessels (n=135, Kruskal-Wallis: h=16.45, df=2, p=0.022). Jump behaviour was observed with just the research vessel in 10.7% of observations (n=120, Kruskal-Wallis: h=24.16, df=2, p=0.027).

Of the 8,057 occasions of recorded bow riding, 84.0% resulted in the split of the focal group due to <25% of the group engaging in the behavioural event (n=6,768), 26.0% of these resulted in a permanent split (n=1,760). In 10.2% of occasions mother-calf pairs were observed approaching vessels during a bow-riding event (n=822). Jump behaviour was not observed to split a focal group.

5.13. Vessels in the BoI

5.13.1. Vessel type

Research vessels effort was consistent across all encounters. The research vessel was also permitted to be positioned to view interacting vessels and not included as a vessel in the three boat rule at the onset of the study. In order to therefore, remove any vessel perception bias of commercial vessels, the research vessel was not included in the following analysis. All vessel numbers and percentages are additional to the research vessel. Whilst it is acknowledged the research vessel may have an unknown effect on dolphin behaviour, any such effect would be consistent and therefore appropriate to exclude.

While private vessels were the most prevalent type of vessels recorded in the BoI (36.0%, n=6,274 observations), both permitted and un-permitted commercial vessels also had a strong presence in the bay, accounting 33.0% (7 different vessels, n=5,752 observations) and 31.0% (~41 different vessels, n=5,403 observations) of the vessels observed, respectively.

The majority of private vessels were powered with engines (i.e. outboard or jet, 56.2%, n=3,779). Yachts and kayaks represented a further 29.4% (n=1845) and 7.8% (n=489) of private vessel traffic, respectively. Of the un-permitted vessels, commercial sailing vessels represented the majority

(65.0%, n=3,512), of which 98.8% (n=5,338) were powered by engine rather than sail in presence of dolphins. All permitted vessels were powered with engines (inboard) (100.0%, n=5,752).

5.13.2. Vessel-dolphin interactions

Out of the 222 encounters with bottlenose dolphins, the research vessel arrived after (9.1%, n=20) and/or departed prior to the interacting vessels (3.6%, n=8), resulting in 12.7% (n=28) of the duration being underestimated. These encounters were removed from further analysis.

5.13.3. Vessel numbers

A mean number of 11 vessels were recorded interacting and actively positioned to view within 300m of dolphins (range=0-25, n=17,429) at the same time.

The effort of all vessel types with bottlenose dolphin, between sunrise and sunset, resulted in a mean of only 11.3 continuous minutes without the presence of vessels (other than the research vessel (range=0-34min, n=17,402)) and only 14.3% of daylight hours without vessels due to cumulative vessel presence (mean=102.6min, range=0-322min, n=17,402). This varied seasonally. The lowest mean time without vessels occurred in summer with only 8.1% of daylight hours (mean=69.7min, range=0-83.1min, n=10,161) and highest in winter with 30.3% of daylight hours (mean=174.1min, range=0-322min, n=1,116). Vessel effort in Spring and Autumn were similar with 16.2% (mean=113.9min, range=0-147min, n=1,777) and 14.3% respectively (mean=105.2min, range=0-142.8min, n=4,375).

The cumulative time a focal dolphin group was exposed to vessel interaction from permitted vessels across all operators exceeded the permitted maximum time of 50 min during 89.3% (mean=213, range=0-330min, n=5,752) of the observed encounters. The cumulative time a focal dolphin group was exposed to vessel interaction from un-permitted vessels resulted in a mean of 42 min (range=0-81min, n=5,403) and 403 min from private vessels (range=0-502min, n=6,274).

All vessel types exerted significantly more cumulative effort in summer/spring than autumn/winter. Permitted vessels effort in summer/spring resulted in a cumulate mean of 309 min (range=0-330min, n=4,084) compared to 106 min in autumn/winter (range=0-213min, n=1,668) (Kruskal-Wallis: h=16.22, df=1, p<0.001, n=5,752). Un-permitted vessels spent significantly less time with dolphin groups in spring/summer (mean=72, range=0-81min, Kruskal-Wallis: h=19.31, df=1, p=0.020, n=3,620) than autumn/winter (mean=35, range=0-40min, n=1,783). Cumulative effort of private vessels was significantly greater in spring/summer (mean=497, range=0-502min, Kruskal-Wallis: h=21.01, df=1, p=0.001, n=4,185) than autumn/winter (mean=281, range=0-296min, n=2,089).

Out of 1,472 mutually exclusive trips observed, a total of 2,015 bottlenose dolphin groups were encountered. Permitted vessels spent significantly more time with dolphin groups (range=0-138, median=62.5, n=5,752) than un-permitted commercial vessels (range=0-48, median=29, n=5,403) (Kruskal-Wallis: h=39.63, df=2, p<0.001). Private vessels spent significantly less time with dolphin groups (range=0-45, median=16, n=6,274) than permitted (Kruskal-Wallis: h=29.43, df=2, p=0.013) and un-permitted vessels (Kruskal-Wallis: h=27.04, df=2, p=0.018).

Permitted vessels spent a mean of 79.2min (range=0-138, SE=2.31, n=5,752) in the presence of bottlenose dolphins. The mean time permitted vessels spent with dolphins per trip was 113 continuous minutes in spring/summer (range=0-138, n=4,084) and 52 continuous minutes in autumn/winter (range=0-77, n=1,668). Permitted vessel spent more than 50 continuous minutes with dolphin in 44.5% of encounters (n=2,561).

Not all un-permitted vessels interacted with dolphins therefore only vessels interacting with dolphins are included in analysis. Un-permitted vessels interacted with dolphins for 37 continuous minutes in spring/summer (range=0-48, n=3,620) and 12 continuous minutes in autumn/winter (range=0-24, n=1,783). Private vessels spent the least time with dolphins in all seasons with 18 continuous minutes in spring/summer (range=0-45, n=4,185) and 9 continuous minutes in autumn/winter (range=0-14, n=2,089).

Permitted vessels also spent significantly more time with nursery groups (presence of calves and neonates) (range=9-78, median=64, n=2,301) than un-permitted commercial vessels (range=2-42, median=14, n=2,756) (Kruskal-Wallis: h=42.16, df=2, $p<0.001$) and private vessels (range=1-31, median=13, n=2,823) (Kruskal-Wallis: h=38.11, df=2, $p<0.001$). Permitted vessels exceeded 30 minutes with nursery groups in 78.0% of encounters (n=1,795).

Further to this, during the imposed 'cetacean lunch break' (1130-1300) under permit conditions, the mean time with only the research vessel present was 8.4 continuous minutes in summer/autumn (range=0-18, n=839) and 19.4 continuous minutes in winter/spring (range=0-26, n=1,909).

The longest recorded continuous presence of two or more vessels in addition to the research vessel was 6.8 hrs. This was recorded during summer (29th December 2014) and included all vessel types. The maximum number of vessels simultaneously observed interacting at any one point within 300 m of the focal group of dolphins was recorded as 86, at Tapeka Point (35°14'31.11'S, 174°7'10.82'E) on 3rd January 2015. This included 4 permitted vessels, 8 un-permitted and 74 private vessels, of which 70.9% (n=61) were stationary.

The maximum number of vessels to interact with one group, over the course of an hour, was 294 vessels (min=1, mean=118). The number of vessels present simultaneously within 300 m (whether interacting or not) was highest within Russell Harbour and totalled 181 vessels (min=1, mean=14). Of these, 65.7% (n=119) were stationary vessels and therefore not positioned to view, the rest were partaking in an organised race event and were positioned to view.

Vessel interactions were observed in high densities areas (>8.01 per km effort) near Tapeka Point, Roberton Island, and between Paihia and Russel harbours (Figure 39). The heavy vessel traffic areas of Tapeka Point and Roberton Island overlap with high density use areas for bottlenose dolphin.

In 25.0% (n=55) of focal follows from the RV, four or more vessels were observed interacting with dolphins simultaneously and in 36.8% (n=81) of focal follows, two or three permitted vessels were observed. This included permitted vessels arriving after three un-permitted boats were already interacting with dolphins (20.9%, n=46).

Vessel traffic interacting with focal dolphin group was unevenly distributed throughout the day (Figure 40). Traffic was highest in the morning and steadily decreased across the rest of the day. Most of the traffic occurred in the first hour of daylight (24.5%, n=4,270). The mean number of vessels was always over three throughout the day (n=17,429).

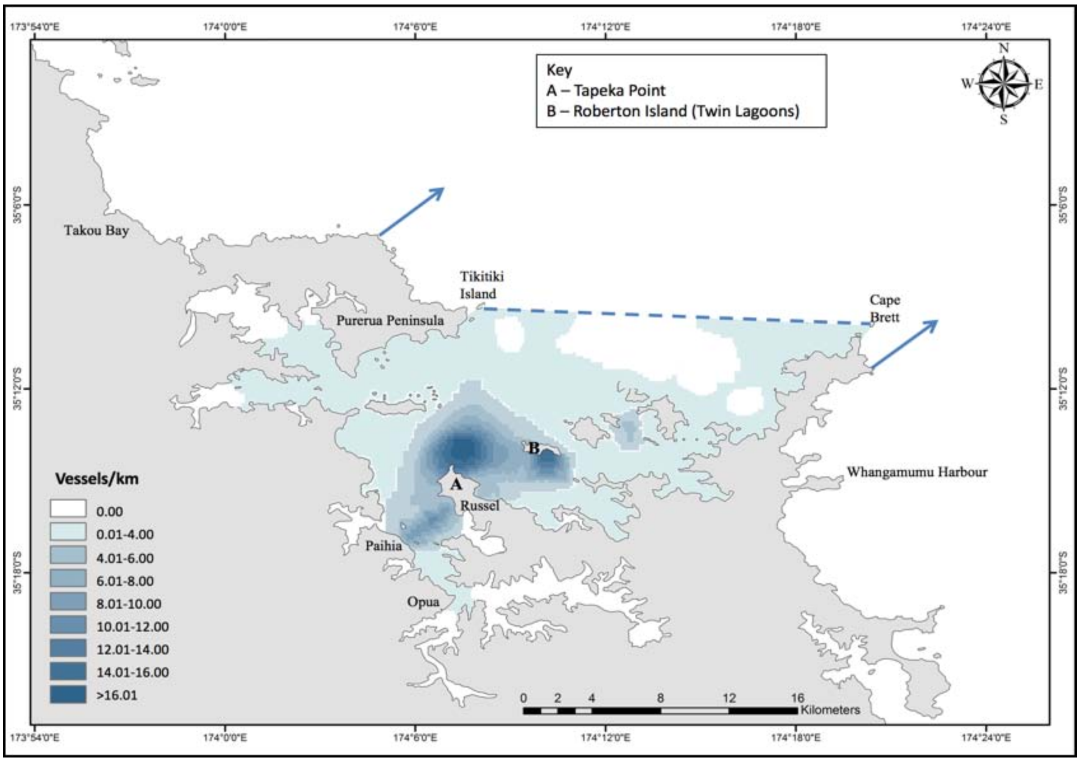


Figure 39: Vessel point density weighed by km effort on encounter between December 2012 and April 2015, in Bay of Islands waters, New Zealand. Contours realised by generating individual new vessel points during encounter corrected for *in encounter* effort. Blue dotted line represents harbour boundaries for the BoI.

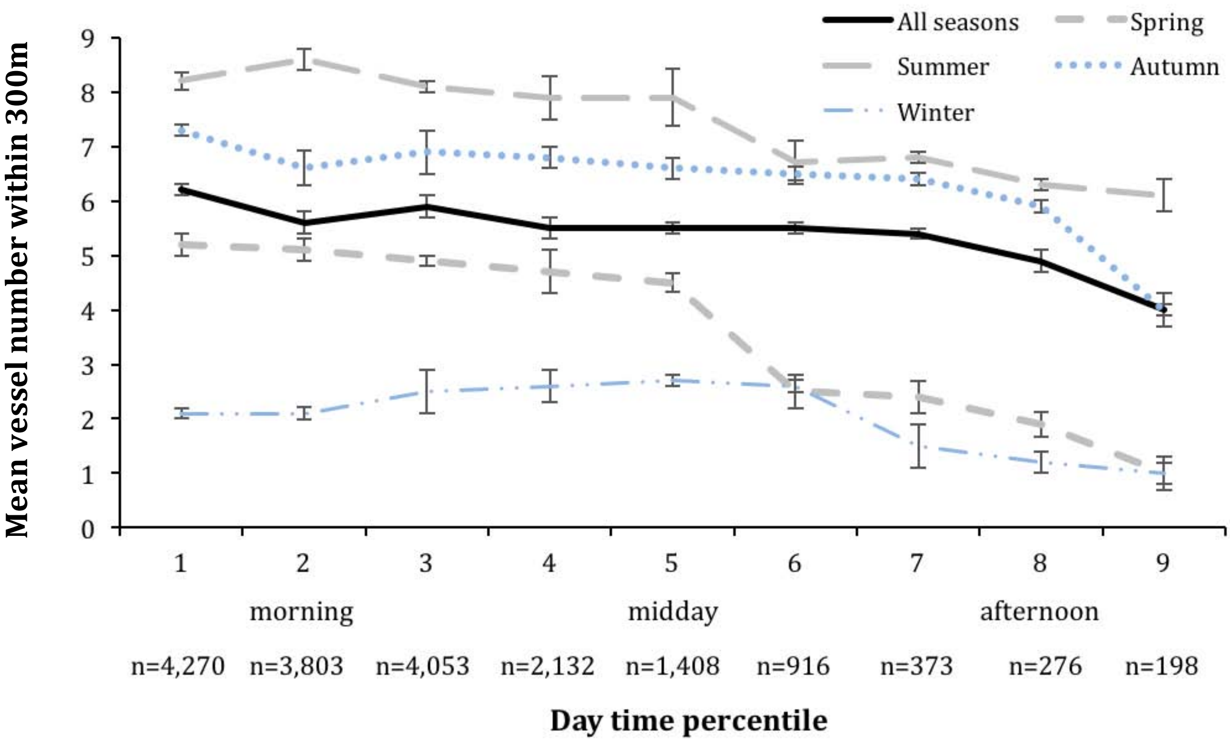
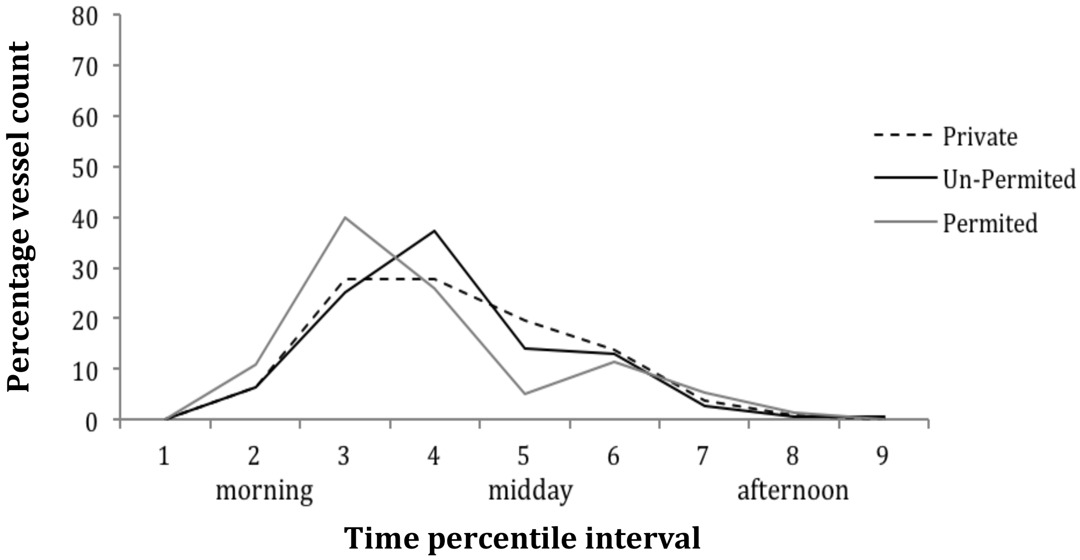


Figure 40: Vessel traffic in relation to percentile of daylight hours and season within 300m of dolphins between December 2012 and April 2015, in Bay of Islands waters, New Zealand. Error bars are standard error.

There were differences in usage of the BoI throughout the day (Figures 41-43). The presence of private vessels peaked between the third and fourth percentile and was lower when light levels were lower (1st and 8th onward). The aforementioned peak corresponds with the busiest time for vessel traffic either leaving or returning to Port Opua, Russell or Paihia. Private vessel owners whose primary activity is fishing tended to be out early in the morning heading out of the Inner Harbour and sit fishing in Middle Grounds and Outer Bays before returning later in the afternoon. The type of vessels more likely to remain within Inner Bays and Inner Islands were kayaks and yachts, as well as private craft used for biscuiting, water skiing, and jet skis.

A



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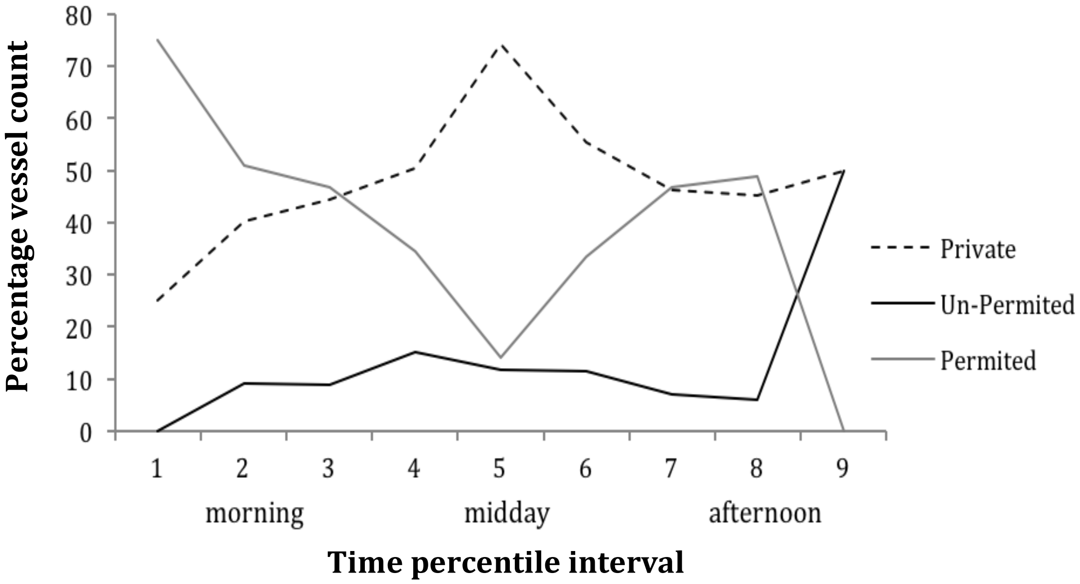

Figure 41: Diurnal variation in vessel traffic within 300m of dolphins between December 2012 and April 2015 in Bay of Islands waters, New Zealand. Daylight percentile is presented to account for seasonal variation in sunrise hour. A) Vessel category diurnal variation and B) Overall diurnal variation of vessels

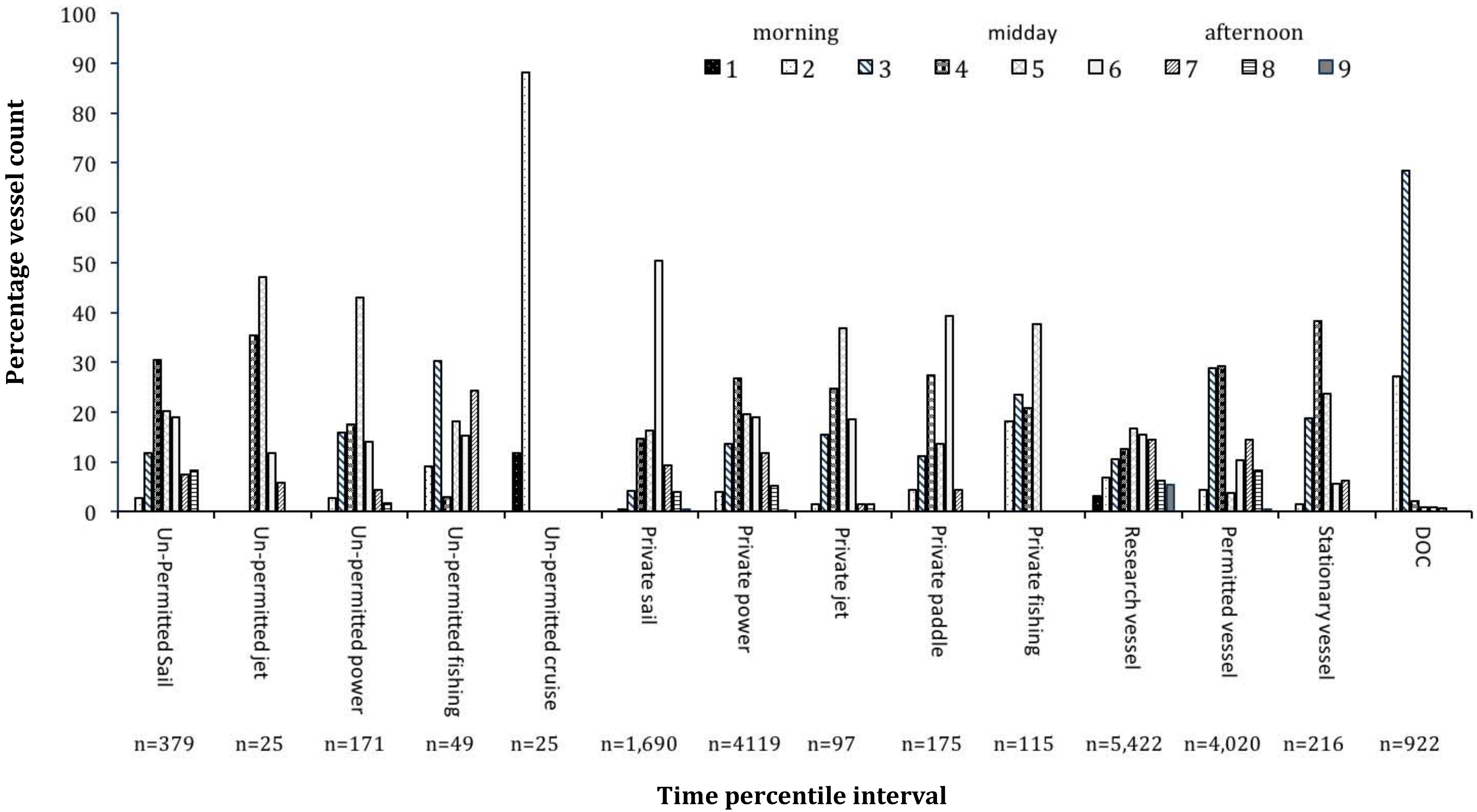

Figure 42: Vessel type diurnal variation in vessel traffic within 300m of dolphins between December 2012 and April 2015 in Bay of Islands waters, New Zealand. Daylight percentile is presented to account for seasonal variation in sunrise hour.

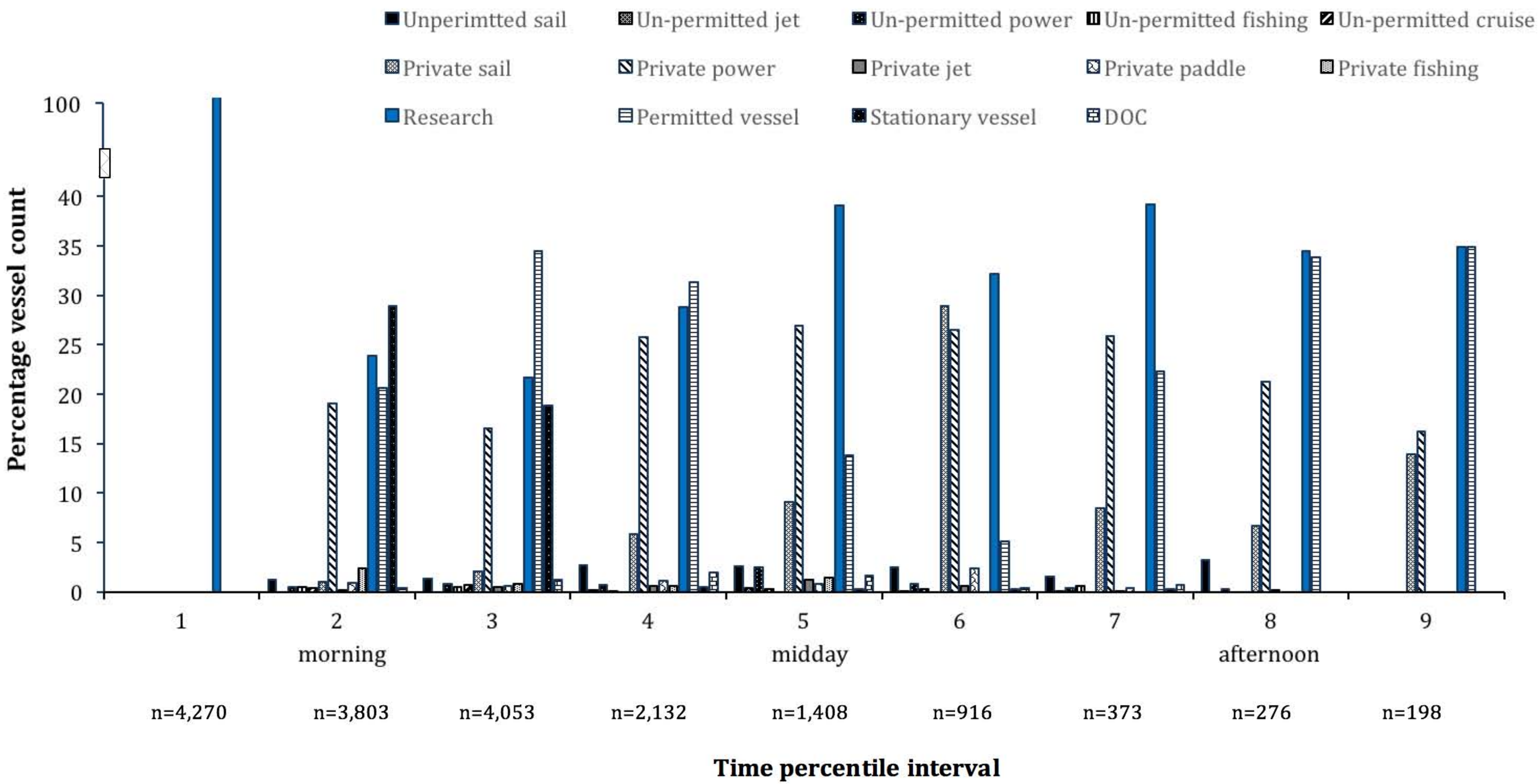

Figure 43: Overall diurnal variation of vessel traffic within 300m of dolphins between December 2012 and April 2015 in Bay of Islands waters, New Zealand. Daylight percentile is presented to account for seasonal variation in sunrise hour.

Un-permitted vessels usage of the BoI showed a similar pattern to private vessels, peaking around the middle of the day (4th percentile) before declining throughout the rest of the day, with a plateau between the fifth and sixth percentile. The percentage of private vessels peaked in quartile five, which corresponded with a decrease in permitted vessels. For permitted boats, the peaks observed (3rd and 6th percentile) correspond to less than an hour after their tour departure times and when most operator vessels (n=5) were out on the water (both watching and swimming). The trough recorded (5th percentile) occurred within the 'cetacean lunch break', when most vessels were back at the wharf in Paihia before their next trip. When assessing vessel traffic across the seasons (Figure 44), differences in usage of the BoI were detected between the different vessel categories.

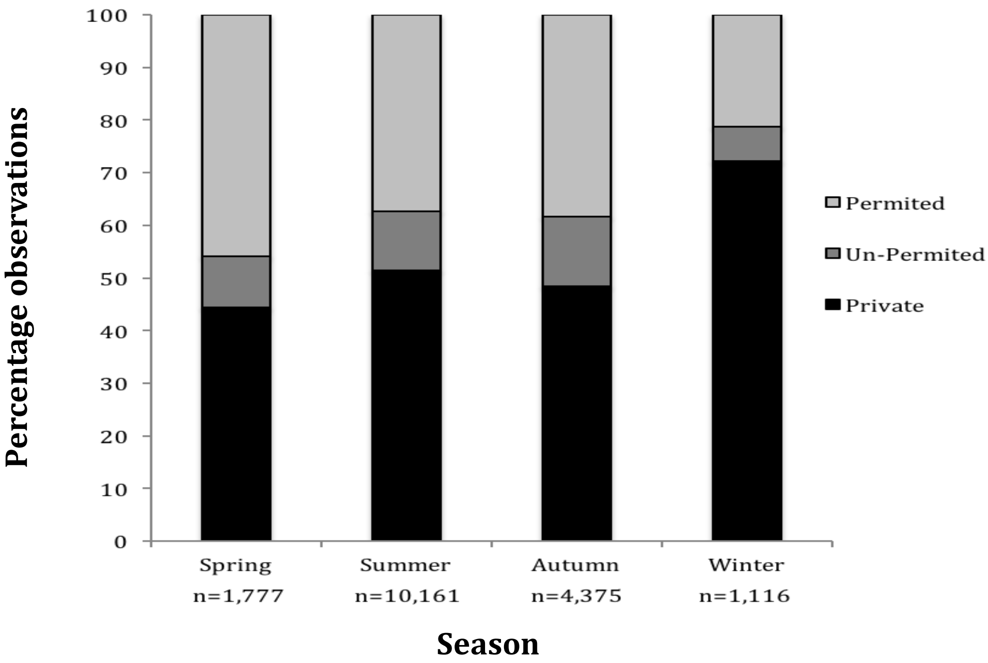

Figure 44: Percentage of vessel traffic within 300m of dolphins by season for various vessel categories in Bay of Islands waters, New Zealand, between December 2012 and April 2015.

Private vessels were the predominant vessel types across all seasons (>40.0%, Figure 45). Research vessel presence was uniform during all months and excluded from the vessel traffic analysis. Permitted vessels had the highest percentage of all vessel type in spring. Some of the dedicated swim-with-dolphin vessels from the summer season come off the water in April after the summer season, reducing the number of dedicated dolphin swim and view vessels from six to three in autumn.

All vessels types were most common in summer. The majority of private vessels used the area in summer and autumn, coinciding with the school holidays (summer and Easter) for most New Zealanders. Unlike other types of private vessels, which were observed more often in summer, private sailboats were more prevalent in spring (Figure 45) (23.1%, n=185). Permitted tourism vessels were also most prevalent in summer and lowest in winter and spring. Un-permitted vessels were recorded least in winter (Figure 45).

Finally, vessel traffic differed between weekdays and weekends. There was no significant difference in the number of commercial and RVs between weekend and weekdays as their activity was dependent on weather and/or demand (Kruskal-Wallis: h=13.62, df=1, p<0.001 and Kruskal-Wallis:

h=17.81, df=1, p<0.001). Conversely, private vessels were observed more frequently during weekends (Kruskal-Wallis: h=52.81, df=1, p<0.001).

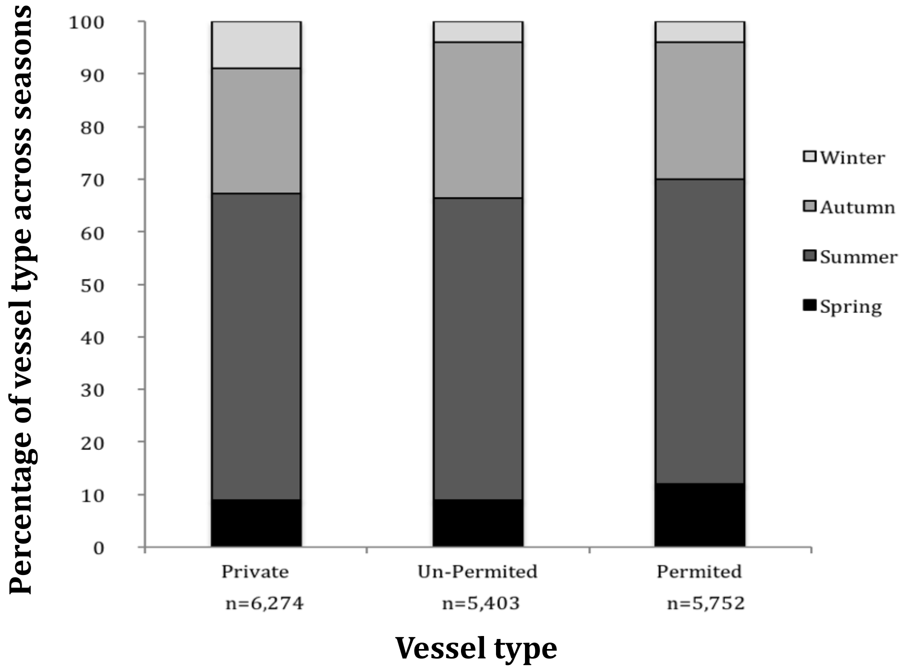

Figure 45: Seasonal vessel traffic by category within 300m of dolphins in Bay of Islands waters, New Zealand, between December 2012 and April 2015.

5.13.4. Vessel manoeuvres

Permitted vessels (both swimming and viewing) were significantly more likely to reverse during encounters (93.1%, n=108) than private and un-permitted vessels combined (6.9%, n=8; Kruskal-Wallis: h=48.32, df=1, p<0.001). In viewing only encounters, reversing was observed less by both permitted (9.3%, n=11) and private and un-permitted vessels (5%, n=6) reversing encounters respectively.

5.13.5. Number and type of approaches per vessel

Permitted vessels primarily approached dolphins once (98.0%, n=5,637) per trip. Occasionally permitted vessels were observed interacting twice with the same focal group (2.0%, n=115) but were never observed interacting more than twice. Similarly, un-permitted and private vessels mainly approached dolphins once (72.0%, n=8,407), although they were more likely to approach the same focal group twice (17.0%, n=1,985) or more (11.0%, n=1,285) with a maximum of four times (4.0%, n=467) than permitted vessels.

When within 300m of the focal dolphin groups, vessel types utilised significantly different approach techniques (Kruskal-Wallis: h=08.24, df=2, p=0.022, figure 46). For the 9,445 vessel approaches recorded, private vessel favoured a non-invasive approach (as per MMPR's) in 51.4% of observations (n=3,225), 86.2% of these approaches occurred when vessel passed through the area and did change path and engage the group (n=2,780). Private vessels approached in an invasive manner in 37.4% (n=2,346) and unspecified in 11.1% (n=1,138). Commercial permitted vessels did not significantly favour invasive over non invasive with 48.1% and 44.0% respectively (n=2,767 and n=2,531 respectively). The vessels to show the highest proportion of invasive approach were un-permitted vessels, with 54.9% invasive (n=2,966), 36.3% non-invasive (n=1,961) and only 8.8% unspecified (n=475).

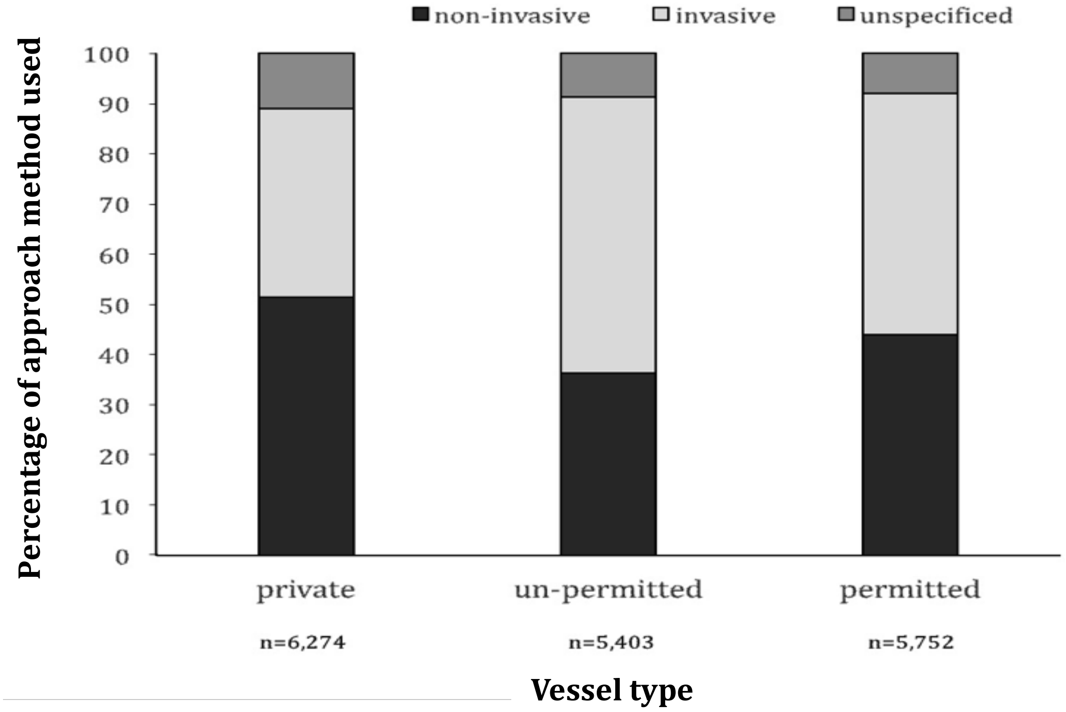

Figure 46: Approach technique utilised by vessel category between December 2012 and April 2015, in Bay of Islands waters, New Zealand.

5.13.6. Vessel speed within 300 m of the focal dolphin group

When within 300m of the focal dolphin groups, vessel types travelled at significantly different speeds (Kruskal-Wallis: h=32.11, df=2, p<0.001).

For the 9,445 vessel speed approaches recorded, non-motorised vessels (e.g. kayaks, stand-up paddleboards or rowing craft) were the slowest (mean=3.1 knt; 0.2 SE, range=0-5knt, n=486). These were followed by commercial un-permitted vessels (mean=8.3, 0.4 SE, range=1-12knt, n=1,403), within this sail driven vessels (with motor assist and non motor assist) were slower than motorised vessels (mean=5.1, 0.2 SE, range=1-12 min, n=1,021 and mean=7.4, 0.6 SE, range=5-11 min, n=382 respectively). The fastest vessels were personal craft/ jet skis (mean=14.7, max=20+, n=650), inboard motor powered launches (mean=15.6, SE, range=1-20+, n=1,293) and outboard motor powered trailer boats (mean=16.2, SE, range=1-20+, n=1,850).

Permitted vessels generally travelled around the *no wake* speed (*ca*. 5 knts) on approach (mean=5.7 knts, SE, range=1-8.1, n=2,860), although the highest speed observed was 8.1 knts on approach. The *no wake* speed was more likely to be observed by both permitted (24.0%, n=903) and commercial un-permitted vessels (18.0%, n=253), than by inboard motor powered launches (79.1%, n=1,024), outboard motor powered trailer boats (86.3%, n=1,596), and by personal craft such as jet skis (90.0%, n=585). Non-motorised vessels always travelled under 5knts.

On departure, permitted vessels generally travelled above the *no wake* speed (mean=11.3knts, n=640), the highest speed observed was 23knts. The *no wake* speed (ca. 5knts) was observed when departing dolphins 17.3% of the time (n=651) by permitted vessels, 89.2% (n=1,252) by commercial un-permitted vessels, 9.5% (n=123) by inboard motor powered launches, 8.1% (n=150) by outboard motor powered trailer boats, and 3.2% (n=16) by personal craft (jet skis). Non-motorised vessels always travelled under 5knts.

5.14. Swimming with dolphins

A total of 92.2% (n=868) and 7.8% (n=73) swim encounters were monitored from permitted vessel platforms and the RV, corresponding to 90.4% (n=2,491) and 9.6% (n=264) of swim attempts, respectively. Swimmers were primarily deployed from permitted vessels (62.5%, n=1,721 attempts), followed by private vessels (28.5%, n=758). An additional 5.9% (n=165) and 5.7% (n=157) swim attempts were recorded from un-permitted vessels and the beach, respectively.

Of the 2,500 permitted swim attempts monitored from permitted vessels, 43.3% (n=1,083) were classified as normal, 34.5% as light (n=863), 14% (n=350) swapped swimmers on board and 8.2% (n=205) had double-loads.

Under their permit conditions, operators must restrict the number of swim attempts to a maximum of 3 per encounter and the number of swimmers to a maximum of 18 per attempt (including *repeat swimmers*). Multiple swim groups occurred when there were more than 18 swimmers on board the vessel (swap). Swimmers would rotate during the same swim attempt on occasion (i.e. one or several swimmers would get back on the vessel, allowing others to enter the water, while other swimmers remained in the water throughout).

A mean of 2.4 (SE=0.002, range=0-6, n=1,721) repeat swimmers per attempt was noted from permitted vessels. While these cannot be listed as separate swim situations, they are, however, worth noting as these involved 25,378 swimmers.

During the 73 swim encounters with bottlenose dolphins monitored from the RV, a maximum number of 20 swimmers were placed in the water at the same time from one permitted vessel (min=1, mean=16, SE=0.003, range 1-20, n=73), with more than 18 swimmers in 28.8% of swims (n=21). A maximum number of 7 swim attempts occurred per swim encounter (mean=2.0, SE=0.001, range 1-7, n=73). A large number of observations included only 1 swim attempt per encounter (n=31, 42.4%, Table 16). Overall, more than 3 swim attempts per operator was observed in 11% of swim encounters (n=93).

Table 16: Swim attempt characteristics with bottlenose dolphins by vessel type between December 2012 and April 2015 in Bay of Islands waters, New Zealand. Standard error=Standard error of the mean.

Vessel Category	Mean number of swim attempts /swim encounter	Range of swim attempts /swim encounter	Maximum swimmers / swim attempt	Maximum swimmers / swim attempt (including repeat swimmers)
Permitted Op1	2.12 (SE 0.03, n=62)	1-3	18 (n=203)	20
Permitted Op2	2.74 (SE 0.07, n=408)	1-4	20 (n=1,158)	21
Permitted Op3	2.61 (SE 0.04, n=376)	1-4	20 (n=1,139)	22
Un-Permitted	1.52 (SE 0.22, n=18)	1-2	3 (n=165)	6
Private	5.13 (SE 0.35, n=50)	1-7	20 (n=758)	29
Shore	2.52 (SE 0.08, n=27)	1-4	8 (n=157)	12

5.14.1. Swim technique and approach

The majority of swim attempts monitored from both research vessel and permitted vessel platforms consisted of free swims (92.8%, n=245 and 93.0%, n=2,316, respectively), while the remaining used a boom net (7.2%, n=19 and 7.0%, n=175). Note, only one permitted vessel uses nets, which explains the difference.

Reversing before and during a swim attempt was a technique used during 43.2% (n=114) and 37.2% (n=927) of the swim attempts observed from the research vessel and permitted vessel platforms, respectively. From both observation platforms, this technique was performed primarily by permitted operators, 42.8% (n=113) and 35.8% (n=892), respectively (Table 17). Dolphins were recorded as approaching during 93.2% of reversing *head-on/in-path* manoeuvres (n=970).

Table 17: Swim placement characteristics with bottlenose dolphins by vessel type between December 2012 and April 2015 in Bay of Islands waters, New Zealand.

Vessel Category	% Swim placement using *line abreast*	% Swim placement through reversing *head-on/in-path*
Permitted Op1	48.1 (n=98)	3.1(n=6)
Permitted Op2	14.2 (n=164)	84.2 (n=975)
Permitted Op3	16.6 (n=189)	76.2 (n=868)
Un-Permitted	75.3 (n=124)	0 (n=0)
Private	50.3 (n=381)	4.4 (n=33)
Shore	N/A	N/A

5.14.2. Duration

For all permitted swim encounters swim attempt duration was calculated from observations taken on-board permitted vessels only to improve accuracy (n=868 min). Under current permit conditions, permitted vessels are restricted to a maximum of 50 min interaction time with bottlenose dolphins per trip. There is no separate additional time limit on swim attempt duration.

Mean swim duration lasted 9.5 min (SE=0.91 min, range=3.38-18.64, n=2,491). The majority of individuals swim attempts (65.0%, n=1,619) lasted less <5 min, while a small percentage (18.0%, n=324) lasted >10 min. Overall, the length of swim encounters ranged from 5-77 min (mean=47.7 ± 11.5 SE) min per encounter. For all other vessel types excluding permitted vessels (n=776 min), mean swim attempt duration lasted 10.6 min (SE=0.23 min, range=0.57-16.31, n=264). Similar to permitted vessels, the majority of swim attempts (37.4%, n=99) lasted <5 min, while a larger percentage (29.1%, n=77) lasted >10 min.

The longest duration recorded for a continuous swim was 43.9 min, and involved a private vessel. The length of swim encounters ranged from 2-104 min, with a higher mean than permitted vessels of 53.2 min per encounter (± 14.4 SE).

5.14.3. Presence of other vessels in the vicinity of swimmers

In 89.0% (n=65) of swim encounters observed from the research vessel, there was another vessel within 300m at some point, equating to 69.2% of the time (n=449 observations, n=1,346 minutes).

Out of the 2,491 swim attempts monitored aboard permitted vessels, 76.0% (n=1,893) were recorded in the presence of other vessels within 300 m. This included one additional and two additional permitted swim vessels 57.3% (n=1,427) and 11.1% (n=277) of the time, respectively.

5.14.4. Group size and composition

Bottlenose dolphin group size recorded aboard the permitted vessels indicated that the majority (76.0%, n=1,894) of swims occurred with small groups (≤10 individuals) and groups containing only adults (40.7%, n=1,014). Swims were documented with larger groups (11-30 and >30 individuals) 17.2% (n=428) and 9.3% (n=232) of the time, respectively (Figure 45). Groups containing adults and juveniles represented only 3.7%, (n=93) of observed swims. On 18.0% (n=449) occasions, calves or neonates were present, which is in contradiction to the MMPR (1992). A very similar trend was recorded aboard the research vessel during all swim attempts with bottlenose dolphins. The majority (56.1%, n=148) of swims occurred with small groups (≤10 individuals), followed by groups containing 11-30 individuals (43.3%, n=144) (Figure 47).

In the majority of swims, only adult dolphins were recorded (64.8%, n=171). Juveniles were present an additional 12.5% (n=33) of the swims, 27.3% of those involving a permitted vessel. The number of swims with calves observed from the research vessel was slightly higher than those recorded aboard permitted vessels (23.1%, n=61). No swim attempt with calves from a permitted vessel was observed. Calves or neonates were sighted, however, in focal dolphin groups prior or post a swim encounter 18.9% of the time (n=50).

5.14.5. Solitary dolphins

For all swims observed from both platforms, 17.3% (n=477) occurred with lone dolphins. In 97.1% of occasions solitary dolphins exhibited initial avoidance (n=463), while in 62.3% of these events, the singleton returned to approach and interact with swimmers (n=289). The aforementioned 62.3% (n=289) occurred with a single identifiable individual. During those swim attempts the mean number of swimmers was 50.4, (SE=0.9, range=8-58) which consisted of swimmers from multiple boats.

5.14.6. Dolphin reaction to swimmers

Behaviour of bottlenose dolphins in the presence of swimmers was monitored from both aboard the permitted vessels (n=2,491 attempts) and the research vessel (n=264), with similar trends observed.

In 31.1% of swim attempts (n=774 and n=82), dolphins approached the swimmers upon entering the water. In 79.0% of observed approaches the dolphins involved were identified as predominantly frequent users (n=676). Predominantly infrequent users (12.0%, n=103) and predominantly occasional visitors (9.0%, n=77) occurred on other occasions.

During 24.5% (n=610) and 23.5% (n=62), of swim attempts respectively, the dolphins avoided swimmers when entering the water. In 58.0% of such observed avoidance responses, the dolphins involved were identified as predominantly infrequent users (n=390), predominantly occasional visitors in 24.7% (n=166) and predominantly frequent users in 17.3% of observations (n=116). In most cases (44.4%, n=1,107, and 45.5%, n=120), no observable response was detected.

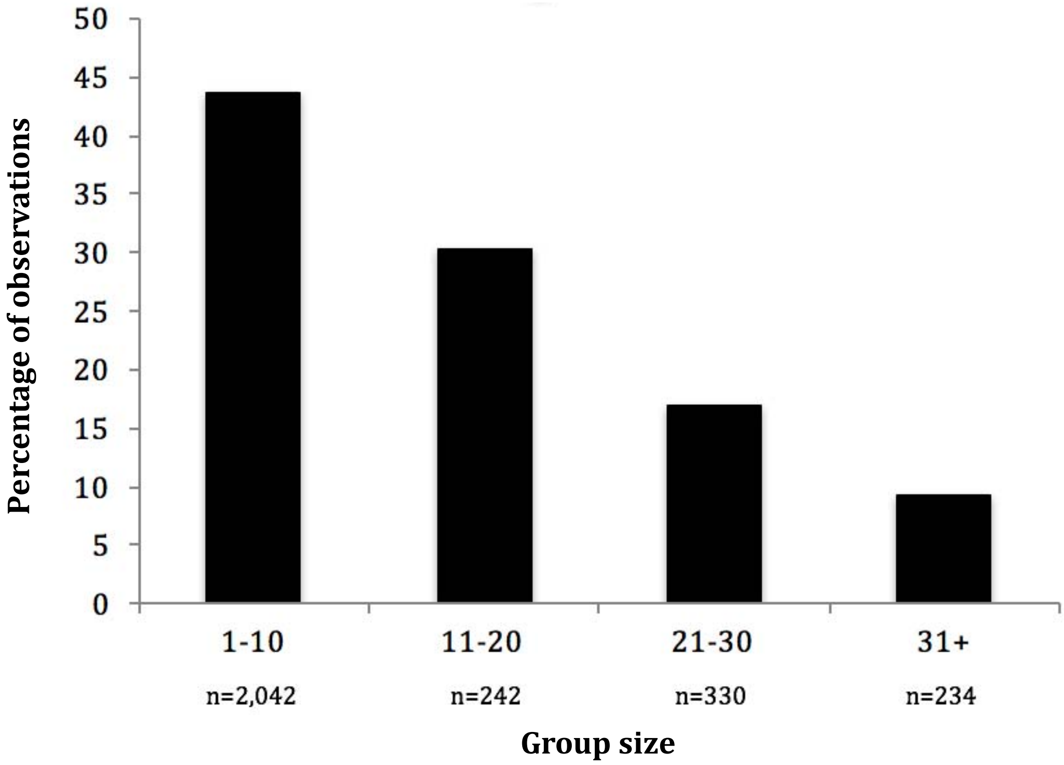

Figure 47: Bottlenose dolphin group size during swim encounters monitored from on-board permitted vessels, between December 2012 and April 2015, in Bay of Islands waters, New Zealand.

5.14.7. Response to vessels/swimmers according to time into an encounter

a) Approach

Dolphin group response was observed during 73 swim encounters. A summary of orientation is presented in Table 18.

Table 18: Orientation of bottlenose dolphin *approach* swimmers and/or vessel(s) relative to time into swim encounters (3 minute-intervals) between December 2012 and April 2015, in Bay of Islands waters, New Zealand.

Time into encounter (min)	Total number of orientations (n)	Total approach orientations	Proportion approach orientation
0-3	815	576	0.707
>3-6	642	431	0.671
>6-9	565	389	0.688
>9-12	144	108	0.750
>12-15	94	74	0.787
>15-18	64	53	0.828
>18-21	54	47	0.870
>21-24	47	41	0.872
>24-27	34	29	0.853
>27-30	10	8	0.800

The best fitting model to explore response to swimmers when dolphin approached was model 3 (Table 19). The goodness-of-fit test of model 3 showed no evidence of lack of fit ($p<0.05$), thereby confirming that this model was a good predictor of the probability of a group of dolphins approaching swimmers and/or vessel(s) as a function of time into an encounter.

Dolphin groups exhibited significant attraction towards swimmers and/or vessel(s) for the duration of a swim encounter ($p<0.05$, Figure 48). However, after the initial 24 min, less than predicted orientation towards swimmers and/or vessel was evident (Figure 48).

Table 19: Analysis of deviance for assessing goodness-of-fit of models performed using logistic regression to predict bottlenose dolphin movement towards swimmers/vessels as a function of time into a swim encounter between December 2012 and April 2015, in Bay of Islands waters, New Zealand. Note: d.f. refers to statistical degrees of freedom.

Model	AIC	Deviance	d.f.	Deviance difference	d.f.	Estimates for fitted equation
Constant	209.87	161.43	9			0.444
Constant + T	87.107	36.664	8	124.760 (ns)	1	-0.267
Constant + T + T^2	85.641	33.198	7	3.466 (*)	1	-0.093
Constant + T + T^2 + T^{δ}	63.147	8.704	6	24.494 (ns)	1	0.527

(ns)=not significant at $p<0.05$. *=significant at $p<0.05$.

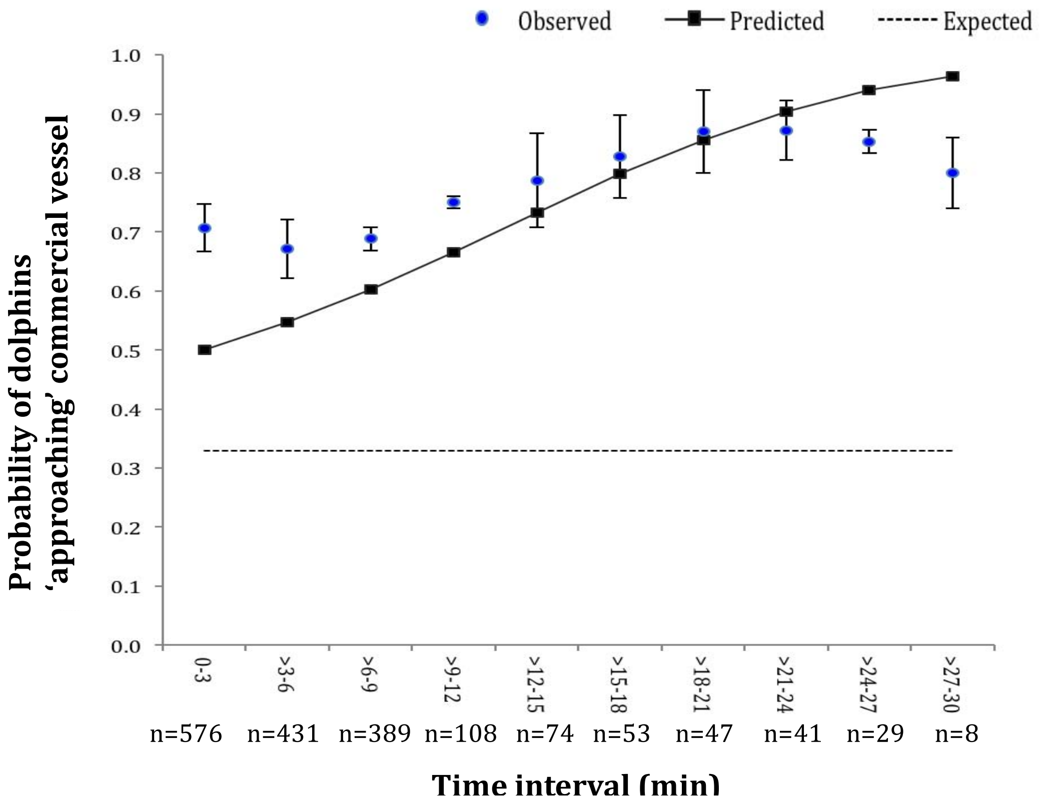

Figure 48: Probability of a dolphin group heading towards swimmers and/or vessel(s) as a function of time (min) into the swim encounter, between December 2012 and April 2015, in Bay of Islands waters, New Zealand. Error bars indicate 95% confidence intervals of predicted probabilities. Note: n=number of observed group orientations in relation to a vessel in a given time interval.

b) Avoid

Responses of bottlenose dolphin groups away from swimmers and/or vessel(s) are presented in Table 20.

There was no evidence that the addition of T, T^2, and/or T^3, further improved the fit (Table 21). As a result, model 1 (constant) was selected. The goodness-of-fit test of model 1 showed no evidence of lack of fit ($p<0.05$), thereby confirming that this model was a good predictor of the probability of a group of dolphins heading away from swimmers and/or vessel(s) as a function of time into an encounter.

Table 20: Orientation of bottlenose dolphin *avoid* response to swimmers and/or vessel(s) relative to time into swim encounters (3 minute-intervals) between December 2012 and April 2015, in Bay of Islands waters, New Zealand.

Time into encounter (min)	Total number of orientations (n)	Total number away orientations	Proportion away orientation
0-3	815	239	0.293
>3-6	642	211	0.329
>6-9	565	176	0.312
>9-12	144	36	0.250
>12-15	94	20	0.213
>15-18	64	11	0.172
>18-21	54	7	0.130
>21-24	47	6	0.128
>24-27	34	5	0.147
>27-30	10	2	0.200

Table 21: Analysis of deviance for assessing goodness-of-fit of models performed using logistic regression to predict bottlenose dolphin movement away swimmers/vessels as a function of time into a swim encounter between December 2012 and April 2015, in Bay of Islands waters, New Zealand. Note: d.f. refers to statistical degrees of freedom.

Model	AIC	Deviance	d.f.	Deviance difference	d.f.	Estimates for fitted equation
Constant	209.87	3.385	9			3.291
Constant + T	87.107	3.386	8	0.0001 (ns)	1	n/a
Constant + T + T^2	85.641	3.371	7	0.0025 (ns)	1	n/a
Constant + T + T^2 + T^{δ}	63.147	2.947	6	0.4762 (ns)	1	n/a

(ns)=not significant at $p<0.05$.

Dolphin groups moved away from swimmers and/or vessel(s) as expected at the beginning of a swim encounter (0-6 minutes) and then significantly less often than expected for the remaining duration of an encounter (Figure 49).

The predicted level of avoidance, while constant, remained low at 0.261 (Figure 49).

In order to explore response to swimmers further, the proportion of the group engaging in swim encounter over time was analysed by user type. Frequent users showed increased attraction to swimmers/vessels over time before a rapid decline after 24 minutes. Infrequent users decreased quickly and then stabilised between >3-12 minutes before declining further after 12 minutes. Occasional visitors showed a steady decline over time (Figure 50).

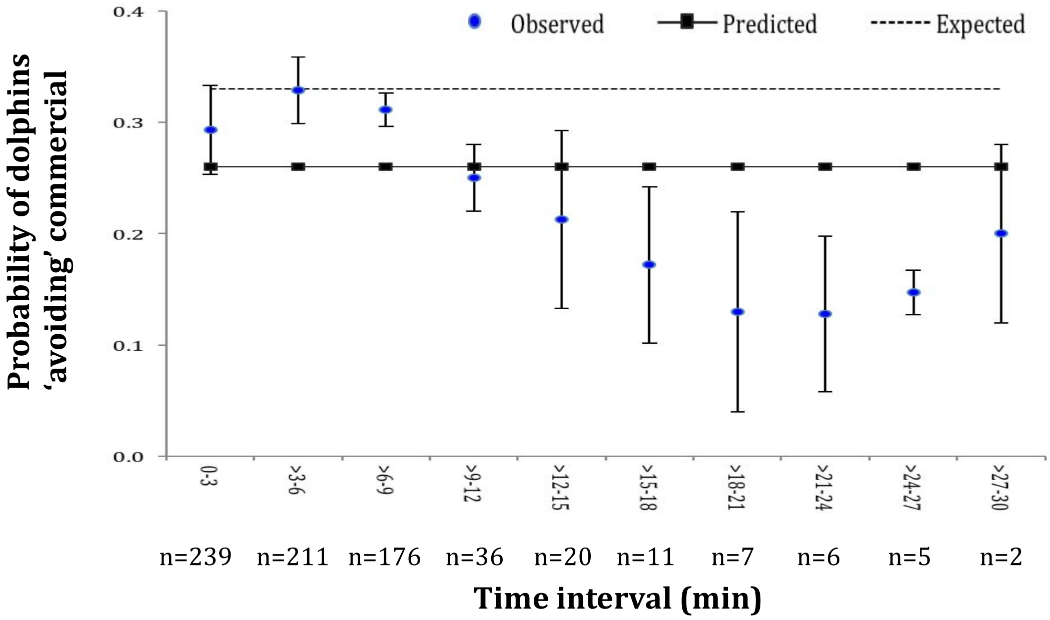

Figure 49: Probability of a dolphin group heading away from swimmers and/or vessel(s) as a function of time into the swim encounter (min), between December 2012 and April 2015, in Bay of Islands waters, New Zealand. Error bars indicate 95% confidence intervals of predicted probabilities. Note: n=number of observed group orientations in relation to a vessel in a given time interval.

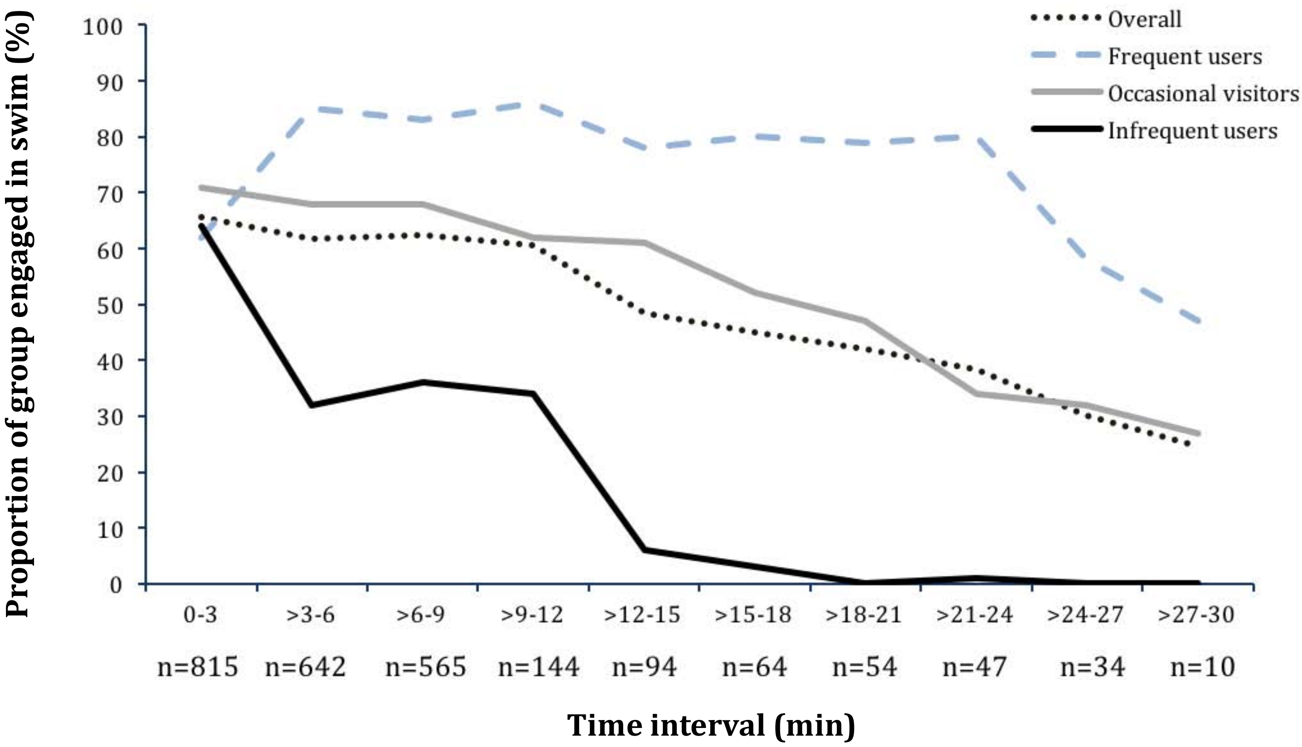

Figure 50: Proportion of a dolphin group engaging with swimmers and/or vessel(s) as a function of time into the swim encounter (min), between December 2012 and April 2015, in Bay of Islands waters, New Zealand. Note: n=number of observed number of animals engaging in a swim in a given time interval.

5.14.8. Swim attempts in relation to season, number of vessels present and type of swim tour

The number of swim attempts varied significantly by season ($F=8.56$, $p<0.001$), number of boats present ($F=10.41$, $p<0.001$) and type of swim tour ($F=12.68$, $p=0.002$). Swim drops were observed significantly ($F=7.83$, $p<0.000$) more in summer and autumn, when SST was higher, compared to spring and winter (Table 22). As the number of permitted swim boats increased, so did the number of observed attempts (Table 22). Since the presence of other vessels than permitted vessels was not included in the analysis, the number of vessels actually interacting with focal dolphin groups is underestimated. In addition, when there were more than 18 swim passengers on-board (double-swap loads) these trips had a significantly ($F=13.22$, $p=0.031$) greater number of drops than light or normal trips (Table 22).

Mean length of swim drops varied significantly by season ($F=7.94$, $p<0.001$) and type of swim tour ($F=2.68$, $p<0.001$), although the number of boats present had no effect on duration ($F=2.93$, $p=0.31$). Swim drops were significantly shorter in summer and autumn than in spring or winter (Table 22).

When the tour type (swimmer numbers) was light or normal, swim attempts were significantly longer than swap or double-load (Table 22).

Swim encounter duration also varied significantly across all tour types ($F=19.82$, $p<0.001$), with the longest swim encounter duration observed in swap and double-load tours. Overall, no significant variation was detected across season ($F=1.52$, $p=0.15$), except between summer and all other seasons ($F=2.93$, $p=0.031$). In the presence of three permitted boats, swim period was significantly higher than when one or two permitted boats were within 300 m ($F=4.71$, $p<0.001$).

Table 22: Swim attempt characteristics with bottlenose dolphins by season, number of tour boats present, and type of swim tour between December 2012 and April 2015, in Bay of Islands waters, New Zealand. Significant differences ($p<0.05$) are denoted by superscripts after the values in the same section.

Season	n	#Swim attempts	Mean Length (min)	Swim Period (min)
Summer	277	4.2 (SE 0.23)^{2,3,4}	5.2 (SE 0.72)^{2,3,4}	42.5 (SE 3.16)^{2,3,4}
Autumn	331	4.1 (SE 0.26)^{1,3,4}	7.2 (SE 0.39)^{1,3,4}	36.4 (SE 2.23)
Winter	70	2.7 (SE 0.52)^{1,2}	8.4 (SE 0.48)^{1,2,4}	34.2 (SE 2.94)
Spring	190	2.6 (SE 0.54)^{1,2}	10.2 (SE 0.41)^{1,2,3}	36.1 (SE 2.57)
#Boats				
1	208	3.5 (SE 0.24)^{2,3}	8.5 (SE 0.63)	32.1 (SE 1.01)^{3}
2	495	4.8 (SE 0.25)^{1}	8.2 (SE 0.37)	34.3 (SE 1.23)^{3}
3	95	4.2 (SE 0.31)^{1}	8.4 (SE 0.54)	41.5 (SE 1.26)^{2,3}
Tour type				
Light	300	3.0 (SE 0.55)^{3,4}	10.2 (SE 0.91)^{3,4}	26.4 (SE 3.06)^{2,3,4}
Normal	376	3.5 (SE 0.54)^{3,4}	10.2 (SE 0.73)^{3,4}	41.6 (SE 2.38)^{1,3,4}
Swap	121	4.3 (SE 0.43)^{1,2,4}	8.0 (SE 0.72)^{1,2}	57.3 (SE 2.22)^{1,2,4}
Double-load	71	5.3 (SE 0.53)^{1,2,3}	8.5 (SE 0.65)^{1,2}	68.0 (SE 2.07)^{1,2,3}

5.14.9. Distance to shore

Permit conditions dictate that vessels and/or swimmers must maintain a minimum distance of 60 m from the shore.

Swims occurred at a mean distance of 884.4m (SE=0.4, range=5.7-913.1, n=2,491), with the large majority recorded at >60 m (97.3%, n=2,423). The remaining 2.7% (n=68) of observations occurred within <60 m of the shore, with dolphins between the vessel and shore. Close to shore observations were primarily recorded in spring and summer (77.9%, n=53) and in the presence of permitted vessel (72.1%, n=49). Similar trends were recorded for the 264 swim attempts monitored from aboard the RV. The mean distance of swims was 898.9m (SE=0.7, range=32.5-3,029.1, n=264). Over 95% of the swim attempts (n=255) occurred >60 m of the shore. The remaining 3.4% (n=9) were observed <60 m from shore, with dolphins between the vessel and shore. Close to shore observations were primarily recorded in spring and summer (77.8%, n=7) and in the presence of permitted vessel (66.7%, n=6).

6. Summary of deliverables

A summary of results is provided for each contractual objective, including discussion of how results presented differ from previous findings presented by Constantine, 2002; Constantine et al., 2004; Hamilton 2013; Hartel et al., 2014; Tezanos-Pinto 2009 and Tezanos-Pinto et al., 2009.

6.1. Determine season-specific extent of bottlenose dolphin range use within BoI waters.

- A total of 96 uniquely identifiable individuals were documented between December 2012-April 2015, demonstrating varying re-sight rates. Frequent users and occasional visitors were observed in the same proportion (both n=19, 19.8%), while the majority group were defined as infrequent users, accounting for 60.4% (n=58) of all individuals observed (Figure 21).
- All 19 f*requent users* were recorded during all months between December 2012-April 2015 (Figure 22).
- Ten identifiable adult females were observed with 12 young of the year calves, whose fates were documented during the study period. However, only 25.0% (n=3) of those calves are suspected to have survived for over two years to perceived independence, with 75.0% mortality observed in the first two years of life (n=9).
- Bottlenose dolphin distribution occurred throughout the study area, though spatial mapping infers higher density use areas in BoI middle ground (Zone D) and inner islands (Zone E) (Figure 14).
- While broad scale distribution is consistent with previous studies (Hartel et al., 2014), fine-scale habitat use has shifted to a small area around Tapeka Point and the eastern end of Roberton Island. Indeed, fine scale distribution patterns of bottlenose dolphins indicate high-density use is focused around Tapeka Point and Roberton Island, while the outer islands areas (Zones H & G) are no longer characterised as high use (Figure 14).
- The largest number of sightings occurred in summer and autumn with 0.03 sightings/km effort (31.0%, n=626 and 30.9%, n=624 of all sightings, respectively) and least in winter with 0.01 sightings/km effort (12.8%, n=259). Dolphins showed a strong seasonal preference for the Inner Islands (Zone E) in winter (58.4%, n=151) and spring (59.6%, n=304). In summer and autumn, sightings were more distributed utilising the Inner Islands (48.6%, n=304 and 44.2%, n=276, respectively) and Middle Grounds (42.8%, n=268 and 35.2%, n=220, respectively). Tapeka Point and Roberton Island were high-density areas year round.

6.2. *Quantify and document the type, level and operational effort of existing bottlenose dolphin tourism activity within the BoI waters.*

6.2.1. *What is the current level of effort (swimming and viewing, private and commercial, permitted and un-permitted)?*

- Private vessels were the most prevalent type of vessels recorded within 300m of dolphins in the BoI (36.0%, n=6,274). However, both permitted and un-permitted commercial vessels also demonstrated a strong presence, accounting 33.0% (n=5,752) and 31.0% (n=5,403) of the vessels observed in the BoI, respectively.
- The cumulative viewing effort of all vessel types, within daylight hours, resulted in a mean of 11.3 continuous min per day without the presence of vessels (other than the research vessel n=17,402).
- The cumulative effort of all vessel types with bottlenose dolphin equates to 14.3% of daylight hours without vessels (n=17,402).
- Effort varied seasonally. The lowest mean time without vessels occurred in summer with 8.1% of daylight hours (n=10,161) and highest in winter with 30.3% of daylight hours (n=1,116). Vessel effort in Spring and Autumn were similar with 16.2% (n=1,777) and 14.3% respectively (n=4,375).
- All vessel types exerted significantly more cumulative viewing effort in summer/spring than autumn/winter.
- Cumulatively, permitted vessels spent significantly more time viewing dolphin groups (n=5,752) than un-permitted commercial vessels (n=5,403). Private vessels spent significantly less time with dolphin groups (n=6,274) than permitted and un-permitted vessels.
- Viewing effort of permitted vessels in summer/spring resulted in a cumulate mean of 309 min (n=4,084) compared to 106 min in autumn/winter (n=1,668).
- The mean continuous time permitted vessels spent viewing dolphins per trip was 113 min in spring/summer (n=4,084) *versus* 52 min in autumn/winter (n=1,668).
- Un-permitted vessels spent significantly less time viewing dolphin groups in spring/summer (n=3,620) than autumn/winter (n=1,783).
- Un-permitted vessels viewed dolphins continuously for a mean of 37 min in spring/summer (n=3,620) *versus* 12 min in autumn/winter (n=1,783).
- Cumulative effort of viewing by private vessels was significantly greater in spring/summer (n=4,185) than autumn/winter (n=2,089).
- Private vessels spent the least time viewing dolphins in all seasons, with a mean of 18 min in spring/summer (n=4,185) *versus* 9 min in autumn/winter (n=2,089).
- A total of 941 swim encounters were monitored, 92.2% (n=868) and 7.8% (n=73) swim encounters from permitted vessel platforms and the research vessel, corresponding to 90.4% (n=2,491) and 9.6% (n=264) of swim attempts, respectively.
- Swimmers were primarily deployed from permitted vessels (62.5%, n=1,721), followed by private vessels (28.5%, n=758). An additional 5.9% (n=165) and 5.7% (n=157) swim attempts were recorded from un-permitted vessels and the beach, respectively.
- Of the 2,500 permitted swim attempts monitored from permitted vessels, 43.3% (n=1,083) were classified as normal, 34.5% as light (n=863), 14% (n=350) swapped swimmers on board and 8.2% (n=205) utilized double-loads.
- Overall, the duration of swim encounters ranged from 5-77 min (mean=47.7 ± 11.5 SE, n=2,491) per encounter.
- When tour type was light or normal, swim attempts were significantly longer than swap or double loads.

- The number of swim attempts varied significantly by season, number of boats present and type of swim tour. Swim drops were observed significantly more in summer and autumn, compared to spring and winter.
- Mean length of swims varied significantly by season and type of swim tour, although the number of boats present had no effect on duration. Swims were significantly shorter in summer and autumn than in spring or winter (Table 20). When the tour type was light or normal, swim attempts were significantly longer than swap or double-load.
- Significant variation in swim encounter duration was detected between summer and all other seasons.

6.2.2. Does the actual current level of effort of swimming and viewing trips correlate with any significant effects on dolphin behaviour?

- The current level of effort does have significant effects on dolphin behaviour.
- Significant effects were observed for behavioural budget, bout length, behavioural transitions and time required to return to a given behavioural state.

- Significant variation was observed as a result of:

Time of day/Season:

- Travelling and foraging budget varied by time of day, with the highest proportion observed in the afternoon when cumulative dolphin exposure to vessels was highest and direct effort was lowest, just after the second trip departure time for permitted vessels.
- Socialising and milling budget varied by time of day, with the highest proportion observed in the morning when cumulative dolphin exposure to vessels was lowest but direct effort of from all vessel type (particularly permitted vessels viewing and swimming) was highest.
- Despite permitted vessels observing the *cetacean lunch break*, true behavioural bout length and budget could not be assessed in the absence of vessels since both private and un-permitted vessels still continued to interact with dolphins during this time.
- Bout length significantly increased for travelling throughout the day, while milling decreased as cumulative exposure increased (Figure 29B). No resting was observed in the afternoon.
- Energetically important behaviours (foraging, travelling) remained lowest in summer when all vessel type effort was highest. Foraging and travelling was highest in winter when vessel exposure was lowest (Figure 29a).
- The proportion of socialising, milling and diving was highest in summer when all vessel type effort was highest (Figure 30).
- Behavioural bout length was shortest for foraging and travelling in summer when all vessel type effort was highest (Figure 29a).
- Behavioural bout length was longest for diving in summer when all vessel type effort was highest (Figure 29a).

Vessel presence:

- Bottlenose dolphins spent significantly less time travelling, foraging and resting and significantly more time socialising, diving and milling in the presence of any vessels within 300m (Figure 31).
- In the absence of vessels, travelling, resting and foraging bouts were longer, while socialising and diving bouts were shorter (Figure 31).

- All behavioural transitions involving milling, resting and diving, as preceding or succeeding behavioural states, were significantly affected. Similar trends were detected for foraging transitions, as preceding or succeeding behavioural states, with the exception of travelling and milling. Socialising transitions (as both preceding and succeeding behaviour) were only significantly affected for milling and resting. Travelling transitions were the least likely to vary at a significant level as a result of interactions with vessels (Figure 38).
- When in the presence of vessels, dolphins were never observed changing their state from diving, milling, travelling or socialising to resting (Figure 37).
- In most cases where an increase in transition probability was detected, socialising was the succeeding behavioural state.
- The likelihood of dolphins staying in a given state in the presence of interacting vessels within 300m was significantly decreased by 11.5% and 21.2% for foraging and resting, respectively. Opposite trends were detected for both milling and socialising, which significantly increased by 13.5% and 3.9%, respectively (Figure 38).
- Time (min) required to return to a given behavioural state was significantly affected by the presence of vessels for all 6 behaviours. Primarily, when travelling, foraging or resting, dolphins took longer to return to these states when vessels were within 300 m. In contrast, the time needed to return to socialising or milling decreased (Table 15).

Vessel number:

- As the number of vessels present within 300 m of dolphins increased, the behavioural budget decreased for travelling, foraging and resting. The magnitude of change further increased as the number of vessels increased, with particularly strong effects noted in the presence of ≥ 4 vessels (Figure 35).
- Socialising, milling and diving increased with the largest magnitude of change in the presence of ≥ 4 vessels. In particular, dolphins spent significantly more time socialising in the presence of ≥ 4 vessels (Figure 35).
- The number of vessels present had a significant effect on mean behavioural bout length (Figure 32).
- As the number of vessels increased from ≥ 2 to ≥ 4, bout length decreased significantly further (Figure 32).
- As vessel numbers increased, resting bout length exhibited a further decrease in length in the presence of ≥ 2 vessels, and a subsequent increase in the presence of ≥ 4. Though the increase was significant, resting bout length was still significantly lower than in the absence of vessels (Figure 32).

Vessel type:

- The behavioural budget of all behavioural states was significantly affected between presence and absence of various vessel types. Mixed vessels had the strongest effect on both diving and milling. Un-permitted vessels had the strongest effects on socialising and foraging (Figure 36).
- Mixed vessel presence had the largest effect on behavioural bout length apart from in milling and foraging situations, when un-permitted vessels demonstrated the largest effect (Figure 33).
- Private and permitted vessels had a similar effect in contrast to un-permitted and mixed. For example, when compared to the absence of vessels, the mean milling bout length increased significantly in the presence of un-permitted and mixed vessels but decreased when private or permitted vessels were present (Figure 33).

- The largest decrease in behavioural bout occurred for foraging in the presence of un-permitted vessels (Figure 33).
- In the presence of un-permitted vessels, milling bout length significantly increased when compared to all other vessel categories (Figure 33).
- Overall, the presence of un-permitted vessels resulted in a decrease in travelling and foraging and an increase in socialising and milling. Diving and resting was not observed in the presence of un-permitted vessels (Figure 33).

Swimming:

- Dolphins exhibited significant attraction towards swimmers and/or vessels for the duration of a swim encounter (Figure 48). Dolphins were observed exhibiting significantly less than expected avoidance, particularly frequent users. This could indicate sensitisation to swim encounters. Infrequent users showed avoidance from the start of a swim indicating avoiding dolphins left quickly and attracted dolphins were the only ones that were engaged in long encounters.
- After the initial 24 min, less than predicted orientation towards swimmers and/or vessel was evident, showing a behavioural change dependent on duration of swim encounter (Figure 48).
- In swims with solitary dolphins higher initial avoidance was observed (97.1%, n=463) compared to swims with groups (>2 dolphins) (24.4%, n=672).

6.3. What further conditions (if any) could be considered in order to minimise any determined effects? These conditions should address the following questions:

6.3.1. What is the average time permitted operators spend with the dolphins? What is the amount of time permitted operators cumulatively spend with dolphins? What period/s during the day do permitted operators activities exert the greatest effort? What season does permitted operators activities exert the greatest effort?

- Permitted vessels accounted for 33.0% (n=5,752) of dolphin vessel interactions observed.
- For cumulative effort of permitted vessels, please refer to section 6.2.1.
- For seasonal variation in cumulative effort of all permitted vessels, please refer to section 6.2.1.
- The mean continuous time permitted vessels spent with dolphins per trip was 113 minutes in spring/summer (range=0-138, n=4,084) and 52 min in autumn/winter (range=0-77, n=1,668).
- Dolphins in the BoI were exposed to the greatest number of permitted vessel interactions during the peak breeding season (December-February).
- The greatest permitted effort observed corresponds to less than an hour post tour departure times, when operator vessels were out on the water (both watching and swimming). The trough recorded occurred within the *cetacean lunch break*, when most permitted vessels were back at the wharf in Paihia before their next trip (Figure 41-43.

6.3.2. What is the average time each un-permitted vessel spends with dolphins? What is the cumulative amount of time un-permitted vessels spend with dolphins? What period/s during the day does non-permitted vessel activity exerts the greatest effort?

- Un-permitted vessels accounted for 31.0% (n=5,403) of vessel dolphin interactions observed.
- For cumulative effort of un-permitted vessels, please refer to section 6.2.1.
- For seasonal variation in cumulative effort of all un-permitted vessels, please refer to section 6.2.1.

- Un-permitted vessels spent significantly less time viewing dolphin groups in spring/summer (n=3,620) than autumn/winter (n=1,783).
- Un-permitted vessels viewed dolphins continuously for a mean of 37 min in spring/summer (n=3,620) *versus* 12 min in autumn/winter (n=1,783).
- Dolphins in the BoI were exposed to the greatest number of un-permitted vessel interactions during the summer and early autumn, specifically between December and April.
- Usage of the BoI by un-permitted vessels showed a similar pattern to private vessels, peaking around midday (4th percentile) before declining throughout the rest of the day (Figure 41-43).

6.3.3. *What is the average time each private vessel spends with dolphins? What is the cumulative amount of time private vessels spend with dolphins? What period/s during the day does private vessel activity exerts the greatest effort?*

- Private vessels accounted for 36.0% (n=6,274) of vessels observed.
- For cumulative effort of private vessels, please refer to section 6.2.1.
- For seasonal variation in cumulative effort of all private vessels, please refer to section 6.2.1.
- Private vessels viewed dolphins the shortest time period of all vessel types, with a mean of 16.31 min (n=289min).
- Majority of private vessels used the area in summer and autumn, coinciding with school holidays (over summer and Easter). The exception was sailboats, which were more prevalent in spring (Figure 45, 23.1%, n=185).

6.4. *What is the level of compliance with operator permit conditions and regulations?*

- Non-compliance was observed for 12 of 19 permit conditions and regulations, at varying levels, by all operators. Non-compliance was particularly high regarding conditions regulating dolphin swimming and interaction times.
- Logistical constraints may be a contributing factor to non-compliance, however one of the three tourism operators showed a comparatively high level of compliance whereas the other tourism operators did not.
- True representation of condition effectiveness (in mitigating disturbance levels on the dolphins) is compromised primarily by a lack of compliance.
- The seven conditions that were essentially complied with included: permitted departure and arrival time for both trips, revisiting of groups, no swimming with juveniles, maximum trips per day and no contact with marine mammals (trips observed the cetacean *lunch break* (11:30-13:00) and designated rest areas). However, a small number of interactions (n=16; 7.1%) occurred within designated rest areas and outside areas of operation.

The 12 conditions and regulations that were frequently breached included:

Permit conditions

- Maximum interaction time of 90min with marine mammals per trip – Permitted vessels spent a mean of 103 min (n=2,290) in the presence of marine mammals per trip.
- Maximum interaction time of 50min with bottlenose dolphins per trip – Permitted vessels spent a mean of 79.2min (n=5,752) in the presence of bottlenose dolphins, exceeding permitted time in 45.0% of encounters (n=2,561). Non-compliance of this condition was particularly high in spring/summer with a mean interaction time of 113 min (n=4,084) per trip.

- Maximum interaction time of 30min with calves/juveniles per trip – Permitted vessels spent significantly more time with nursery groups (presence of calves and neonates) than allowed (n=2,301). Permitted vessels exceeded 30 minutes with nursery groups in 78.0% of encounters (n=1,795).
- Maximum number of three swim attempts – Two of the three permitted companies undertook up to a maximum of 4 swim attempts per swim encounter. The third permitted operator observed the regulations and did not breach this condition. Overall, more than 3 swim attempts per operator was observed in 11.0% of swim encounters (n=93).
- Maximum number of 18 swimmers per attempt (including repeat swimmers) – Two of the three permitted operator companies breached this condition by taking up to 20 swimmers per attempt, with more than 18 swimmers in 28.8% of swims (n=21). The third permitted operator did breach the maximum swimmer permit condition. When repeat swimmers were included, all three permitted operators exceeded the maximum of 18 swimmers per attempt condition (Table 16).
- Swim placement using *line abreast* placement and no reversing – Reversing before and during a swim attempt was a technique used during the majority of swim attempts for 84.2% (Operator 2, n=975) and 76.2% (Operator 3, n=868) of swim attempts observed, though rarely observed by Operator 1 (3.1%, n=6). This does not follow the *line abreast* swimmer placement regulations (Table 17). Dolphins often approached vessels reversing *head-on/in-path* (93.2%), indicating sensitisation to this manoeuvre.
- Minimum vessel distance of 60m from shore – Sightings were recorded with an overall mean distance of 997.9m (n=2,019). However, 2.1% (n=42) of observations occurred within 60m of the shore. Furthermore, dolphins were typically located between the vessel and shore. In total, 78.6% (n=33) of such encounters involved at least one permitted vessel.
- Minimum swimmer distance of 60 m from shore - 2.7% (n=68) of observed swims occurred within <60 m of the shore, with dolphins recorded between the vessel and shore. This occurred primarily in spring and summer (77.9%, n=53) and in the presence of at least one permitted vessel (72.1%, n=49). The greatest distance from shore was observed in summer and autumn (Mean=1,098.9), while the closest to shore occurred in winter and spring (Mean=865.2).

  MMPR
- *No wake* speed within 300m - Permitted vessels generally travelled around the *no wake* speed (*ca*. 5 knts) on approach (n=2,860), although the highest speed observed was 8.1 knts on approach. However, this condition was violated on leaving, see below.
- Leave proximity of marine mammal at speeds no greater than 10 knots increasing speed gradually - On departure, permitted vessels generally travelled above the *no wake* speed (n=640), the highest speed observed was 23knts. The *no wake* speed (ca. 5knts) was observed when departing dolphins 17.3% of the time (n=651) by permitted vessels.
- *Three boat rule* – Permitted vessels arriving after three un-permitted boats were already within 300m of the dolphins (20.9%, n=46).

6.5. What is the potential long-term significance of the current level of tourism activities on bottlenose dolphins in the BoI?

- The cumulative effort from all vessel types interacting with dolphins resulted in a mean of only 102.6 minutes without vessels within daylight hours per day in the BoI. While the volume of vessel traffic varied between December 2012-April 2015, it remained high in the BoI throughout the study. Further to this at least one frequent user was present in 86.7% of encounters (n=1,747 encounters). The potential long-term effects of such high boat numbers and interaction level is unknown but the behavioural changes reported here (which extend beyond just differences in activity budgets reported previously) warrant further consideration (refer to recommendations in section 7).

- While it is challenging to infer long-term consequences from detected short-term changes (Bejder et al., 2006; Lusseau 2003; Williams et al., 2002), results presented herein are cause for major concern. Reductions in foraging and resting behaviours in the presence of vessels are likely to impact on the overall energetic budget of individuals, which in conjunction with declining population and high calf mortality, necessitate management change. The results presented within this study illustrate conclusively that current management tools (MMPR's, permit conditions) do not sufficiently mitigate vessel impacts on the declining local population, this is in part due to poor compliance.
- In the presence of vessels within 300m, bottlenose dolphins were less likely to travel, forage and rest, while more likely to socialise, mill and/or dive. Milling may represent a chance to conserve energy in times when resting is less likely owing to need for vigilance as a consequence of high vessel traffic. Alternatively, milling could be a transitional behaviour, or reflect uncertainty in group cohesion and the need to maintain physical contact.
- Behavioural changes were significantly stronger for socialising, milling and diving as the number of vessel increased. Effects were more prevalent when the MMPR (1992) were breached (i.e. more than 3 vessels present). This could have significant impacts on the population. Disturbance that interrupts biologically significant behaviours (i.e., resting and feeding) may carry energetic costs that can affect individual fitness. A reduction in fitness may have long-term consequences for the population (Christiansen et al., 2010; Lundquist et al., 2012; Peters et al., 2013; Filby et al., 2014).
- All vessels breached the MMPR (1992) with respect to departing from the vicinity of marine mammals at less than 10knts speed. The potential for this to encourage energetically costly behaviours over a long time period via habituation is of concern (Lusseau & Bejder 2007; Steckenreuter et al., 2012; Filby et al., 2014). The lack of adherence with MMPR's indicates that more efficient regulatory tools may be required than a combination of MMPR's and permit conditions (refer to section 7 for management recommendations).
- Bow riding behaviour occurred frequently (n=8,057) with 84.0% resulting in the split of the focal group due to <25% of the group engaging in the behavioural event (n=6,768). The individuals that approach moving vessels become the main interaction group for both permitted and un-permitted interaction. As a result, these groups frequently transition their initial behaviour in the presence vessels and instigate alternate behaviours such as bow riding. Consequently, disruption of vital behaviours could potentially lead to long-term population level consequences, as reported elsewhere (Bejder et al., 2006; Higham et al., 2009; Lusseau & Bejder, 2007; Steckenreuter et al., 2012; Filby et al., 2014). When resting behaviour is disrupted, the survival of calves is put at risk, as nursing often takes place while animals are resting (Stensland & Berggren, 2007). Further, these *risk taker* groups are at risk of habituation (Filby et al., 2014; Stone & Yoshinaga, 2000) i.e., over time, they approach vessels more frequently, thereby increasing their risk of vessel strike.
- Mother-calf pairs were observed approaching vessels to bow-ride during 10.2% of events observed (n=822). The interaction of groups containing calves with moving vessels across time is of concern, as neonates and calves are particularly vulnerable to vessel collision (Dwyer et al., 2014; Laist et al., 2001; Martinez & Stockin, 2013; Stone & Yoshinaga, 2000). Dolphin tourism efforts in the BoI has been continuous and thus dolphins may be display long-term behavioural changes such as habituation (Hawkins & Gartside, 2008). Habituated dolphins may display reduced caution and let their calves interact with vessels more closely and frequently than non-habituated individuals (Bejder & Samuels, 2003). Equally important

is the disruption of socialising behaviour when vessels that frequently get too close to dolphin, which in turn can affect nursing behaviour of young calves (Filby et al., 2014; Samuels et al., 2003).

- Concerns are particularly warranted for swims with calves or neonates, which are contrary to the MMPR (1992), and occurred during 18.5% (n=510) of the swim attempts monitored (although these were not conducted by permitted operators). This level of interaction could potentially be higher as calves or neonates were observed within the focal dolphin groups post or prior a swim, indicating calves in the vicinity of swims. This may have long-term significance on the population given a) the importance of mother-calf bond (Mann et al., 2000), b) the presence of frequent core individuals (Christiansen et al., 2010), and c) a high calf mortality rate within the local population (Tezanos-Pinto et al., 2009; 2013). Given the extent of non compliance with the MMPR's and the overall situation of the local BoI dolphin population efficient and increased advocacy is urgently needed to achieve better protection of mother calf pairs. The DOC has recently introduced a voluntary maximum approach distance to pods containing mother calf pairs in summer 2015 / 16 however it is unlikely that voluntary measures will be sufficient given the overall level of non-compliance even with mandatory regulations and permit conditions observed in this study.

6.6. *Integrate the recommendations of former historical research. Specific questions are addressed in order to better understand the effects of vessel traffic on bottlenose dolphins and develop clear measures and guidance. This includes describing behavioural responses of individuals (where possible), groups and specified age groups. This will be used to determine if such responses have population level consequences for seasonal and inter-seasonal range use. This is based on the above to i) avoid or minimise human impacts, and ii) to measure impacts that quantify thresholds over which further impacts must not occur.*

6.6.1. *What are the short-term behavioural responses of dolphins in relation to commercial and non-commercial viewing and swimming vessels? Do behavioural responses vary between what is currently and what was previously reported?*

- Short-term behavioural responses observed are detailed in full within section 5.12.

In accordance with previous research:

- Constantine (2002) indicated dolphins were found in deeper waters in summer when water temperature was highest, and in shallow waters in winter when the water temperature was lowest. Seasonal variation observed here was consistent with Constantine (2002); the greatest distance from shore was observed in summer and autumn (Mean=1098.9), and closest to shore in winter and spring (Mean=865.2) (Figure 14).
- Tezanos-Pinto (2009) inferred a 41.5% (n=17) and 22.2% (n=4) mortality rate prior to the first and second year of life, respectively, with 52.2% mortality overall in the first two years. The present study infers 75.0% (n=9) of calves observed within the present study period were suspected not to have survived past the first two years of life, while a 66.7% (n=8) 1st year mortality and a further 25.0% (n=1) 2nd year mortality was observed. This is an absolute percentage increase of 44.2% mortality in the first two years of life, with 61.4% increase in 1st year mortality and 12.6% increase in 2nd year mortality from Tezanos-Pinto (2009).
- Resting decreased while milling behaviour increased as vessel numbers interacting with bottlenose dolphins increased, concurring with Constantine et al., (2003) (Figure 32).
- In accordance with Constantine et al., (2003), a difference in dolphin resting and milling behaviours was observed in the presence of permitted vs. un-permitted vessels.
- Bouts of resting behaviour were rarely observed in the presence of permitted vessels,

concurring with Constantine et al., (2003) (Figure 32).

- Resting behaviour in the present study occurred only during 0.5% (n=5) of occasions in the presence of permitted vessels. Overall, resting was only reflected 1.1% of all behaviours observed in the present study (n=72). This is comparable to resting which was observed during only 0.5% of the time in the presence of more than three boats (Constantine 2002). Constantine (2002) also only recorded bouts of resting in the presence of the permitted operators on 6 occasions (8.1%, n=74).
- Dolphins were rarely observed utilising current designated rest areas (Waikare Inlet, Te Puna Inlet, Deep Water Cove, and the area northeast of Waewaetorea Island) established as a consequence of Constantine et al., (2003). In accordance with Hartel (2010), the present study found these areas are no longer of significant importance to this population (Figure 14).

In contrast to previous research:

- In the BoI only 96 uniquely identifiable individuals were documented between December 2012 and April 2015. This represents a 65.5%, 39.6% and 13.1% less than the 278 identified reported in 1997-1999 (Constantine 2002), 159 identified in 2003-2005 (Tezanos-Pinto et al., 2009, 2013) and 112 identified in 2009-2010 (Hamilton 2013) respectively (Figure 20).
- Mean group size between 2012 and 2015 was 14.8 (n=2,015) which is smaller than that reported from previous studies in the BoI (Constantine & Baker 1997, Tezanos-Pinto 2009), though within a similar range. Constantine (2002) reported group size ranged from 2 – 50 dolphins, with 80% of groups (n=160) containing 2-20 dolphins. Group size in the present study was skewed towards smaller groups, yet more than 68.0% (n=1,370) of groups comprised more than 10 individuals (Figure 16-18).
- A mean of 2.8 bottlenose dolphin groups encountered per day were observed in the bay between 2012 and 2015 (n=2,019), compared to an average of only 1.2 groups of dolphins reported between 1997 and 1999 (Constantine 2002).
- Constantine (2002) reported the number of groups with calves' present increased from 32.1% (n=17) in 1997 to 62.7% (n=47) in 1999. Herein, 41.9% of groups (n=845) comprised at least one calf/neonate.
- In contrast to Constantine et al. (2003), a significant difference in dolphin behaviour was not detected between the presence of un-permitted and private vessels. This is likely due to a lower number of observations in previous study. A higher number of observations in the present study allowed for the effects of vessel types to be assessed independently.
- Constantine et al. (2003) indicated there was a difference in dolphin resting and milling behaviour in the presence of permitted vs. non-permitted boats. Overall, significantly more resting and less milling behaviour was observed in the presence of the non-permitted (private and un-permitted) boats. In the present study, un-permitted vessels had the strongest effects on socialising and foraging not resting and milling. Overall, significantly more foraging and socialising and less milling behaviour was observed in the presence of the un-permitted boats (Figure 33 & 36).

In addition to previous research:

- Constantine's study (2002), was compromised by a management change which effected swimmer number conditions part way through the study period. The current study was able to assess the effect of swimmer numbers as management had remained essentially constant since the moratorium declared in 2009 which prevented any increases in permitted operational effort or impacts on bottlenose dolphins. When tour type was light or normal, swim attempts were significantly longer than swap or double load indicating as number of swimmer increases so the length of time dolphins interact with swimmers decreases (Table

17).

- The present study addressed behavioural transitions, time to return to behavioural state and behavioural bout length, in conjunction to the basic activity budgets previously presented by Constantine 2002. Furthermore, confounding variables such as vessel presence, type of vessel and number of vessels were addressed in more detail (refer to section 6.2.2).
- All behavioural transitions involving milling, resting and diving, as preceding or succeeding behavioural states, were significantly affected (Figure 37-38).
- In most cases where an increase in transition probability was detected, socialising was the succeeding behavioural state (Figure 37-38).
- The probability of remaining in a foraging or resting state after a vessel interaction decreased by 11.5 and 21.2%, respectively (Figure 38).
- The probability of remaining in a socialising or milling state increased by 13.5 and 3.9%., respectively (Figure 38).
- The transition probability from diving to travelling decreased in the presence of vessels by 69.7%. Contrary to this, the transition probability from foraging to socialising increased in the presence of vessels by 183.3% (Figure 38).
- No transition from resting to diving and diving to socialising were observed in the absence of vessels but were observed as 4.0% of resting transitions and 10.0% of diving transitions when interacting with a vessel (Figure 38).
- Time required to return to a given behavioural state post a vessel interaction was significantly affected by the presence of vessels for all 6 behaviours, with the overall mean return time increasing from 40.7min to 72.3min (77.5% increase) (Table 15).
- Travelling, foraging and resting bottlenose dolphins took 132.3%, 262.0% and 725.6%, more time to return to their initially behavioural state post a vessel interaction, respectively. In contrast, the time required to return to socialising, milling or diving decreased by 36.8%, 58.7% and 95.6%, respectively (Table 15).
- Average behavioural bout length (min) varied significantly in the presence of vessels for all behavioural states except milling (Figure 31).
- In the presence of vessels, travelling, resting and foraging bouts decreased by 35.7%, 22.9% and 13.3%, respectively. Meanwhile, socialising and diving bouts increased by 21.1% and 118.3%, respectively (Figure 31).
- No resting bouts were initiated when a vessel interacted with dolphins.

6.7. Are these activities significant for the population of the BoI?

- Significant behavioural response was detected for all behavioural states in the presence of vessels within 300m (refer to section 6.2.2. for details, Figure 31).
- Differences between historical and current research findings were observed, indicating further sensitisation and/or habituation to vessels interactions (refer to section 6.7.1. for details).
- Concerns are warranted given presented evidence of a further local population decline and increased calf mortality rate to that reported initially by Tezanos-Pinto et al., (2009, 2013) (refer to section 6.7.1 for details).
- Dolphins in the BoI spend on average 85.7% of daytime with at least one vessel. Therefore, for 85.7% of the time they follow a behavioural budget presence chain, and for the remaining 14.3% their behavioural budget is similar to the one of the control chain. Their cumulative diurnal behavioural budget (85.7% impact + 14.3% control) did vary significantly from the control behavioural budget.

- The diurnal behavioural budget of dolphins significantly varies from the behavioural budget without vessels, due to spending only 14.3% of daylight hours without interaction. This means a reduction of 100.0% resting, 60.0% foraging and 37.5% travelling and an increase of 600.0% diving, 135.7% milling and 78.6% socialising. Results indicate that management change is required to protect bottlenose dolphins from undue disturbance and mitigate adverse effects at the population level.

6.8. Produce statements and recommendations based on all of the above regarding existing and future tourism activity particularly in the BoI waters. Including any conditions that need review since previous study, whether areas should be excluded from the commercial operators' permit areas and / or tourism pressure in general, year round or season-specifically and implications on the level of effort permitted in the BoI for each activity?

- For specific management recommendations refer to Section 7.

7. Critical issues & management recommendations

The local BoI bottlenose dolphin population is at high risk of a continued decline to localised extinction unless critical action is taken.

Management in the BoI must apply to all vessels utilising the area to address the trend of continued decline. Protection measures should be adaptive, extend beyond permit conditions and be supplemented with educational and enforcement programs (Keane et al., 2008) to promote compliance with regulations. Cumulative existing effort with dolphins needs to be down regulated. Clearly defined legislation which allows significant authority, including that of revoking operator permits (Bejder et al., 2006b; Higham & Bejder, 2008) and penalising any non-compliance (Scarpaci et al., 2003), regardless of vessel type is required, in a way that is fair and reasonable. This study demonstrates that 88% of all encounters between permitted vessels and marine mammals involve bottlenose dolphins. The localised loss of this species from the BoI would result in the regional marine mammal tourism industry losing its economic core and long-term viability.

This report evaluates multiple options for better managing vessel/dolphin encounters in the BoI, including simplifying the current permit conditions. Recommendations include establishing a minimum approach distance, prohibiting vessel activities of concern and creating applicable temporal and spatial closures. Management action would need to be comprehensive, adaptable, easy to understand and practical (considering local conditions and permitted operator expertise). Crucially, such actions need to be enforceable.

The following are suggested for consideration by DOC, permitted commercial operators and other stakeholders.

Critical issue 1: Significant decline in *nationally endangered* bottlenose dolphin BoI population and potential risk of localised extinction

A continuing decline in dolphin numbers (278 to 96 individually identifiable dolphins, representing a 65.5% decline since 1999) utilising the BoI has been documented. Results suggest frequent users were present during 86.7% of encounters (refer to section 6.5).

In the interests of the long-term sustainable management of tourism interactions with bottlenose dolphins in the BoI, urgent management action is required. It is recommended:

- For the current moratorium to remain in place until at least full population analyses are completed for *Tursiops* across their broader north-east, North Island range to prevent any increases in permitted activity. This would allow site fidelity and cumulative effects to be clearly determined. Datasets with respect to Hauraki Gulf (GBI) and BOP are currently available and could be used to address this issue.
- For the DOC to apply year round management (as opposed to limiting management measures to peak periods, refer to section 6.1). This is due to all 19 *frequent users* being observed during all four seasons.
- An integrated and adaptive management plan be implemented, as per Higham et al. (2009). This management model highlights the importance of integrating multiple stakeholder perspectives in a way that is both research-informed and adaptive. In the BoI, management should include the monitoring of the local population at regular intervals.
- For the DOC to review and/or potentially remove current designated rest areas (in their current form) within the BoI since dolphins no longer utilise these areas on a regular basis. General use of BoI waters by bottlenose dolphins is widespread and variable across seasons (refer to section 6.1). Consequently, newly imposed static area specific management zones (such as the current permit exclusion zones) would likely be redundant.
- For the DOC to replace current permit exclusion zones with improved efficient spatial tools. Spatial management has been demonstrated as effective in protecting cetaceans (Gormley et al, 2012). As part of an integrated adaptive management plan, larger spatial and temporal (e.g. seasonally specific) exclusions zones, which allow for observed spatial distribution, are recommended (refer to section 6.1). A clearly defined spatial or temporal refuge should allow monitoring of compliance and therefore, enforcement of all vessels to be easier for managers.
- For the DOC to engage with a NGO or community initiative in the BoI to provide education, on-water monitoring and hold enforcement powers (similar to Honorary Fisheries Officers https://www.mpi.govt.nz, DOC threatened species ambassadors and Soundwatch: on-the-water education and monitoring (http://whalemuseum.org/pages/soundwatch-boater-education-program)).
- For the DOC to make provision for compulsory, efficient and locally relevant training for all commercial permitted operator crew annually, preferably ahead of peak season. The aim being to minimise disturbance of tour boats, provide updated research information on the bottlenose population and known effects of tourism activities, as well as to reinforce a) the importance of regulations and operator obligations under the MMPR (1992) and b) existing commercial permits restrictions (refer to section 6.4 and appendix 2).
- For the DOC to engage in a significant public education campaign along the lines of “Saving the BoI dolphins” aimed at public engagement (e.g. via community initiatives) and ultimately, significant behaviour changes in private vessel owners (refer to sections 6.3 and 6.5).

Critical issue 2: High and unsustainable calf mortality

Over the study period, only 25.0% (n=3) of calves were estimated to have survived two years to perceived independence. This is a 61% and 13% increase from previously reported first and second year calf mortality, respectively (ref to section 6.1, 6.5 and 6.6.1).

Therefore, specific measures to protect dolphin calves are required. It is recommended:

- A mandatory approach distance to mother calf pairs be applied. A precautionary distance of 150m is suggested due to the sensitisation/habituation observed (refer to section 6.5). The DOC has introduced a voluntary maximum approach distance to pods containing mother calf pairs in summer 2015/16. However, it is unlikely that such voluntary measures alone will be useful given the overall level of non-compliance with mandatory regulations and permit conditions reported herein (refer to section 6.4).
- Spatially and temporally appropriate no interaction zones be instigated. Given regular shifting observed, dolphin habitat use would need to be re-assessed at regular time periods to ensure that biologically important areas are protected appropriately. Season specific exclusion (or slow zones if areas cannot be excluded, refer to section 6.1) are suggested, with temporal adaptation to provide protection during calving season.
- For the DOC to improve information dissemination to the general public within BoI about the MMPR (1992), with a special emphasis on the prohibition of swimming with neonates and calves (refer to section 5.14.4). This could be achieved via improved advocacy, monitoring and compliance in conjunction with honorary wardens.
- For the DOC to mitigate the disturbance and/or potential injury to calves from vessel traffic. It is specifically recommended all racing events with high vessel speeds be excluded from the BoI during identified peak breeding season (refer to section 6.1).

Critical issue 3: Vessels and swim-with activities disturb/disrupt behaviours critical to bottlenose dolphin survival

The effect of vessel interactions on bottlenose dolphins in the BoI is significant and at a level that could lead to a reduction in fitness due to the disruption of foraging and resting behaviours. Transition to and from both behaviours was affected, while no resting was observed in the presence of permitted vessels (refer to section 6.2.2). In order to minimise this, it is recommended:

- The minimum approach distance be increased during foraging and resting events (refer to section 6.5 and 6.6.1). A precautionary distance of 100m is suggested to allow skipper and crew appropriate distance to accurately identify and react to dolphin behaviours observed. As indicator behaviours could be misinterpreted or missed, mandatory training on behavioural identification for all crew is recommended.
- For the DOC to implement aforementioned spatial or temporal exclusion zones. Whilst not providing full mitigation of effects observed on critical behaviours, this approach would simplify monitoring and enforcement. Compliance with current exclusion zones was satisfactory between 2012-2015 (refer to section 6.4) indicating this could be successfully instigated in the BoI. Ideally, such areas would be expansive enough to allow animals to engage in biologically important behaviours without being disturbed by vessels in multiple locations. The impact on the dolphin-watch permitted industry would be similar to that of establishing a greater viewing distance as opposed to precluding dolphin viewing activity all together. As vessels would have to sit on the boundary or move away, this would reduce encounter time and eliminate herding behaviour observed of skippers (refer to section 6.3.1).

Critical issue 4: Higher than sustainable vessel effort exerted on local population

Between 2012-2015, the entire diurnal behavioural budget and bout length of the local dolphin population was affected, with just ca 14% of daylight hours that dolphins spent without vessels (refer to section 6.7). To mitigate this, it is recommended all vessel types are addressed concurrently as listed below.

Permitted and un-permitted vessels have the greatest potential to affect dolphin behaviour based on duration of contact and volume of interactions with dolphins, respectively (refer to section 6.3.2 and 6.3.3). To achieve better mitigation of effects it is recommended:

- The DOC increase compliance monitoring and enforcement action. To do so, the department needs to be better informed of operator compliance on a daily basis via self-monitoring of the industry.
- An extension of the current moratorium be considered to guarantee no additional permitted effort (including any increase in the number of permits and daily trips). Data presented herein indicates any rise in effort (permits or daily trips) is contrary to the best interests of this dolphin population, regardless of compliance, due to the observed behavioural effects reported (refer to section 6.2).
- Full compliance by all permitted operators with all MMPRs and permit conditions be achieved and maintained (refer to appendix 2 and section 6.4).
- The DOC simplify and condense specific permit conditions (formerly put in place based on Constantine 2002, ref to appendix 2) to increase comprehension by permitted vessel staff and to facilitate enforcement (refer to section 6.4).
- A reduction in the times that permitted vessels may interact with dolphins be instigated (refer to section 6.3.1 and 6.4). The permitted time should be less than the mean time to return to a behaviour (40.7min) in the absence of vessel disturbance (refer to section 6.6.1).
- A potential change to permit conditions to include a maximum time of encounter per group (instead of per trip), with no repeats allowed is investigated. The permitted time should be less than the mean time to return to a behaviour (40.7 min) in the absence of vessel disturbance (refer to section 6.6.1). This would reduce cumulative interaction time per dolphin group without compromising operator trip success since more numerous yet smaller dolphin groups are frequenting the BoI than previously reported by Constantine 2002 (refer to section 6.2.1 and 6.6.1). This will also eliminate the possibility of extended encounters from all vessels on days when only one group of bottlenose dolphin is observed in the region.
- Full compliance with MMPR (1992) be observed (refer to appendix 2) and no interaction with a group if 3 or more vessels are already viewing and/or swimming with dolphins within 300 m be enforced (including private vessels) (Refer to section 6.4 and 5.13.3). Specifically, permitted vessels must stand off outside 300 metres until less than three vessels remain. This would reduce vessel pressure around dolphins, given that effects were greater when MMPR (1992) regulation 20 was breached (refer to section 6.2.2). Crucially, full compliance would further educate private boaters and patrons about the legal limitations on vessel numbers around cetaceans.
- Publically accessible communication systems that broadcast dolphin locations be avoided. A cease in the use of radio channels to publically discuss dolphin locations for both permitted and un-permitted commercial vessels is suggested. This will reduce active targeting of dolphins by un-permitted vessels (refer to section 6.2.1) and ensure opportunistic nature of interactions thereby reducing cumulative interaction times (refer to section 6.2.1).
- The DOC implement and enforce new local regulations preventing un-permitted commercial vessels approaching within 300m of dolphins within BoI waters (Refer to section 6.2.1 and 6.3.2). Currently unpermitted operators can legally (in accordance with the MMPR's) interact with marine mammals where they co-incidentally come across them but they must not target them. Based on the documented level of interaction between bottlenose dolphins and un-permitted operators, this distinction is unworkable in the BoI (refer to section 6.2.1 and

6.3.2). The high encounter rate between unpermitted operators and bottlenose dolphins therefore undermines the permit system. With a moratorium on permits operational since 2009, issuing further permits is not considered an appropriate option to better mitigate the impact of unpermitted operators on bottlenose dolphins.

Private vessels are the most numerous and least regulated vessel type in the BoI. Private vessels were most likely to swim with calves and were shown to alter dolphin behaviour (refer to section 5.14.4). To achieve better mitigation (beyond already identified recommendations) it is recommended:

- The DOC encourage establishment of land based viewing stations adjacent to exclusion zones to advocate no disturbance / no impact viewing. This approach has been successfully implemented elsewhere (e.g. the Adelaide dolphin sanctuary http://www.environment.sa.gov.au.). The level of private interest observed suggests exclusion with no alternative will be ineffective (refer to section 7.2.1 and 7.3.3). DOC would be able to regulate the information contact of commercial land based dolphin viewing through the permit system.
- The DOC to establish enforceable regulations for un-permitted and private vessels. In some areas voluntary codes of conduct (COC) have been employed; however, they are regularly ignored and ineffective in achieving their original purpose (Allen et al., 2007; Wiener et al., 2009). In the BoI, the lack of compliance with MMPR (1992) indicates voluntary COC are not appropriate tools for the area (refer to section 6.5) and regulation should be enforceable across all vessel types.

Swimming with dolphins is likely to be trivialised in the BoI, thus increasing swimming effort (Refer to section 5.14 and 6.5). To mitigate this, the following are recommended:

- No swim-with attempts from any vessel other than permitted vessels be allowed in BoI waters (refer to current levels of effort section 5.14 and 6.2).
- The DOC ensure permitted vessels comply with the no swim within 60m from shore rule. If 60m cannot be complied with due to difficulty in judging distance, a larger precautionary zone of 100m is suggested to mitigate effects observed (refer to section 5.14.9). Additionally, this will further simplify permit conditions by having a standard distance across all recommendations.
- The DOC ensure permitted operators do not swim with solitary dolphins as significantly higher behavioural effects were observed during swims with singletons (refer to section 5.14.5).
- The DOC ensure permitted vessels improve and reinforce education to their patrons during swim encounters. It is suggested this is achieved through assessment of all education content during compulsory workshops with permitted operators.

Critical issue 5: Poor compliance across all vessel types utilising BoI waters

Best practice management has demonstrated to be ineffective in this circumstance, with only one of three operators showing reasonable level of compliance (refer to section 6.5).

To mitigate issues of non compliance it is recommended:

- The DOC review and improve current management tools. Revised management tools must be easily understood, be realistic/feasible in the field and be easily enforceable.
- The DOC improve compliance/acceptance of regulations. In order to achieve this a top-down remit for the production of new regulations should be instigated with a bottom-up involvement in their construction via an extensive consultation process.
- The DOC address the chronic lack of ability to enforce regulations and conditions. Enforcement must apply to all vessel types in the BoI.
- The DOC provision dedicated independent observers (similar to MMO's). MMO's should regularly board permitted vessels to monitor interactions with dolphin groups as well as collect standardised data (especially during swim encounters). The aim is to a) improve compliance with MMPR (1992) and reduce violations documented herein (refer to section 6.4), and b) increase data uniformity and availability to researchers and managers.

The cumulative time a focal dolphin group is exposed to vessel interaction from permitted vessels has exceeded the permitted maximum time of 50 min with bottlenose per trip (refer to section 6.4). The mean time of encounter was similar to the mean time to return to behavioural state (72.3 min) in the presence of vessels, suggesting non compliance of this condition is significantly affecting dolphin behaviour (refer to section 6.4, 6.5 and 6.6.1). To mitigate this, it is recommended:

- The DOC extend compliance monitoring and action on all commercial operations to improve and monitor compliance issues based on the overall mean time of encounter (79.2 min) (Refer to section 6.4).
- Real-time as opposed to retrospective data collection of encounter duration times to be employed by all operators. Operators are encouraged to establish a more efficient data collection system to facilitate timely monitoring of permitted maximum interaction times, thereby improving current compliance issues and supplying DOC with accurate data on a daily basis.

Reviews of permit conditions (instigated following Constantine 2002 recommendations, refer to appendix 2) indicate some conditions are no longer appropriate and/or respected by operators while viewing or swimming with bottlenose dolphins (refer to section 6.4). To address this issue, and in addition to previous recommendations (adaption of rest areas, penalty for non-compliance, compulsory training of commercial crew), it is recommended:

- All permit conditions in the BoI consider cumulative effort of all vessels rather than just permitted operators. This effect is observed regardless of vessel type (refer to section 6.2).
- All permit conditions which are subjective, complex, include infraction and/or grey areas are reviewed and simplified (refer to section 6.4).
- Swim placement permit conditions be amended to reflect a more practical solution than what is currently being utilised by permitted operators (refer to section 5.14.1). Whilst best-practice would be preferable, current data suggests the implementation of *line abreast* following previous research recommendations has been unsuccessful due to logistical constraints (i.e. impeded vessel vision and movement resulting in unsuccessful swims). It is therefore recommended that a compromise or change in vessel configuration be instigated in order to improve compliance while minimising impacts of dolphins swims as best as practically possible. If compliance cannot be achieved, it is recommended swimming with bottlenose dolphin in the BoI not be permitted (for any vessel).

Non-compliance with the MMPR (1992) by all vessels (particularly unpermitted and private vessels) has been regularly documented while viewing and/or interacting with dolphins (e.g. speed and number of vessels, refer to section 6.5). In addition to the aforementioned recommendations regarding increased public awareness (including signage at boat ramps media campaign, mandatory exclusion zones) and to improve compliance, it is recommended:

- The DOC provide compulsory area specific annual training for all un-permitted vessel skippers and crew undergoing commercial operation in BoI waters.

8. Future research

- Incorporation of restricted historical photo-identification and behavioural datasets in order to facilitate long-term temporal comparison of bottlenose dolphins in the Bay of Islands.
- Continuation of regular photo-identification, specifically along the full range of the North-East coast population. Comparisons of individual identification catalogues between regions will provide information on fine-scale movements. This information should be used to design a PVA analysis for the 'total' North Island population. Ideally, surveys should be conducted on a relevant temporal scale to allow for a multisite mark-recapture analysis.
- Undertaking of systematic post-mortem examinations on beach cast carcasses to assess life-history parameters and incidence of disease, and anthropogenic interaction (e.g. entanglements, boat strike, pollutants).
- Assessment of prey availability, diet and foraging strategies of bottlenose dolphins in the Bay of Islands.

9. Conclusion & perspectives

Bottlenose dolphins are the most encountered cetaceans in the BoI. Consequently, they remain the primary target species of permitted commercial vessels. As such, bottlenose dolphins form the economic core of the marine mammal tourism industry in this region. Findings presented here indicate that the current high level of vessel interactions (permitted, un-permitted and private) with bottlenose dolphins in the BoI is not benign, and the magnitude of effects has increased significantly since previous studies. Five critical issues are identified.

Firstly, a continuing decline in identifiable individuals (278 to 96, representing a 65.5% decline since 1999) utilising the BoI. Results suggest 88% of encounters involve frequent users exposing them to high levels of vessel disruption. The local BoI bottlenose dolphin population is at legitimate risk of a continued decline resulting in localised extinction unless major action is taken. This is particularly pertinent given the warm season impacts on the cumulative behavioural budget during peak tourism season, which also represents the calving and breeding season for the *nationally endangered* bottlenose dolphin.

Secondly, the BoI local population has previously been reported as showing a high calf mortality rate (Tezanos-Pinto et al., 2009; Tezanos-Pinto et al., 2013). Here, this study demonstrated only 25% (n=3) of calves observed within BoI waters during the 2012-2015 study period were confirmed as having survived to independence, affecting the persistence of the local population (Tezanos-Pinto 2013). This suggests a marked increase in calf mortality since the previous study (44.2% survival (1994-2006) Tezanos-Pinto 2009).

Thirdly, in the BoI, vessel interactions (both permitted and un-permitted) levels are unsustainable with significant effects on critical bottlenose dolphin behaviours documented for nearly 20 years. Despite various management efforts, the present study indicates that such effects remain yet to be mitigated. Results of fine-scale habitat use presented here suggest bottlenose dolphins have shifted their distribution across the BoI to a smaller area around Tapeka Point and the eastern end of Roberton Island. This refined distribution exposes them to the highest density of vessel traffic in the BoI. Fourthly, between 2012-2015 the entire diurnal behavioural budget and bout length of the local dolphin population was effected, with dolphins spending only ca 14% of daylight hours without vessels. During such exposure, dolphins demonstrated increased engagement in energetically expensive behaviours of socialising and diving at the cost of foraging or resting. Furthermore, the substantial increase in transition probability from foraging to socialising may represent a response mitigating the effect of boat presence on foraging bouts and indicate sensitisation via increased socialising. Notably, the mean time to return to a behavioural state if disturbed by a vessel was longer than the mean time dolphins spent without vessels. As such, a return to initial state was not observed during daylight hours for any of the behaviours

Fifthly, such findings are further exacerbated by current compliance issues, which collectively indicate 9 of the 14 conditions are regularly breached by a number of permitted commercial operators within the region. All vessel types utilising the BoI did not comply with MMPR (1992), to varying extents. Collectively, these findings give rise to represent legitimate concern regarding the short- and potential long-term effects of intensive tourism activities, both at the individual and population level.

The dolphin tourism industry in the BoI is of notable economic and cultural importance to the local community. For this industry to become sustainable, on going monitoring of the broader population is vital to our understanding of tourism effects. The BoI is not in isolation, so effects reported here need to be understood across the entire population and allow for the recruitment of individuals into the local BoI population. Management in the BoI must address all vessels utilising the area. New and improved rules must be adaptive, extend beyond permit conditions and be supplemented with educational and enforcement programs (Keane et al., 2008) to help ensure compliance with regulations. Moreover, clearly defined regulatory tools must have significant authority (Bejder et al., 2006b; Higham & Bejder, 2008) and address un-permitted and private vessels. Without enforcement, management may fail to meet their goals and, ultimately, fail to protect the long-term viability of the sole economic core of the marine mammal tourism industry in this region.

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11. Appendix 1

Definitions of observed behavioural events of bottlenose dolphin groups in BoI waters, NZ (Constantine 2002; Constantine et al., 2004).

Behavioural event	Definition
Socialising	
Horizontal jump	At least one dolphin engaged in horizontal airborne forward progression of at least one body length while in dorsal position
Vertical jump	At least one dolphin engaged in vertical airborne forward progression of at least one body length while in dorsal position with abrupt lunges out of water with only shallow submerges
Noisy jump	At least one dolphin engaged in airborne forward progression with Maximum/flat body contact with the surface of the water upon entry
Head Flop	At least one dolphin engages in partial breach above the surface of the water with side of head making sharp, noisy contact with surface upon entry
Top of body out	At least one dolphin orientated to hold top of body above the surface of the water
Tail Out	At least one dolphin orientated to present and hold tail and/or flukes above the surface of the water
Upside down Swim	At least one dolphin orientated to Swim with ventral side towards the water surface
Bite	Teeth of one dolphin makes contact with any other individual
Lobtail	At least one dolphin orientated in horizontal body position relative to the surface of the water. Dolphin makes contact with surface via a jerky whole body movement to flex tail. Individuals are likely to slap several times
Chase conspecific	Persistent following of one or more dolphin for a prolonged period
Pounce	At least one dolphin makes contact with one or more other individuals, with ventral to dorsal contact
Bubble blowing	At least one dolphin releases a large volume of air through its blowhole while submerged in one short burst
Surfing waves	At least one dolphin engaged forward progression in the direction of swell/waves
Bowriding/Wakeriding	At least one dolphin engaged in persistent approach of a vessel bow and/or oriented to swim in the vessels bow or wake wave
Playing with kelp	One dolphin picking up and carrying any naturally occurring object, often on the dorsal fin
Belly away	At least one dolphin orientated to not display ventral side to one or more other individuals
Penis out	Dolphin penis visible and protruding from body
Body contact	At least two dolphins make contract. One engages in touching of the body (Connor *et al.* 2000) and includes biting, pectoral touch, body touch, or rolling together at the surface
Belly present	At least one dolphin orientated to display ventral side to one or more other

	individuals
Spyhop	Brief vertical or near vertical surfacing of the head, eye and rostrum above the water line followed by sinking return to water
Copulation	Two dolphin contact confirmed observation of sexual approach with ventral joining and intromission of conspecific
Possible copulation	Two dolphin contact between genital zone and intromission suspected but not observed
Nursing (rostro-genital contact)	confirmed observation of calf rostrum touching ventral surface of adult in area of mammary slits, with position held.
Foraging	
Chin out	At least one dolphin orientated with chin and rostrum present over the water line
Feeding	At least one dolphin observed feeding with confirmed visual of prey in mouth
Surface rushes	At least one dolphin engaged in fast and directional swimming on the surface with dorsal fin creating white-water splash
Synchronised swimming	Two or more dolphins matching speed and orientation in persistent forward movement
Horizontal flex	At least one dolphin orientated to perform Side flex or horizontal bending of the body for manoeuvring during feeding
Swimming on side	At least one dolphin orientated with lateral side towards the water surface
Fish toss	At least on dolphin tossing of fish using head, pectoral flipper or fluke where fish is thrown clear of the surface
Resting	
Logging	At least one dolphin observed stationary with no persistent movement at the surface for 5sec or more.

12. Appendix 2

Regulatory and other tools for dolphin bottlenose dolphin protection in BoI waters, NZ and their applicability. Provided by E. Reufels, DOC.

<table>
<tr><th>Purpose</th><th>Item</th><th colspan="3">Level of compliance required</th></tr>
<tr><th></th><th></th><th>Permitted operators</th><th>Unpermitted operators</th><th>Private vessels</th></tr>
<tr><td colspan="5">Relevant MMPR 1992 (part 3, behaviour around marine mammals. For complete list refer http://www.legislation.govt.nz/regulation/public/1992/0322/latest/DLM168286.html)</td></tr>
<tr><td>No commercial operation without permit allowed</td><td>Regulation 5</td><td>N/A</td><td>mandatory</td><td>N/A</td></tr>
<tr><td>No wake speed within 300 meters</td><td>Regulation 18 (l)</td><td colspan="3" rowspan="6">mandatory</td></tr>
<tr><td>Leave proximity of marine mammal at speeds no greater than 10 knots increasing speed gradually</td><td>Regulation 18 (m)</td></tr>
<tr><td>No vessel to proceed through a pod of dolphins</td><td>Regulation 20 (a)</td></tr>
<tr><td>No swimming with juvenile dolphin</td><td>Regulation 20 (b)</td></tr>
<tr><td>3 Boat rule</td><td>Regulation 20 (e)</td></tr>
<tr><td>Approach of 3rd boat</td><td>Regulation 20 (f)</td></tr>
<tr><td colspan="5">Permit conditions(in force since 2004, based on measures intended to mitigate tourism impacts which were recommended by and based on research by R Constantine (2002))</td></tr>
<tr><td>Lunch break</td><td>Special condition 1</td><td rowspan="10">mandatory</td><td colspan="2">Voluntary (local guideline)</td></tr>
<tr><td>Interaction Time limits</td><td>Special condition 2</td><td colspan="2" rowspan="8">N/A</td></tr>
<tr><td># swim attempts</td><td>Special condition 3</td></tr>
<tr><td># swimmers</td><td>Special condition 4</td></tr>
<tr><td>Line abreast swimmer placement</td><td>Special condition 5</td></tr>
<tr><td>Distance to shore condition</td><td>Special condition 6</td></tr>
<tr><td>No reversing except for safety reasons and swimmer retrieval</td><td>Special condition 7</td></tr>
<tr><td>Re-approach of dolphin group</td><td>Special condition 8</td></tr>
<tr><td>Provision of interaction data</td><td>Special condition 9 and 10</td></tr>
<tr><td>Permit area / exclusion areas</td><td>Schedule 2 clause 2</td><td colspan="2">Exclusion areas apply on voluntary basis</td></tr>
<tr><td colspan="5">Guidelines(refer http://www.doc.govt.nz/parks-and-recreation/places-to-go/northland/bay-of-islands-marine-mammals-brochure/)</td></tr>
<tr><td>Minimum 100 meter distance to mother calf pairs</td><td>Local guideline (since December 2015)</td><td colspan="3">voluntary</td></tr>
</table>