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Effects of commercial tourism activities on bottlenose and common dolphin populations in East Coast Bay of Plenty waters

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I. Executive summary

Eight commercial marine mammal tour operators are permitted to view and swim with common (*Delphinus* sp.) and bottlenose dolphins (*Tursiops truncatus*) in the East Coast Bay of Plenty (ECBOP), New Zealand. This report outlines a dedicated study into the ecology and behavioural responses of these dolphins to such tour vessels. The study aimed to determine occurrence and ecology of both species in ECBOP waters. The effect of interacting vessels on common and bottlenose dolphins was assessed, and the level of vessel traffic and swimming activities were examined. Recommendations have been formulated in order to minimise potential long-term impacts on the targeted populations and to ensure a sustainable tourism activity in the region.

Between November 2010 and May 2013, a total of 417 boat-based surveys were conducted from Tauranga (95.4%, n=398) and Whakatane (4.6%, n=19), of which 36% (n=150) were undertaken from an independent research vessel (RV) and 64% (n=267) from seven different tour vessels (TV). A total of 23,872km were surveyed *on effort*, comprising 8,718 and 15,154km from the RV and the TV, respectively. Out of a total of 508 independent marine mammal encounters, common dolphins were the most encountered species (59.4%, n=302), while bottlenose dolphins were observed only very rarely (1.8%, n=9).

Dolphin behavioural states were assessed and recorded using three-minute focal-group scan sampling. Fifty eight focal follows were conducted from the RV: 55 focal follows with common dolphins (7,634min, *i.e.* 127.23hrs, and 828.5km *on effort*) and three focal follows with bottlenose dolphins (424min, *i.e.* 7.67hrs, and 70.2km *on effort*). Focal follows were conducted in the presence of the RV only, *i.e. control* sequences (≥ 15min, common dolphins: 38%, n=38; bottlenose dolphins: 33.3%, n=2), and in the presence of both the TV and/or other vessels (commercial TV and/or non-TV within 300m of the group of dolphins), *i.e. interaction* sequences (≥ 15min, common dolphins: 62%, n=62, bottlenose dolphins: 66.7%, n=4).

Common dolphins showed a seasonal distribution and were found in offshore (median=18.5km from the coastline, n=87) and deep (median=73.4m deep, n=87) waters in autumn and winter, and closer to shore (median=14.8km from the coastline, n=192) in shallower waters (median=57.1m deep, n=178) in spring and summer. Overall, common dolphins were predominantly observed in small groups of ≤ 20 individuals (51.2%, n=133), often containing juveniles and calves. Group size varied diurnally, and is likely associated with dolphin behaviour. Assessment of initial behaviour, at first sighting, suggests common dolphins in this region spent more time travelling (46.7% of encountered groups, n=91) compared to foraging (24.6%, n=48), milling (17.9%, n=35), socialising (6.7%, n=13), and resting (4.1%, n=8). Common dolphins spent more time foraging in the morning and less time foraging throughout the day. Resting occurred most in the morning post-foraging, and in the afternoon. It is hypothesized that this resting period occurs prior to nocturnal feeding. This behavioural budget, and more specifically foraging, was affected by the presence of interacting vessels. Common dolphins increased their time travelling by 10.1% in the presence of interacting vessels and reduced their time foraging by 12.4%. Moreover, the likelihood of continuing to forage after the arrival of the TV significantly

decreased by 91.4%. Conversely, transitions from travelling to foraging behaviour significantly decreased by 67.9% in the presence of TV.

Bottlenose dolphins were rarely observed during the study, thus both results and recommendations presented herein are limited. The few sightings observed mainly occurred in summer (89% of the encounters, n=8) and likely represent both forms of *Tursiops* occurring in New Zealand waters. The coastal form (55.6%, n=5) was observed in mono-specific groups of 20 individuals, closer to shore (median=1.7km from the coastline, n=5) and in shallow (median=13.1m deep, n=5) waters. Conversely, the oceanic form (44.4%, n=4) occurred in larger groups (*ca.* 137 individuals) usually associated with false killer whales (*Pseudorca crassidens*). This form was sighted further offshore (median=21.7km from the coastline, n=4) and in deeper (median=73.3m deep, n=4) waters. Both ecotype groups contained juveniles and calves. Bottlenose dolphins spent 51% (n=25) of their time foraging, 26.5% (n=13) travelling, and 22.4% (n=11) milling. While *Tursiops* spent less time foraging (12.1%, n=4) and milling (6.1%, n=2), they spent more time travelling (81.8%, n=27) in the presence of an interacting vessel. However, few conclusions can be drawn due to the limited sample size.

Given that foraging is a critical component of any activity budget and given the patchily distributed resource in ECBOP, the potential long-term effect of interacting vessels is likely to be a reduction in overall energy acquisition, at least for common dolphins. Commercial TV have the greatest potential to affect dolphin behaviour, primarily because tourism corresponds to the breeding season, and because of the duration of encounters (median interaction time TV=32min *vs* non-TV=2min) and vessel manoeuvring while viewing and/or swimming with the dolphins. Non-compliance to Marine Mammals Protection Regulations (MMPR, 1992) or specific permit regulations, as observed in the present study, may result in further effects yet undetected. This could prove detrimental not only to local dolphin population, but to the local industry itself.

Photo-identification (photo-ID) resulted in 101,070 and 6,000 digital images of common and bottlenose dolphins, respectively. Due to the logistical difficulties of *Delphinus* photo-ID, currently only 17% of common dolphins have been analysed. However, a minimum abundance of 362 individuals have thus far been identified within this region, of which 8% (n=29) showed at least seasonal site fidelity. For coastal bottlenose dolphins, 79 and 26 individuals were identified in 2012 and 2013, respectively. Out of these, 92.4% (n=73) and 65.4% (n=17) have previously or subsequently sighted off Great Barrier Island, Auckland and the Bay of Islands, Northland, suggesting high movement patterns across the north east coast of the North Island. In addition, a further 70 oceanic bottlenose individuals have been further identified. Fifty percent of these (n=35) have so far been matched to oceanic bottlenose dolphins observed in Far North waters.

II. Introduction

In the global economy, tourism has become one of the largest sectors (UNWTO, 2013), of which nature tourism is experiencing the fastest world-wide expansion (Balmford *et al.*, 2009). The economic benefits of marine mammal based-activities represent a significant part of this ecotourism industry (Hoyt, 2001; O' Connor *et al.*, 2009). Indeed, over nine million people participated in whale/dolphin watching across 87 countries and territories in 1998, generating more than US$1 billion in total expenditure (Hoyt, 2001). In 2008, more than thirteen million people took cetacean-watching tours in 119 countries, generating total expenditure of US$2.1 billion (O' Connor *et al.*, 2009). An estimated 3,300 operators offered trips worldwide, employing *ca*. 13,200 people. The dolphin-watching industry in the Oceania, Pacific Islands and Antarctica region followed this global trend and became widespread in 17 countries within the regions.

In the history of marine mammal exploitation, marine mammal tourism has often been positively considered compared to lethal whaling activities (Parsons and Draheim, 2009; Chen, 2011). This industry was also regarded as less harmful than other human activities such as fisheries by-catch (Silvani *et al.*, 1999; Ross and Isaac, 2004; Carretta *et al.*, 2005) or toxicological contamination (Kuiken *et al.*, 1994; Bustamante *et al.*, 2004; Das *et al.*, 2004; Stockin *et al.*, 2007). Moreover, watching free-ranging dolphins is becoming a popular alternative to watching dolphins in captivity (Hughes, 2001). However, effects of commercial tourism on marine mammals are becoming difficult to ignore. Since the 1990s, research has raised concerns about the effects of commercial tourism on marine mammal behaviour, reporting various short-term responses from a wide range of species (Appendix 1). Vessel presence has been shown to change the behaviour of numerous species. For example, dolphins were found to increase their travelling behaviour at the expense of foraging (common dolphins: Neumann and Orams, 2006; Stockin *et al.*, 2008a), resting (bottlenose dolphins: Lusseau, 2003; common dolphins: Stockin *et al.*, 2008a), or socialising (Indo-Pacific bottlenose dolphins: Stensland and Berggren, 2007; Christiansen *et al.*, 2010). Inter-species differences have been illustrated by some species avoiding approaching vessels (common dolphins: Neumann and Orams, 2006; humpback whales, *Megaptera novaeangliae*: Stamation *et al.*, 2010; Steckenreuter *et al.*, 2012), while others indicated habituation (sperm whales, *Physeter macrocephalus*: Richter *et al.*, 2006). Finally, changes in group cohesion have been observed for bottlenose dolphins, forming tighter groups in the presence of vessels in eastern Australia (*T. aduncus*: Steckenreuter *et al.*, 2011; Steckenreuter *et al.*, 2012), whilst dispersing in smaller groups in western Australia (*T. truncatus*: Arcangeli and Crosti, 2009). Differences in habitat, behaviour and tourism pressure can therefore affect local populations in various ways, making it difficult for managers to establish recommendations based on previous studies only. Consequently, understanding the potential effects of human activities is critical to the management and conservation of targeted population at a local level.

Concerns about marine mammal-based tourism have now grown as a consequence of recent studies that have argued that short-term behavioural changes can have long-term implications for targeted populations by disrupting critical energy budgets, reducing energy uptake and/or increasing physical demands (Boggs, 1992; Williams *et al.*, 2006; Lusseau *et al.*, 2009; Christiansen *et al.*, 2013). For example, as a consequence of tourism pressure, bottlenose dolphins in Shark Bay, Australia, were found to have been displaced and declined in abundance (Bejder *et al.*, 2006). A similar pattern was evident in Fiordland (Lusseau, 2004, 2005; Currey *et al.*, 2007), although the cause remains unclear.

In summary, it is clear from the literature that boat based marine mammal tourism is not benign and that careful management is needed to minimise potential negative effects on targeted populations. In New Zealand, commercial marine mammal tourism operations are regulated under the Marine Mammals Protection Act (MMPA, 1978) and the MMPR (1992) administered by the Department of Conservation (DOC). Permits to commercially watch and/or swim with marine mammals in New Zealand increased from 90 in 2005 (International Fund for Animal Welfare, 2005) to 112 in 2011 (Young, pers. comm.) and cover both the North and South Island. A number of the marine mammal species targeted by tourism operations in New Zealand are endemic species, such as the endangered Hector's dolphin, *Cephalorhynchus hectori hectori* (Martinez *et al.*, 2011), the threatened New Zealand sea lion, *Phocarctos hookeri* (Hollingworth, 2001) and the New Zealand fur seal, *Arctocephalus forsteri* (Boren *et al.*, 2002). The two most widely distributed dolphin species are also subject to tourism operations; bottlenose dolphins are targeted in the Bay of Islands (Constantine *et al.*, 2004), the Marlborough Sounds (Markowitz *et al.*, 2004), and Fiordland (Lusseau *et al.*, 2003), while common dolphins remain the focus of tourism in the Hauraki Gulf (Stockin *et al.*, 2008a) and Mercury Bay (Neumann and Orams, 2006). Both of these species are of interest for commercial operators in the ECBOP. The vast majority of scientific studies have evaluated the effects of tourism activities on marine mammal behaviour post establishment of the industry (Bejder and Samuels, 2003), with ECBOP being no exception. While an earlier study focused on the ecology and behaviour of common dolphins in Mercury Bay, the north western part of the region (Neumann, 2001b), no study to date has examined common and bottlenose dolphins in the ECBOP, where eight permitted operators can view and swim with both species. The study outlined in this report examined, over a three year period (November 2010-May 2013), occurrence, site fidelity and behavioural responses to vessel interactions of these two species.

III. Objectives

DOC is required under the MMPR (1992) to ensure that dedicated tourism operations do not have any detrimental effect on marine mammals. Presently, however, there are limited data on which to assess the effects of the current activities on dolphin behaviour.

This present study aimed to:

1. Determine season-specific extent of bottlenose and common dolphin range use within the Bay of Plenty waters, in particular and within the wider region generally.

2. Determine inter-seasonal use of regional waters of bottlenose and common dolphin groups, within the Bay of Plenty waters.

3. Determine the potential effects of interacting with common and 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.

4. Develop clear measures and guidance based on 1-3 above to *i*) avoid or minimise human impacts, and *ii*) to measure impacts that quantify thresholds over which further impacts must not occur.

5. Produce statements and recommendations based on 1-4 above regarding existing and future tourism activity particularly in the Bay of Plenty waters, but also in the wider regions generally.

IV. Materials and methods

A. Study area

The study area was situated within the coastal waters of the ECBOP (Fig. 1), on the north east coast of the North Island, New Zealand. The primary survey area comprised the area off Tauranga, between Karewa Island to the west, Mayor Island to the north, and Plate Island to the east. This area was particularly selected as it includes the daily range covered by six permitted commercial tour companies. The area extending between Whakatane and White Island was additionally surveyed between November 2011 and February 2012, once permission had been granted by local tour operators to access their vessels.

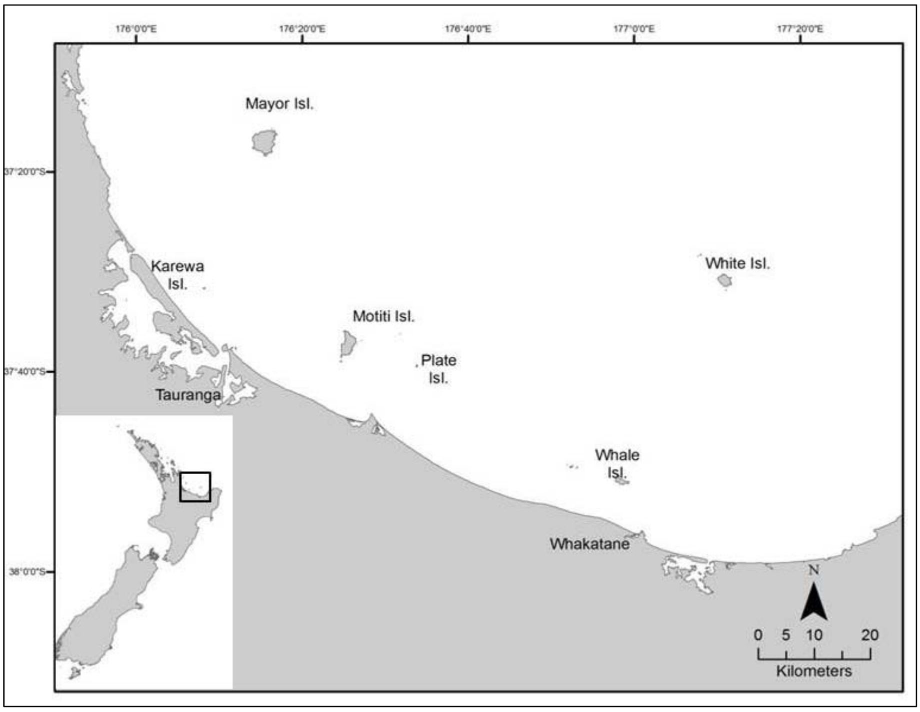

Figure 1: The East Coast Bay of Plenty, New Zealand.

B. Observation platforms

Surveys were conducted between November 2010 and May 2013 from two types of platform: a research vessel (RV) and seven tour vessels (TV).

A dedicated Massey University RV, *Aronui Moana* (Fig. 2A), a 5.5m stabicraft trailer-launched vessel powered by a 90hp four-stroke engine, was used to collect data on dolphin occurrence, behaviour in relation to presence and absence of vessels, and to conduct photo-ID.

Seven TV (*Catchup III*, a 12m motorised launch – Fig. 2H; *Diveworks*, a 10.5m motorised trailer-launched vessel – Fig. 2D; *Gemini Galaxsea*, an 18m motorised sailing vessel – Fig. 2F; *Guardian*, a 15m motorised catamaran – Fig. 2B; *Orca*, a 14.5m motorised launch – Fig. 2C; *PeeJay IV*, a 18.3m motorised launch – Fig. 2E; and *PeeJay V*, a 22.3m motorised launch – Fig. 2G) were used as opportunistic platforms to collect photo-ID and data on dolphin occurrence in relation to abiotic parameters (*e.g*, depth, distance to the coastline). When not aboard the RV, and when permitted, the project leader (AMM) and research assistants would board one or more TV concurrently, in order to cover the widest spatial area possible, thus increasing the likelihood of encountering independent dolphin groups. Depending on the season, surveys aboard the TV commenced between 0730 and 0900hrs and terminated approximately between 1200 to 1500hrs aboard *Diveworks*, *Guardian*, *Orca, PeeJay IV and PeeJay V*, and between 1700 and 2000hrs aboard *G. Galaxsea*.

Survey tracks were opportunistic and selected randomly, although they were often influenced by prevailing weather conditions. Vessel speed was *ca*. 8kts for *Gemini Galaxsea,* and *ca.* 10kts for *Aronui Moana*, *Catchup III*, *Guardian* and *Orca*. In Whakatane, *Diveworks*, *PeeJay IV and PeeJay V* surveyed the area at a speed of *ca*. 20kts. In full compliance with DOC guidelines and the MMPR (1992), and to minimise effects on dolphin behaviour, consistent and careful handling of the RV was necessary when approaching and tracking dolphin groups, as detailed in established published protocols (Lusseau, 2003; Stockin *et al.*, 2008a).

Figure 2: A) Massey University RV *Aronui Moana B*) Tauranga TV *Guardian* C) Tauranga TV *Orca D) Whakatane TV Diveworks E) Whakatane TV PeeJay IV F) Tauranga TV Gemini Galaxsea G)* Whakatane TV *PeeJay V* H) Tauranga TV *Catchup III* (Photographs: H. Cadwallader, N. Shaw, M. Vorenhout, A. M. Meissner).

C. 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 the RV, and consequent reduced detectability of dolphins, surveys were conducted in excellent weather conditions (Beaufort sea state ≤ 3) and in good visibility (≥ 1km). Surveys aboard the TV were conducted in good weather conditions (Beaufort sea state ≤ 4) and in good visibility (≥ 1km). Observations ceased when any of the aforementioned weather conditions precluded the continuation of a survey.

For each survey, departure and return times from Tauranga harbour and Whakatane river were recorded in addition to the date, the vessel name, the skipper, and the crew.

Whilst *on effort*, the vessel was travelling along the survey track. At least two experienced observers were actively searching for dolphins by naked eyes and/or binoculars (Tasco Offshore OS36 7 x 50 magnification), using continuous scanning methodology (Mann, 1999).

Sighting cues used to detect dolphins included splashes, silhouettes of dolphins, water disturbance due to surface activity of animals, sighting of dorsal fins, and/or the presence of feeding birds, especially Australasian gannets (*Morus serrator*), known to associate with common dolphins during foraging (Stockin *et al.*, 2009; Wiseman *et al.*, 2011).

Once the vessel departed the survey track to approach a group of dolphins, the survey mode switched to *off effort* until returning back to the track to resume searching for another group of dolphins or until the vessel returned back to the harbour. Therefore, more than one independent focal group was occasionally encountered during a survey. Groups were considered independent if they were separated spatially (> 5km) and temporally (> 30min) to a degree that would prevent animals becoming resampled during the second focal follow (Stockin *et al.*, 2009). Photo-ID was opportunistically taken to confirm the independence of groups.

D. Habitat use

Whilst *on effort*, abiotic parameters (Table 1) were collected and logged every ten minutes.

Vessels observed along the survey track and/or interacting with the dolphins were categorised as:

- non-motorised craft (*i.e.* kayaks, stand up paddleboards or rowing crafts)
- commercial TV (Fig. 2B-H)
- motorised recreational launches (*i.e.* inboard vessels)
- motorised recreational trailer-launched vessels (*i.e.* outboard vessels less than 8m)
- motorised personal water craft (*i.e.* jet skis)
- motorised commercial vessels (*i.e.* container ships, commercial fishing vessels)

Table 1: Data collected from aboard the research vessel (RV) and/or the tour vessels (TV), when *on effort* and during focal group follows, between November 2010 and May 2013, in the ECBOP, New Zealand.

Abiotic parameters	Units	10-min sampling along the survey track when *on effort* (RV + TV)	Three-minute sampling during focal group follows (TV only)
Time	Hours (hr) and minutes (min)	✓	✓
GPS position: latitude, longitude	WGS 84 datum	✓	✓
Vessel course	Magnetic bearing	✓	
Vessel speed	Knots (kts)	✓	✓
Swell height and direction	Meters (m) and magnetic bearing	✓	
Sea state	Beaufort scale	✓	
Wind speed and direction	Beaufort scale and magnetic bearing	✓	
Cloud coverage	%	✓	
Water depth	Meters (m)	✓	✓
Water turbidity	Meters (m), measured by a Secchi disk	From the RV only	
Sea surface temperature (SST)	Degrees celsius (°C)	From the RV only	
Number and type of other vessel(s)	Categories described in section D	Within 1km around the survey track	Within 300m of the focal dolphin group
Vessel activity	*e.g.* moving/stationary	Within 1km around the survey track	Within 300m of the focal dolphin group
Approximate speed of any other vessel	Knots (kts), estimated according to the speed of the RV/TV	Within 1km around the survey track	Within 300m of the focal dolphin group

A group of dolphins was defined as any number of animals observed in association, moving in a similar direction and usually engaged in a similar behavioural state (Shane, 1990). Members were assumed to be part of a group when they remained within 100m of each other (Bearzi *et al.*, 1997). Beyond this distance, the structure was qualified as sub-groups. At the outset of each independent encounter, the following parameters were recorded: sighting cue, distance (estimated by eye) and bearing of the group, species, group size, dispersion and composition, initial behavioural state (*i.e.* behaviour at first sighting) and presence of associated species, (*i.e.* mammalian or avian) within 100m (Bearzi, 2006). The RV would subsequently approach the group in a slow and continuous manoeuvre, and travel slowly parallel to the course of moving dolphins (Stockin *et al.*, 2008a). Start and end times of the encounter were recorded.

For both species, group size was recorded in the field following Dwyer and Stockin (2011, 2012):

- absolute minimum number of dolphins counted,
- best estimate for the most likely number of dolphins estimated to be in the group,
- maximum number of dolphins likely to be in the group.

For both species, group dispersion was categorised following Neumann (2001a), Stockin (2008) and Stockin *et al.,* (2008a; 2009):

- tight: less than one body length apart,
- grouped: one to three body lengths apart,
- loose: more than three body lengths apart,
- dispersed: when the limit of the group was out of sight.

For both species, group composition was categorised as adults only *vs* adults and immatures (*i.e.* neonates, calves and/or juveniles). Adults were defined as dolphins fully grown (*ca*. over 1.8 and 3m long for common and bottlenose dolphins, respectively) and independent. Juveniles were defined as individuals approximately two-thirds the size of an adult, frequently observed swimming in association with an adult animal, although not in the infant position, suggesting they were weaned (Mann *et al.*, 2000). Calves were defined as animals approximately half the size (or less) of an adult and observed swimming in association with an adult, presumed to be the mother (Fertl, 1994). Neonates were defined as small calves, which exhibited diagnostic features indicative of newborns (*e.g*. the presence of dorso-ventral foetal folds and/or a curved dorsal fin, Stockin *et al*., 2008a).

The primary activity of the group was assessed using behavioural categories modelled on Neumann (2001a) and Stockin *et al*., (2008a), defined in Table 2. The predominant behaviour was determined as the behavioural state in which more than 50% of the dolphins within the group were involved at the time of sampling (Lusseau, 2003; Stockin *et al.*, 2008a). Where groups exhibited an equal percentage of individuals engaged in different behaviours, all represented behaviours were recorded. Only behaviours that could be reliably and consistently recorded (Mann, 1999) were sampled.

Table 2: Definitions of behavioural states of common and bottlenose dolphin groups in the ECBOP, New Zealand, with abbreviations for each state given in parentheses (Shane *et al.*, 1986; Neumann, 2001a; Constantine, 2002; Stockin *et al.*, 2008a).

Behavioural state	Definition
Foraging (FOR)	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. Prey can often be observed at the surface during foraging activity. High number of non-coordinated re-entry leaps, rapid changes in direction and long dives are observed.
Milling (MIL)	Dolphins exhibit non-directional movement, 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.
Resting (RES)	Dolphins observed in a tight group (< one body length apart), engaged in slow manoeuvres (slower than the idle speed of the observing boat) with little evidence of forward propulsion. Surfacings appear slow and are generally more predictable (often synchronous) than those observed in other behavioural states.
Socialising (SOC)	Dolphins observed in diverse interactive 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 breaching are frequently observed.
Travelling (TRA)	Dolphins engaged in persistent, directional movement making noticeable headway along a specific compass bearing at a constant speed (usually faster than the idle speed of the observing boat). Group spacing varies and individuals swim with short, relatively constant dive intervals.

E. Swimming with the dolphins

Commercial TV in the ECBOP are permitted to view and swim with common and bottlenose dolphins. Skippers used different swim techniques (*e.g.* swim bars, mermaid lines and free swimming/snorkelling, Fig. 3).

A swim encounter consisted of one or several swim attempts. A swim attempt was judged to have commenced when the first swimmer entered the water and ended when the last swimmer got back aboard the TV. 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. Swim attempts were monitored from both the RV and TV, when possible (Table 3).

Figure 3: Swim techniques used to swim with dolphins in the ECBOP, New Zealand: A) swim bars B) mermaid lines and C) free swimming/snorkelling.

An assessment of the behavioural state of the entire focal group was not attempted from the TV during swim encounters. Indeed, only a subset of the focal group usually approached the swimmers at the stern of the vessel, enabling the researcher/research assistant to assess the behavioural state of the entire focal group.

Dolphin response to swimmers was adapted from Martinez *et al.,* (2011) as follows:

- neutral presence: no apparent change in dolphin behaviour. At least one dolphin remained within 5m of the swimmers for at least 5 seconds. Interaction time was recorded when at least one dolphin was within 5m of the swimmers,
- neutral absence: no apparent change in dolphin behaviour. Dolphins were > 5m distant from the swimmers and did not approach within 5m of the swimmers,
- avoidance: change in dolphin behaviour. Dolphins were within 5m of the swim bars/mermaid line and departed as swimmers entered the water,
- interaction: change in dolphin behaviour. Dolphins were > 5m distant from the swimmers and at least one dolphin approached the swimmers at least once and for at least 5 seconds.

Table 3: Swim data collected during swim attempts from aboard the research vessel (RV) and/or the tour vessels (TV) between November 2010 and May 2013, in the ECBOP, New Zealand. na: not applicable.

Collected from aboard the TV	Collected from aboard the RV
Swim attempt number	
Average boat speed during the swim attempt (kts, from GPS when from aboard the TV or estimated according to the speed of the RV)	
Swim technique (*i.e.* free swim, swim bar, mermaid line)	
Number of swimmers (adults/children under *ca*. 15 years old, males/females if possible)	
Time in/out the water	
Entering technique (*i.e.* sliding, jumping)	
Number and type of other vessel(s) within 300m and 1km of the TV, and if interaction with dolphins occurred	
Behaviour of swimmers in the water (*i.e.* noise in/out the water, splashing)	na
Number of dolphins (adults, juveniles, calves) within 5m of the swimmers	na
Presence of dolphins at the stern of the vessel before swimmers entered the water	na
Dolphins response to swimmers	na
Time of dolphin presence (< 5m from the swimmers)	na
Reason for ending the swim encounter	na
Swimmers feedback (*i.e.* swimmers did/did not see the dolphins, touched the dolphins)	na

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 due to viewing conditions or the decision was made to find a more interactive group,
- loss of sight of dolphins, *i.e.* the dolphin group could not be viewed from the surface,
- skipper's decision, due to time restrictions, *i.e.* the maximum time allowed for dolphin encounters was reached, or because swimmers were cold/tired,
- presence of calf(ves) detected during the swim attempt.

F. Effects of viewing and swimming activities on dolphin behaviour

Effects of vessel interaction, including viewing and swimming activities, on dolphin behaviour were only examined from aboard the RV, using focal group scan sampling (Altmann, 1974; Mann, 1999). As highlighted by Neumann (2001a) and Stockin *et al.,* (2009), focal individual follows (Mann, 1999) were neither feasible nor appropriate for this study owing to the difficulties of identifying individuals in the field, and the increased probability of disturbance to a group when tracking one individual. The focal group was scanned from the left to the right in order to include all individuals (Stockin *et al.*, 2009), and to avoid attention being drawn to only conspicuous individuals and/or behaviour (Mann, 1999). If individuals left the focal group, the largest subgroup would become the focal group.

Once the focal group follow started, abiotic parameters (Table 1), group size, dispersion, composition (see section D) and behavioural state of the dolphin group (Table 2) were assessed and recorded every three minutes.

A focal group follow constituted one or several sequences, *i.e.* succession of behavioural states, considered as *control* sequences in the presence of the RV only, and as *interaction* sequences when other vessel(s) (see section D) were within 300m of the focal group of dolphins (Lusseau, 2003; Stockin *et al.*, 2008a). *Interaction* sequences included viewing and swimming with dolphin activities.

All focal follows ended when fuel reserves became low, weather deteriorated (Beaufort sea state > 3, visibility < 1km) and/or daylight was imminent or when contact with the dolphins was lost. The end of a focal follow was, therefore, not dependent on the behaviour of the focal group (Stockin *et al.*, 2008a).

G. Photo-identification

Photo-ID was undertaken following standardised methods (Würsig and Jefferson, 1990; Neumann et al., 2002; Tezanos-Pinto, 2009), in favourable weather conditions (*e.g.* no rain, fog or glare, swell < 1 m, Beaufort sea state ≤ 3) and in the presence and absence of interacting vessels. Images of individuals were taken randomly, irrespective of their level of marking (Bearzi, 1994).

Previous catalogues of common dolphins have been established for both Mercury Bay and the Hauraki Gulf (Massey University, unpubl. data). As both catalogues used only the left side of the dorsal fins, photo-ID taken as part of this study focused on the left side of the dorsal fins for comparative purposes. For bottlenose dolphins, both sides were captured following previous protocols (Constantine, 2002; Berghan *et al.*, 2008; Tezanos-Pinto *et al.*, 2013).

Digital photo-ID of individuals was predominantly undertaken using digital SLR Nikon D90 and D50 cameras fitted with high-speed auto-focus adjustable 70-300 and 18-105mm lenses. When on the RV, photo-ID was undertaken at the start and end of each focal follow, when possible. Images were collected by maintaining a parallel position and travelling at the same speed as the dolphins being photographed (Würsig and Jefferson, 1990). Photo-ID sessions would terminate when an image of each animal was estimated to have been obtained, when weather conditions precluded further photo-ID (*e.g.* rain, fog, glare, swell > 1m, Beaufort sea state > 3), or when dolphins exhibited avoidance behaviour (*e.g.* moving away from the research vessel and/or changing direction).

TV were used as platforms of opportunity to conduct photo-ID. Once aforementioned data relating to the group were recorded, photo-ID was undertaken. Photo-ID sessions ended when the dolphins moved away from the vessel, when the skipper ended the encounter or when weather conditions deteriorated.

H. Data analysis

1. Dolphin distribution and seasonality

Survey tracks and dolphin group encounters were plotted using a Geographic Information System (GIS) created using ArcGIS version 9.3.1 (© ESRI Inc.). GPS location of each group encountered was plotted, taking into consideration the size, the composition, and the behavioural state of each independent group. Distance from the shore was calculated using the Calculate Geometry Tool in ArcMap. Water depth data were converted into a raster layer using the Raster Conversion Tool in ArcToolbox. For locations where depth was not available aboard the vessel, data were extracted from the depth raster using the Marine Geospatial Ecology Tools (Roberts *et al.*, 2010). Seasonal analyses were based on the austral seasons as follows: Spring (September to November), summer (December to February), autumn (March to May) and winter (June to August).

2. Group size and composition

For comparative reasons, group size was categorised at two resolutions as per Stockin *et al.* (2008b; 2009). On a broad scale, two categories were defined: ≤ 50 or > 50 animals. Size on a fine scale was classified as 1-10, 11-20, 21-30, 31-50, 51-100, 101-200, and 200+ animals. The composition of the group was analysed according to the presence or absence of immatures (adults only groups *vs* adults and immatures).

3. Behaviour

The behavioural state in which ≥ 50% of the animals were involved was examined. Where groups exhibited an equal percentage of individuals engaged in different behaviours, both behavioural states were included, as single records. Diel patterns in behaviour were investigated by assigning each observation to a 2hrs time period within the sequence 0800-0959hrs, 1000-1159hrs, through to 1600-1759hrs (Stockin *et al.*, 2008b).

4. Effects of vessel interaction on dolphin activity budget

Consecutive behavioural observations are unlikely to be statistically independent (Glass *et al.*, 1975), particularly on a three minute basis. As a result behavioural observations were modeled as a series of time-discrete Markov chains (Markov, 1906;

Bakeman and Gottman, 1997). First-order Markov chains quantify the dependence of a behavioural state on the preceding state (refer to Guttorp, 1995; Caswell, 2001 for further details). Transition probabilities (*i.e.* the probability of a specific behavioural state occurring, given the occurrence of another behavioural state) can conform to a stochastic matrix model. These models have been applied to conservation behaviour, including cetacean tourism impact studies (*e.g.* Lusseau, 2003; Stockin *et al.*, 2008a; Martinez, 2010).

As Markov chain analysis does not account for multiple behavioural states when collected simultaneously (*i.e.* when the group was split equally between two behavioural states), double states were excluded from the analysis. Matrices or two-way contingency tables (preceding *vs* succeeding behavioural states) were developed as described in Lusseau (2003). If no vessel interaction occurred between two behavioural samples, the transition between these two samples was tallied in a *control* table. If a vessel interaction occurred between two samples, the transition was tallied in an *interaction* table. Since it was not possible to determine the extent of the potential effect of a vessel interaction, the transition between a sample succeeding an interaction and the following sample was excluded from the matrices (Lusseau, 2003; Stockin *et al.*, 2008a; Martinez, 2010). Specifically, if a vessel interaction occurred between samples 1 and 2, the transition between samples 2 and 3 was discarded. Similarly, if sample 2 was affected by a vessel interaction, the transition between samples 2 and 3 was discarded also. The program UNCERT (available from http://uncert.mines.edu) was used to develop the two-way contingency tables and calculate the number of transitions between the five behavioural states in both *control* and *interaction* conditions.

a. Markov chain assumptions

Before analysing the data using Markov chains, it is necessary to determine the order of Markov chain. The analysis is based on a zero-order Markov chain if it ignores all previous states. The analysis is first-order Markov chain if the analysis examines the immediately previous state, and so on. To determine whether a first-order relationship exists in the transitions, the first-order chain must provide more information than a zero-order chain. Following assumptions detailed by Lusseau (2003), the amount of information contained in zero-order and first-order chains was compared using a Bayes Information Criterion (BIC). A BIC quantifies the amount of information explained by the model and penalises models for the number of parameters used to explain the data. The fit of each Markov chain model is given by:

$$BIC = 2l(\theta|data) - k \ \ln(n) \qquad (1)$$

where $l(\theta|data)$ is the value of the maximised log-likelihood over the unknown parameter (θ), given the model and the data set; *k* is the number of parameters used in the chain, and *n* is the sample size (Guttorp, 1995).

The BIC quantifies the most parsimonious model. It is a consistent estimate of the order of Markov chains (Katz, 1981). The higher the BIC, the more information the order provides on the sequences (Guttorp, 1995). A BIC difference between the chain orders must be equal to or above 2 log 100 (= 9.2) to determine the best chain (Guttorp, 1995).

A log-linear analysis was applied to assess the independence of the behavioural transitions for all combinations of parameters and interactions between parameters. The maximum likelihood for the model being tested is approximated by G^2. The difference in goodness of fit between the saturated model and the model considering all the two-way interactions was used to test for the effect of boat presence on the behavioural transitions (Lusseau, 2003) and calculated as:

$$\Delta G^2 = G^2_{2\,way} - G^2_{saturated} \qquad (2)$$

b. Markov chain modelling

Transition probabilities (from preceding to succeeding behavioural state) were determined for both *control* and *interaction* chains by:

$$p_{ij} = a_{ij} \;/\; \sum_{j=1}^{n} a_{ij} \;, \sum_{j=1}^{n} p_{ij} = 1 \qquad (3)$$

where i is the preceding behavioural state, j is the succeeding behavioural state (i and j range from 1 to 5, because there were five behavioural states as defined in Table 2), a_{ij} is the number of transitions observed from behavioural state i to j, and p_{ij} is the transition probability from i to j in the Markov chain, n is the total number of behavioural states (herein, n=5 as defined in Table 2). *Control* and *interaction* transition probabilities were calculated using Equation (3) and compared by pairs using a binomial Z-test for proportions (Fleiss, 1981) and 95% confidence intervals (CI) were calculated.

To assess the effect of vessel interactions on the behavioural states of the dolphins, the average time (min) it took dolphins to return to each initial behavioural state was calculated. The expected number of transitions it took the dolphins to return to each behavioural state was first approximated for both *control* and *interaction* chains (Higgins and Keller-McNulty, 1995) using:

$$E(T_j) = \frac{1}{\pi_j} \qquad (4)$$

where (Tj) denotes the time (*i.e.* number of transitions) it takes to return to state j given that the dolphins are currently in state j, and π is the steady-state probability of each behaviour in the chain. The expected number of transitions (Equation 4) was multiplied by the length of each transition unit (*i.e.* three min) in order to calculate the average time (min) it took the dolphins to return to each initial behavioural state. These average times were compared between *control* and *interaction* conditions in order to assess the effect of tour boat interactions on the behavioural states of the dolphins.

The average bout length (or period of time spent in each behavioural state, in min) $\overline{t_{ii}}$ was approximated for both *control* and *interaction* chains from the mean of the geometric distribution of p_{ii} (Guttorp, 1995) using:

$$\overline{t_{ii}} = \frac{1}{1 - p_{ii}} \qquad (5)$$

with a standard error of:

$$SE = \sqrt{\frac{p_{ii} \times (1 - p_{ii})}{n_i}} \qquad (6)$$

where n_i is the number of samples with i as preceding behavioural state. The average bout length for each state was subsequently compared between *control* and *interaction* chains using the Student's *t*-test.

Finally, it was possible to compare the behavioural budget of dolphins (*i.e.* the proportion of time dolphins engaged in each behavioural state) in *control* and *interaction* conditions (Lusseau, 2003; Stockin *et al.*, 2008a; Martinez, 2010). Following the Perron-Frobenius theorem (Caswell, 2001), the behavioural budget under each condition was approximated by the left eigenvector of the dominant eigenvalue of the transition matrices using the Excel add-in PopTools (Version 3.2, Hood, 2010). Differences between *control* and *interaction* behavioural budgets were tested with a binomial Z-test for proportions (Fleiss, 1981) and 95% confidence intervals (CI) were calculated. Any observed difference in the budget was inherent to the presence of interacting vessels.

5. Levels of vessel traffic

Each vessel interacting with dolphins during a focal follow was considered an independent sampling unit. Vessel traffic analysis examined the presence (min), number and type of vessels (see section D) interacting with the dolphins, as well as the overall number of vessels that interacted with a single group, the amount of vessels interacting simultaneously with a single group and the number of approaches per vessel. The cumulative time that a focal group spent in the presence of vessels was defined as the total time the group spent interrupted or uninterrupted in the presence of successive vessels, and compared according to the type of vessel. When a vessel interacted with a focal group more than once, successive encounters were cumulated and interaction time was summed. The duration of these encounters was examined with regards to vessel type and the maximum time of 90min allowed in the tourism permits. The speed of each vessel was collected every 3min (Table 1). If a vessel encountered a focal dolphin group and attempted to approach and interact more than once with that same group, the second attempt was excluded from the speed analysis to ensure independence across encounters (Martinez, 2010).

6. Swimming with the dolphins

The number of swim encounters, swim attempts, and swimmers per swim attempt were examined, according to the platform of observation used. This is due to differences observed in regulation compliance. The different swim techniques and duration of the swims was assessed. The presence of other vessels in the vicinity of the swimmers, the group size and composition of the focal group, dolphin behavioural state and reaction to the swimmers were monitored. Finally, the reasons for ending the swims are reported.

7. Photo-identification

Images were downloaded and labelled with the following information:

- location (BOP for Bay of Plenty)
- date (YearMonthDate, *e.g.* 20130316)
- encounter number (*e.g.* E1, E2, E3…)
- frame number (4 digits)
- platform of observation
- photographer initials

For example, an image taken by AMM on the RV on 16 March 2013 during the second encounter was labelled as BOP_20130316_E2_0001_Aronui_AMM.

Images were assigned separate folders by location and date (*e.g.* BOP_20130316). Following Merriman *et al.* (2009), Martinez (2010) and Tezanos-Pinto *et al.* (2013), the quality of the selected images was evaluated according to five attributes: Focus (*i.e.* sharpness), exposure (*i.e.* light), size of the fin in relation to the photographic frame, angle (*i.e.* orientation of the body relative to the photographic frame) and environmental interference (*e.g.* water splash, bird, boat or other dolphin masking a part of the dorsal fin, Appendix 2). This process was undertaken using the original un-cropped image so the focus was not affected by pixilation (*i.e.* when the fin was enlarged due to cropping) and the size of the dorsal fin was easily estimated from the entire frame. Each attribute was rated 0 to 2 (Appendix 2). A combination of the five rated attributes determined the quality (excellent, good, fair, and poor) of the dorsal fin (Appendix 3). Only excellent and good quality images were considered for further analysis. High quality images were then cropped and cross-matched visually by two researchers (AMM and a research assistant) in order to identify unique individuals within each observation day. The best image of each individual was selected.

Each individual fin was subsequently categorised by distinctiveness (*i.e.* very distinct, distinct, not distinct/unmarked, Appendix 4) based on the presence, shape and size of notches/nicks on the trailing edge. Additionally, marks/scars on the fin and pigmentation were used as secondary features to confirm matches. In contrast to other species, dorsal pigmentation patterns were observed to be stable at least seasonally (Neumann *et al*., 2002) and therefore useful as a secondary feature. Only very distinct and distinct individuals were considered for further analysis (Rankmore, in prep.).

The best image of each individual was then catalogued in the New Zealand Common Dolphin Catalogue – Bay of Plenty database (NZCDC_BOP, Meissner, unpubl. data). Before adding a new individual into the catalogue, the best image was visually cross-matched to the rest of the catalogue and examined by a second researcher to reduce false positive errors (*i.e.* identifying two different individuals as the same one, see Friday *et al*., 2000). Data on the individual was entered into the catalogue as a re-sighting if the match was confirmed, or assigned a new identification number if no match was found.

Images of the dorsal fin of each unique individual were compared across encounters in order to assess the minimum number of individuals using ECBOP waters, site fidelity, and any possible individuals that exhibit continued attraction to tour vessels.

8. Statistical analysis

Statistical analyses were performed using the statistical software R (© Foundation for Statistical Computing, Vienna, Austria). Non-parametric Kruskal-Wallis tests were used to assess any patterns in common dolphin distribution according to season, group size, and composition. Kruskal-Wallis tests were also performed to examine any patterns in common dolphin habitat use in relation to abiotic parameters (*i.e.* depth, distance to the coast/mainland). Distribution and size of mono- and poly-specific groups of bottlenose dolphins were compared using Kruskal-Wallis tests. Pearson's χ^2 tests were used to analyse potential differences in common dolphin occurrence, group size, and composition in relation to abiotic (*i.e.* platforms, time of the day, season) and biotic parameters (*i.e.* group size and composition). Non-parametric Kruskal-Wallis tests were used to examine the time different type of vessels spent around the dolphins and compare their speed within 300m of the focal groups. All tests were considered statistically significant at $p \leq 0.05$.

V. Results

A. Survey effort

Data were collected between November 2010 and May 2013, comprising 417 boat-based surveys (Appendix 5), of which 36% (n=150) were based from the independent RV. The remaining 64% (n=267) surveys were conducted from seven different TV in Tauranga and Whakatane waters (Appendix 5). Surveys were undertaken from the TV from a random selection of the trips tour operators undertook during that period (*e.g.* when availability allowed). Surveys off Tauranga aboard the independent RV started in November 2010. Data collection aboard TV commenced in January and November 2011 off Tauranga and Whakatane, respectively. As limited surveys (n=19, 4.5%) were conducted off Whakatane, those data were not included in the following seasonal analysis. In the Tauranga region, 67.4% (n=167) of the surveys aboard the TV occurred in the austral summer, 28.2% (n=70) in autumn, and the remaining 4.4% (n=11) in winter and spring (Appendix 5).

A total of 23,871.9km of track were surveyed *on effort* (Fig. 4), including 8,718.4 and 15,153.5km from the RV and the TV, respectively, of which 14,315.2km occurred off Tauranga and 838.3km off Whakatane.

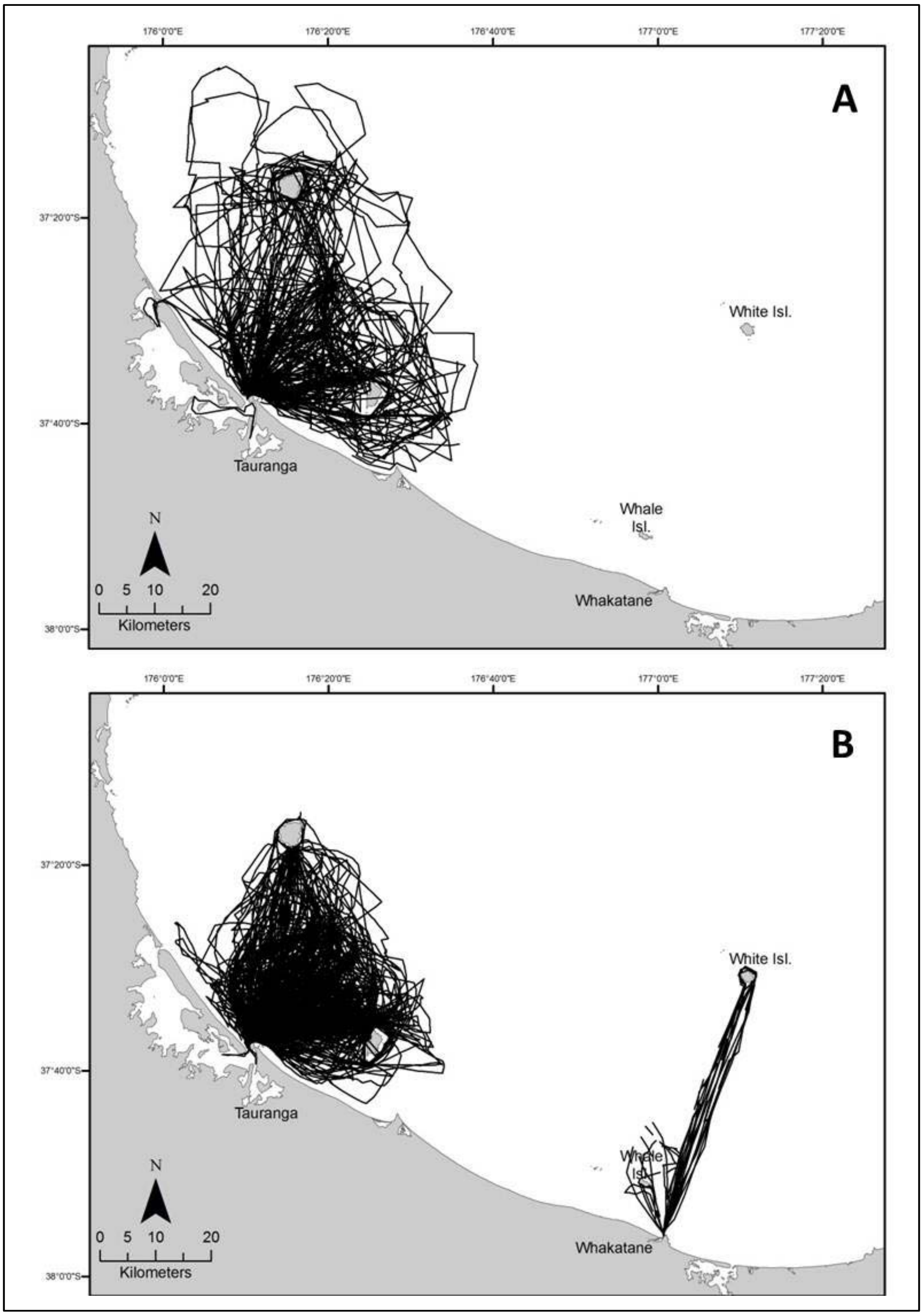

Figure 4: Tracks surveyed *on effort* from aboard A) the research vessel and B) the tour vessels between November 2010 and May 2013, in the ECBOP, New Zealand.

B. Overall sightings

Five hundred and thirty nine marine mammal encounters occurred during 417 surveys. Of these, 30.4% (n=164) occurred from the RV, while 69.6% (n=375) were recorded aboard the TV. However, only 508 encounters (94.2%) were deemed independent and used further for analysis. The remainder (5.8%, n=31) represented duplicate encounters where two or more vessels collected data on the same group, and were therefore excluded.

Out of the 508 independent marine mammal encounters, common dolphins were the most encountered species within the study area (59.4%, n=302, Appendix 6, Fig. 5), In contrast, bottlenose dolphins were observed rarely (1.8%, n=9) and usually associated with false killer whales (44.4%, n=4). Other marine mammal sightings included killer (*Orcinus orca*, 2.2%, n=11), blue (*Balaenoptera musculus*, 1.2%, n=6), pilot (*Globicephala melas,* 0.6%, n=3), minke (*B. acutorostrata bonaerensis*, 0.8%, n=4), and Bryde's whales (*B. brydei*, 0.2%, n=1), and one unidentified whale species (0.2%, n=1). Fur seals were additionally observed in this region (33.7%, n=171). One dead sperm whale was also encountered in February 2013.

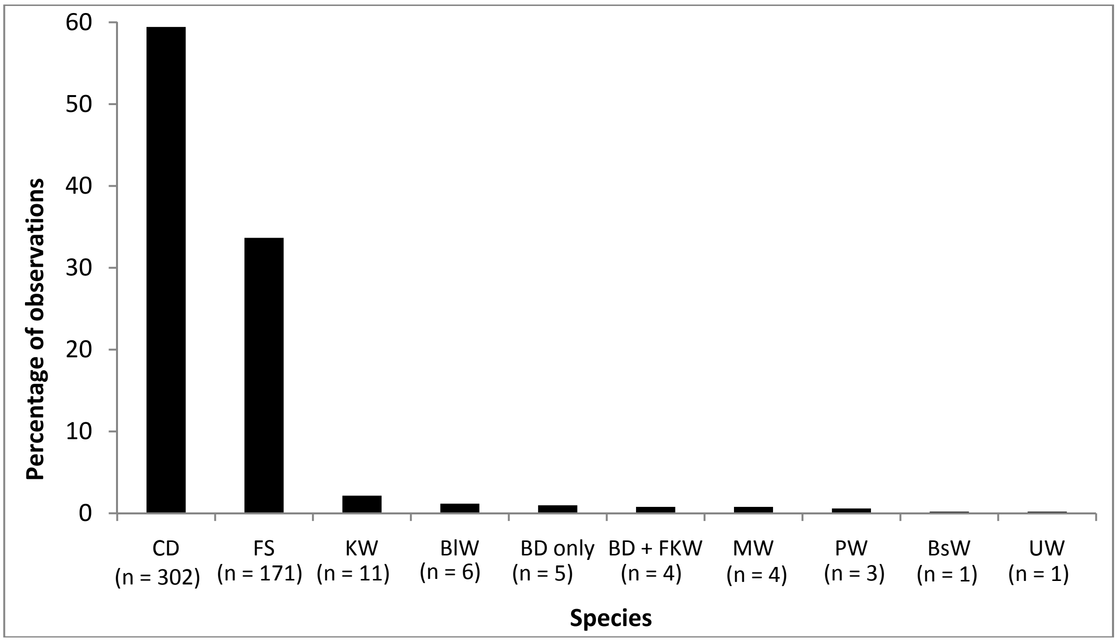

Figure 5: Marine mammal encounters, between November 2010 and May 2013, in the ECBOP, New Zealand. CD=common dolphins, FS=New Zealand fur seals, KW=killer whales, BlW=blue whales, BD only=bottlenose dolphins (mono-specific groups), BD+FKW=bottlenose dolphins associated with false killer whales, MW=minke whales, PW=pilot whales, BsW=Bryde’s whales, UW=unidentified whale species.

C. Common dolphins

Out of the 508 independent marine mammal encounters, 59.4% (n=302) involved common dolphins (Fig. 5), of which 21.5% (n=65) occurred from the RV and 78.5% (n=237) from the TV (Appendix 7). No observation of common dolphins was made from *PeeJay IV*.

Out of the 302 common dolphin sightings, 7.6% (n=23) were interacting with another vessel (TV, non-TV or RV) prior to approach. Therefore, the following analysis on distribution, group size and composition, and behaviour were undertaken on the remaining 92.4% (n=279) groups. Note these groups did not undergo any other interaction within 30 min prior to interaction with the RV.

1. Distribution and seasonality

Out of the 279 common dolphin encounters, limited data were collected during spring (n=4, 1.4%) and winter (n=5, 1.8%), compared to summer (n=188, 67.4%) and autumn (n=82, 29.4%). For comparative purposes, data were pooled between spring and summer (n=192, 68.8%), and autumn and winter (n=87, 31.2%), respectively (Neumann, 2001c).

When considering distance to the shore (mainland and islands), common dolphins were found further offshore (median=9.1km, SE=0.4, n=87) in autumn and winter, compared to spring and summer (median=7.7km, SE=0.3, n=192) (Kruskal-Wallis: h=4.7, df=1, p=0.030, Fig. 6). The difference was even more significant when considering the mainland coastline. Dolphins were found further offshore (median=18.5km, SE=0.8, n=87) in autumn and winter, compared to spring and summer (median=14.8km, SE=0.5, n=192, Kruskal-Wallis: h=12.7, df=1, $p < 0.001$, Fig. 7).

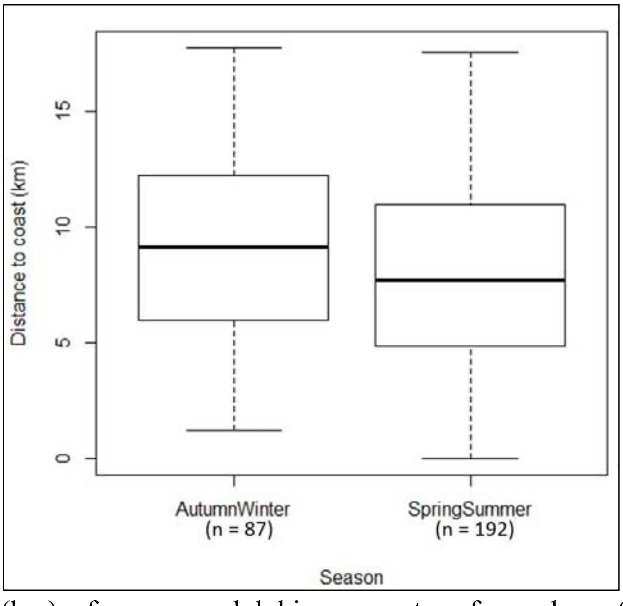

Figure 6: Distance (km) of common dolphin encounters from shore (mainland or island) according to season, between November 2010 and May 2013, in the ECBOP, New Zealand. This boxplot represents the minimum distance, lower quartile (Q1 or 25th percentile), median, upper quartile (Q3 or 75th percentile), and maximum distance.

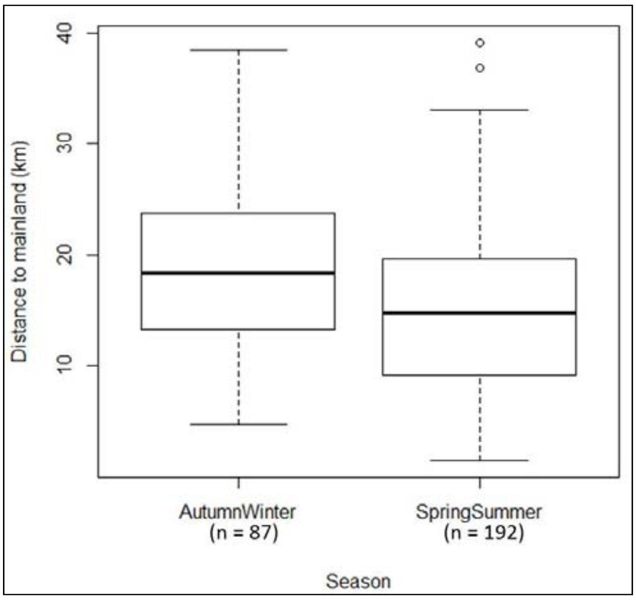

Figure 7: Distance (km) of common dolphin encounters from the mainland according to season, between November 2010 and May 2013, in the ECBOP, New Zealand. This boxplot represents the minimum distance, lower quartile (Q1 or 25th percentile), median, upper quartile (Q3 or 75th percentile), and maximum distance. Dots represents outliers.

Common dolphins were located in deeper waters in autumn and winter (median=73.4m, SE=6.4, n=87), compared to spring and summer (median=57.1m, SE=2.4, n=178) (Kruskal-Wallis: h=18.17, df=1, $p < 0.001$, Fig. 8).

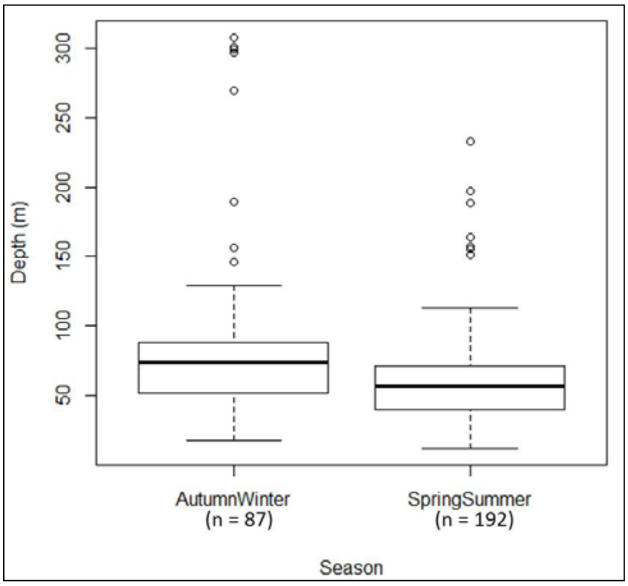

Figure 8: Water depth (m) of common dolphin encounters according to season, between November 2010 and May 2013, in the ECBOP, New Zealand. This boxplot represents the smallest depth (minimum), lower quartile (Q1 or 25th percentile), median, upper quartile (Q3 or 75th percentile), and largest depth (maximum). Dots represents outliers.

2. Group size

Out of 279 independent sightings, group size was assessed at initial onset of the encounter for 94.2% of groups (n=260).

Small groups (≤ 50 individuals) were sighted more often (67%, n=31 and 79%, n=170) compared to large groups (> 50 individuals: 33%, n=15 and 21%, n=44) from the RV and TV, respectively (Fig. 9). However, no significant difference was detected between platforms (Pearson's χ2: χ^2=2.48, df=1, p > 0.05), and data were therefore pooled.

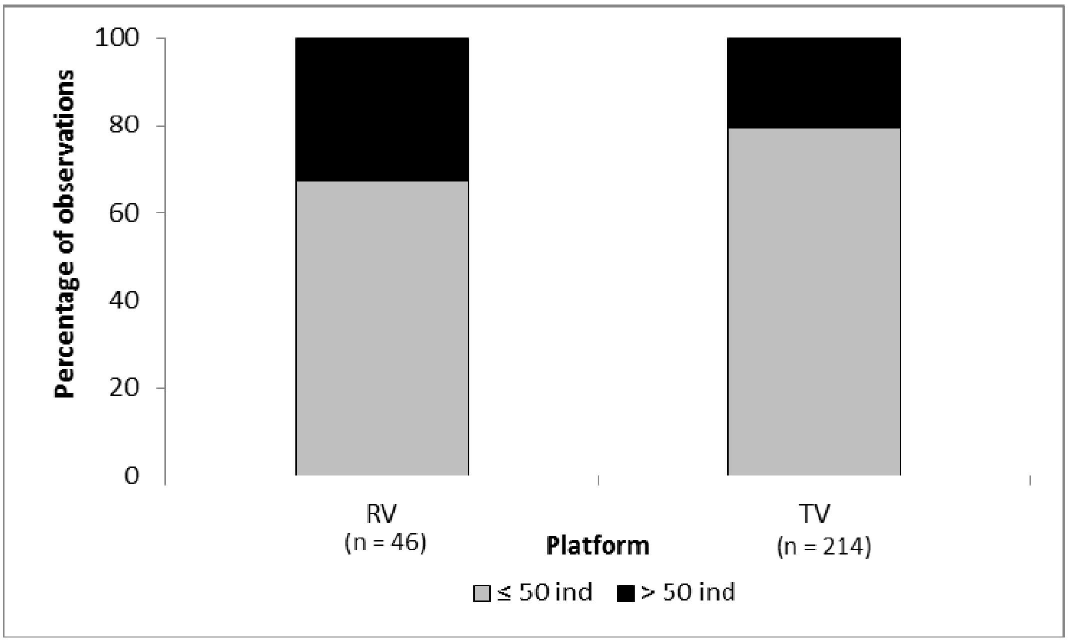

Figure 9: Common dolphin group sizes (≤ 50 individuals, > 50 individuals) according to platform (RV=research vessel, TV=tour vessels) of observation, between November 2010 and May 2013, in ECBOP, New Zealand.

Group size ranged from singletons (n=1) to *ca*. 600 dolphins (n=1) with a mean size of 42.7 individuals (median=20, SE=4.3, n=260). Overall, dolphins were predominantly observed in small groups of ≤ 20 individuals (51.2%, n=133, Fig. 10). Additionally, groups of 21-50 and 51-100 individuals accounted for 26.2% (n=68) and 16.2% (n=42) of observed groups, respectively. Large groups (>100 individuals) were reported 6.5% of the time (n=17).

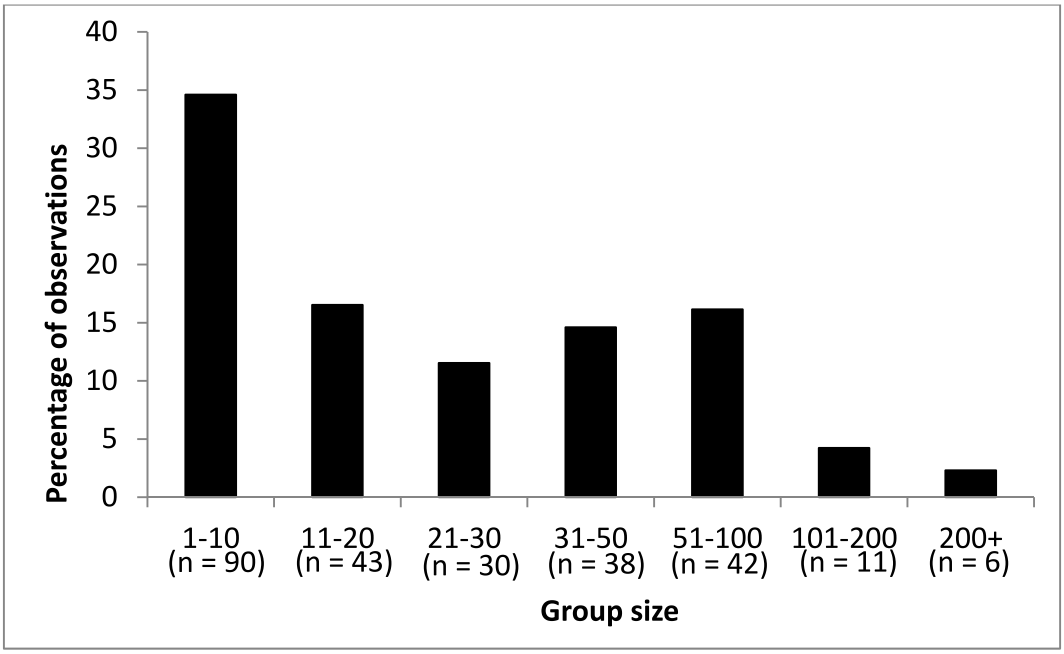

Figure 10: Common dolphin group sizes, between November 2010 and May 2013, in the ECBOP, New Zealand.

Although smallest groups (≤ 10 animals) were most frequently recorded in spring and summer (39.2%, n=69) compared to autumn and winter (25%, n=21), a similar proportion of group sizes were observed across the seasons (Pearson's χ^2: χ^2=6.76, df=6, $p > 0.05$, Fig.11).

Group size varied significantly diurnally (Pearson's χ^2: χ^2=43.2, df=4, $p < 0.001$, Fig. 12). The proportion of groups > 50 individuals increased from 0800-0959hrs to 1200-1359hrs (18%, n=13 to 33%, n=19, respectively), and decreased after 1400hrs. Conversely, the proportion of smaller groups (≤ 50 individuals) decreased (82%, n=59 to 67%, n=39, respectively) during that time. After 1400hrs, the majority of encountered groups were smaller than 50 individuals (> 87%).

While no obvious pattern in the distribution of small (≤ 50 individuals) and large (> 50 individuals) groups was detected (Fig. 13), dolphins did occur over significantly deeper waters according to their group size (Kruskal-Wallis χ2: χ^2=23.4, df=6, p=0.0006, Fig. 14).

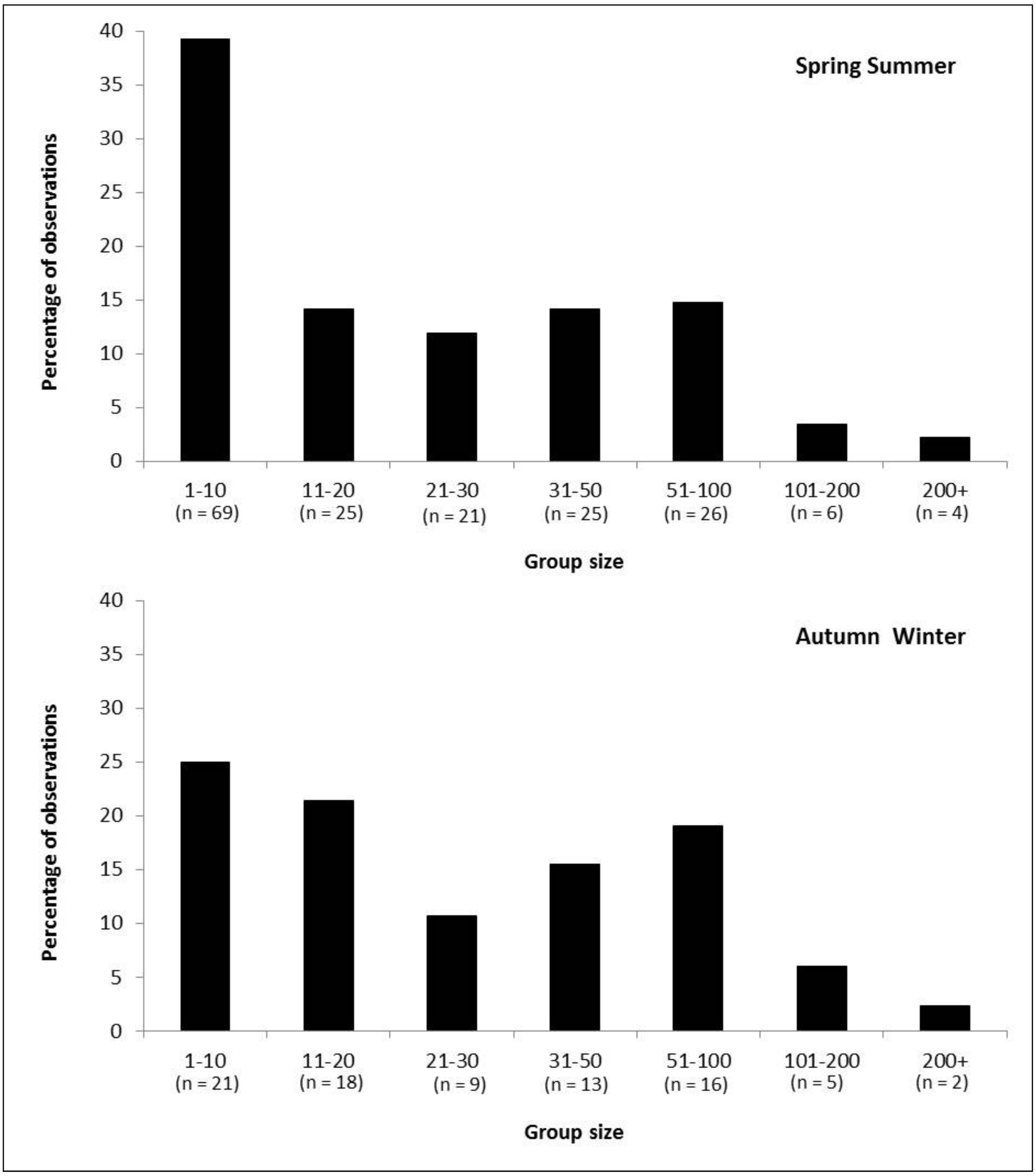

Figure 11: Common dolphin group sizes according to season, between November 2010 and May 2013, in the ECBOP, New Zealand.

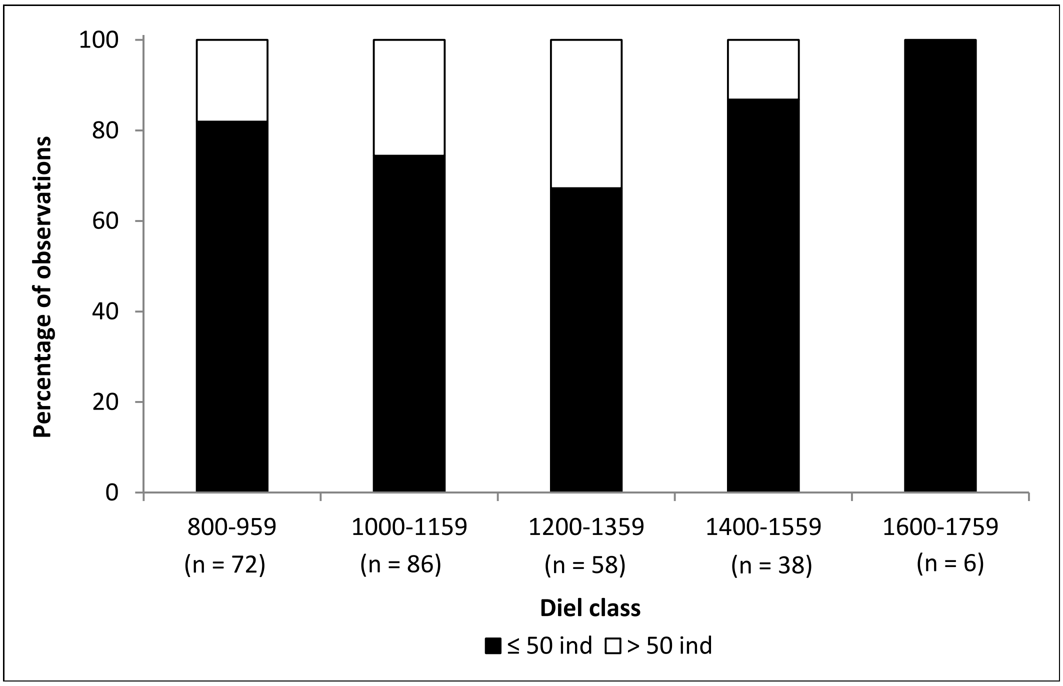

Figure 12: Common dolphin group sizes (≤ 50 individuals, > 50 individuals) according to time, between November 2010 and May 2013, in the ECBOP, New Zealand.

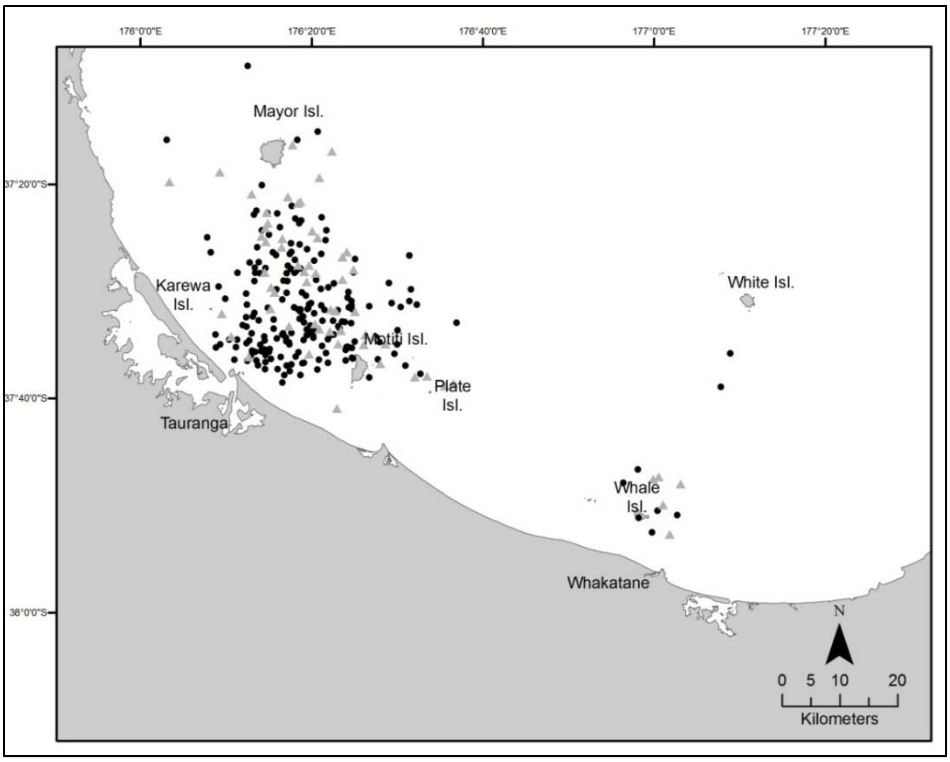

Figure 13: Location of common dolphin encounters according to group size (• ≤ 50 individuals and ▲> 50 individuals), between November 2010 and May 2013, in the ECBOP, New Zealand.

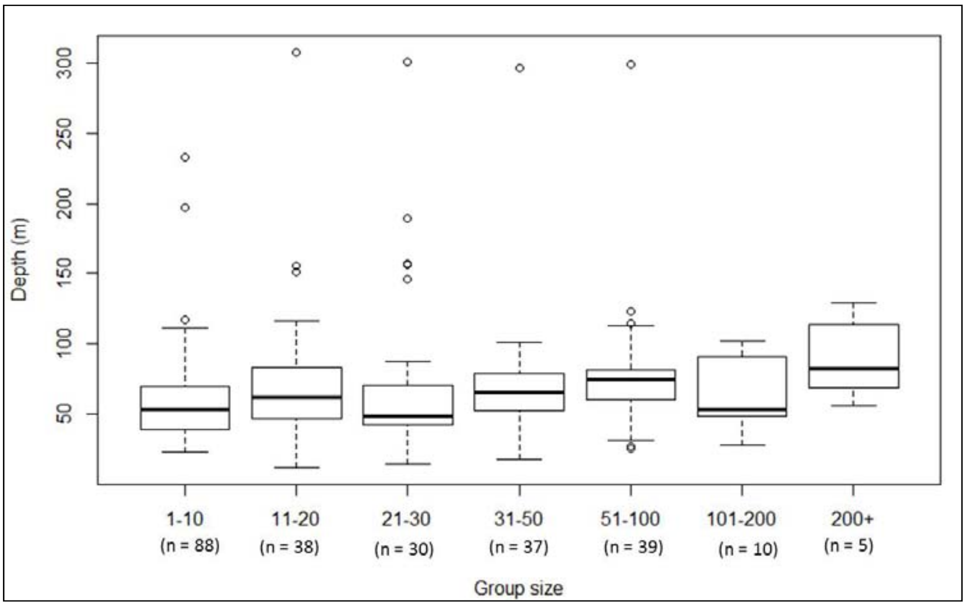

Figure 14: Water depth (m) of common dolphin encounters according to group size, between November 2010 and May 2013, in the ECBOP, New Zealand. This boxplot represents the minimum depth, lower quartile (Q1 or 25th percentile), median, upper quartile (Q3 or 75th percentile), and maximum depth. Dots represent outliers.

3. Group composition

Out of the 279 independent groups encountered, composition was assessed for 76.7% (n=214). Groups of adults only were observed in similar proportions regardless of platform type (36%, n=14, and 38%, n=66 for the RV and the TV, respectively, Fig. 15). Regarding groups containing juveniles, 33% (n=13) were observed from the RV, and 30% (n=52) were observed from the TV. Similarly, groups containging juveniles and calves were observed for 31% (n=12) of encounters on the RV and 33% (n=57) of encounters from the TV. As there was no significant difference between platforms (Pearson's χ2: χ^2 =0.25, df=2, $p > 0.05$), data were pooled for further analysis.

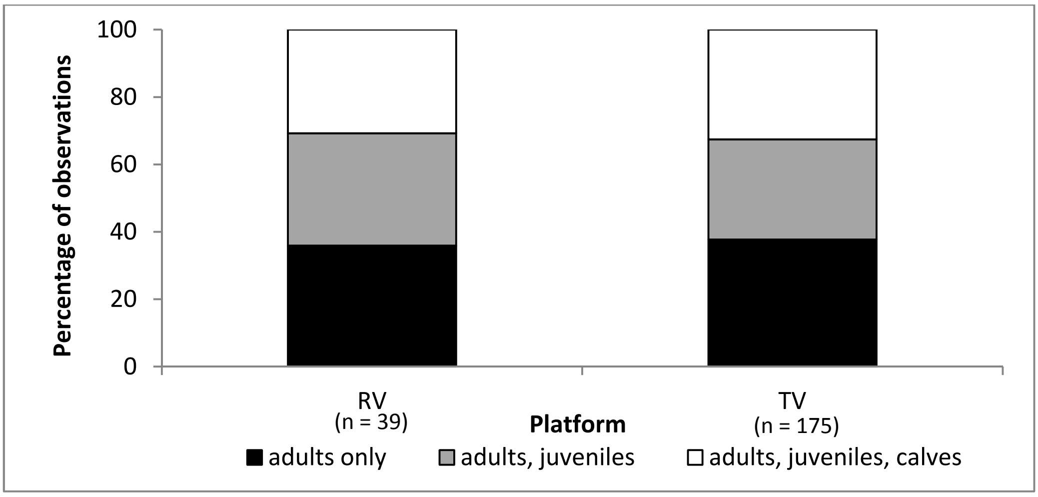

Figure 15: Common dolphin group composition according to platform of observation (RV=research vessel, TV=tour vessels), between November 2010 and May 2013, in the ECBOP, New Zealand.

The proportion of adult only groups gradually decreased from 57% (n=39) to 9% (n=1) as group size increased (Fig. 16). Groups containing juveniles were similarly distributed across all group sizes (22 to 35%) and with a maximum occurrence in groups > 200 animals (50%, n=2). Only 10% (n=7) of groups of less than 10 individuals contained immatures, while higher proportions (32 to 64%) were found in larger groups. The composition of groups significantly changed with group size (Pearson's χ^2: χ^2=26.2, df=6, $p < 0.001$).

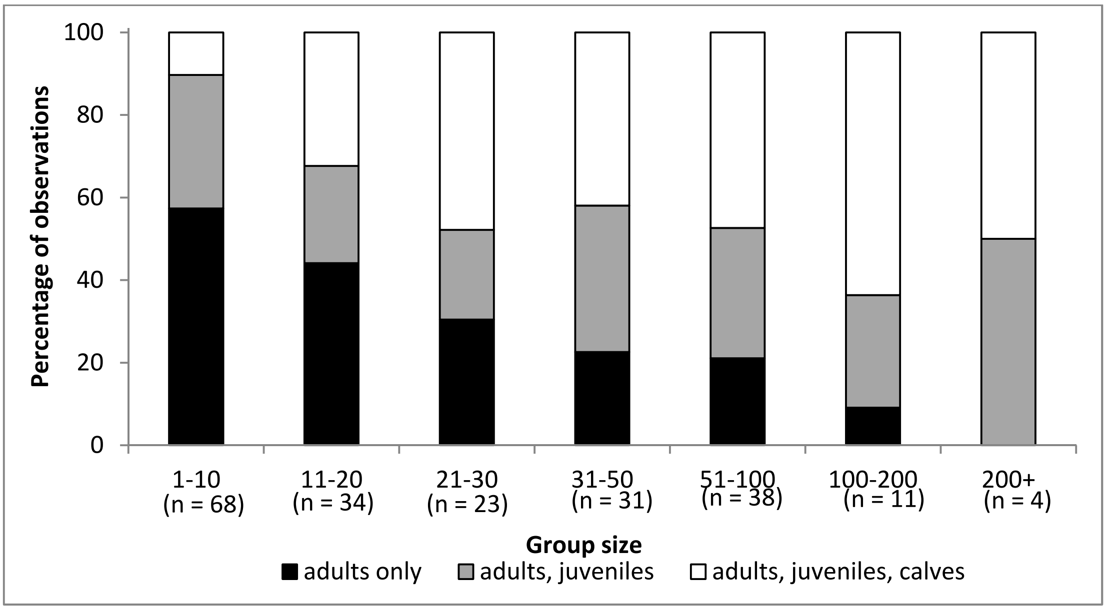

Figure 16: Composition of common dolphin groups according to group size, between November 2010 and May 2013, in the ECBOP, New Zealand.

Groups containing immature dolphins were observed throughout the year (Fig. 17). However, composition of groups significantly changed seasonally (Pearson's $\chi2$: χ^2=7.26, df=2, p=0.027), with the proportion of groups comprising adults only higher in autumn and winter (49.3%, n=35) compared to spring and summer (31.5%, n=45). Conversely, the proportion of groups containing immatures was higher in spring and summer (35.0%, n=50 for juveniles and 33.6%, n=48 for juveniles and calves) compared to autumn and winter (21.1%, n=15 for groups with juveniles and 29.6%, n=21 for groups with juveniles and calves). Overall, an increase of 17.9% of immature groups occurred between the two main seasons.

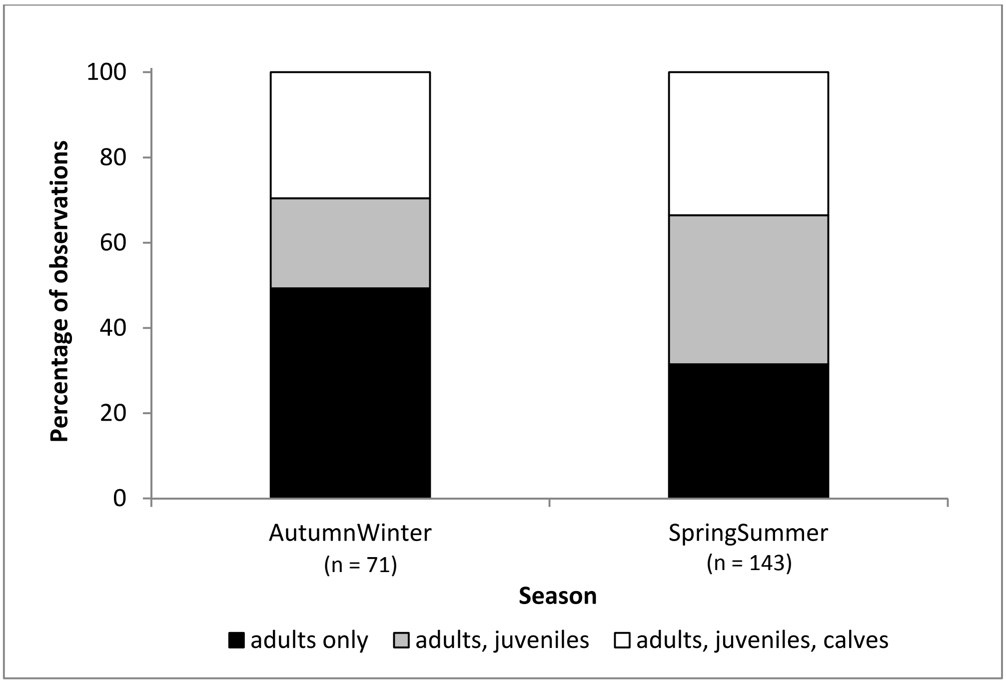

Figure 17: Composition of common dolphin groups according to season, between November 2010 and May 2013, in the ECBOP, New Zealand.

No pattern in the distribution of groups according to their composition was detected (Fig. 18). Common dolphins were encountered in similar water depths (median=61.4m , n=208) regardless group composition (Kruskal-Wallis χ2: χ^2=0.9, df=2, p > 0.05, Fig. 19).

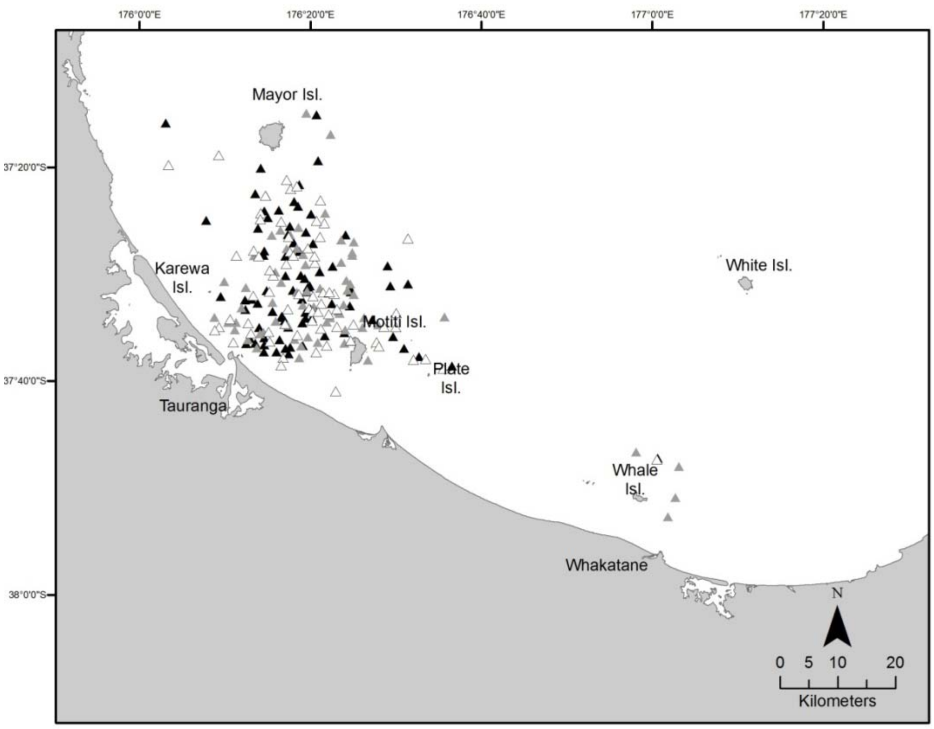

Figure 18: Location of common dolphin groups: adults only (▲), adults with juveniles (▲), adults with juveniles and calves (△), between November 2010 and May 2013, in the ECBOP, New Zealand.

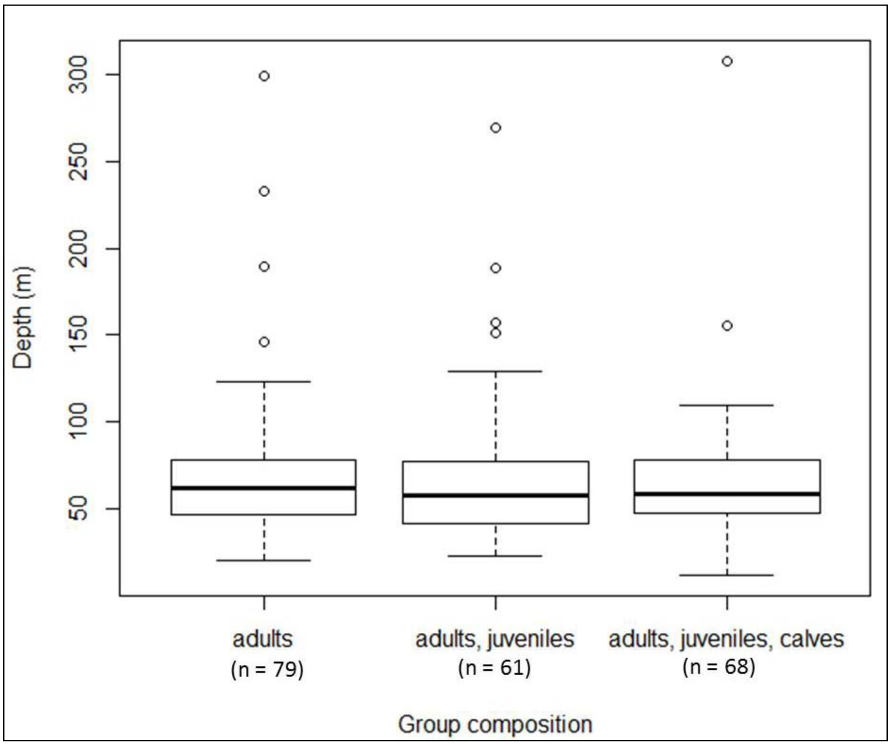

Figure 19: Water depth (m) of common dolphin encounters according to group composition, between November 2010 and May 2013, in the ECBOP, New Zealand. This boxplot represents the smallest minimum depth, lower quartile (Q1 or 25th percentile), median, upper quartile (Q3 or 75th percentile), and maximum depth. Dots represent outliers.

4. Behaviour

Out of the 279 independent sightings, initial behavioural states for 61.3% (n=171) of encountered common dolphin groups were assessed. Of these, 86% (n=147) of groups were involved in a single behavioural state, while 14% (n=24) focal groups were involved in two states simultaneously (*i.e.* FOR-MIL, FOR-SOC, RES-MIL, SOC-MIL, TRA-FOR, TRA-MIL, TRA-SOC).

Initial behavioural states were recorded aboard the RV and TV 19.3% (n=33) and 80.7% (n=162) of the time, respectively. On the RV, travelling (57.6%, n=19) and foraging (21.2%, n=7) were the most prevalent states (Fig. 20), followed by resting (9.1%, n=3), milling (6.1%, n=2), and socialising (6.1%, n=2). Initial behavioural states recorded on TV indicated travelling as the most prevalent activity (44.4%, n=72) followed by foraging (25.3%, n=41), milling (20.4%, n=33), socialising (6.8%, n=11) and resting (3.1%, n=5). The initial behavioural state did not differ significantly between platform type (Pearson's $\chi 2$: χ^2=6.76, df=4, $p > 0.05$), thus data were pooled across platforms. Overall, travelling was the most frequently recorded behavioural state (46.7%, n=91), followed by foraging (24.6%, n=48) and milling (17.9%, n=35). Socialising (6.7%, n=13) and resting (4.1%, n=8) were the least observed behavioural states.

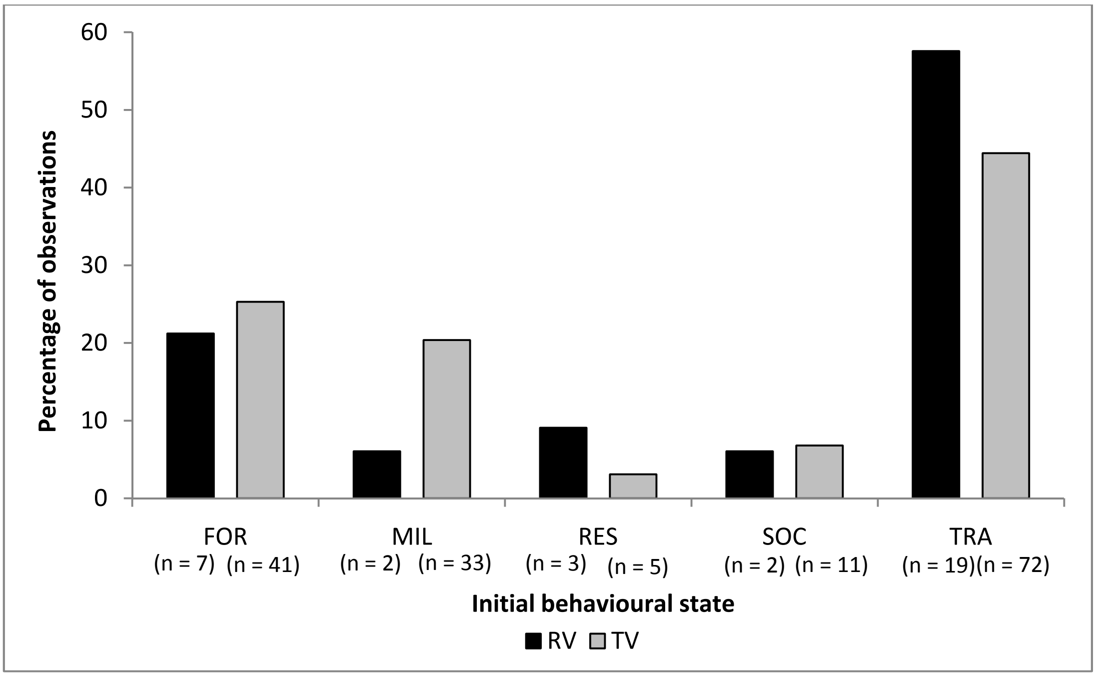

Figure 20: Initial behavioural state of common dolphin groups, between November 2010 and May 2013, in the ECBOP, New Zealand, according to platform (RV=research vessel, TV= tour vessels, FOR=foraging, MIL=milling, RES=resting, SOC=socialising, TRA=travelling).

Travelling was less frequent (38%, n=21) in the early morning (0800-0959hrs), and increased throughout the day (> 50% after 1400hrs, Fig. 21). Conversely, foraging was more frequently observed between 0800-0959hrs (35%, n=19) and gradually decreased throughout the day (7%, n=2 between 1400-1559hrs). Milling was observed throughout the day (15-23%). Resting was primarily recorded in the morning (7%, n=4 between 0800-0959hrs) and also observed late afternoon (33%, n=1 between 1600-1759hrs). Socialising occurred mainly around midday to early afternoon (1200-1359hrs and 1400-1559hrs, 10%, n=5 and 13%, n=4, respectively). Despite observed differences, no significant diel pattern in dolphin behaviour was detected (Pearson's χ^2: χ^2=25.6, df=16, $p > 0.05$).

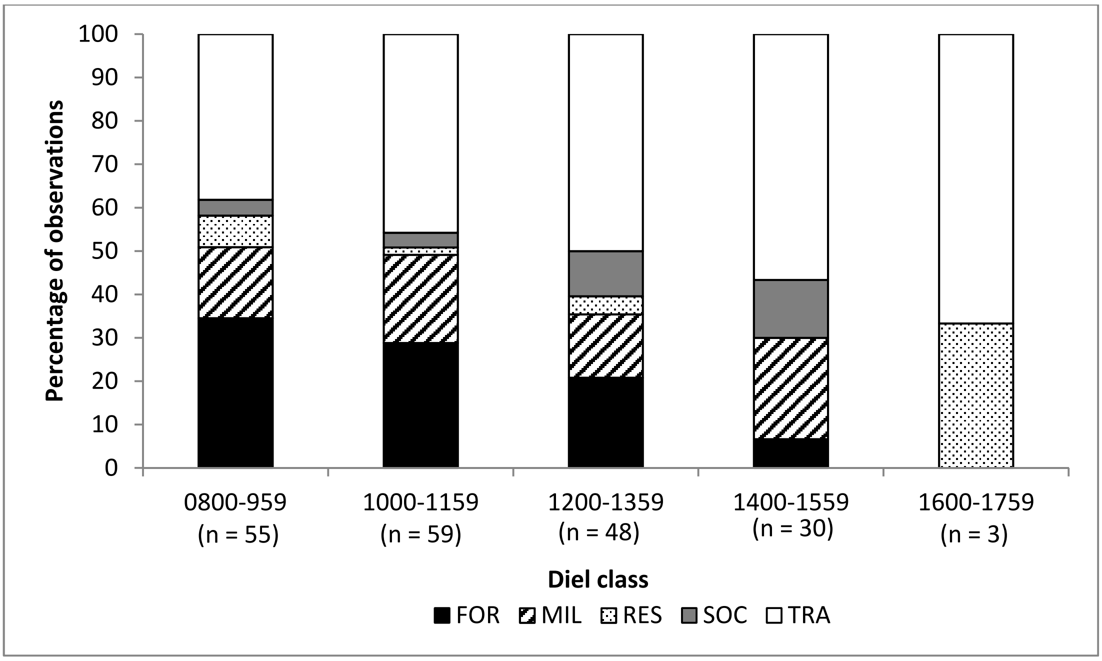

Figure 21: Diel behavioural pattern of common dolphin groups, between November 2010 and May 2013, in the ECBOP, New Zealand. FOR=foraging, MIL=milling, RES=resting, SOC=socialising, TRA=travelling.

Overall, no pattern in the distribution of each behaviour was detected (Fig. 22). Common dolphins were encountered in similar depths (median=57.9m, SE=3.1, n=189) regardless of their initial behavioural state (Kruskal-Wallis χ2: χ^2=5.2, df=4, $p > 0.05$, Fig. 23). Similarily, distance to the coast (median=8.2, SE=0.3, n=195) did not vary significantly according to dolphin behavioural state (Kruskal-Wallis χ2: χ^2=1.8, df=4, $p > 0.05$, Fig. 24).

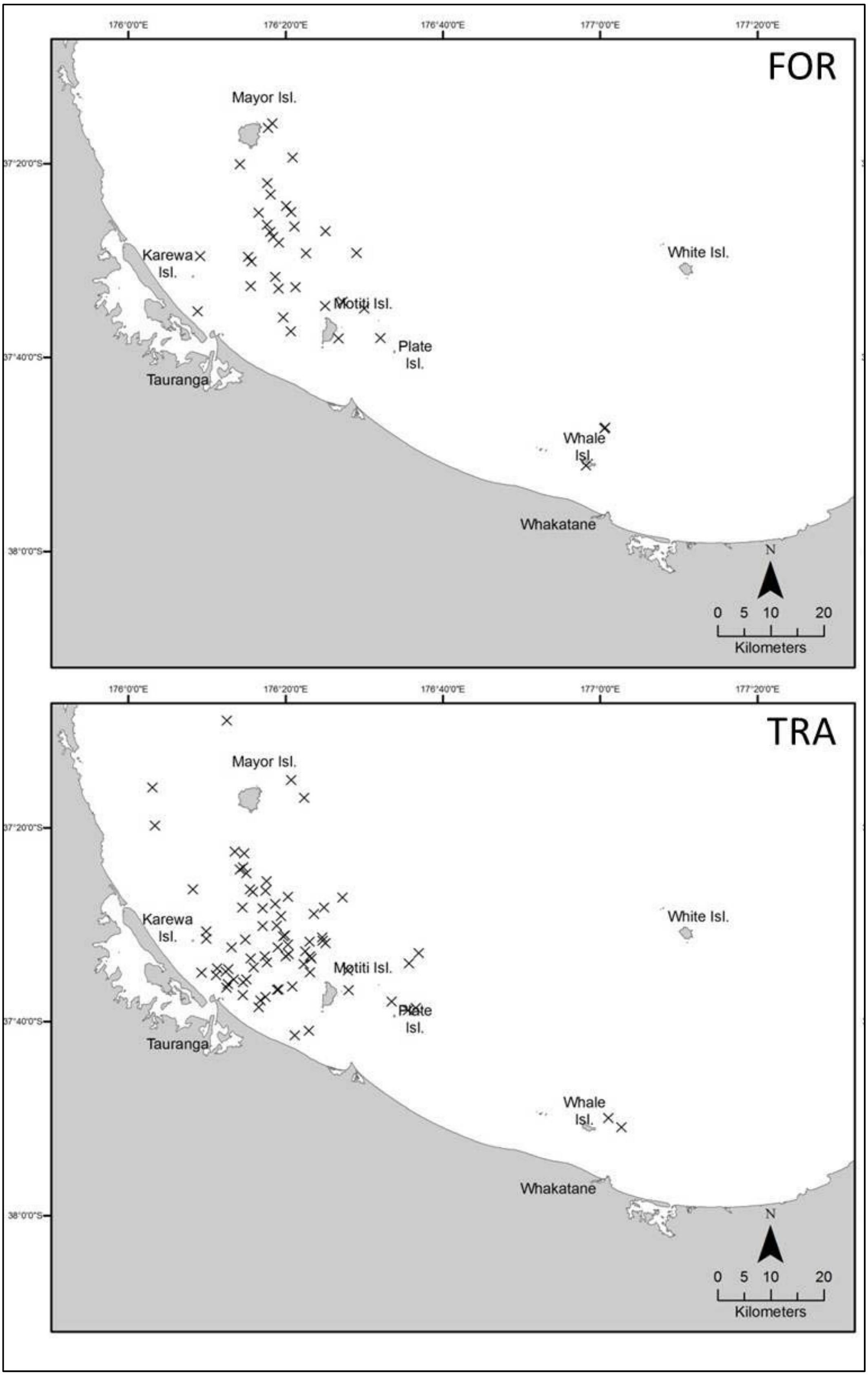

Figure 22: Location of common dolphin groups according to initial behavioural state, between November 2010 and May 2013, in the ECBOP, New Zealand. FOR=foraging, MIL=milling, RES=resting, SOC=socialising, TRA=travelling.

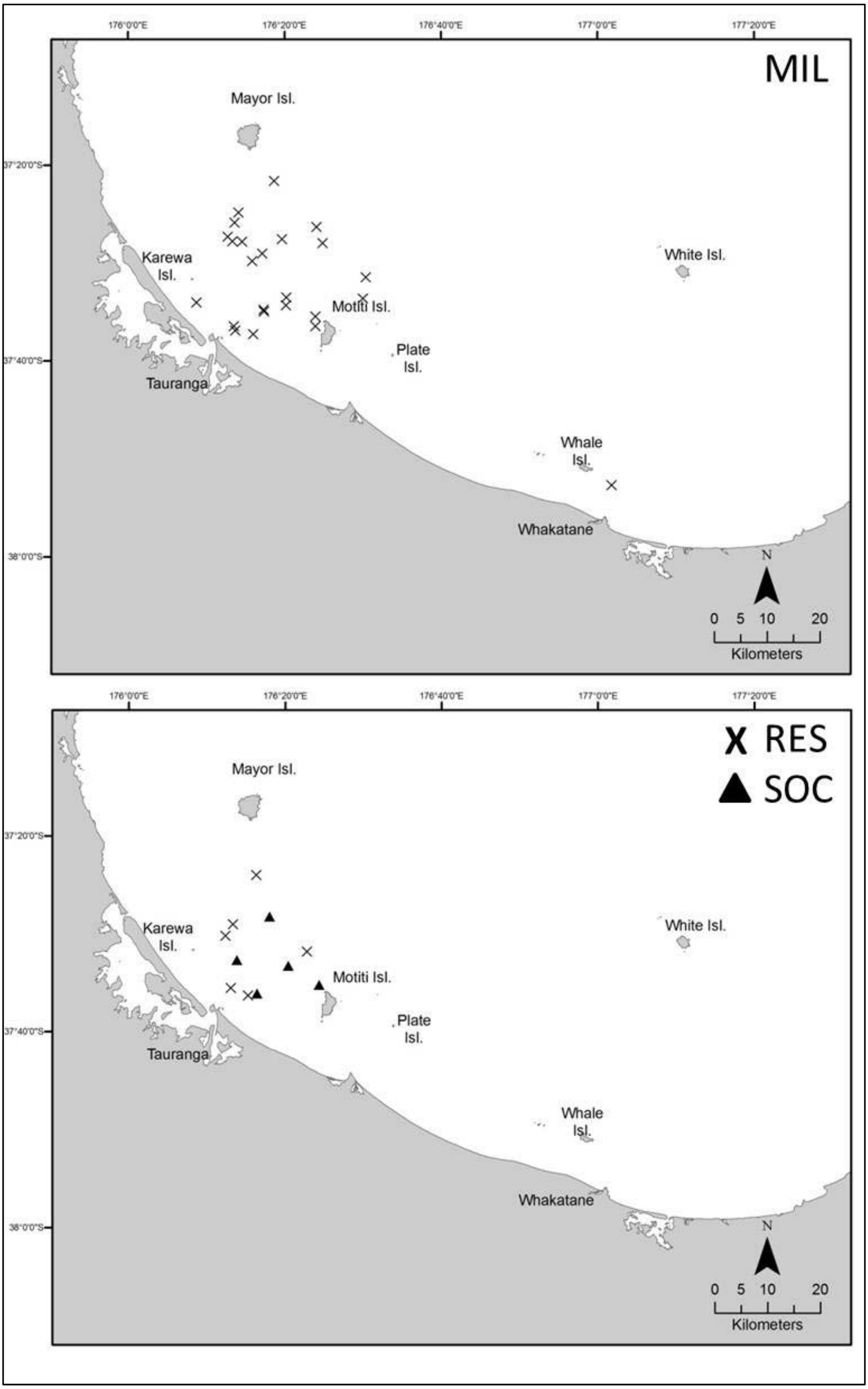

Figure 22 (*continued*): Location of common dolphin groups according to initial behavioural state, between November 2010 and May 2013, in the ECBOP, New Zealand. FOR=foraging, MIL=milling, RES=resting, SOC=socialising, TRA=travelling.

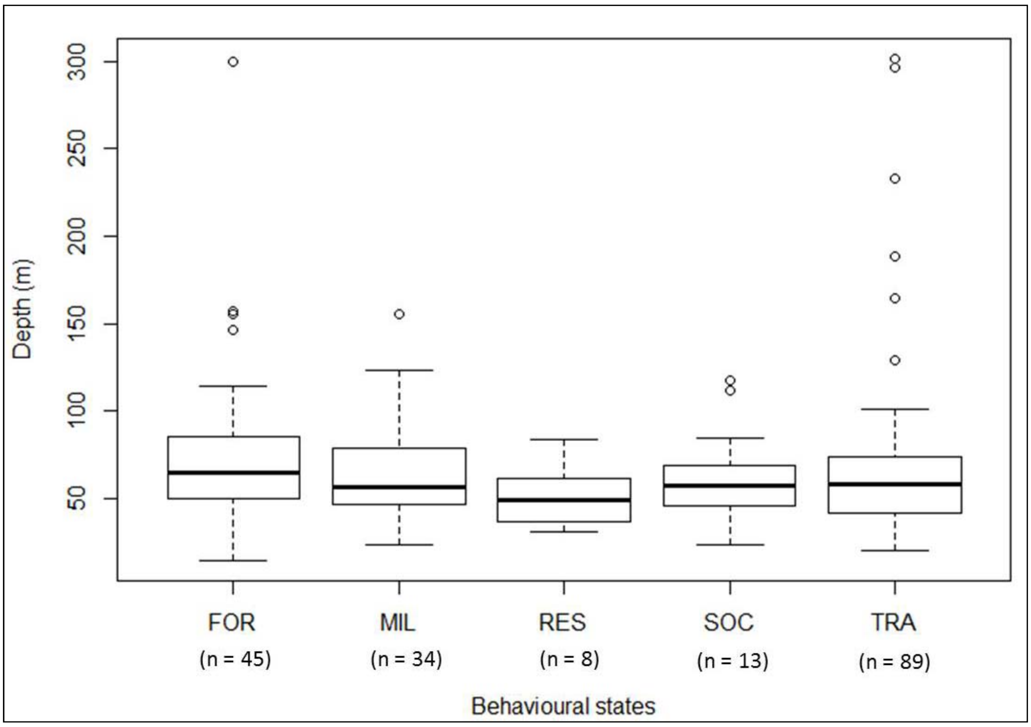

Figure 23: Water depth (m) of common dolphin encounters according to initial behavioural state, between November 2010 and May 2013, in the ECBOP, New Zealand. This boxplot represents the minimum depth, lower quartile (Q1 or 25th percentile), median, upper quartile (Q3 or 75th percentile), and maximum depth. FOR=foraging, MIL=milling, RES=resting, SOC=socialising, TRA=travelling.

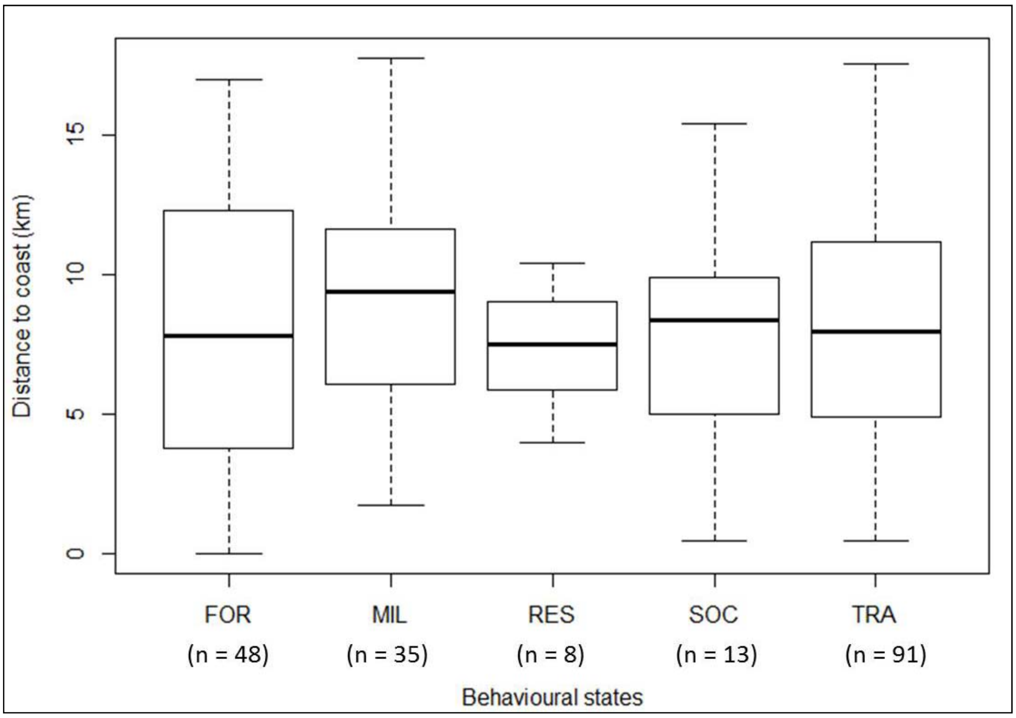

Figure 24: Distance (km) of common dolphin encounters from the mainland according to initial behavioural state, between November 2010 and May 2013, in the ECBOP, New Zealand. This boxplot represents the minimum depth, lower quartile (Q1 or 25th percentile), median, upper quartile (Q3 or 75th percentile), and maximum depth. FOR=foraging, MIL=milling, RES=resting, SOC=socialising, TRA=travelling.

5. Effects of vessel interaction on dolphin activity budget

a. Survey effort

From November 2010 to May 2013, a total of 55 common dolphin focal follows were undertaken during 7,634min (*i.e.* 127.23hrs) and 828.5km of survey effort across 50 days aboard the RV. Those focal follows were conducted in the presence of the RV only (*i.e. control* sequences) and in the presence of the RV and other vessels (*i.e. interaction* sequences). *Post-interaction* sequences were also recorded following *interaction* sequences, *i.e.* immediately following the departure of interacting vessel(s), and conducted in the presence of the RV only.

Control and *interaction* sequences of ≥ 15min (*i.e.* composed of a minimum of five transitions and six behavioural states) were considered (as per Stockin *et al.*, 2008a). Foraging, milling and travelling behaviours are likely to be affected by the previous interaction 15 minutes following the departure of the vessel. Consequently, *post-interaction* sequences of 15 minutes, immediately following the departure of interacting vessels, were added to the *interaction* sequences for further analysis.

Out of the 55 focal follows, 100 sequences were obtained, of which 38% (n=38) were *control* sequences and 62% (n=62) were *interaction* sequences. Control and interaction sequences lasted on average 52min (range=15-279min, n=38) and 21min (range=15-81min, n=62), respectively. This corresponds to a total of 1,106 behavioural transitions, of which 59.9% (n=662) were *control* transitions and 40.1% (n=444) were *interaction* transitions (Table 2).

Under *control* conditions, common dolphins spent the majority (51.7%, n=362) of their time travelling (Fig. 25). Foraging represented an important proportion of their behaviour (23.4%, n=164), while milling accounted for only half of that time (12.7%, n=89). Resting and socialising were the two less represented states (8.3%, n=58 and 3.9%, n=27, respectively). Under *interaction* conditions, dolphins spent more time travelling (53.8%, n=272, Fig. 25). Conversely to *control* conditions, they spent more time milling (18.8%, n=95), and less time foraging (13%, n=66). Finally, dolphins spent more time socialising (8.5%, n=43) and a similar amount of time resting (5.9%, n=30). The percentage of time common dolphins spent in each behavioural state was significantly different between *control* and *interaction* conditions (Pearson's $\chi2$: χ 2 =37.05, df=4, $p < 0.001$).

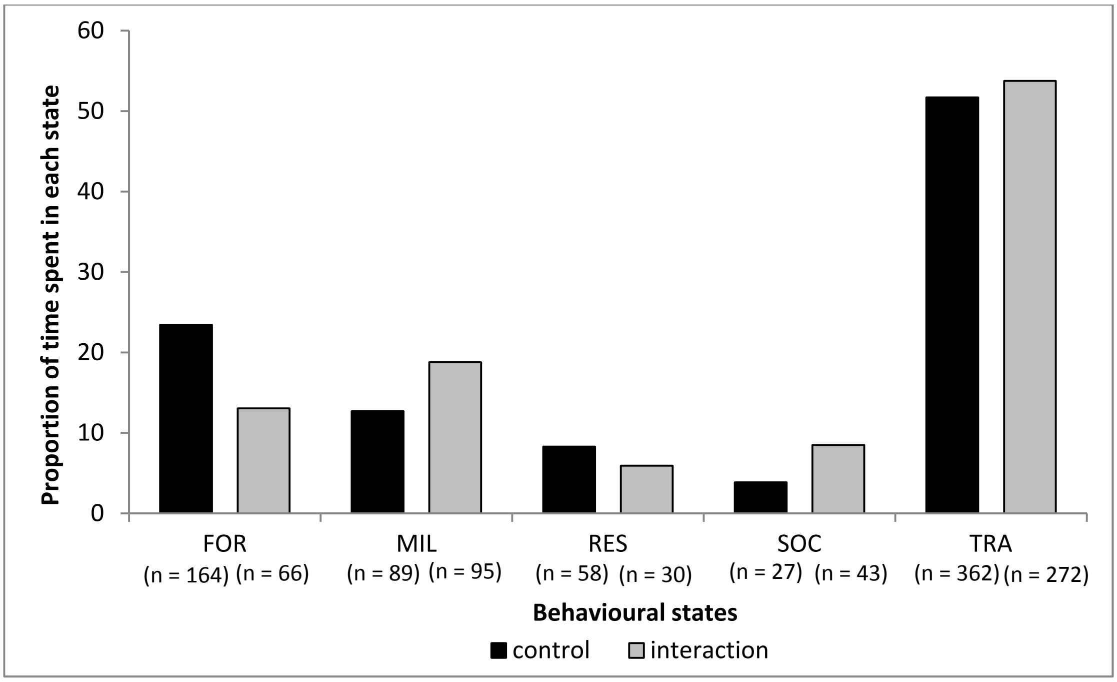

Figure 25: Proportion of time common dolphins spent in each behavioural state under *control* and *interaction* conditions (*interaction* + *post-interaction* sequences), between November 2010 and May 2013, in the ECBOP, New Zealand. FOR=foraging, MIL=milling, RES=resting, SOC=socialising, TRA=travelling.

Under *control* conditions, no transition was recorded between foraging and resting, or between resting and socialising. Moreover, dolphins did not change their behavioural state from travelling to resting or socialising, nor did they change from resting to milling. Under *interaction* conditions, no transition has been observed between resting and socialising. Furthermore, dolphins did not change their behaviour from resting to milling, foraging to resting, from socialising to foraging, or travelling to resting. Given the low proportion of transition probabilities between resting and socialising and the other behavioural states, resting and socialising were excluded from further analysis. Specifically, any transitions containing resting and/or socialising states were discarded. Markov chain analyses were therefore examined taking into account the three remaining behavioural states: foraging, milling, and travelling. After excluding resting and socialising, 88 sequences remained, of which 38.6% (n=34) were *control* sequences, and 61.4% (n=54) were *interaction* sequences. This corresponds to a total of 937 behavioural transitions, of which 60.2% (n=564) *control* and 39.8% (n=373) *interaction* transitions, respectively.

b. Markov chain assumptions

The first-order transitions provided more information than zero-order transitions in both *control* and *interaction* conditions (Table 4).

Table 4: Chain order selection using BIC. A higher order chain provides more information than a lower chain order if Δ BIC > 2 log 100 (= 9.2).

Chain	Chain order	BIC	Δ BIC
control	0	-509.3	156.9
control	1	-352.4	
interaction	0	-345.6	136.1
interaction	1	-209.5	

c. Effect of vessel presence and interactions

Transition probabilities

Regardless of the preceding behavioural state, the most probable succeeding state remained the same (Fig. 26), under *control* and *interaction* conditions.

The effect of interacting vessels was not homogeneous throughout all transitions. The transition TRA → FOR significantly decreased by 67.9% (Z-test: $z=2.47$, p-value < 0.05, Fig.27). An increase in the transitions FOR → FOR, FOR → MIL, MIL → MIL, MIL → TRA, and TRA → TRA, and a decrease in the transitions FOR → TRA, MIL → FOR, and TRA → MIL were observed, although these differences were not significant (p-value > 0.05, Fig. 27).

Probability of staying in a given state and average time required to return to that state once disrupted

The average time taken for common dolphins to return to their initial behavioural state was altered in the presence of vessels. Time taken to return to milling and travelling decreased by 13.3% to 17min and by 14.6% to 4.4min, respectively (Table 5) in the presence of another vessel. Conversely, foraging dolphins took longer to return to foraging, with an increase of 91.4% to 22.1min (Table 5).

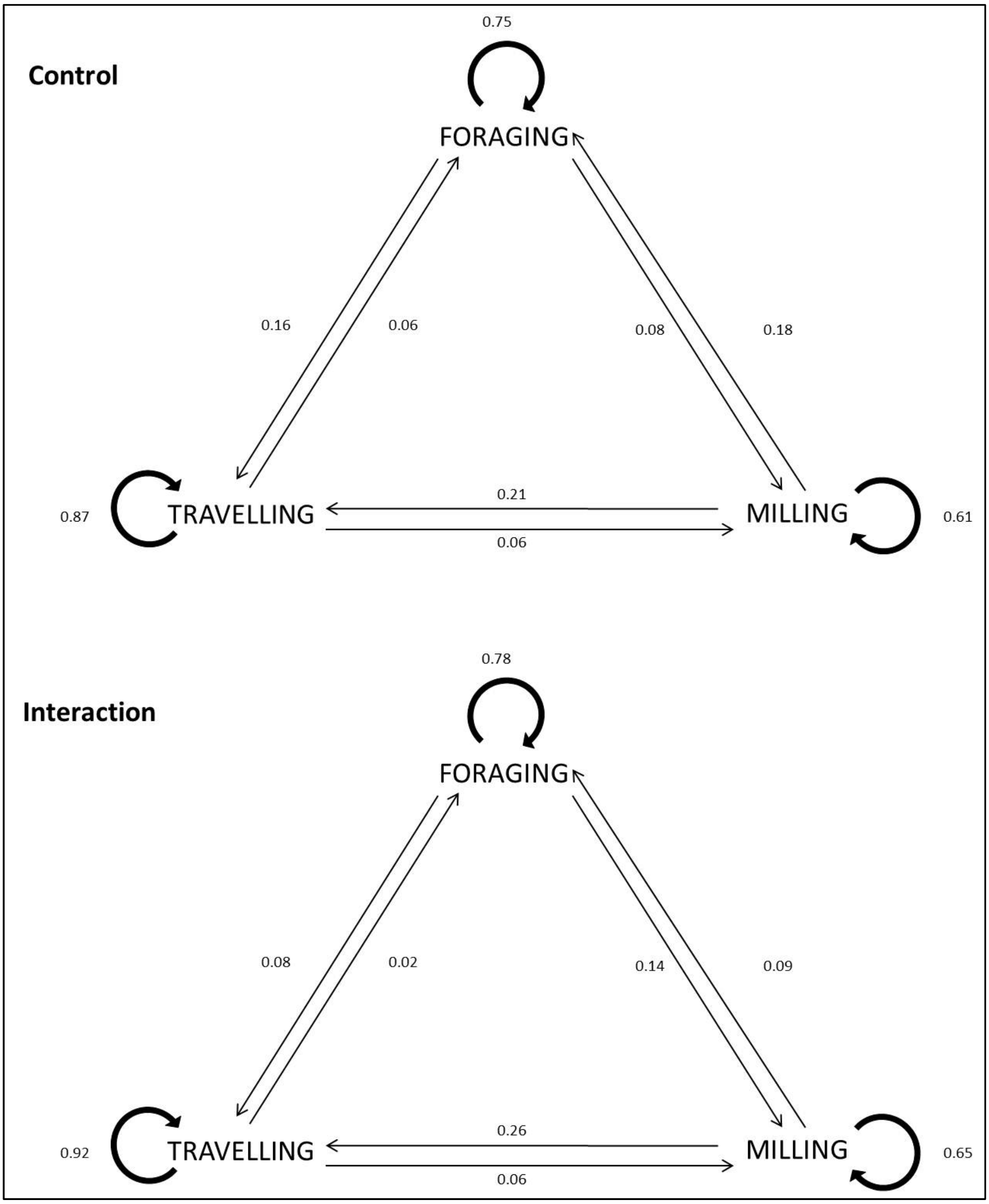

Figure 26: Transition probabilities in *control* and *interaction* chains. Values represent transition probabilities.

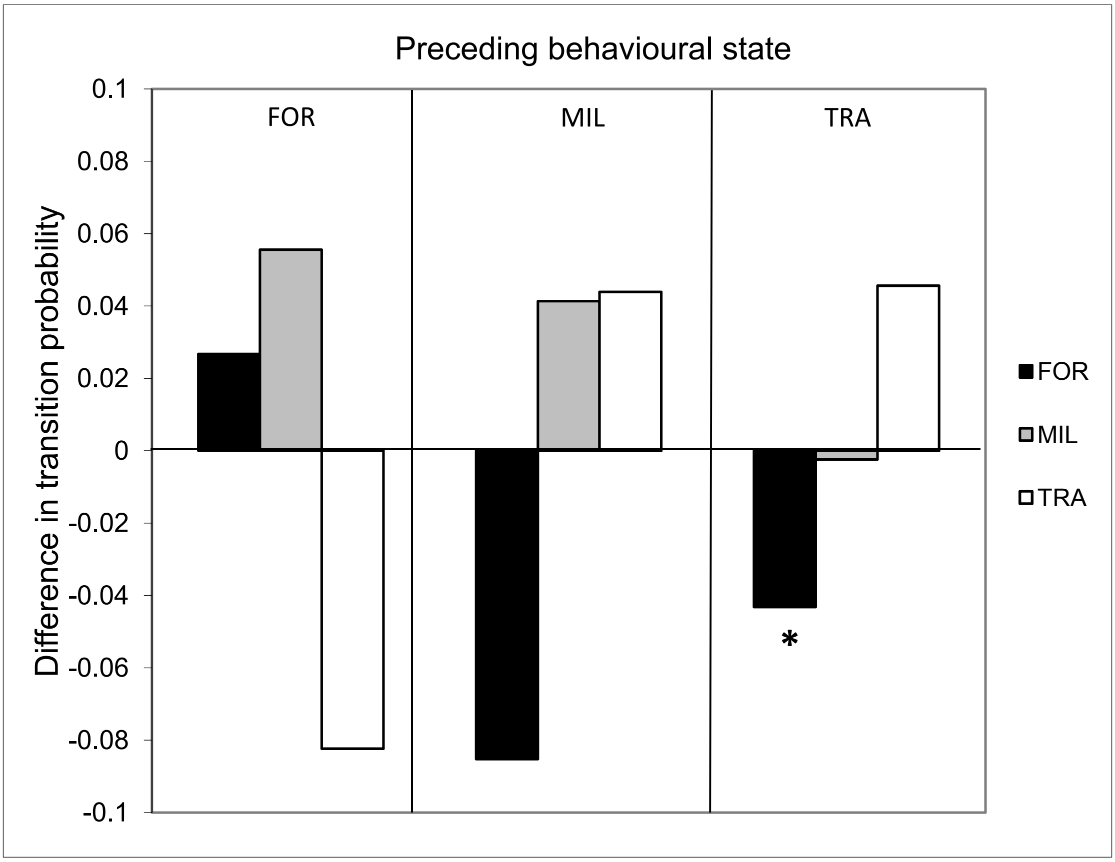

Figure 27: Effects of vessel presence on transitions in behavioural state of common dolphins between November 2010 and May 2013, in the ECBOP, New Zealand. Based on differences in transition probabilities (pij(interaction) – pij(control)). A negative value means that the behavioural transition of the *control* chain is superior to the *interaction* chain. Bars correspond to succeeding behavioural states. FOR=foraging, MIL=milling, TRA=travelling. Transitions with a significant difference ($p < 0.05$) are denoted by an (*).

Table 5: Probability of being in a particular state (π_j), average number of transitions (or 3min-time units) taken to return to a behavioural state $E(T_j)$, and time (min) required to return to a behavioural state once it was interrupted under *control* and *interaction* conditions. A negative value in percentage change denotes an extension in time to return to that state when vessels are present. Note: n/a=not applicable.

Condition	Behavioural state	π_j	$E(T_j)$	Behavioural state resumed (min)
Control	*Foraging*	0.260	3.8	11.5
	Milling	0.153	6.5	19.6
	Travelling	0.587	1.7	5.1
Interaction	*Foraging*	0.136	7.363	22.1
	Milling	0.177	5.664	17.0
	Travelling	0.688	1.454	4.4

Mean bout length

The average length of behavioural bouts significantly varied when vessels were present (Fig. 28, Table 6). The duration of travelling, foraging, and milling significantly increased by 55.9, 12.2, and 11.9%, respectively, in the presence of vessels.

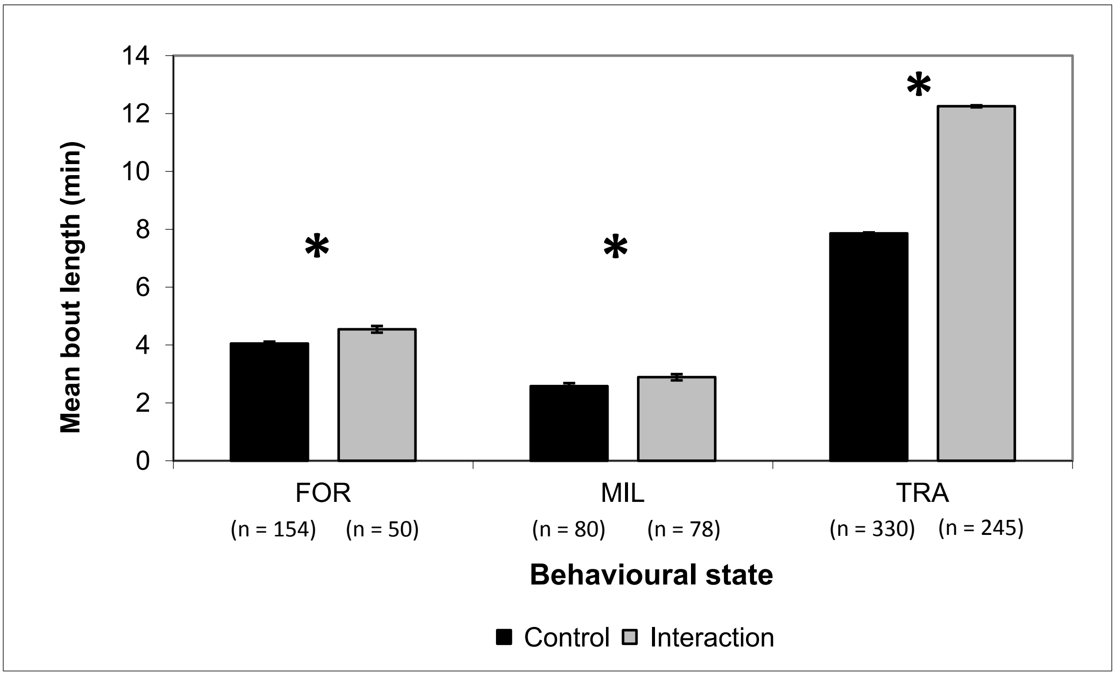

Figure 28: Mean bout length (t_{ii}) for *control* and *interaction* chains. Bars represent 95% confidence intervals. FOR=foraging, MIL=milling, TRA=travelling. Significant differences ($p < 0.05$) are denoted by an (*).

Table 6: Two sample t-tests comparing the average bout length of *control* chains against *interaction* chains. A negative value indicates an increase in mean bout length in the presence of vessels. df refers to statistical degrees of freedom.

Behavioural state	Difference (min)	% change	95% CI	t-statistic	p	df
Foraging	-0.49	-12.2	-0.64 – -0.36	-7.2	0.00	202
Milling	-0.31	-11.9	-0.46 – -0.16	-4.05	0.00	156
Travelling	-4.39	-55.9	-4.44 – -4.34	-168.33	0.00	573

Behavioural budget

The behaviour of common dolphins differed in the presence of vessels (Fig. 29). Travelling increased by 10.1% (95% CI: 3.69 – 16.43 %, $z = -2.2$, $p < 0.05$), while foraging decreased significantly by 12.4% (95% CI: 7.01 – 17.81 %, $z = 5.05$, $p < 0.05$).

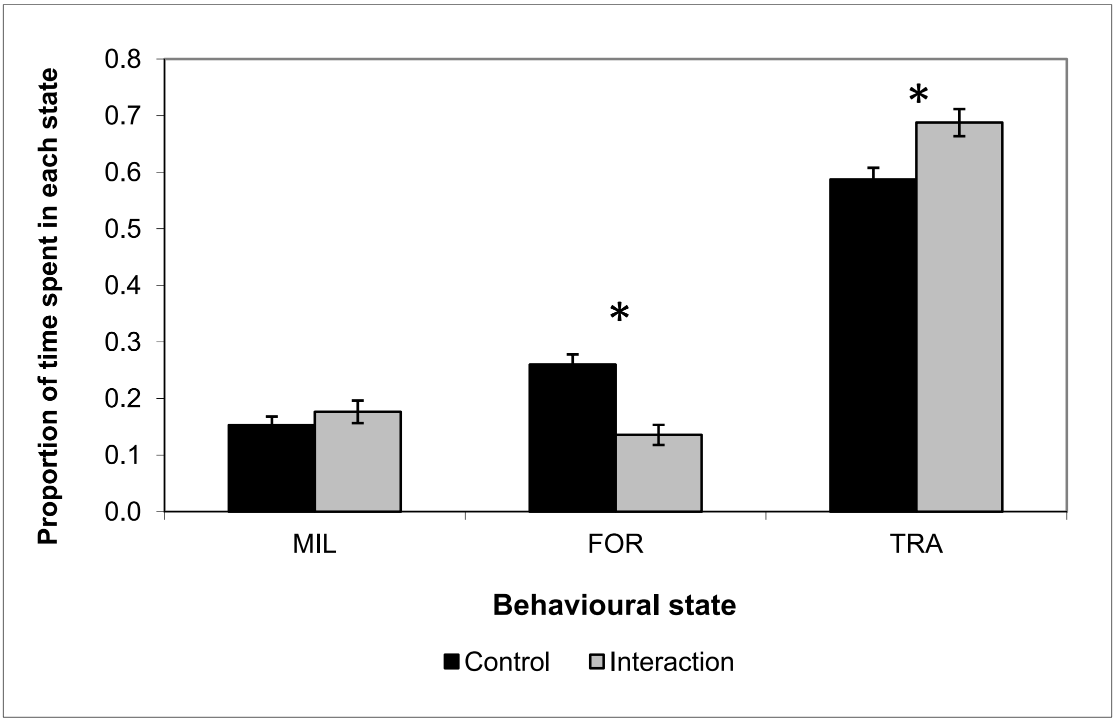

Figure 29: Effect of vessel interactions on the behavioural budget of common dolphins between November 2010 and May 2013, in the ECBOP, New Zealand. Values relate to the proportion of time spent in each state. Bars are 95% confidence intervals. FOR=foraging, MIL=milling, TRA=travelling. Significant differences ($p < 0.05$) are denoted by an (*).

6. Site fidelity

A total of 101,070 images were collected during 215 surveys, over 154 days, of which 29.8% (n=64) were from the RV and 70.2% (n=151) from the TV. Since photo-ID is labour intensive, images are still currently being graded and catalogued following standardised criteria (Markowitz *et al.*, 2003; Tezanos-Pinto, 2009). Consequently, only provisional results are presented here.

Out of 17,540 images (*ca.* 17% of the total dataset), 362 common dolphin individuals have so far been identified across 39 days, throughout a period of 722 days (*ca*. 2 years, Fig. 30). A total of 29 individuals (8.0%) have been encountered more than once, totalling 35 re-sightings (Appendix 8). Overall, 82.8% (n=24) were sighted twice, 13.8% (n=4) were sighted three times, and just 3.4% (n=1) recorded four times (Appendix 8). The shortest time between two encounters was two days (n=1), while the longest duration was 405 days (*i.e.* 1 year and 39 days, n=1). The majority (69.0%, n=20) of re-sightings between two encounters occurred within less than 30 days, 3.4% (n=1) between 30 and 60 days, 3.4% (n=1) between 60 and 90 days, and 24.1% (n=7) over 90 days.

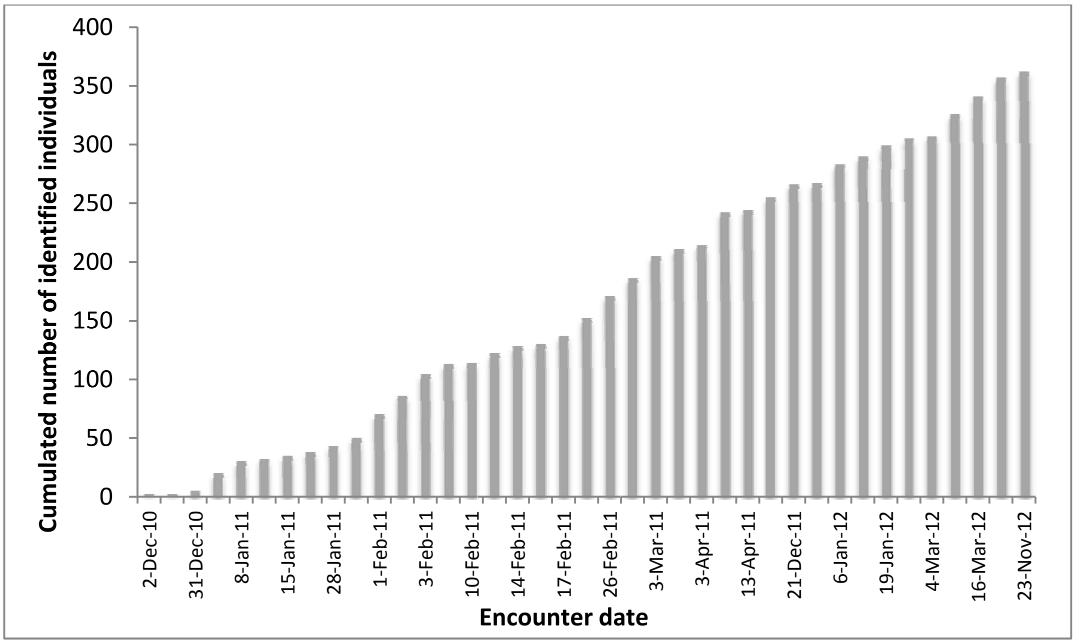

Figure 30: Cumulative number of identified common dolphin individuals, between November 2010 and November 2012, in the ECBOP, New Zealand.

D. *Bottlenose dolphins*

Due to a low sample size, results presented herein for bottlenose dolphins are severely constrained due to a lack of statistical power. However, descriptive data are still provided for each category as general information only. This data should be viewed in that context and interpreted with caution. Bottlenose dolphins were observed on nine occasions between November 2010 and May 2013 off Tauranga, representing only 1.8% of marine mammal encounters (Appendix 6, Figs. 5 and 31). No encounter with bottlenose dolphins occurred in Whakatane waters during the present study (Fig. 31).

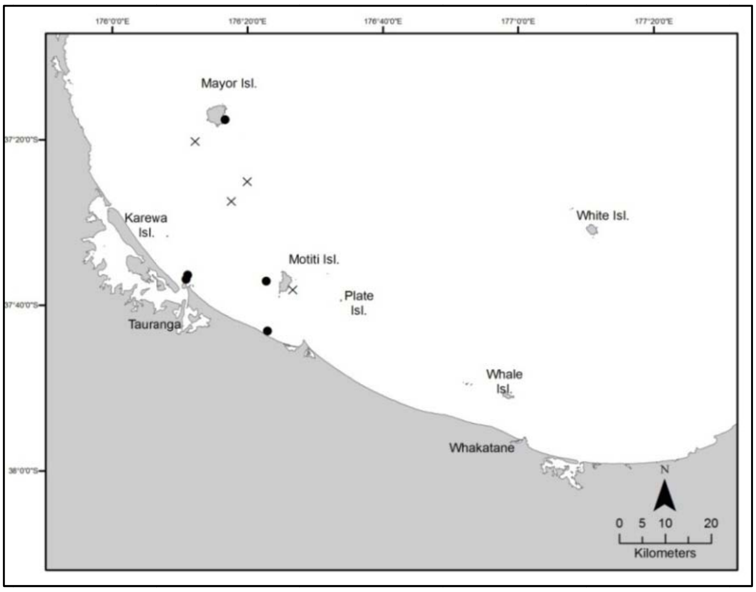

Figure 31: Location of encounters with bottlenose dolphin (●) and bottlenose dolphins associated with false killer whales (X) between November 2010 and May 2013, in the ECBOP, New Zealand.

1. Distribution and seasonality

Bottlenose dolphins were associated with false killer whales during 44.4% (n=4) of the observed encounters, occurring mainly in summer (88.9%, n=8, Table 7).

Table 7: Monthly summary of bottlenose dolphin (BD) and bottlenose dolphin and false killer whale (BD + FKW) encounters according to platform (RV=research vessel, TV=tour vessels), between November 2010 and May 2013, in the ECBOP, New Zealand. The number of focal follows conducted by the RV is shown in parentheses.

		BD					BD + FKW				
		RV	TV				RV	TV			
		A. Moana	G. Galaxsea	Guardian	Sub-total	Total	A. Moana	G. Galaxsea	Guardian	Sub-total	Total
2010											
2011	December						1 (1)				1
	January							1	1	2	2
2012	February		1		1	1	1 (1)				1
	June	1 (1)				1					
2013	February		1	2	3	3					
	Total	1 (1)	2	2	4	5	2 (2)	1	1	2	4

Bottlenose dolphins were typically found closer to the shore (mainland or islands) when alone (median=0.9km, SE=0.4, n=5), compared to when associated with false killer whales (median=9.6km, SE=3.4, n=4, Fig. 32), although this difference was not significant (Kruskal-Wallis: h=3.84, df=1, p=0.0500). Similarly, mono-specific bottlenose dolphin groups showed preference to near-shore waters when considering the mainland coastline (median=1.7km, SE=5.6, n=5), while bottlenose within poly-specific aggregations occurred further off-shore (median=21.7km, SE=3.1, n=4, Fig. 33). However, given one encounter occurred near Mayor Island (30km from the shoreline), this outlier renders the difference insignificant (Kruskal-Wallis: h=2.16, df=1, p=0.1416).

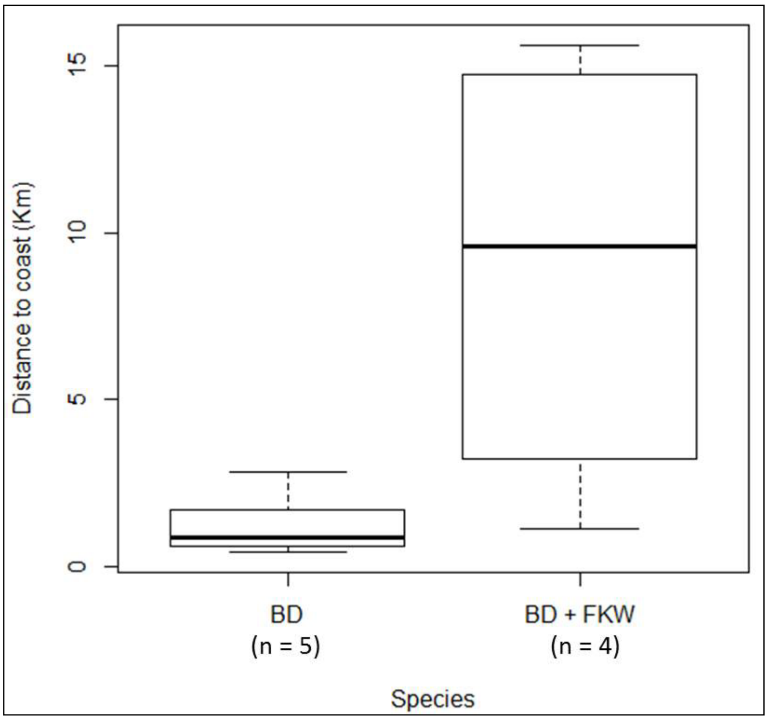

Figure 32: Distance (km) of encounters of bottlenose dolphins (BD) and bottlenose dolphins associated with false killer whales (BD + FKW) from shore (mainland or island), between November 2010 and May 2013, in the ECBOP, New Zealand. This boxplot represents the minimum depth, lower quartile (Q1 or 25th percentile), median, upper quartile (Q3 or 75th percentile), and maximum depth. FOR=foraging, MIL=milling, RES=resting, SOC=socialising, TRA=travelling.

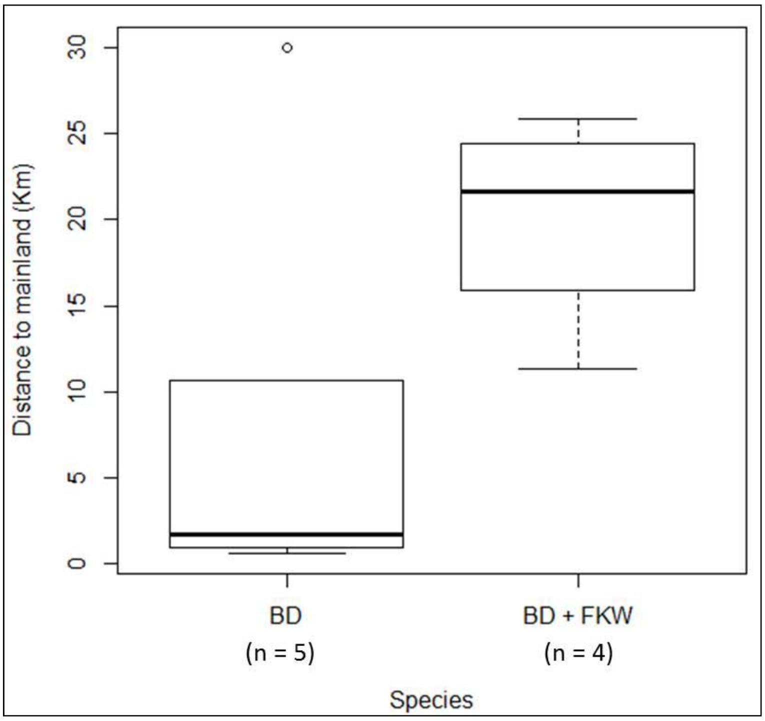

Figure 33: Distance (km) of encounters of bottlenose dolphins (BD) and bottlenose dolphins associated with false killer whales (BD + FKW) from mainland, between November 2010 and May 2013, in the ECBOP, New Zealand. This boxplot represents the minimum depth, lower quartile (Q1 or 25th percentile), median, upper quartile (Q3 or 75th percentile), and maximum depth. FOR=foraging, MIL=milling, RES=resting, SOC=socialising, TRA=travelling.

Bottlenose dolphins were encountered in shallower waters (median=13.1m, SE=6, n=5) when alone as compared to within poly-specific groups (median=73.3m, SE=14.2, n=4, Kruskal-Wallis: h=4.86, df=1, p=0.0275, Fig. 34).

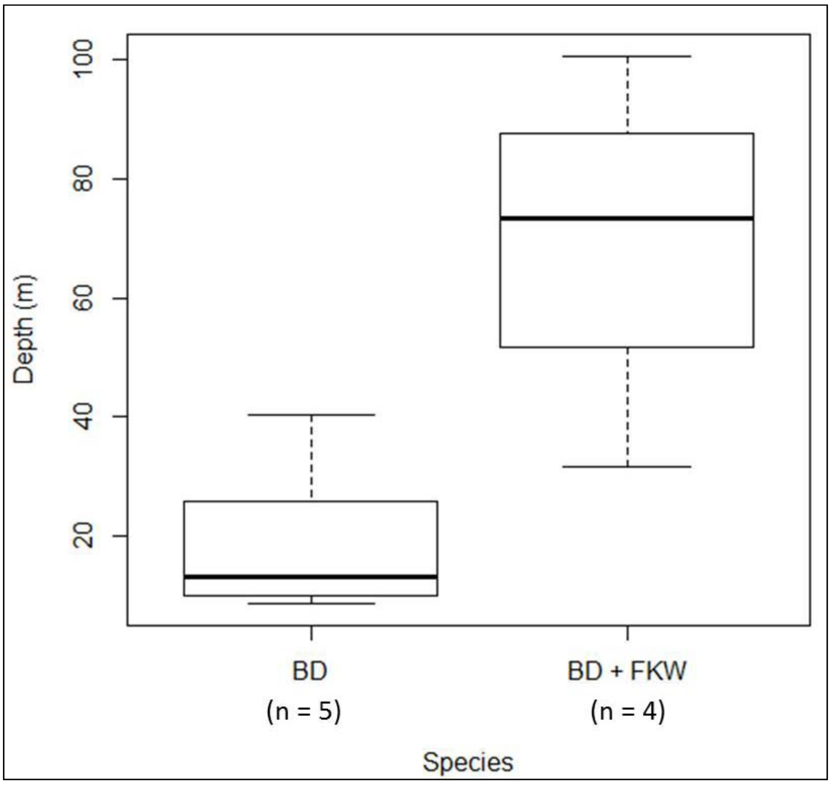

Figure 34: Water depth (m) of encounters of bottlenose dolphins (BD) and bottlenose dolphins associated with false killer whales (BD + FKW), between November 2010 and May 2013, in the ECBOP, New Zealand. This boxplot represents the minimum depth, lower quartile (Q1 or 25th percentile), median, upper quartile (Q3 or 75th percentile), and maximum depth. FOR=foraging, MIL=milling, RES=resting, SOC=socialising, TRA=travelling.

2. Group size

Group size of bottlenose dolphins ranged from singletons (n=2) to 40 individuals (n=1) (median=20, SE=7.8, n=5). Group size of bottlenose dolphins associated with false killer whales ranged from 30 to *ca.* 200 dolphins (median=137.5, SE=35.7, n=4, Fig. 35). Groups of bottlenose dolphins were significantly smaller than groups of bottlenose associated with false killer whales (Kruskal-Wallis: h=4.41, df=1, p=0.0358, Fig 35).

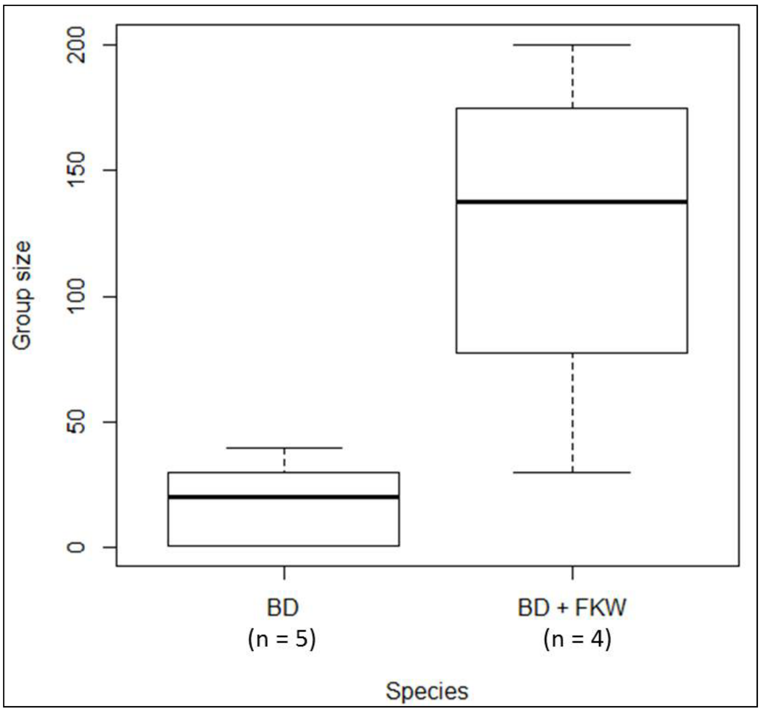

Figure 35: Group size of bottlenose dolphins (BD) and bottlenose dolphins associated with false killer whales (BD + FKW), between November 2010 and May 2013, in the ECBOP, New Zealand. This boxplot represents the minimum depth, lower quartile (Q1 or 25th percentile), median, upper quartile (Q3 or 75th percentile), and maximum depth. FOR=foraging, MIL=milling, RES=resting, SOC=socialising, TRA=travelling.

3. Group composition

Sixty percent of single species sightings (n=3) comprised adults only, though this includes sightings of singletons (n=2, Fig. 36). The other 40% (n=2) contained juveniles and/or juveniles and calves. No adult only groups of bottlenose dolphins were associated with false killer whales, with juveniles (n=1, 25%) or juveniles and calves (n=3, 75%) always being present.

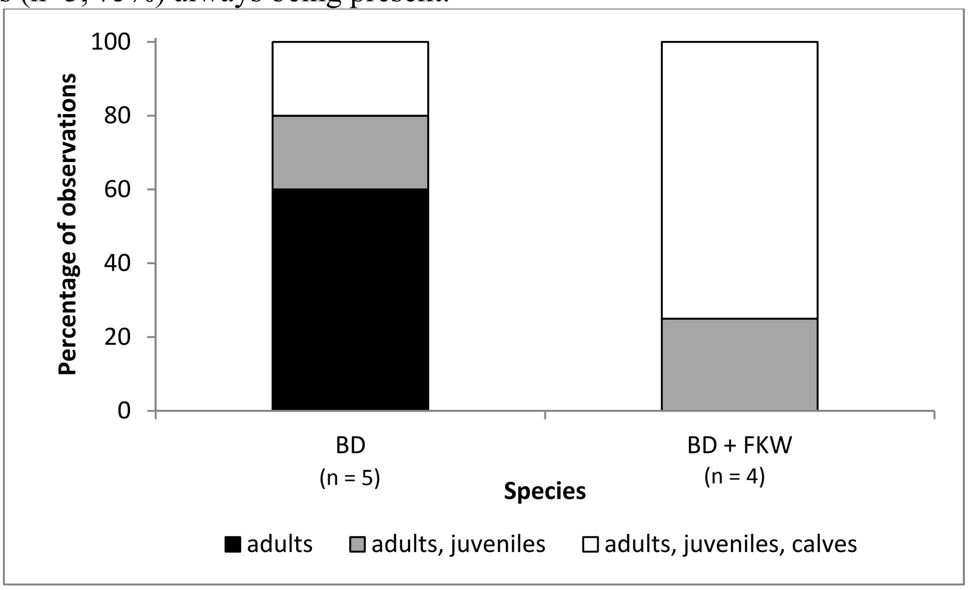

Figure 36: Group composition of bottlenose dolphins (BD) and bottlenose dolphins associated with false killer whales (BD + FKW), between November 2010 and May 2013, in the ECBOP, New Zealand.

4. Behaviour

Initial behavioural states of 66.7% (mono-specific n=3; poly-specific n=3) groups were recorded. Initial behavioural states were recorded 33.3% (n=2) and 66.7% (n=4) of the time aboard the RV and TV, respectively. However, given the limited sample size, data were pooled across both platforms for descriptive purposes only.

Foraging was the most frequently recorded behavioural state (42.9%, n=3), followed by travelling and milling (28.6%, n=2, respectively for both). Socialising or resting were never observed as initial behavioural states.

Mono-specific groups were found foraging and travelling during midday (1200-1359hrs, n=1, respectively for both), and milling in the morning (0800-0959hrs, n=1). Poly-specific groups were observed foraging in the morning and midday (0800-0959hrs: n=1, 1200-1359hrs, n=1), travelling in late morning (1000-1159hrs, n =1) and milling in the morning (0800-0959hrs, n=1).

Mono-specific groups of bottlenose dolphins were observed foraging and milling close to the shore and in shallow waters (0.5km, 26m deep, n=1 and 0.6km, 10m, n=1, respectively). Bottlenose dolphins associated with false killer whales were observed foraging both in neritic and pelagic waters (1.1km, 31.6m deep, and 15.6km, 71.8m deep, respectively), while travelling and milling occurred in deep offshore waters (13.8km, 100.5m deep, and 15.6km, 71.8m deep, respectively).

5. Effects of vessel interaction on bottlenose dolphin activity budget

Only three focal follows were undertaken on bottlenose dolphins, making results presented here descriptive only. The first, involving bottlenose dolphins associated with false killer whales (09/12/11), lasted 217min *i.e.* 3.62hrs, and covered 33.2km of effort. Dolphins were monitored in *control* (64min, *i.e.* 1.07hrs), *interaction* with a commercial TV (30min), and in *post-interaction* conditions (117min, *i.e.* 1.95hrs). The second focal follow (09/02/12) was a *control* sequence following bottlenose dolphins also associated with false killer whales and lasted 84min *i.e.* 1hr 24min covering 13.1km *on effort*. The third focal follow (17/06/12) monitored a mono-specific group in *control* (6min), *interaction* with eight non-TV (36min), and in *post-interaction* sequences (81min, *i.e.* 1.35hrs), covering a distance of 23.9km on effort. Clearly these three follows at best, offer a very limited insight to effects of vessel interactions on bottlenose dolphins.

Out of these three focal follows, six sequences were obtained, of which 33.3% (n=2) were *control* and 66.7% (n=4) were *interaction* sequences. This corresponds to a total of 82 behavioural transitions, of which 59.8% (n=49) were *control* and 40.2% (n =33) were *interaction* transitions. Socialising was only observed on one occasion, while resting was not observed during any follow. These two behavioural states were therefore not considered in the analysis. Consequently, transitions were recorded only between the three behavioural states: foraging, milling and travelling.

Under *control* conditions, bottlenose dolphins spent 51% (n=25) of the time foraging, 22.4% (n=11) milling, and 26.5% (n=13) travelling (Fig. 37). Under *interaction* conditions, bottlenose dolphins spent 12.1% (n=4) of the time foraging, 6.1% (n=2) milling, and 81.8% (n=27) travelling (Fig. 37). While behaviour was significantly different under *control* and *interaction* conditions (Pearson's $\chi 2$: χ 2 =24.1, df=2, p=5.744^{e-06}), this likely was affected by the very small sample size and thus, should be interpreted with caution.

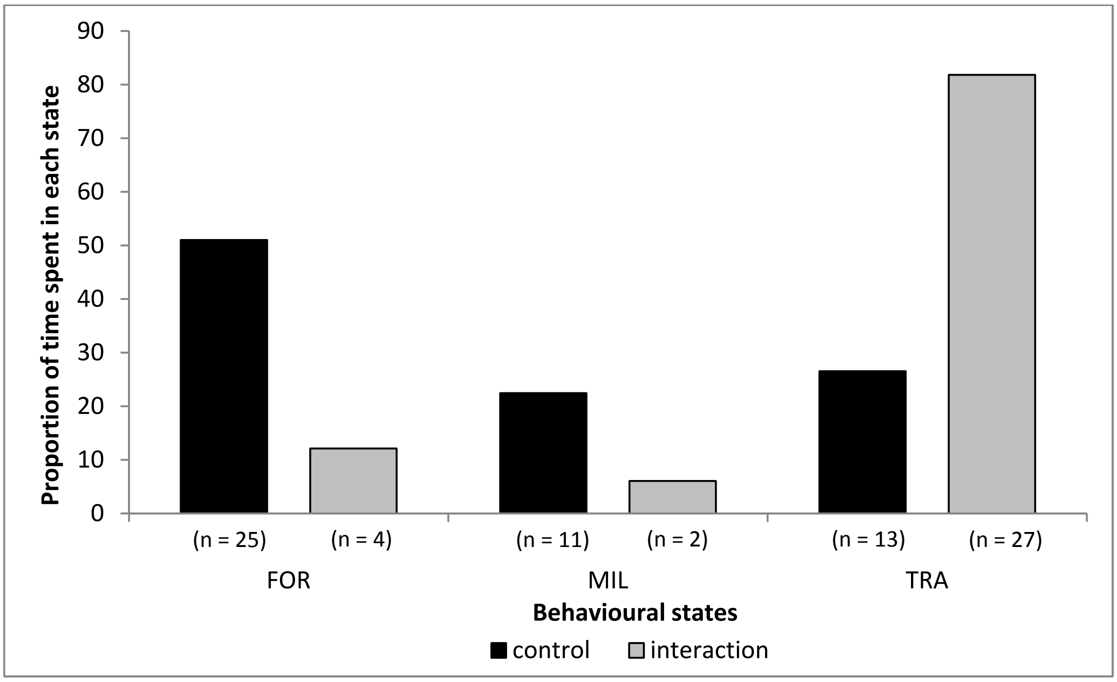

Figure 37: Proportion of time bottlenose dolphins spent in each behavioural state under *control* and *interaction* conditions (*interaction* + *post-interaction* sequences), between November 2010 and May 2013, in the ECBOP, New Zealand. FOR=foraging, MIL=milling, TRA=travelling.

Regardless of the preceding behavioural state, the most probable succeeding state remained consistent under *control* and *interaction* conditions (Fig. 38). When in the presence of interacting vessels, bottlenose dolphins were not observed to change from milling to either foraging or travelling, nor were they observed changing from travelling to foraging or foraging to milling (Fig. 38). However, the small sample size again somewhat constrains interpretation of these results.

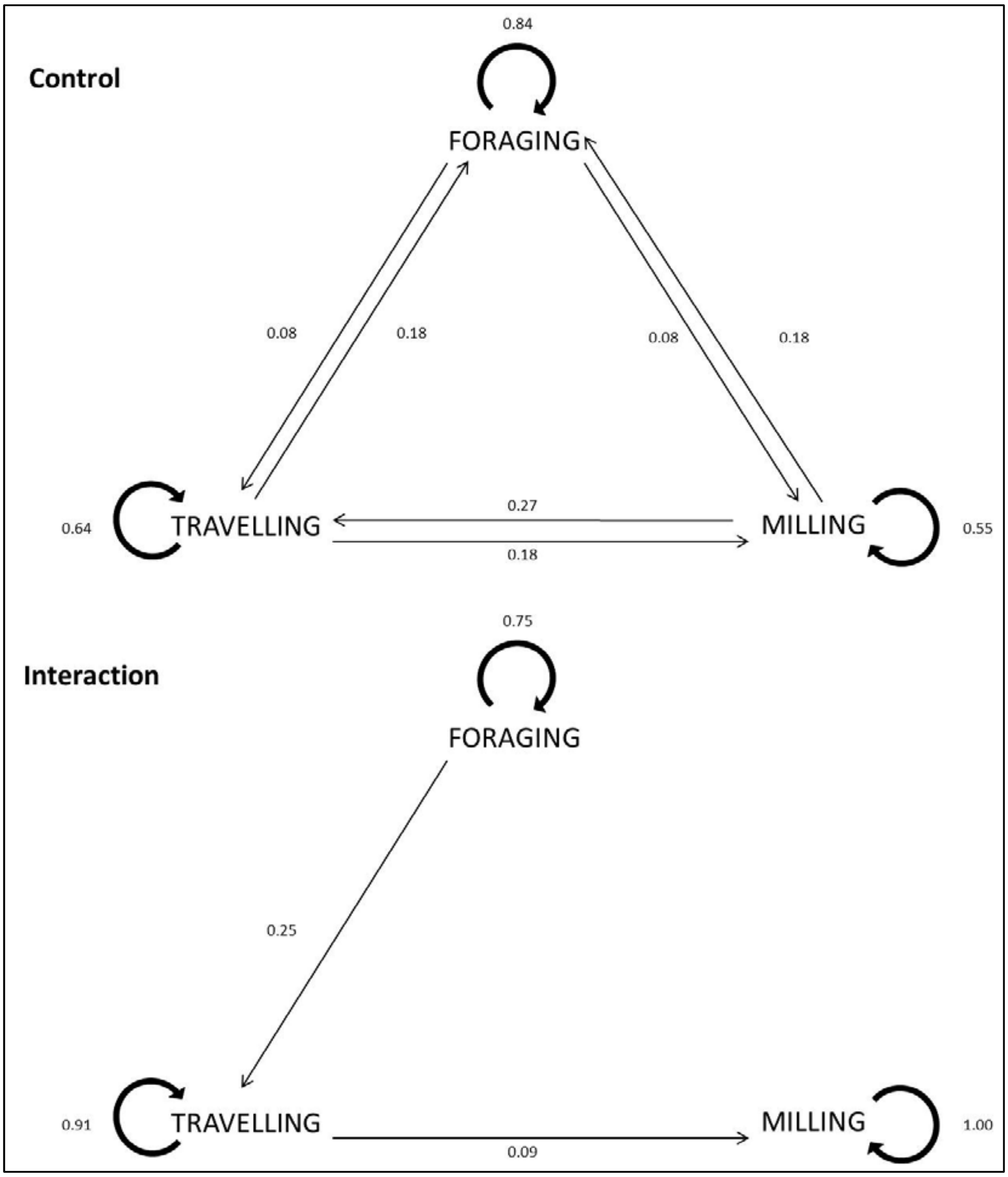

Figure 38: Transition probabilities in *control* and *interaction* (*interaction* + *post-interaction* sequences) chains. Values represent transition probabilities.

Given the limited number of sightings, Markov chain analysis could not be applied to the bottlenose dolphin dataset.

6. Site fidelity

Approximately 6,000 digital images were taken during encounters with bottlenose dolphins. In total, 70 oceanic individuals were identified during three encounters, 50% (n=35) of these previously or subsequently observed in Far North waters. From the mono-specific groups, 79 and 26 individuals have been identified in 2012 and 2013 encounters, respectively. Out of these, 92.4% (n=73) and 65.4% (n=17) have previously or subsequently been sighted in Great Barrier Island and Bay of Islands, of which only one individual was re-sighted across both encounters (Dwyer *et al.*, *in review*).

E. Dolphin tourism in the ECBOP

Interactions between vessels and dolphins were monitored aboard the RV during 58 focal follows (55 and three following common and bottlenose dolphin groups, respectively), and during 267 surveys aboard the TV (256 and six interactions with common and bottlenose dolphin groups, respectively).

1. Levels of vessel traffic

1.1. Type of interacting vessels and their presence around the dolphins

During 55 common dolphin focal follows from the RV, TV and non-TV interacted with dolphins on 63.6% occasions (n=35). More specifically, 45.7% (n=16) involved both types of vessel, 31.4% (n=11) involved only TV, and 22.9% (n=8) involved only non-TV.

Out of the 7,634min (*i.e.* 127.23hrs) of focal follows, common dolphins were observed in the presence of vessels during 21% of the time (1,604min, *i.e.* 26.73hrs), of which 6% (459min, *i.e.* 7.65hrs) with TV only, 1.7% (133min, *i.e.* 2.22hrs) with non-TV only, and 13.3% (1,012min, *i.e.* 16.87hrs) with both types of vessel (Fig. 39).

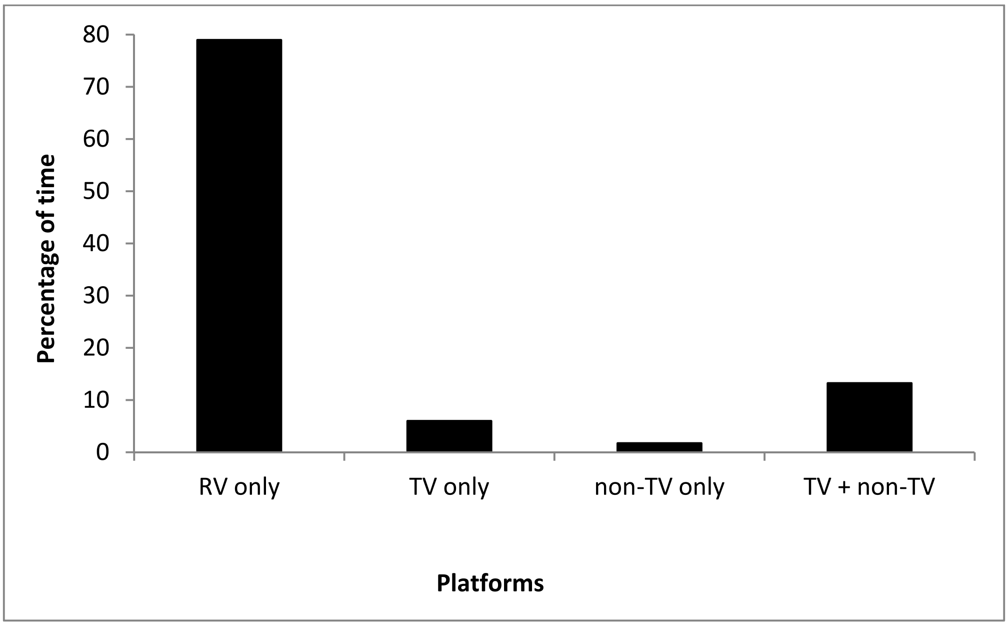

Figure 39: Percentage of time different platforms (RV: research vessel, TV: tour vessels, non-TV: non-tour vessels, both types of vessels: TV + non-TV) were present around common dolphins during 35 focal follows, from November 2010 and May 2013, in the ECBOP, New Zealand.

Common dolphin focal groups spent between one and 140 minutes (n=35) of cumulative time in the presence of vessels. Dolphins spent significantly more time in the presence of TV (min=5min, max=94min, median=45min, n=11) than in the presence of non-TV (min=1min, max=86min, median=9min, n=8) (Kruskal-Wallis: h=5.170, df=1, p=0.02, Fig. 40). When both vessel types interacted with a focal group, the cumulative duration extended (min=4min, max=140min, median=45min, n=16).

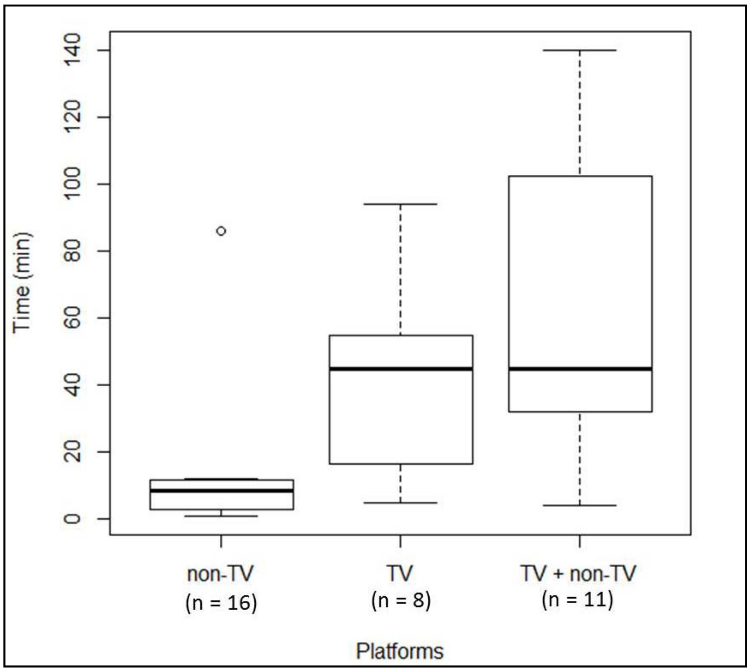

Figure 40: Boat presence (min) around a single focal group of common dolphins, according to the type of vessels, between November 2010 and May 2013, in the ECBOP, New Zealand. This boxplot represents the minimum depth, lower quartile (Q1 or 25th percentile), median, upper quartile (Q3 or 75th percentile), and maximum depth. FOR=foraging, MIL=milling, RES=resting, SOC=socialising, TRA=travelling.

Out of three bottlenose dolphin focal follows, one TV interacted with bottlenose dolphins and false killer whales (33.3%, n=1), while eight non-TV interacted with a mono-specific bottlenose dolphins (33.3%, n=1). One further focal follow on a poly-specific group occurred in the presence of the RV only.

During the 433min (*i.e.* 7.22hrs) of focal follows, bottlenose dolphins were observed in the presence of boats for 16.6% of the time (72min), of which 7.6% involved TV (33min) and 9% non-TV (39min, Fig. 41).

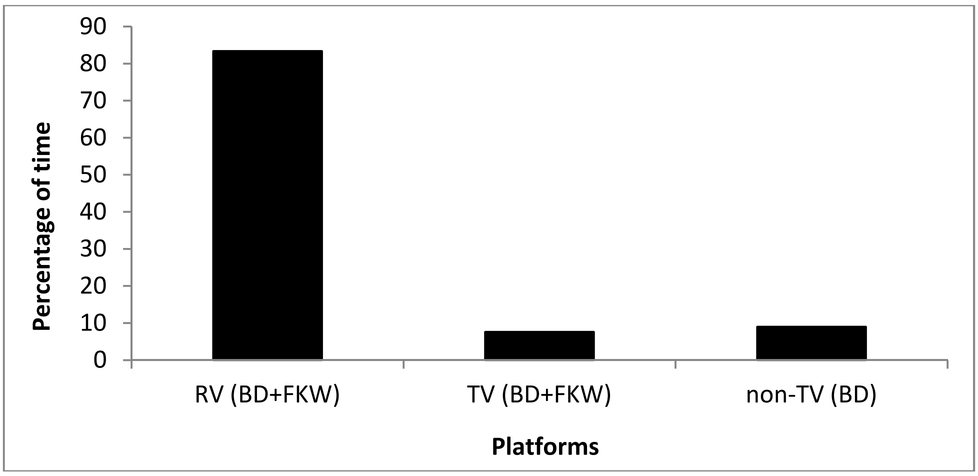

Figure 41: Percentage of time different platforms (RV: research vessel, TV: tour vessels, non-TV: non-tour vessels) were present around bottlenose dolphins (BD) and bottlenose dolphins associated with false killer whales (BD + FKW) during three focal follows, between November 2010 and May 2013, in the ECBOP, New Zealand.

Out of these three focal follows, the TV interacted with the group of bottlenose dolphins and false killer whales for 34min. Non-TV spent a cumulative time of 39min with the mono-specific group of bottlenose dolphins (min=1min, max=32min, median=1min, n=8).

1.2. Interaction time per vessel

Out of the 186 interactions with common dolphins, the RV arrived after (11.3%, n=21) and departed prior to (1.6%, n=3) the interacting vessels, resulting in 12.9% (n=24) of the duration being underestimated, and therefore removed from further analysis. TV spent significantly more time with a group of common dolphins (min=4min, max=89min, median=37min, n=23) than non-TV (min=1min, max=24min, median=1min, n=139) (Kruskal-Wallis: h=55.31, df=1, p < 0.001, Fig. 42).

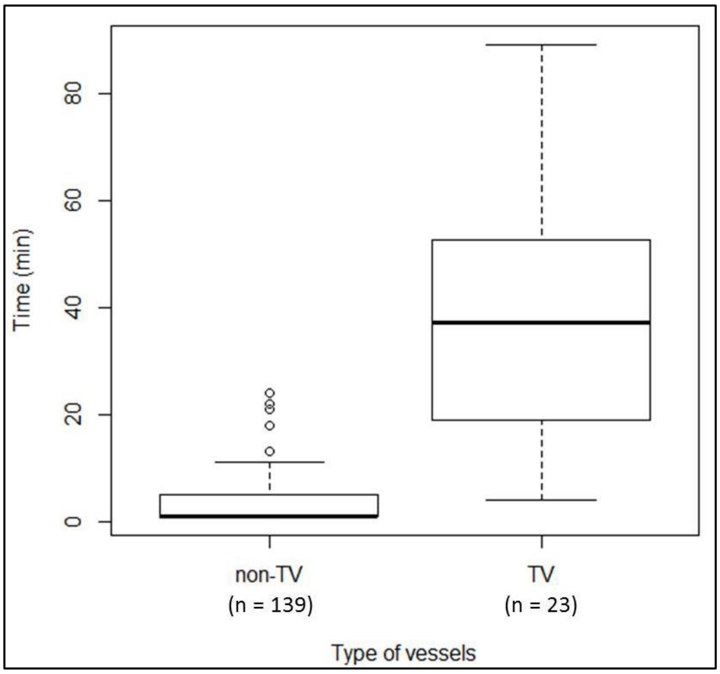

Figure 42: Total time (min) each vessel interacted with a common dolphin group (TV=tour vessels, non-TV=non-tour vessels), between November 2010 and May 2013, in the ECBOP, New Zealand. This boxplot represents the minimum depth, lower quartile (Q1 or 25th percentile), median, upper quartile (Q3 or 75th percentile), and maximum depth. FOR=foraging, MIL=milling, RES=resting, SOC=socialising, TRA=travelling.

When following bottlenose dolphins, the RV arrived before and departed after any interacting vessel. Only one TV interacted with bottlenose dolphins and false killer whales for 34min (Fig. 43). Non-TV generally passed through the area and spent little time engaged with the bottlenose dolphins (median=1min, SE=3.8, n=8), although a single sea kayak followed the dolphins for 32min (Fig. 43).

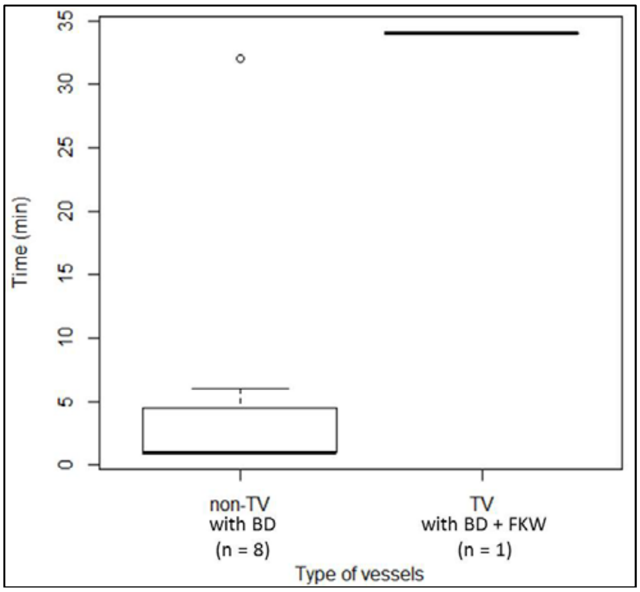

Figure 43: Time different platforms (TV=tour vessels, non-TV=non-tour vessels) interacted with bottlenose dolphins (BD) and bottlenose dolphins associated with false killer whales (BD + FKW) during two focal follows, between November 2010 and May 2013, in the ECBOP, New Zealand.

Out of 267 trips aboard the TV, a total of 256 common and six bottlenose dolphin groups were encountered during 175 and 6 surveys, respectively. TV spent between one to 148min with a group of common dolphins (median=40.5min, n=256). They spent five to 102 min (median=30min, n=4), and 71 to 169min (n=2), with a group of bottlenose dolphins and bottlenose dolphins associated with false killer whales, respectively. Overall, TV engaged for between one and 169 min with cetaceans per trip (median=63min, n=187), exceeding the maximum time of 90 min per trip 21.8% of the time (n=41, Fig. 44). The majority (92.7%, n=38) of the non-compliance applied to trips for which only common dolphins were encountered. The remaining applied to trips with common dolphins and killer whales (2.4%, n=1), bottlenose dolphins (2.4%, n=1), and bottlenose dolphins associated with false killer whales (2.4%, n=1).

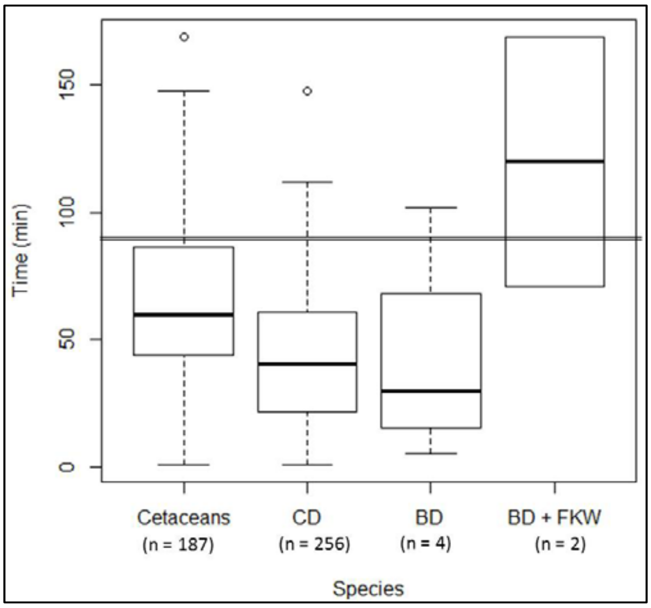

Figure 44: Time (min) spent by TV with cetaceans (per day), common dolphins (CD) (per group), bottlenose dolphins (BD) or bottlenose dolphins associated with false killer whales (BD + FKW) (per group), between November 2010 and May 2013, in the ECBOP, New Zealand. This boxplot represents the minimum depth, lower quartile (Q1 or 25th percentile), median, upper quartile (Q3 or 75th percentile), and maximum depth. FOR=foraging, MIL=milling, RES=resting, SOC=socialising, TRA=travelling.

1.3. Total number of vessels interacting with a focal group

During 80% (n=28) of the focal follows, between one and three vessels interacted with a focal group of common dolphins (Fig. 45). Four or more vessels approached the remaining 20% (n=7) of dolphin groups, of which a maximum of 31 and 61 vessels, including TV, were observed when dolphins were inside Tauranga harbour.

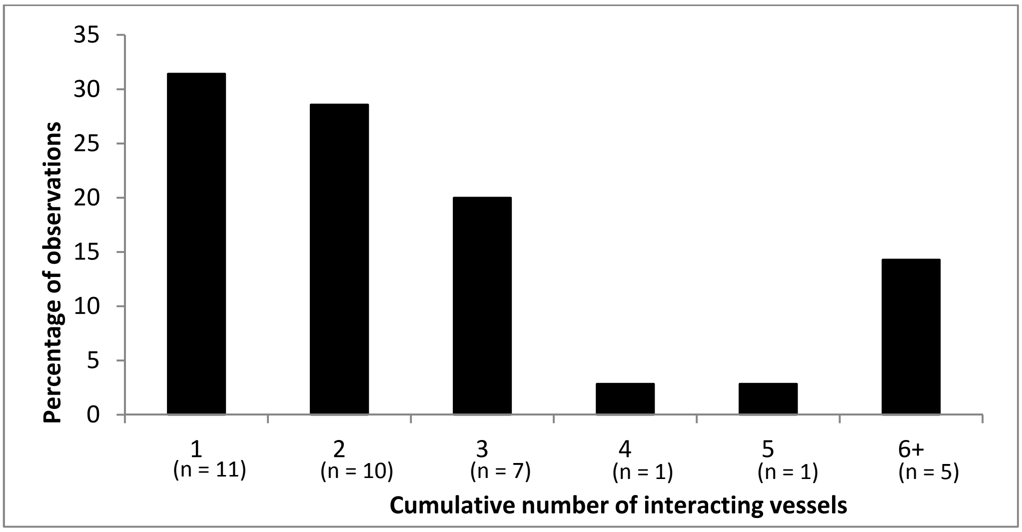

Figure 45: Total number of vessels interacting with common dolphins during a single focal follow, between November 2010 and May 2013, in the ECBOP, New Zealand.

Out of the three focal follows on *Tursiops*, a total number of one TV and eight non-TV were observed interacting with a focal group.

1.4. Number and types of vessels interacting simultaneously with the dolphins

Out of the 35 common dolphin groups subject to vessel interaction, 42.9% (n=15) were approached simultaneously by two or more vessels (Table 8). Overall, 29 simultaneous independent interactions were reported. The majority (75.9%, n=22) involved two or three vessels. The remaining 24.1% (n=7) involved four or more vessels, including TV arriving after three non-TV vessels were already within 300m of the dolphins.

Table 8: Number and type of vessels simultaneously interacting with a single group of dolphins, between November 2010 and May 2013, in the ECBOP, New Zealand. The double line represents the maximum amount of three vessels of any type allowed within 300m of a group of dolphins (MMPR, 1992). (TV=tour vessel, non-TV=non-tour vessel, both types of vessels = TV+non-TV).

	Common dolphins			Bottlenose dolphins
	Type of vessels			
Number of vessels simultaneously interacting	TV only	Non-TV only	Both types of vessels	Non-TV only
2	2	2	11	1
3	1	2	4	1
4		2		1
5		1	1	
6		1	1	
7		1		

Out of the two bottlenose dolphin groups subject to vessel interaction, only one was approached by several vessels, which were all non-TV. Overall, vessels interacting simultaneously with *Tursiops* were reported three times (Table 8). Moreover, a maximum of four vessels interacted simultaneously with this group at the entrance of Tauranga harbour.

1.5. Number of approaches per vessel

During the 35 focal follows, 186 vessel-common dolphin interactions were observed. TV mainly approached dolphins once (88.6%, n=39), and have only been observed interacting up to twice with the same focal group (11.4%, n=5, Fig. 46). Similarly, non-TV mainly approached dolphins primarily once (90.1%, n=128), although did approach the same focal group twice (9.2%, n=13) or up to four times (7.0%, n=1, Fig. 46).

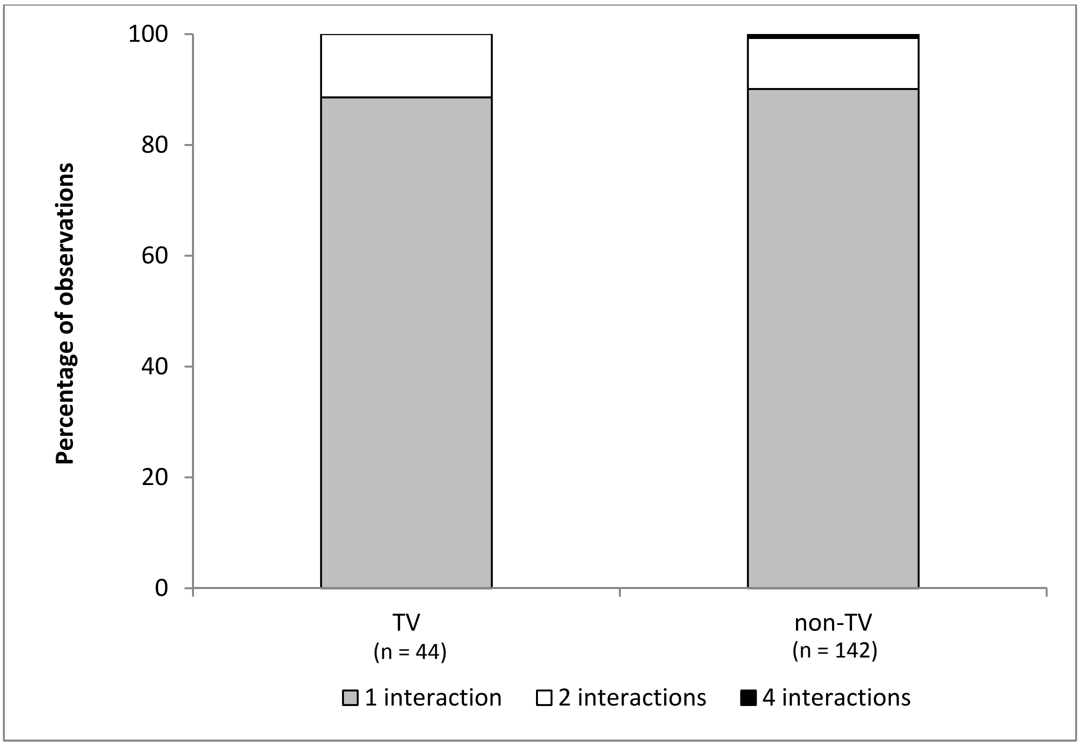

Figure 46: Percentage of common dolphin approaches according to platform (TV=tour vessels, non-TV=non-tour vessels), between November 2010 and May 2013, in the ECBOP, New Zealand.

A total of nine approaches were monitored for bottlenose dolphins, of which 11.1% (n=1) were from a TV and 88.9% (n=8) from a non-TV. Both vessel types approached dolphins only once.

1.6. Vessel speed

Vessel types travelled at significantly different speeds (Kruskal-Wallis: h=76.0817, df=5, p<0.001, Fig. 47) when within 300m of dolphin groups. Non-motorised vessels, such as kayaks, stand up paddleboards or rowing craft, were the slowest (mean =2.4kts, max=4kts, n=12). These were followed by commercial vessels (mean =8.0kts, max=25, n=19). The fastest vessels were inboard motor powered launches (mean =11.5kts, max=27kts, n=20), outboard motor powered trailer boats (mean =11.5kts, max=25, n=71), and personal craft/jet skis (mean=14.3kts, max=25, n=3). TV generally travelled around the “no wake” speed (mean =5.3kts, n=275), although the highest speed observed was 10.0kts.

The “no wake” speed (*ca*. 5kts) was exceeded 51.3% of the time (n=141) by TV, 63.2% (n=12) by commercial non-TV, 90.0% (n=18) by inboard motor powered launches, 76.0% (n=54) by outboard motor powered trailer boats, and 66.7% (n=2) by personal craft (jet skis). Non-motorised vessels always travelled under 5kts.

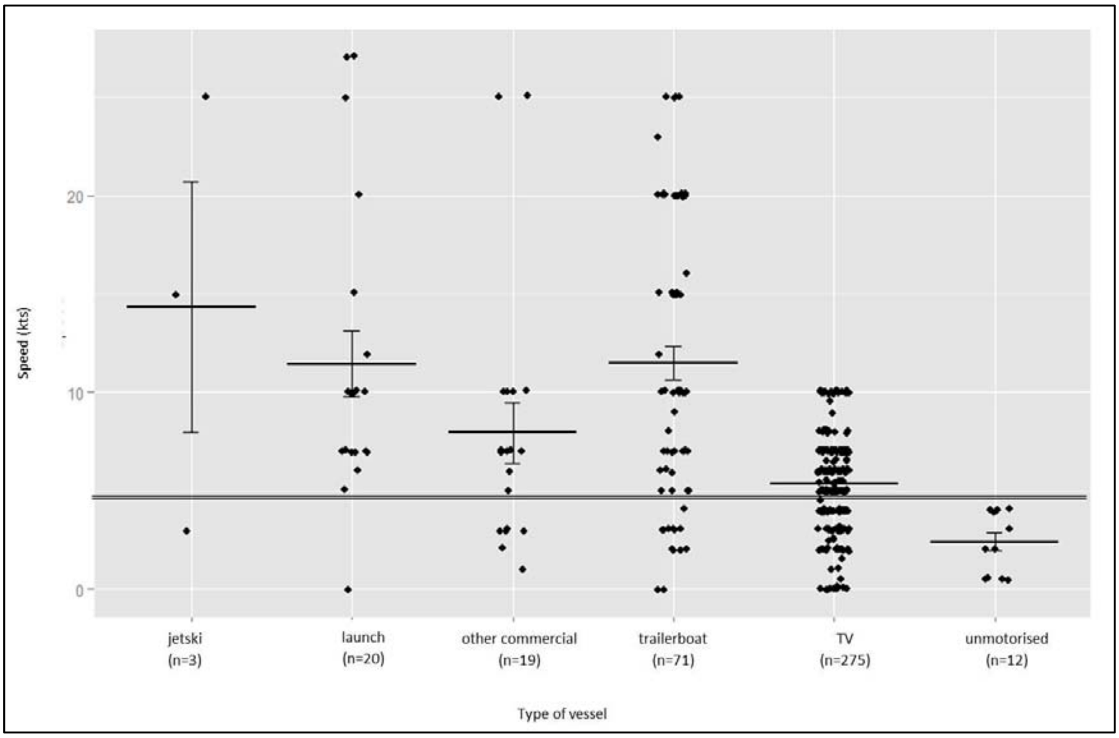

Figure 47: Speed (kts) of tour vessels (TV) and non-tour vessels (non-TV, *i.e.* launches, trailer boats, other commercial vessels, jet skis and non-motorised craft) within 300m of common dolphins, between November 2010 and May 2013, in the ECBOP, New Zealand. Means and standard errors are presented for each type of vessels. The double line represents the 5kts limit speed, which corresponds to the "no wake" speed permitted within 300m of any dolphin (MMPR, 1992).

When interacting with bottlenose dolphin, non-motorised vessels (*i.e.* a single kayak) were the slowest (mean=4kts, max=4kts, n=1, Fig. 48). The fastest vessel types were launches (mean=12.6kts, max=18kts, n=5) and trailer boats (mean=18.3, max=20, n=3). One TV interacting with *Tursiops* recorded an average speed of 4.13kts (max=4.13kts, n=1). Differences in speed according to vessel type were significant (Kruskal-Wallis: h= 19.6857, df=3, p<0.001).

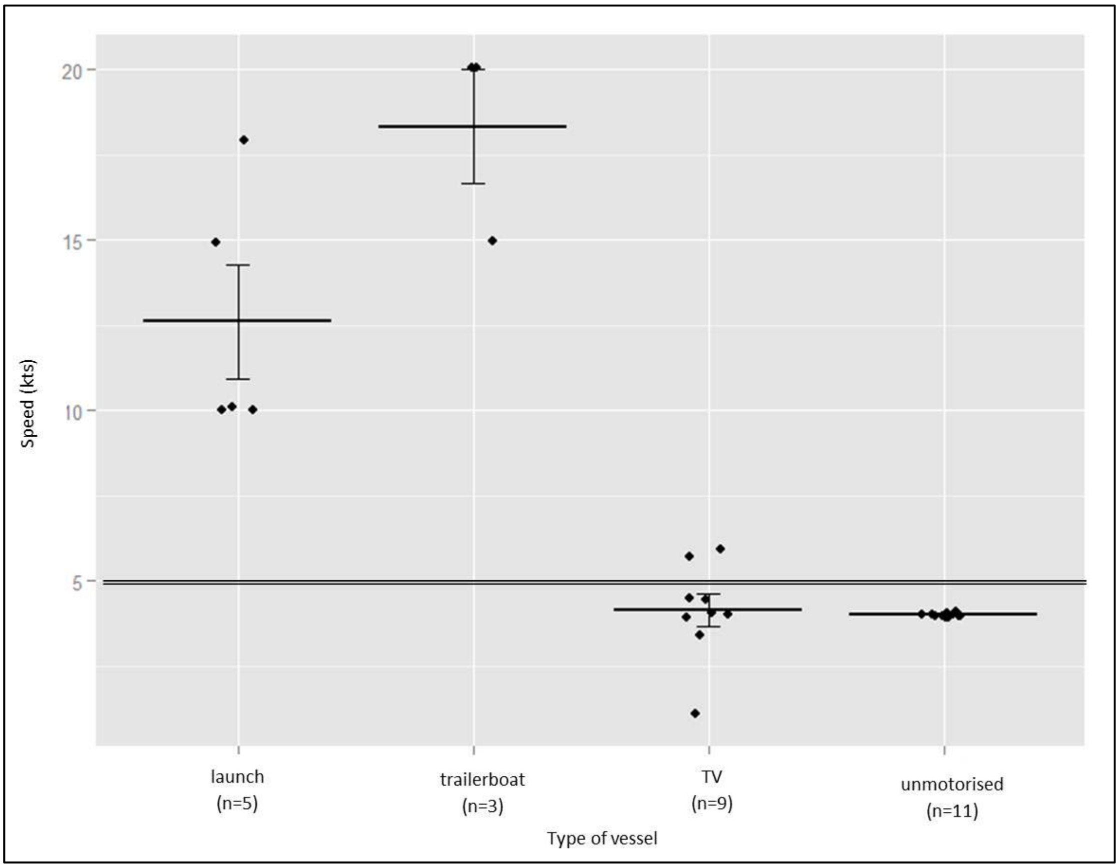

Figure 48: Speed (kts) of tour vessels (TV) and non-tour vessels (non-TV, *i.e.* launches, trailer boats, and non-motorised craft) within 300m of bottlenose dolphins, between November 2010 and May 2013, in the ECBOP, New Zealand. Means and standard errors are presented for each type of vessel. The double line represents the 5kts limit speed, which corresponds to the "no wake" speed permitted within 300m of any dolphin (MMPR, 1992).

2. Swimming with the dolphins

Twenty six swim attempts (exclusively common dolphins) were monitored during 12 swim encounters from the RV. Additionally, 73 swim attempts during 26 swim encounters were monitored from aboard the TV. The majority of the latter swims (91.8%, n=67) occurred with common dolphins. Only one swim encounter (six swim attempts, 8.2%) occurred with bottlenose dolphins. Swimmers were usually advised not to splash when entering the water but encouraged to make noise in their snorkel in an attempt to attract and maintain attention of the dolphins.

2.1. Type of vessels

During the 12 swim encounters with common dolphins monitored from the RV, swimmers were primarily deployed by the TV (n=10, 83.3%), although recreational boats (*i.e.* trailer boat) dropped single swimmers on two different independent occasions (16.7%). Generally, TV skippers piloted their vessel slowly (1-2kts) while swimmers held on to the swim bars or the mermaid line or occasionally engines were placed into idle when the swimmers were snorkelling.

2.2. Number of swim attempts and number of swimmers

Under their permit conditions, operators must restrict the number of swim attempts to a maximum of eight per trip and the number of swimmers to a maximum of ten per swim attempt. Different swim groups were organised by the crew if more than ten swimmers were aboard the vessel. Occasionally, swimmers would rotate during the same swim attempt (*i.e.* one or several swimmers would get back aboard the vessel, allowing others to enter the water, while other swimmers remained in the water throughout).

During 12 swim encounters with common dolphins monitored from the RV, a maximum number of ten swimmers were placed in the water at the same time. A maximum number of three swim attempts occurred per swim encounter. However, because new swimmers were usually deployed while previous ones were still getting out of the water, distinguishing between distinct swim attempts was not possible, and they were therefore counted as a single swim attempt. The number of swim attempts is an underestimate due to the TV starting a swim attempt after the RV had arrived on site on 50% of occasions (n=6).

When common dolphin swims were monitored from aboard the TV, a majority (60%, n=15) of two and a maximum of seven (4%, n=1) swim attempts per swim encounters were observed, respectively (Fig. 49). The majority (97%, n=65) of those swim encounters involved a maximum of ten swimmers (Fig. 50). However, on two occasions (3%), the maximum permitted limit of ten swimmers was exceeded.

Four to five swimmers were placed in the water during the encounter with bottlenose dolphins.

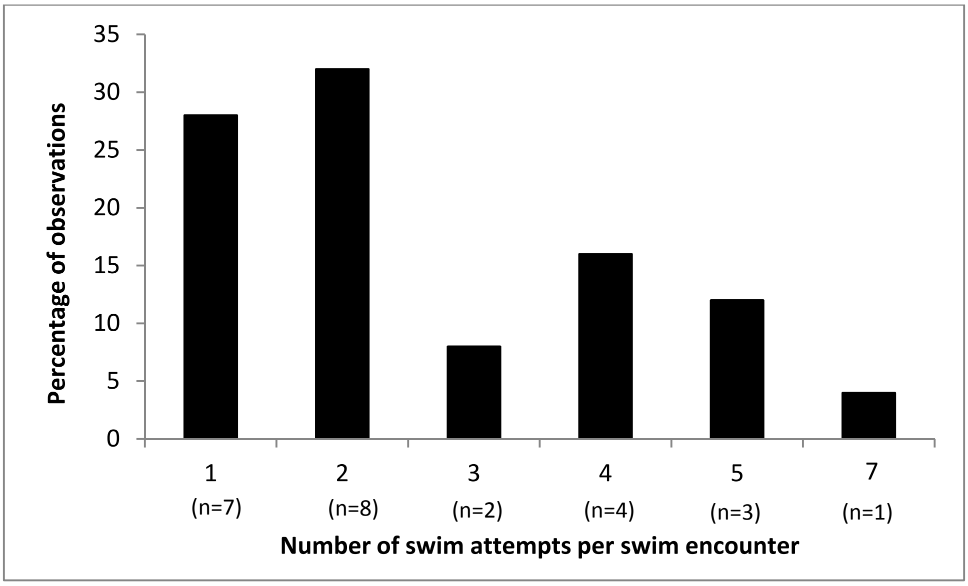

Figure 49: Number of swim attempts per swim encounter with common dolphins, as monitored from aboard the tour vessels, between November 2010 and May 2013, in the ECBOP, New Zealand.

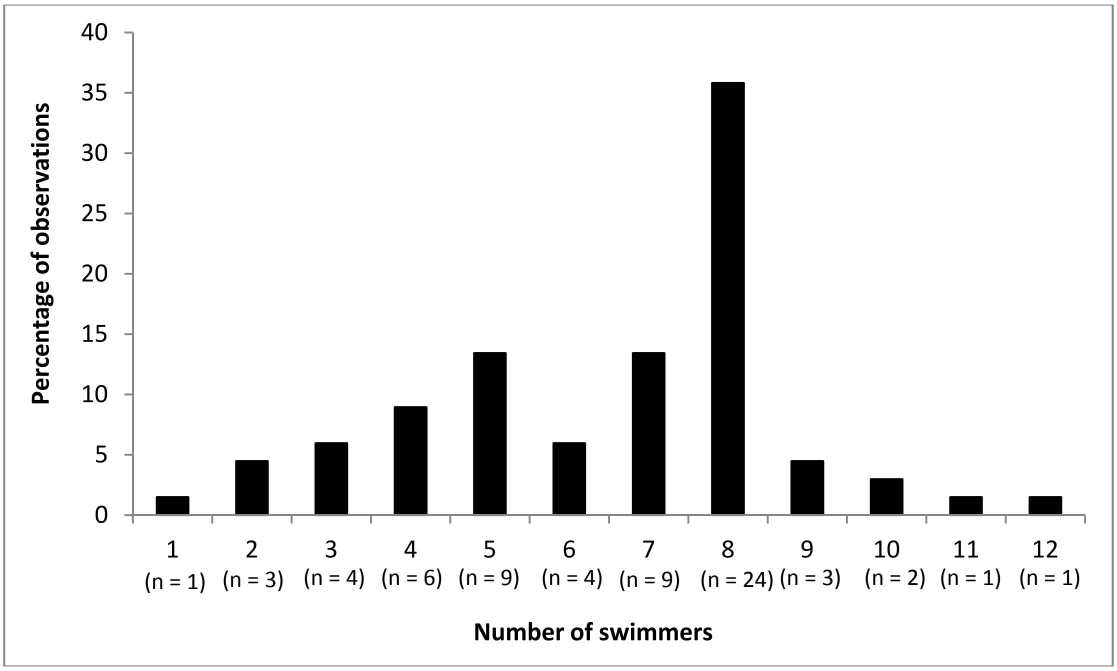

Figure 50: Number of swimmers per swim attempt with common dolphins, as monitored from aboard the tour vessels, between November 2010 and May 2013, in the ECBOP, New Zealand.

2.3. Swim techniques

During swim attempts with common dolphins monitored from the RV, swimmers used swim bars (66.7%, n=10), a mermaid line (6.7%, n=1) or free swam (26.7, n=4) amongst the dolphins.

For swim attempts monitored aboard the TV, swimmers used swim bars (89.1%, n=57), mermaid lines (4.7%, n=3) or free swam (6.3%, n=4). Swimmers always used swim bars (100%, n=6) when swimming with bottlenose dolphins.

2.4. Duration

Under their permits conditions, operators are restricted to 90min of interaction with dolphins per trip, of which 60min can be used to swim with common and/or bottlenose dolphins. The time spent in the water by a group of swimmers was assessed for 91% (n=61) of the common dolphin swim encounters monitored aboard the TV. On average, swims lasted 5.15min (SD=3min 56sec, n=61). The majority of swims (59.0%, n=36) lasted less than five minutes, while a small proportion (11.5%, n=7) lasted more than ten minutes (Fig. 51). The swims with bottlenose dolphins lasted average of 2.5min (SD=27sec, n = 6).

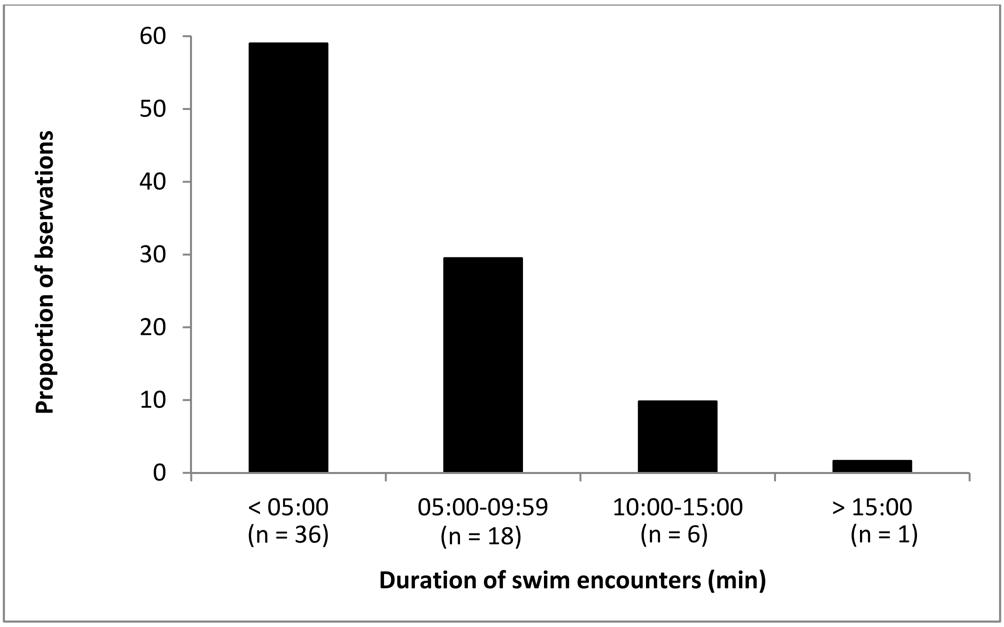

Figure 51: Duration (min) of common dolphin swim encounters monitored from aboard the tour vessels, between November 2010 and May 2013, in the ECBOP, New Zealand.

2.5. Presence of other vessels in the vicinity of the swimmers

During 33.3% of the time (n=4) that swim encounters were monitored from the RV, another vessel (recreational or fishing charter boat) was within 300m of the swimmers. Out of the 73 swim attempts monitored aboard TV, other vessels were present within 300m of the TV during 21.9% (n=16) of the time and within 1km 8.2% (n=6) of the time.

2.6. Group size and composition

Group size was recorded aboard the TV during 35 swim encounters with common dolphins. The majority (77.1%, n=27) of swims occurred with small groups (1-10 individuals), containing only adults (Fig. 52). Twenty percent (n=7) of the swims occurred with larger groups (11-30 individuals) containing adults and juveniles, and on one occasion calves. Only one swim encounter (2.9%) occurred with a group larger than 200 individuals containing adults, juveniles and calves. Tourists swam only once with a small group of eight adult bottlenose dolphins.

Out of the 12 swim encounters monitored from the RV, calves were observed in the group prior, during or after the swim during 83.3% of the time (n=10: TV n=9, recreational boat n=1), in contravention to the MMPR (1992). Juveniles were present during all 12 swim encounters.

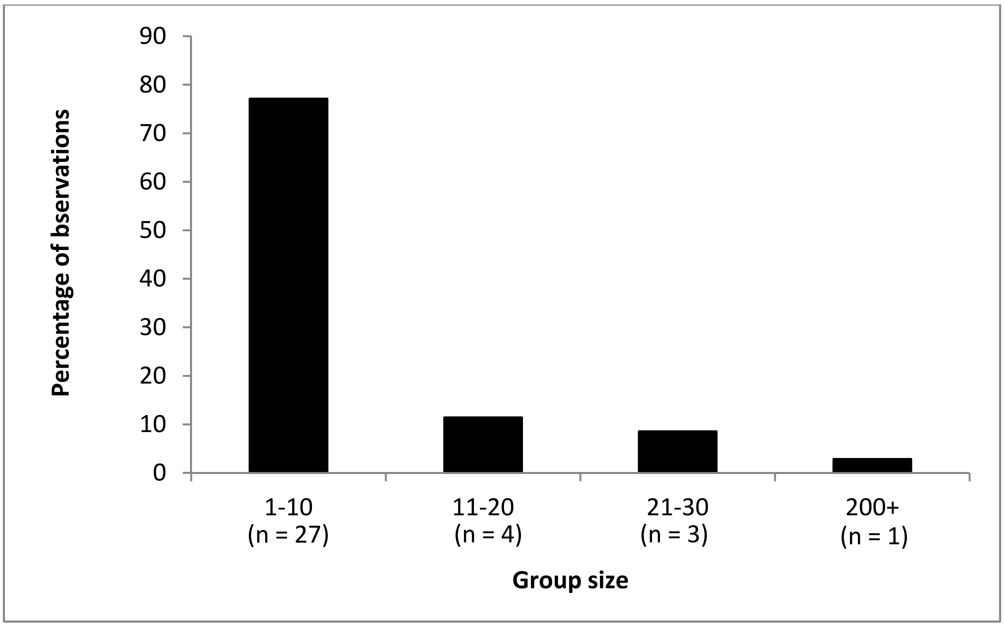

Figure 52: Common dolphin group size during swim encounters monitored from aboard the tour vessel, between November 2010 and May 2013, in the ECBOP, New Zealand.

2.7. Dolphin reaction to swimmers

Behaviour of common dolphins in the presence of swimmers was monitored from aboard the TV during 37 swim attempts. Generally, there was no observable change in the behavioural state when swimmers were present (56.8%, n=21). However, during 32.4% (n=12) of observations, common dolphins approached the swimmers, while during 10.8% (n=4) of the observations, dolphins avoided the swimmers.

2.8. Dolphin behavioural state

Swimmers were placed in the water when common dolphins were travelling (34%, n=17), foraging (26%, n=13), socialising (22%, n=11) or milling (18%, n=9). Swimmers were not observed entering the water when common dolphins were resting (Fig. 53). During the only encounter with bottlenose dolphins, swimmers were placed in the water while dolphins engaged in foraging.

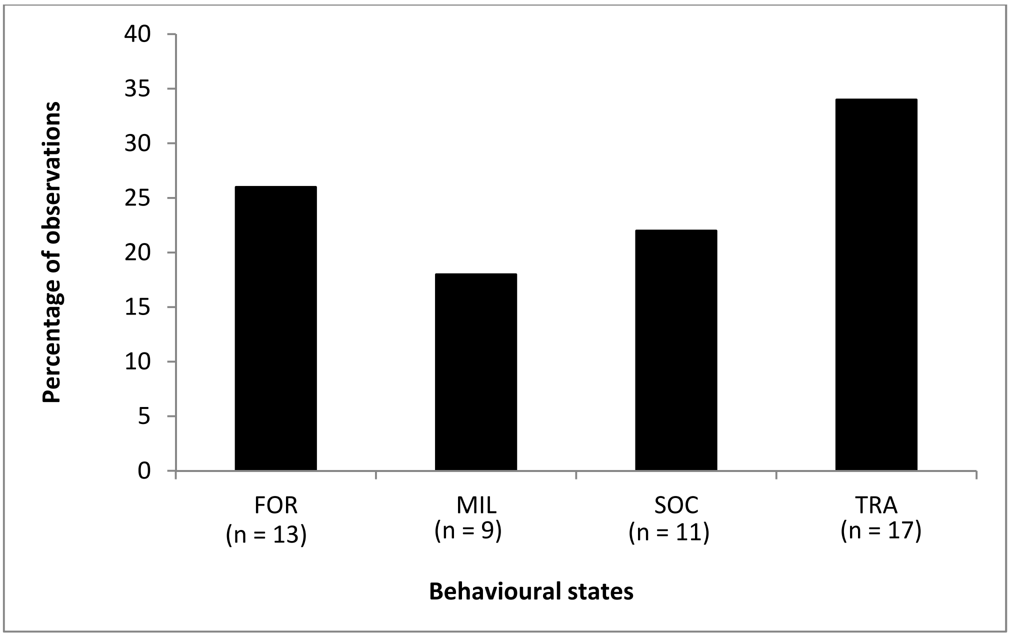

Figure 53: Behavioural state of common dolphin groups, between November 2010 and May 2013, in the ECBOP, New Zealand, when swim attempts occurred, as monitored from aboard the tour vessels. FOR=foraging, MIL=milling, SOC=socialising, TRA=travelling.

2.9. Ending of the swim encounters

Swim encounters with common dolphins ended 70.1% of the time (n=47) because of skippers decision, 28.4% (n=19) of the time because of loss of sight of dolphins, and 1.5% of the time (n=1) because of calf presence.

Swim encounters with bottlenose dolphins ended 50.0% of the time (n=3) as a consequence of the skippers decision, 33.3% (n=2) of the time because of loss of sight of dolphins, and 16.7% of the time (n=1) because swimmers could not view dolphins subsurface.

Overall, 53.7% (n=39) and 50% (n=3) of the swimmers reported that they did see common and bottlenose dolphins during swim encounters, respectively.

VI. Discussion

A. Ecology of common dolphins in the ECBOP

Between November 2010 and May 2013, common dolphins were the most prevalent marine mammal species (59.4%) in the ECBOP area. Common dolphins have previously been reported in the bay year round (Gaborit-Haverkort and Stockin, 2011), therefore the absence of sightings between August and October during the present study more likely reflects limited survey effort undertaken during that period. Additionally, common dolphins are also known to undertake a seasonal shift offshore in this region (Neumann, 2001c). In the present study, common dolphins were found to be present in shallower waters (median=57.1 m) closer to shore (median=14.8km) in spring and summer, while they were found in deeper waters (median=73.4m), further offshore (median=18.5km) in autumn and winter. This shift in dolphin distribution has been observed in the western part of the Bay of Plenty (Neumann, 2001c), and to a lesser extent in the Hauraki Gulf (Stockin *et al.*, 2008b). However, as common dolphins occur in warm-temperate to tropical waters worldwide (Jefferson *et al.*, 1993), it is unlikely that a seasonal change in water temperature in New Zealand is the primary factor influencing dolphin distribution. Instead, dolphins are more likely influenced by the distribution of prey species, which is associated with water temperature (Neumann, 2001c) and specifically, with the subtropical East Auckland Current (Stockin *et al.*, 2008b).

Overall, common dolphins were primarily observed in small groups of ≤ 20 individuals (51.2%), with a mean size of *ca*. 43 individuals per group. This is consistent with previous studies in the Hauraki Gulf (mean = 48, Stockin *et al.*, 2008b) and Mercury Bay (mean = 57, Neumann, 2001c). Although, smaller groups were more frequent throughout the austral summer, a pattern also observed in the Hauraki Gulf (Stockin *et al.*, 2008b), there was no evidence of seasonal variation in the group size in the ECBOP. Smaller groups of common dolphins were predominantly observed in shallower waters, while larger groups were most frequently recorded in deeper waters, as previously reported in the Hauraki Gulf (Stockin *et al.*, 2008b). This pattern could amongst other reasons, be driven by predator avoidance. Shark species, such as shortfin mako (*Isurus oxyrinchus*), blue (*Prionace glauca*), and smooth hammerhead (*Sphyrna zygaena*) sharks, as well as killer whales have regularly been observed in ECBOP waters, and are potential predators of common dolphins (Stockin *et al.*, 2008b; Visser *et al.*, 2010).

Juvenile common dolphins were present in similar proportions regardless of group size. However, the proportion of calves increased with group size, and may be explained by predator presence in the region. This contrasts with Mercury Bay, where Neumann (2001b) found that groups containing calves ranged between five and 20 dolphins, while those including adults with juveniles occurred in larger groups (up to 400 individuals). In the present study, the proportion of groups with immature dolphins (neonates, calves and juveniles) was found to be higher in summer, a pattern previously reported for both Mercury Bay (Neumann, 2001a) and the Hauraki Gulf (Stockin *et al.*, 2008b). Neonates were observed between mid-January and mid-February in the study area. This is consistent with observations from the Hauraki Gulf (Stockin *et al.*, 2008b) and suggests seasonality for the New Zealand population may relate to prey resources for the lactating females and suitable water temperatures for the calves. The occurrence of neonates also indicates that females likely calve within ECBOP waters.

Common dolphin group size varied significantly diurnally. Smaller groups (≤ 50 individuals) were more frequent in the morning and afternoon, while larger groups (> 50 individuals) were observed in the middle of the day. This group dynamic is likely to be associated with dolphin activities. Indeed, the activity budget exhibited a diel pattern, with feeding decreasing throughout the day and socialising primarily occurring in the middle of the day (1200-1559hrs). Findings suggest that common dolphins in the ECBOP primarily forage in the morning in smaller groups before fusing with other groups later in the day to socialise. Moreover, dolphins were found resting before 1000 and after 1600hrs. This resting period could be explained by nocturnal foraging activities, as previously suggested (Neumann, 2001a; Meynier *et al.*, 2008; Stockin *et al.*, 2008a). In New Zealand, common dolphins have been documented to feed on mesopelagic species from the deep scattering layer (Meynier *et al.*, 2008). Findings from the current study suggest that common dolphins in the ECBOP likely forage on nocturnal migrating prey until early morning.

Overall, 46.7% of encountered groups were travelling, a state observed throughout the day. Although the main foraging activity is suspected to occur nocturnally (Neumann, 2001a), 24.6% of observed groups were foraging across all temporal classes with the exception of 1600-1759hrs, which is likely reflective of the small sample size (1.5%). Common dolphins are known to also feed during the daytime on epipelagic shoaling species (Meynier *et al.*, 2008). The activity budget observed in the ECBOP is consistent to that observed by Neumann (2001a) for Mercury Bay but in contrast to that reported by Stockin *et al.,* (2009) for the Hauraki Gulf. In Mercury Bay, common dolphins spent 55.6% of their time travelling and 16.2% foraging (Neumann, 2001a), while in the Hauraki Gulf, 46.7% and 28.9% of the activity budget of common dolphins was dedicated to foraging and travelling, respectively (Stockin *et al.*, 2008a). A higher resource availability in the Hauraki Gulf and/or higher proportion of nursing groups (*i.e.* lactating females) may explain why dolphins spend more time foraging (Stockin *et al.*, 2008a) in that particular area. ECBOP waters likely represents a similar environment to that reported for Mercury Bay (Neumann, 2001a), a western sector of the Bay of Plenty. In each of these locations, common dolphin prey resources are dispersed throughout the habitat and, as a consequence, dolphins travel and forage throughout the region as opposed to focussing on any specific area(s) for foraging. The higher proportion of feeding behaviour in the Hauraki Gulf (twice as high compared with the ECBOP), support the hypothesis that common dolphins in the ECBOP possibly feed at night, as individuals would unlikely meet their energetic demands if only foraging during the day.

Overall, common dolphins spent 17.9% of their time milling, which is similar to that reported in Mercury Bay (Neumann, 2001a) but considerably more than observed in the Hauraki Gulf (Stockin *et al.*, 2009). Milling is considered a transitional phase between different behavioural states, often preceding foraging in areas where dolphins hunt for available prey, or occurring in between travelling periods to allow a period of respite (Neumann, 2001a). Given the proportion of time common dolphins spent travelling and foraging in the ECBOP, milling was not surprisingly the third most-frequent activity observed. This seems plausible given no specific area was deemed prevalent for milling, and therefore occurred throughout the habitat in the same manner as travelling or foraging.

Socialising was recorded for 6.7% of observed common dolphin groups. The activity occurred primarily in the middle of the day and increased during periods of decreased foraging. This suggests that diel behavioural patterns follow the dolphins' energy requirements (Bearzi *et al.*, 1999) and that common dolphins in the ECBOP dedicate most of their time to travelling between foraging patches.

While the overall activity budget for common dolphins in the ECBOP resembles that of Mercury Bay (Neumann, 2001a) and differs to that reported for the Hauraki Gulf (Stockin *et al.*, 2008a), time spent resting was found to be an intermediate between these two other regions. Common dolphins allocated 4.1% of their time to resting in the ECBOP, 7.7% in the Hauraki Gulf (Stockin *et al.*, 2009) and 0.4% in Mercury Bay (Neumann, 2001a). Neumann (2001a) suggested that resting was likely underestimated in Mercury Bay because of the inconspicuous surface activity of the dolphins, making it likely to miss resting groups. However, resting has been reported as the most stable behavioural state for common dolphins in the Bay of Islands (Constantine and Baker, 1997) and the Hauraki Gulf (Stockin *et al.*, 2008a). It is therefore suggested that a stringent approaching protocol, consistent, and careful handling of the RV, and use of a four-stroke engine, minimised dolphin disturbance during the present study.

Preliminary photo-ID analysis has to date identified a total 362 individuals across 39 days, primarily in summer 2011 and 2012. The lack of a plateau in the cumulative discovery curve suggests that only a subset of dolphins in the area have been identified. Additional analysis will allow the identification of further individuals and a comprehensive assessment of site fidelity. To date, only 29 individual common dolphins have been re-sighted over the study period. However, based on the low mark rate and logistical constraints of *Delphinus* photo-ID, this remains an early indication of at least seasonal site fidelity in the ECBOP for some individuals. For example, individuals 75, 111, 293, 367, and 508 were all encountered in summer 2011 and re-sighted 10-13 months later during summer 2012.

B. Ecology of bottlenose dolphins in the ECBOP

Bottlenose dolphins were rarely encountered in the area (1.8% of marine mammal encounters) and primarily in summer. This constrains what conclusions can be meaningfully drawn about this species in ECBOP. Sightings involved both mono-specific (55.6%) and poly-specific groups (44.4%), the latter of which were associated with false killer whales. The two groups exhibited a different distribution, with mono-specific groups typically found closer to the shore (median=0.9km) and in shallower waters (median=13.1m), compared to the poly-specific groups (median=9.6km, median depth=73.3m). The occurrence of both forms of bottlenose dolphins in Northland has been previously reported (Zaeschmar *et al.*, 2013a; Zaeschmar *et al.*, 2013b). The oceanic form tends to occur in larger groups (*ca*. 100 individuals) associated with false killer whales (Zaeschmar *et al.*, 2013a; Zaeschmar *et al.*, 2013b), while the coastal form typically occurs in mono-specific groups of approximately 20 individuals (Lusseau and Slooten, 2002; Merriman *et al.*, 2009; Tezanos-Pinto, 2009). Bottlenose dolphins sighted in ECBOP waters likely correspond to both forms. Dolphins associated with false killer whales in the Bay of Plenty are documented to form part of the oceanic form, migrating along the New Zealand coasts (Zaeschmar *et al.*, 2013a).

Regardless of their type or form, all bottlenose dolphins qualify as visitors to the ECBOP based on the limited number of encounters, during extensive survey effort, over the three year study. All bottlenose dolphin visits to the region are suspected to be related to foraging, as reflected in the activity budget observed within this study (foraging 42.9%; travelling 28.6% and milling 28.6%). However, the restricted dataset presented here could explain why resting and socialising were not observed at all. Higher rates of resting behaviour have been reported elsewhere in New Zealand. Indeed, in the Bay of Islands and Doubtful Sound, bottlenose dolphins were observed resting during *ca.* 11% of their time (Lusseau, 2003; Constantine *et al.*, 2004). However, resting only accounted for 2% and 0.2% of the activity budget in bottlenose dolphins in the Shannon Estuary, Ireland (Ingram, 2000) and in the Sado Estuary, Portugal (Harzen, 1998), respectively. It is suggested that marine environmental characteristics may explain those behavioural differences (Constantine *et al.*, 2004). When observed foraging in the ECBOP, coastal *Tursiops* fed in shallow waters closer to the shore, compared to the oceanic form. This is likely indicative of different habitat use and may be explain by dietary differences (Hoelzel *et al.*, 1998). Regardless, the bottlenose dolphin dataset in the ECBOP needs to be considered as preliminary rather than conclusive due to its limited size.

Cross matching has revealed that of the two coastal groups observed on June 2012 and February 2013, 73 and 17 individuals have previously or subsequently been recorded in Great Barrier Island and the Bay of Islands (Dwyer *et al.*, *in review*). This further supports their classification as coastal *Tursiops* and suggests both a relatively small population size and a high level of movement across the northeast coast of the North Island. Previous photo-ID revealed 59% of coastal bottlenose individuals overlapped between the Hauraki Gulf and Bay of Islands (Berghan *et al.*, 2008). This suggests, despite their low occurrence in ECBOP waters, that the northeast North Island coastal bottlenose dolphin population has an extended home range. Additionally, of the further 70 oceanic individuals identified during the present study, 50% (n=35) have been reported within Far North waters. The occurrence of both bottlenose dolphin forms in ECBOP waters warrants further investigation, especially if tour vessels remain permitted to interact with *Tursiops*. This is critical given the likelihood of cumulative tourism pressure from other parts of the known home range.

C. Dolphin tourism in the ECBOP

1. Levels of vessel traffic level

The Bay of Plenty is second only to Bay of Islands as the busiest destination for cetacean-watching in North Island, New Zealand (O' Connor *et al.*, 2009). Overall, focal follows revealed that common and bottlenose dolphins were observed in the presence of vessels 21% and 16.6% of the time, respectively. In the Bay of Islands, bottlenose dolphins were accompanied 58% of the time by boats (Constantine *et al.*, 2004). The difference between the two regions could be explained by differences in the number of vessels, size of the search area or other operational considerations. Conversely, differences may simply relate to a high number of core users within the Bay of Islands (Tezanos-Pinto *et al.*, 2013) compared to occasional visitors to ECBOP. When comparing both species, bottlenose dolphins in the Bay of Islands occur closer to the shore (Constantine, 2002) than common dolphins in the ECBOP, likely resulting in more vessel interactions. In Akaroa Harbour, Hector's dolphins were observed in the presence of vessels 35.2% of the time (Martinez, 2010). However, Akaroa Harbour is 30 times smaller ($42km^2$ *vs* $1,350km^2$), so despite a similar number of commercial TV (five *vs* six), tour vessel activity is clearly less concentrated in ECBOP compared with Akaroa.

Although the surveys aboard the TV reported herein are not exhaustive of the amount of trips undertaken by the operators overall, they remain a good indicator. Better weather conditions typically marked the onset of dolphin trips in spring. However, the majority (67.4%) of the surveys aboard the TV occurred during the austral summer. This was as a consequence of the New Zealand and Australian summer holiday period (and thus increased tourism), good weather conditions and higher occurrence of common dolphins closer to the shore. This peak in encounters typically occurs between December and April, which also corresponds to the calving season (Stockin *et al.*, 2009). What direct consequence this has on nursing groups remains unclear, although the reduction in feeding documented for all groups during boat interactions is likely to be more significant for pregnant and lactating females.

Depending on the location of the interaction, the same dolphin group could be targeted by several vessels. Indeed, common dolphins were generally approached by one to three vessels over the course of a focal follow. However, two independent encounters observed inside Tauranga harbour resulted in a total of 31 and 61 total vessels, including TV, interacting with a single group of dolphins. Outside the harbour, up to 15 and eight vessels were observed approaching single groups of common and bottlenose dolphins, respectively. These examples firstly demonstrate the potential for encounters with high numbers of vessels and dolphins within nearshore ECBOP waters and secondly, non-compliance of TV by interacting with dolphins inside the Tauranga harbour limits. In addition, simultaneous interactions where one vessel interacting with dolphins was joined by others were relatively frequent. For example, almost half (42.9%) of common dolphin groups followed by the RV, were approached by two or more vessels simultaneously. This also occurred in the case of bottlenose dolphins, where a maximum of four vessels simultaneously interacted with the dolphins. In the Bay of Islands, bottlenose dolphins were affected by an increase in the number of interacting boats (Constantine *et al.*, 2004), with dolphins milling more to the detriment of resting. A similar pattern of increased milling was also evident in the ECBOP.

In New Zealand, a maximum of three vessels of any type are allowed within 300m of a group of dolphins (MMPR, 1992). This regulation was breached seven times during 35 focal follows with common dolphins and once during the three focal follows on bottlenose dolphins. Recreational vessels may not always be aware of the regulations protecting marine mammals, or alternatively may simply disregard them. However, despite the presence of a monitoring RV, TV were also observed breaching the three boat regulation, with no radio communication apparent by tour operators to coordinate between themselves access to the dolphin group. Given that tourists aboard commercial vessels pay to interact with dolphins, a frequently vocalised opinion is that TV have the priority over recreational vessels. Adherence to management regulations and guidelines have been shown to reduce effects of vessel interactions on dolphin behaviour (Lusseau, 2006), and should therefore be strictly respected in order to minimise any effect on dolphin populations and ensure sustainable tourism activity.

Vessels were most frequently observed interacting once with a single group of dolphins (88.6% for TV and 90.1% for non-TV). Multiple interactions usually occurred when the interacting vessel was travelling slower than the focal group and as a consequence, the main group moved over 300m ahead while the vessel remained interacting with a subgroup of dolphins at the rear. Thus, the interacting vessel did not deliberately leave the dolphin group and seek to subsequently engage with it, although this situation was observed (pers. obs.). Tour operators were also observed shortening encounters with small groups of dolphins or groups containing calves in order to find larger groups or groups composed of only adults in order to swim. In this scenario, if no other dolphin groups could be found, the TV would then return to interact with the original group of dolphins. This type of interaction can have potential cumulative effects on the targeted group.

Overall, 23.7% and 11.1% vessels observed interacting with common and bottlenose dolphins were TV, respectively. The low proportion of commercial TV compared with non-TV is similar to that reported for Akaroa harbour (21.6% *vs* 78.4%) (Martinez, 2010). However, despite this low proportion, commercial TV interacted significantly longer with common dolphins compared with non-TV. The 58 focal follows monitored from aboard the RV showed that non-TV usually spent a few minutes with dolphins (common dolphins median=1min; bottlenose dolphins median=1min). Conversely, TV engaged > 30min with dolphins (common dolphins median=37min; bottlenose dolphin single encounter=34min). This concurs with the duration of interactions recorded aboard the TV themselves (median: common dolphins=40min, bottlenose dolphins=30min; encounter times of bottlenose dolphins associated with false killer whales=71min and 169min). Prolonged interaction times have been reported in other regions. In the Bay of Islands, TV spent on average 57.5min interacting with bottlenose dolphins (Constantine, 2002). In Akaroa harbour, commercial TV spent twice as much time with Hector's dolphins when compared to non-TV (*ca*. 14min *vs* 8min, Martinez, 2010). This difference likely reflects operational differences since TV specifically target dolphins with the intention to maintain contact with the group, whereas private vessels typically encounter dolphins opportunistically while undertaking other marine recreational activities (*e.g.* fishing). Overall, such differences in boat manoeuvring and encounter durations likely explain changes in dolphin behaviour (Janik and Thompson, 1996). However, it is acknowledged that the effects of multiple short interactions by non-TV remain unclear and indeed, may pose as equal or greater concern to dolphin populations as prolonged TV interactions described here.

When considering cumulative encounters, a single group of common dolphins spent significantly more time in the presence of TV compared to non-TV (median 45min *vs* 9min), a result similar to that for bottlenose dolphins (median 34min *vs* 1min). This can be explained by the common practise of "handing over" whereby a group of dolphins at the end of an encounter is passed onto another commercial vessel (pers. obs.). This has been reported for other regions (*e.g.* Akaroa Harbour, Martinez, 2010). Within sighting distance, commercial vessels are also easily recognisable when in the presence of dolphins as they usually reduce their speed and change orientation during engagement. This change in manoeuvring often alerts other vessels, especially recreational fishers and other TV, to the presence of dolphins.

In 78.2% of the interactions observed from aboard the TV, the maximum time limit of 90min with dolphins was observed. Compliance levels are, therefore, relatively high within the region. While tour operators generally adhered to their permit restrictions, the exceeded time in the presence of the dolphins lasted between three and 58min, and 12 to 79min for common and bottlenose dolphins, respectively. More noticeable were breaches with respect to bottlenose dolphins. As this species is rarely observed in the ECBOP, encounters were deemed "exceptional", especially when in association with false killer whales. Operator encounter times were often double the maximum stated within their permit during such occasions.

Vessel speed varied considerably with vessel type during dolphin interactions. Non-motorised craft such as kayaks were the slowest while interacting with dolphins. Conversely, recreational launches and commercial non-TV (*i.e.* container ships, commercial fishing vessels…) typically passed within 300m of dolphins without altering their course or speed. Out of all the motorised recreational craft, trailer-launched vessels, and personal water craft (jet skis) most frequently approached dolphins. As a result, trailer boats and personal water craft showed a wide range of speeds: on average 0-25kts and 15-20kts around *Delphinus* and *Tursiops*, respectively for trailer boats, and 3-25kts around *Delphinus* for personal water craft. These vessels typically reacted to dolphin presence by suddenly altering course and/or speed (pers. obs.). Due to their higher manoeuvrability, trailer boats and personal water craft were also observed circling and pursuing dolphins during several observations.

Tour-vessels demonstrated a wide range of speeds whilst within 300m of dolphins (0-10kts and 1-6kts for *Delphinus* and *Tursiops*, respectively). Under the MMPR (1992), permitted operators are restricted to a "no wake" speed (*ca*. 5kts) within 300m of dolphins. The exceeded speed limits observed in the present study can be explained by TV often reducing their speed while closer than 300m of the group, catching up with fast travelling individuals and/or after a swim encounter (pers. obs.). When leaving a group, vessels were travelling at faster speed to outdistance the fast travelling dolphins. However, on occasion, this was also observed when dolphins were moving slower than a "no wake" speed. Dolphins have been shown to avoid high speed vessels and conversely, associate longer with slower craft (*e.g*. kayaks, sailing vessels, Martinez, 2010). Besides changes in dolphin behaviour (Nowacek *et al*., 2001; Miller *et al*., 2008), high speed can also result in an elevated risk of collision (Wells and Scott, 1997; Nichols *et al*., 2001; Martinez and Stockin, 2013). The presence of the RV (stationary or travelling at idle speed) did not alter the speed or course of fast powered recreational vessels (launches, trailer boats or personal water craft). Regardless of vessel type, ignoring the MMPR (1992) poses not only a danger to dolphins (*i.e.* risk of collision, Martinez and Stockin, 2013, Dwyer *et al*., 2014) but also represents a safety hazard for swimmers.

2. Behavioural responses of dolphins to vessel interaction

The presence of interacting vessels significantly affected the activity budget of common dolphins, which spent 12.4% less time foraging. Moreover, once disrupted, dolphins took nearly twice as long to return to foraging when compared to control conditions. Furthermore, transition from travelling to foraging decreased by 67.9%. Conversely, dolphins increased by 12.2% their time foraging when in the presence of interacting vessels. Foraging tactics used by common dolphins include cooperative herding of the prey (Neumann, 2001b; Neumann and Orams, 2003). It is possible that change in the behaviour of some individuals, as a result of approaching vessels, could compromise the success of the overall foraging event. Moreover, manoeuvring the vessel through a group of dolphins, as it has been observed, is likely to split the dolphins as well as the school of prey. In both scenarios, dolphins would presumably have to re-establish group cohesion in order to successfully capture the prey, ultimately resulting in an increased time between foraging bouts. Thus, results presented indicate common dolphin foraging behaviour is significantly affected by the presence of interacting vessels in the ECBOP. Foraging is a critical component for any predator and disruption to this activity can potentially result in energy intake reductions that can have long-term implications if the population is limited by resource availability (Williams *et al*., 2006). In an environment like the ECBOP, where prey resources are patchy in distribution, and dolphins spend most of their time travelling between patches in search of prey, the potential effect of interacting vessels is likely a reduction in overall energy acquisition.

Preliminary results (albeit based on small sample size) suggest that the overall activity budget of bottlenose dolphins was also affected by the presence of interacting vessels. As most observations considered poly-specific groups, and association with false killer whales could potentially have affected bottlenose dolphin behaviour, results should also be considered with caution. Bottlenose dolphins spent less time foraging and milling when in the presence of interacting vessels (12.1% *vs* 51% and 6.1% *vs* 22.4%, respectively). Conversely, dolphins spent more time travelling in the presence of interacting vessels (81.8% *vs* 26.5%). Notably, no foraging bouts were initiated when vessels were interacting with dolphins. Conversely, transition probabilities from foraging to travelling increased by 32%. While constrained by sample size, early indications from this study suggest feeding behaviour is the most likely state to be affected by the presence of interacting vessels. This differs to other New Zealand regions experiencing tourism where short-term behavioural responses reported include boat avoidance (Constantine, 2001; Lusseau *et al.*, 2003), decreased resting and increased travelling behaviour (Lusseau *et al.*, 2003).

Since few studies have explored the potential long-term changes in dolphin behaviour as a consequence of tourism pressure, it is difficult to predict the implications of tourism activity. However, a limited number of longer-term studies have provided some indications of the potential effects. For example, in Fiordland, bottlenose dolphins were shown to have changed their habitat as a consequence of tour vessel activity (Lusseau, 2004, 2005). Tourism, amongst other anthropogenic factors, are also debated as a cause for the decline of this local population (Currey *et al.*, 2007). Bottlenose dolphins were historically more frequently encountered in the ECBOP (Gaborit-Haverkort and Stockin, 2011). Between 2000 and 2010, 64 records of bottlenose dolphins within the ECBOP Conservancy were reported, although primarily all near White Island in the Bay of Plenty. This difference may relate to differences in search areas covered as a consequence of platforms used (*i.e.* coastal *vs* oceanic). Alternatively, the reduced number of bottlenose dolphin encounters may represent a real decline in usage of ECBOP waters by this species. With so few data available in this study, it is not possible to further discuss.

3. Swimming with dolphins

In the North Island, commercial swimming with common and bottlenose dolphins is permitted in the Bay of Islands, Hauraki Gulf (for common dolphins only) and in the Bay of Plenty. During the study period, only one swim with bottlenose dolphins was observed in the ECBOP. This likely reflects the low encounter rate with the species in addition to the presence of false killer whales, which negates any wet encounter in accordance with the MMPR (1992).

Overall, common dolphins did not approach swimmers often (32.4% of encounters). However, this is higher than that recorded for Mercury Bay (20.5%, Neumann and Orams, 2006) and the Bay of Islands (24%, Constantine and Baker, 1997), but much lower than those reported for bottlenose, Hector's, and dusky dolphins

(*Lagenorhynchus obscurus*), all of which ranged above the 50% mark (Constantine, 1995; Barr, 1997; Bejder *et al.*, 1999). Out of a permitted 60min maximum wet encounter time with dolphins, swimmers typically spent only five minutes in the water, similar to that previously reported in Mercury Bay and Bay of Islands (Constantine and Baker, 1997; Neumann and Orams, 2006). In terms of duration, common dolphins seem to be less receptive compared with dusky or Hector's dolphins, for which attempts lasted 9.1min and 10-18.8min, respectively (Markowitz *et al.*, 2009; Martinez *et al.*, 2011). While only half of the swimmers reported actually observing common dolphins under the water, only 11.6% of swims with Hector's dolphins were deemed as "poor" as a comparison (Martinez *et al.*, 2011). Several reasons can explain the limited success of such swim encounters. Firstly, water turbidity can minimise, if not prevent, swimmers successfully observing dolphins. Swimmer confidence and capability is also a key factor for a successful water encounter. Dolphins have been shown to approach or at least not avoid swimmers who are active in the water. Dolphin activity state is also a key influence on swim success, with dolphin groups more interactive when socialising compared to when travelling or milling (Neumann and Orams, 2006). In the present study, dolphins were approached by swimmers while travelling (34%), foraging (26%), and milling (18%), which could explain dolphin avoidance and non-interest. Moreover, the general small size of the groups (<30 individuals) might have influenced the poor success for swim encounters, as previously reported (Neumann and Orams, 2006). Finally, the manoeuvring of the vessel during the swim encounter (slowing down/stopping to place people in the water, and then pursuing the dolphins) might also explain the low dolphin interest. A change of speed is likely to be the key factor, and could explain why dolphins appeared uninterested in free swimmers.

Other boats were present in the vicinity of the TV during 33.3% and 21.9% of the swim encounters monitored from the RV and from aboard the TV, respectively. Recreational vessels placed swimmers in the water on two occasions, accounting for 16.3% of the swim encounters monitored from the RV. Observing swimmers from TV is likely to increase this kind of activity from recreational vessels. As discussed previously, recreational boaters are often ignorant of the MMPR (1992), particularly in relation to the prohibition of swimming with immature dolphins. In contravention of the MMPR (1992), calves were present during two and ten swim attempts monitored from aboard TV and the RV, respectively. Moreover, fission-fusion of dolphin groups can occur before and during a swim attempt which can result in a change in composition, and subsequently, ambiguity about whether swimmers should remain in the water or return to the platform. The maximum number of ten swimmers was complied with for 97.3% of swim encounters monitored from aboard TV. While skippers usually know about the MMPR (1992), crew members seemingly are less aware. Despite training for staff being a requirement under the MMPR (1992) and it being a condition of the permit, there does still appear to be a culture of ignorance among crew.

VII. Summary and recommendations

A. Ecology of common dolphins in the ECBOP

- Dolphins exhibited a seasonal distribution, occurring more in offshore deep waters during austral autumn and winter, compared to spring and summer, where they were observed closer to shore, in shallower waters.
- Dolphins generally occurred in small groups (≤ 20 individuals, 51.2%), composed of adults, juveniles and/or calves. The proportion of immatures increased with group size.
- Groups containing immature dolphins were more frequent in spring and summer compared to autumn and winter (68.6% *vs* 50.7% of encountered groups). Furthermore, neonates and newborns were observed in summer suggesting reproductive seasonality in the ECBOP.
- Dolphins spent more time travelling (46.7%), compared to foraging (24.6%), and milling (17.9%). The proportion of these states are likely related to the patchy prey resources within the ECBOP.
- Dolphins spent little time resting (4.1%). Like foraging, resting and is suspected to be primarily a nocturnal activity.
- Dolphins exhibited a diel behavioural pattern which changed with group size. Foraging and resting were more frequent during the morning and late afternoon involving smaller groups, while socialising was more prevalent during the middle of the day, typically involving larger groups.
- No particular area within the study site was specific for any particular behavioural state except resting.
- Provisional analyses identified 362 individuals, out of which 8% (n=29) were re-sighted two to four times during the study. This likely underestimates site fidelity due to the low mark rate for *Delphinus* and the constraints of photo-ID on gregarious populations.
- The majority (69%) of re-sightings occurred within a month, suggesting at least a proportion of the population exhibit seasonal fidelity within ECBOP waters. Further data analysis is required to assess the full extent of seasonal and/or annual site fidelity.

B. Ecology of bottlenose dolphins in the ECBOP

- Dolphins were rarely encountered in ECBOP waters (1.8% of marine mammal encounters) and are regarded as visitors to the region.
- Dolphins were primarily observed in the summer (88.9% of encounters).
- Two forms of bottlenose dolphins were encountered in the region. Small mono-specific groups (~20 individuals) likely representing coastal *Tursiops* and larger poly-specific groups (~100+ individuals) associated with false killer whales, defined as oceanic *Tursiops*.
- Coastal form were found closer to the shore and in shallow waters, while oceanic bottlenose dolphins occurred further offshore and in deeper waters.
- Both forms identified within ECBOP waters were observed with juveniles and calves.

- Provisional analyses identified 75 oceanic individuals, of which at least 35 matched to oceanic bottlenose previously observed off the Bay of Islands. The presence of oceanic bottlenose forming long-term associations with false killer whales has also been previously reported within and beyond Bay of Plenty waters.
- Out of the two coastal groups encountered in 2012 and 2013, 73 and 17 individuals respectively, have been previously or subsequently sighted off Great Barrier Island and in the Bay of Islands. Similar to the oceanic form, this suggests high movement patterns across the north east coast of the North Island and the potential for cumulative effects across the broader range of this species.

C. Vessel interactions with dolphins in the ECBOP

1. Levels of vessel traffic in the ECBOP

- Dolphins in the ECBOP were exposed to the greatest number of vessel interactions during the austral summer (67.4% of surveys from aboard the TV), specifically between December and April. This corresponds with the breeding season for the species.
- Commercial dolphin trips occurred primarily between 0800 and 1500hrs, when common dolphins were most frequently observed resting and socialising.
- The total number of vessels approaching a single group of dolphins was location dependent. A total of 31 and 61 vessels interacted with common dolphins within the Tauranga harbour, including TV which represents a contravention of a permit restriction. Outside of the harbour, a maximum of 15 and eight vessels approached common and bottlenose dolphins, respectively.
- Dolphins subject to vessel interactions were approached by two or more vessels simultaneously during 42.9% of encounters. Overall, 32 simultaneous interactions were monitored, of which 25% (including TV) did not comply with the *maximum three boats within 300m* regulation.
- Vessels generally interacted once with a single group of dolphins. Multiple interactions occurred only if the interacting vessel was slower than the focal group.
- Compliance with the maximum 90min time restriction was 100% when monitored from the RV. However, in the absence of the RV, this regulation was breached 21.8% of the time. This likely reflects operational differences by skippers in the visible presence of the RV *vs* inconspicuous presence of researchers aboard the TV.
- Although non-TV interacted more frequently with dolphins compared to TV (142 *vs* 44 and eight *vs* one for common and bottlenose dolphins, respectively), the cumulative interaction time per dolphin group was significantly longer for TV compared to non-TV. Commercial TV therefore, have the greatest potential to affect dolphin behaviour based on duration alone. However, the long-term effects of repeated short interactions from non-TV remain unclear and warrant further investigation.
- Regardless of vessel type, the regulation of "no wake" speed within 300m of dolphins was breached by all motorised vessels: 51.3% of the time for TV, 63.2% for commercial non-TV, 66.7% for personal craft (jet skis), 76% for

outboard motor powered trailer boats, and 90% for inboard motor powered launches.

- The difference in boat manoeuvring (pursuing and remaining with dolphins *vs* passing in the vicinity of dolphins opportunistically), vessel speed and the duration of encounters (TV > non-TV) likely explain changes in dolphin behaviour.

2. Swimming with the dolphins

- Swimming with common dolphins generally occurred from TV (83.3%), although occasionally also from recreational vessels (16.7%).
- Other vessels were observed in the vicinity of a TV between 21.9% and 33.3% of the swim encounters, depending on the platform of observation.
- The maximum number of ten swimmers was complied with during 97% of swim encounters monitored from aboard TV.
- Presence of calves (83.3%) and juveniles (100%) was observed prior, during and/or after the swim encounters monitored from the RV. Presence of calves (2.9%) and juveniles (22.9%) was observed during swim encounters monitored from aboard TV.
- Dolphins did not approach swimmers often (32.4% of encounters), similar to what was reported in other regions, but lower than what has been reported for other species.
- Similar to other regions, swim interactions in ECBOP were very brief (< 5min), and the converse of swim interactions involving other species.
- Only half of the observed swim encounters in ECBOP were ranked as good.

3. Effects of vessel interaction on dolphin behaviour

- *Delphinus* significantly reduced their foraging by 12.4% and increased time spent travelling by 10.1% in the presence of interacting vessels.
- The likelihood of common dolphins continuing to forage, when already foraging, significantly decreased by 91.4% in the presence of interacting vessels.
- Behavioural transitions from travelling to foraging significantly decreased by 67.9% for common dolphins when interacting vessels were present.
- *Tursiops* significantly reduced their foraging and milling (51% and 22.4% in *control* compared with 12.1% and 6.1% in *interaction* conditions) and increased time spent travelling (26.5% in *control* compared with 81.8% in *interaction* conditions) in the presence of interacting vessels.
- When in the presence of interacting vessels, bottlenose dolphins were never observed to change their state from milling or travelling to foraging.
- Interactions between dolphins and swimmers were affected by the behavioural state of dolphins upon engagement.
- Given the limited sample size for bottlenose dolphins in this study, it is impossible to predict the long-term effect of vessels on this species in ECBOP waters. However, based on the potential for cumulative effects across the entire range of this species, the possibility of reduced feeding due to boat disruption (as evident for common dolphins) is certainly a possibility.

D. *Objectives of the study*

The present study is the first to examine the ecology and effects of interactions between vessels and common and bottlenose dolphins in ECBOP waters. The objectives of the study were specifically to:

1. Determine season-specific extent of bottlenose and common dolphin range use within the Bay of Plenty waters, in particular and within the wider region generally.

- *Delphinus* is the most prevalent species in ECBOP waters.
- Common dolphins showed a seasonal distribution, occurring in offshore deep waters in austral autumn and winter, compared to spring and summer.
- Common dolphins generally occurred in small groups (≤ 20 individuals 51.2%), composed of adults, juveniles and/or calves. The proportion of immature dolphins increased with group size.
- Common dolphin groups containing immature dolphins were more frequent in spring and summer compared to autumn and winter. Neonates and newborn calves were observed in summer suggesting reproductive seasonality in the ECBOP.
- Common dolphins were not found foraging, milling, travelling or socialising in any particular area.
- Common dolphins spent more time travelling, compared to foraging and milling. This likely reflects uneven prey distribution in the ECBOP.
- Common dolphins spent little time resting during the day, which affirms suggestions that resting (in addition to foraging) are primarily nocturnal activities within this region.
- *Tursiops* were rarely encountered in ECBOP waters and therefore regarded as visitors to the region.
- Two forms of bottlenose dolphin were encountered in ECBOP waters. Small mono-specific groups (~20 individuals) likely representing coastal *Tursiops* and larger poly-specific groups (~100 individuals) associated with false killer whales, presumed to be oceanic *Tursiops*.
- Bottlenose dolphins were primarily observed in the summer and involved groups comprising both juveniles and calves.
- Coastal bottlenose dolphins were found closer to the shore and in shallow waters, while oceanic bottlenose dolphins were recorded further offshore and in deeper waters.

2. Determine inter-seasonal use of regional waters of bottlenose and common dolphin groups, within the Bay of Plenty waters, in particular and within the wider region generally.

- Three hundred and sixty two *Delphinus* individuals were identified during the summer 2010-2012.
- Of these, 8% of common dolphin individuals were re-sighted in the ECBOP. This is an underestimate of site fidelity based on the low mark rate of this species and small proportion of images analysed to date.
- Provisional re-sight data suggest at least some degree of seasonal site fidelity within ECBOP waters exists.

- Both forms of *Tursiops* are considered as visitors to the ECBOP, with re-sightings confirmed off Great Barrier Island and in the Bay of Islands.
- A total of 105 coastal and 70 oceanic bottlenose dolphin individuals were identified from ECBOP waters during the present study. Many have either previously or subsequently observed in the Hauraki Gulf and/or Bay of Islands.
- Bottlenose dolphins associated with false killer whales in ECBOP waters likely form part of the offshore oceanic *Tursiops* that transit along the north-east North Island coast.
- Coastal bottlenose dolphins visiting the ECBOP exhibit high movement patterns across the north east coast of the North Island, making them susceptible to cumulative effects of tourism across their entire range.

3. Determine the potential effects of interacting with common and 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.

   - *Delphinus* spent significantly less time foraging and more time milling and travelling in the presence of interacting vessels.
   - Common dolphins took 91.4% longer to return to foraging after disruption from an interacting vessel.
   - Common dolphins decreased by 67.9%, the transition time from travelling to foraging in the presence of an interacting vessel.
   - *Tursiops* spent less timing foraging and milling but more time travelling in the presence of an interacting vessel.
   - Bottlenose dolphins were never observed to change their behaviour to foraging when in the presence of interacting vessels.
   - Overall, interacting vessels had a significant effect on dolphin behaviour, particularly in relation to foraging. However, small samples sizes achieved for bottlenose dolphins in this study warrant caution.
   - TV have the greatest potential to influence dolphin behaviour for viewing and swimming as a consequence of interaction duration.
   - The impact of repetitive short interactions with non-TV remains unclear and requires further investigation.
   - Swimming with dolphins occurs from both TV and non-TV in the ECBOP.
   - The brevity of interactions observed in this study and the low proportion of sustained interaction suggest common dolphin are less receptive to contact with swimmers compared with other species in New Zealand waters.
   - Full compliance with permit conditions was not observed while viewing or swimming with dolphins. Violations with respect to maximum number of vessels within 300m of the dolphins, area of operation, and speed were observed. Violations with respect to swimming in the presence of calves and exceeding the maximum number of swimmers were both also recorded.

4. Develop clear measures and guidance based on 1- 3 above to *i*) avoid or minimise human impacts, and *ii*) to measure impacts that quantify thresholds over which further impacts must not occur.

- Compliance to both the MMPR (1992) and specific permit restrictions were not fully respected while viewing and/or swimming with dolphins in ECBOP waters. Both commercial and recreational operations must adhere to regulations in order to ensure future sustainability of tourism activities in the ECBOP.
- To improve the *status quo*, regular and increased compliance monitoring is recommended. Any breach of permit conditions needs to be investigated and further action taken if required.
- While training/education of operators is a permit requirement, it is not always effective. Briefing of all new commercial crew as well education around marine mammal legislation for recreational boat users is recommended at the outset of each summer season.
- A moratorium on further tourism permits is recommended until after the population analysis of all photo-identification data from this region is complete. This will improve our understanding of site fidelity, movement between key regions (Bay of Islands, Hauraki Gulf, Bay of Plenty) and the potential for cumulative effects of tourism across the broader North east North Island range for both *Delphinus* and *Tursiops*.

5. Produce statements and recommendations based on 1-4 above regarding existing and future tourism activity in the Bay of Plenty waters, in particular, and in the wider regions generally.

- For clarity purposes, management recommendations are detailed below in section VII.E.

E. Management recommendations

Based on findings reported in this study, management recommendations are suggested for consideration for DOC, commercial operators and other stakeholders.

As dolphins were rarely observed in the absence of vessels in the ECBOP, we recommend:

- A moratorium on further tourism permits be extended until population analyses are completed for both *Delphinus* and *Tursiops* across their broader north east, North Island range. This will allow site fidelity and cumulative effects to be determined. Two current studies at Massey University have the ability to address this issue for both bottlenose and common dolphins and will complete in Dec 2017. A proposed moratorium until mid 2018 (allowing time for results to be disseminated) is recommended.
- Commercial trips be limited to one per day per permit.
- Commercial TV await the departure of any recreational vessels already viewing dolphins prior to engagement. This will serve to reduce boat pressure around the dolphins (negating the breaches highlighted in this study) while further educating recreational boaters and patrons about the legal limitations on vessel numbers around dolphin groups.
- A dedicated observer (funded by tourism levies) be employed to board TV to monitor dolphin groups, especially during wet encounters, in order to improve compliance with the MMPR (1992) and commercial permits restrictions violations documented in this study.

Commercial TV have the greatest potential to affect dolphin behaviour based on duration of contact with dolphins. To mitigate this, we recommend:

- Commercial operators strictly comply with current regulations (slow approach, no pursuing or circling the group, no unpredictable manoeuvring in speed and direction, duration of contact and limit of vessels around a group to be strictly respected).
- DOC extend surveillance and compliance checks on commercial operations to ensure regulations are being adhered to.
- DOC provide (or outsource via tourism levies) training of all commercial operator crew at the beginning of each new season in order to reinforce the regulations and their obligations under the MMPR (1992) and existing commercial permits restrictions.
- DOC extend the moratorium on tourism permits while site fidelity and potential cumulative effects undergo assessment via extended photo-ID cross matching between Bay of Islands, Hauraki Gulf, Tauranga (and where data is available, Whakatane).

Infringement of the MMPR (1992) has been observed while permitted operators interacted simultaneously with dolphins. To reduce this, we recommend:

- Commercial TV await the departure of TV and non-TV prior to their engagement with dolphin groups.
- Commercial tour operators stagger their departure times to minimise infringements recorded within this study.

Infringement of the permit restrictions has been observed while commercial operators interacted with dolphins inside Tauranga harbour. To reduce this, we recommend:

- DOC extends surveillance and compliance checks on commercial operations to ensure regulations are being adhered to.
- Commercial TV who do not comply with their permit restrictions by interacting with dolphins and/or whales inside Tauranga harbour face penalty.

The cumulative time a single group of dolphins is exposed to vessel interaction has been shown to exceed the permitted maximum time of 90 minutes. To mitigate this we recommend:

- No hand over of dolphins be permitted between TV.

The permitted maximum time of 90 minutes was not respected in the absence of an obvious monitoring presence (*i.e.* the RV). We recommend:

- DOC extends surveillance and compliance checks on commercial operations to ensure regulations are being adhered to.
- Commercial TV who do not comply with permit restrictions around the 90min maximum time limit face penalty.

Because tour operators typically sought larger dolphin groups to improve the chances of a high quality swim encounter, the likelihood of juveniles and calves being present increased. Indeed during this study, observed swimming with dolphins in the presence of calves was observed, in direct contravention to the MMPR (1992). To minimise this we recommend:

- A dedicated observer (funded by tourism levies) to be employed to monitor dolphin groups, especially during wet encounters, in order to improve compliance with the MMPR (1992) and commercial permits restrictions.
- Commercial TV who do not comply with their permit restrictions around swims encounters face penalty.

The effect of tourism operations on dolphins (particularly *Delphinus*) in the ECBOP, is a potential reduction in fitness due to a disruption of foraging behaviour. Given that foraging is the most recognisable behaviour to skippers, to minimise this, we recommend:

- Commercial vessels do not engage with dolphins while foraging and/or
- Contact distance be increased to >300m during foraging events and/or
- Delayed departure times (to post 1000hrs), in order to minimise potential disruption during the peak feeding period.

Non-compliance with the MMPR (1992) by non-TV has been observed during interactions with dolphins (speed, number of vessels around the same group) and/or, swim with dolphins. To minimise this, we recommend:

- DOC undertakes/improves public education for recreational boaters in the ECBOP in order to improve compliance.
- Commercial TV await the departure of recreational vessels prior to their engagement with dolphin groups already being viewed.

Swimming with dolphins is likely to be trivialised amongst recreational boaters. To mitigate this, we recommend:

- No swimming with dolphins by TV to be allowed within the observable vicinity of non-permitted vessels.
- Tour operators improve and reinforce education to their patrons on swim encounters.
- DOC improves information dissemination to the general public within ECBOP about the MMPR (1992).

Bottlenose dolphins are visitors to the ECBOP. However, during their occurrence within the area, encounters resulted in numerous breaches of MMPR (1992). Given the endangered threat status of *Tursiops*, and the potential cumulative effect of tourism across this populations' broader range, we recommend:

- DOC excludes interactions with bottlenose dolphins in ECBOP waters for existing and/or new permits
- DOC utilises its recently reformed structure to engage all neighbouring area offices to develop management strategies that supersede former conservancy boundaries.

Given the paucity of baseline data on common and bottlenose dolphins in this region, and the opportunity TV offer as opportunistic platforms, we recommend:

- Access to all commercial platforms by DOC employees and/or their representatives (including but not limited to university researchers) be incorporated within the written terms and conditions of new/renewed permits.
- Tour operators be obliged under their permit conditions, to complete a standard encounter form as part of their daily trip which is to be submitted to DOC monthly for research purposes.

VIII. Conclusions

New Zealand has faced a rapid growth in dolphin-based tourism over the last 15 years (O' Connor *et al.*, 2009). In 2011, there were 112 marine mammal watching permits nationally, of which eight were within the Bay of Plenty prior to any study of dolphin ecology commencing. Currently, 10 commercial vessels are permitted to view and swim with bottlenose and common dolphins in the ECBOP. As with much research on New Zealand marine mammals, the present study has been contracted by DOC to estimate the current level of tourism activities in the area, due to concerns about sustainability. The present study was undertaken during a moratorium which expired 11th October 2013. An extension of the moratorium for a further nine months was agreed until findings of the present report could be disseminated.

The present study determined the ecology, behaviour and site fidelity of dolphins subject to *ca*. 15 years of tourism influence. Results suggest tourism activities have the greatest potential to affect foraging. Like many other areas, boat traffic in Tauranga harbour is very high for both commercial export and recreational use. It is therefore acknowledged that dolphins in the ECBOP have been exposed to vessel traffic for many years. However, differences in the duration of contact with dolphins likely explain significant changes in dolphin behaviour when in the presence of TV (Janik and Thompson, 1996). It has also been shown that non-TV do not just view but also regularly swim with dolphins. While this is not illegal, short-term interactions have shown to have long-term consequences if they detract from critical, biologically significant behaviours such as foraging. In the ECBOP, where dolphin resources are sparsely distributed and where dolphins have been shown to spend most of their time travelling between feeding patches, the potential effect of commercial TV is likely to be an overall reduction in energy acquisition. As previously demonstrated (*e.g.* Lusseau, 2006; Martinez, 2010), dolphins are likely to use the area until the costs of tolerance exceed the benefits of remaining in that habitat. In species such as dolphins, the long-term effects of tourism activities can take decades to detect (Wilson *et al.*, 1999; Thompson *et al.*, 2000). Common dolphins are therefore, unlikely to immediately discontinue use of the ECBOP, despite facing human disturbance (*e.g.* recreational vessel traffic, commercial pressure, etc), thus regular monitoring of the local population is required.

Finally, the present study raises concerns regarding *Tursiops*. While only recorded as visitors during the present study, *Tursiops* were more frequent and considered as seasonally resident in a former study (Gaborit-Haverkort and Stockin, 2011). While this decline remains unexplained, timing of these studies do overlap with the rapid expansion in tourism activities within ECBOP waters. As such, further monitoring of *Tursiops* presence along with tourism activities is both warranted and recommended within ECBOP waters.

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XI. Appendices

Appendix 1

Examples of short-term behavioural responses of cetacea to the presence of vessels.

Behavioural effect	Species	Area	References
Changes in vocal behaviour	*Tursiops truncatus*	Australia - New South Wales	Scarpaci *et al*., 2000
	Sousa chinensis	Australia - Queensland	Van Parijs and Corkeron, 2001
	Physeter macrocephalus	New Zealand - Kaikoura	Richter *et al*., 2006
Erratic movements	*Megaptera novaeangliae*	New Caledonia	Schaffar *et al*., 2013
	Balaenoptera acutorostrata	Iceland	Christiansen *et al*., 2013
Vessel avoidance	*Tursiops truncatus*	New Zealand - Fiordland, Bay of Islands	Lusseau, 2003, Constantine, 2001
	Tursiops aduncus	Australia - New South Wales	Steckenreuter *et al*., 2012
	Megaptera novaeangliae	Australia - New South Wales	Stamation *et al*., 2010
	Delphinus sp.	New Zealand - Mercury Bay	Neumann and Orams, 2006
	Sotalia fluviatilisi	Brazil	Carrera *et al*., 2008
	Delphinapterus leucas	Canada - Quebec	Blane and Jaakson, 1994
Habituation to vessels	*Physeter macrocephalus*	New Zealand - Kaikoura	Richter *et al.,* 2006

Appendix 1 *(continued)*

Behavioural effect	Species	Area	References
Increase in swim speed	*Eubalaena australis*	Argentina	Lundquist *et al*., 2013
	Delphinapterus leucas	Canada - Quebec	Blane and Jaakson, 1994
Reduced in blow intervals and time at the surface	*Physeter macrocephalus*	New Zealand - Kaikoura	Richter *et al*.,2006
Tighter group cohesion	*Cephalorhynchus hectori hectori*	New Zealand - Porpoise Bay	Bejder *et al*., 1999
	Tursiops aduncus	Australia - New South Wales	Steckenreuter *et al*., 2011; Steckenreuter *et al*., 2012
	Delphinapterus leucas	Canada - Quebec	Blane and Jaakson, 1994
Dispersed group cohesion	*Tursiops truncatus*	Australia - Western Australia	Arcangeli and Crosti, 2009
Increase in travelling behaviour	*Tursiops* spp.	New Zealand - Fiordland	Lusseau, 2003
	Delphinus sp.	New Zealand - Mercury Bay, Hauraki Gulf	Neumann and Orams, 2006; Stockin *et al*., 2008a
	Lagenorhynchus obscurus	New Zealand - Kaikoura	Lundquist *et al*., 2012
	Eubalaena australis	Argentina	Vermeulen *et al*., 2012; Lundquist *et al*., 2013
	Tursiops aduncus	Tanzania	Stensland and Berggren, 2007; Christiansen *et al*., 2010
Increase in diving behaviour	*Tursiops* spp.	New Zealand - Fiordland	Lusseau, 2003
Increase in social behaviour	*Cephalorhynchus hectori hectori*	New Zealand - Banks Peninsula	Martinez, 2010

Appendix 1 *(continued)*

Behavioural effect	Species	Area	References
Decrease in resting behaviour	*Tursiops aduncus/truncatus*	New Zealand - Fiordland	Lusseau, 2003
		Australia - Western Australia, New South Wales	Arcangeli and Crosti, 2009; Steckenreuter *et al*., 2011
		Tanzania	Christiansen *et al*., 2010
	Delphinus spp.	New Zealand - Bay of Islands, Hauraki Gulf	Constantine *et al*., 2004; Stockin *et al*., 2008a
	Lagenorhynchus obscurus	New Zealand - Kaikoura	Lundquist *et al*., 2012
	Eubalaena australis	Argentina	Vermeulen *et al*., 2012; Lundquist et al., 2013
Decrease in feeding behaviour	*Delphinus* sp.	New Zealand - Mercury Bay, Hauraki Gulf	Neumann and Orams, 2006; Stockin *et al*., 2008a
	Tursiops truncatus	Australia - Western Australia	Arcangeli and Crosti, 2009
	Tursiops aduncus	Tanzania	Christiansen *et al*., 2010
	Tursiops aduncus	Australia - New South Wales	Steckenreuter *et al*., 2011; Steckenreuter *et al*., 2012
	Sotalia fluviatilisi	Brazil	Carrera *et al*., 2008
	Lagenorhynchus obscurus	Argentina	Dans *et al*., 2012
	Balaenoptera acutorostrata	Iceland	Christiansen *et al*., 2013
Decrease in socialising behaviour	*Eubalaena australis*	Argentina	Vermeulen *et al*., 2012; Lundquist *et al*., 2013
	Tursiops aduncus	Tanzania	Stensland and Berggren, 2007; Christiansen *et al*., 2010
Decrease in travelling behaviour	*Cephalorhynchus hectori hectori*	New Zealand - Banks Peninsula	Martinez, 2010

Appendix 2

Description of the five attributes used to evaluate the quality of dorsal fin photographs of common dolphins between November 2010 and May 2013, in the East Coast Bay of Plenty, New Zealand.

Attributes	Rating description	Illustration
Focus	0 - entire dorsal fin is blurred	
	1 –dorsal fin is partially blurred: the trailing edge isn't sharp but some details on the fin (*i.e.* pigmentation) are in focus, and vice versa	
	2 - entire dorsal fin is sharp and in focus	

Appendix 2 *(continued)*

Exposure	0 - dorsal fin is either over or under exposed and only the outline of the dorsal fin is visible	
	1 - dorsal fin is partially under or over exposed, but the outline of the dorsal fin and some details are visible	
	2 - outline and all the details of the dorsal fin are visible	

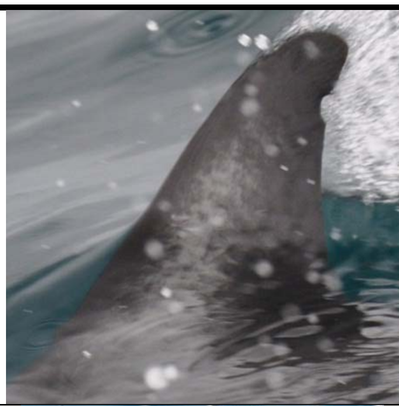
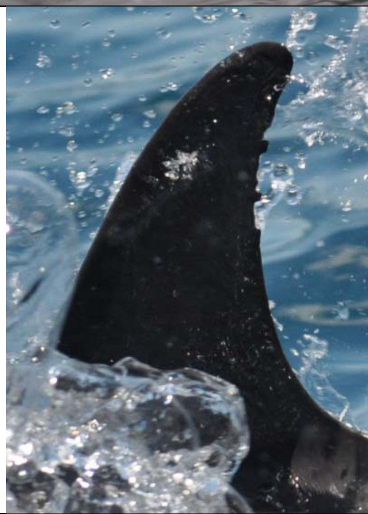
Appendix 2 *(continued)*

Size	0 - dorsal fin occupies < 25% of the frame	
	1 - dorsal fin occupies 25-50% of the frame	
	2 - dorsal fin occupies >50% of the frame	

Appendix 2 *(continued)*

Angle	0 - dorsal fin is 60-90° relative to the photographer	
	1 - dorsal fin is 30-60° relative to the photographer	
	2 - dorsal fin is 0-30° relative to the photographer	

Appendix 2 *(continued)*

Environmental Interference	0 - <1/3 of the dorsal fin is free of interference	
	1 - 1/3 – 2/3 of the dorsal fin is free of interference	
	2 - >2/3 of the dorsal fin is free of interference	

Appendix 3

Description of the quality of the dorsal fin photographs of common dolphins, between November 2010 and May 2013, in the ECBOP, New Zealand.

Quality of the photograph	Rating description	Illustration
Poor	≥3 attributes were rated 0	
Fair	2 attributes were rated 0	
Good	1 attribute was rated 0	
Excellent	No attributes were rated 0	

Appendix 4

Description of the distinctiveness of the dorsal fin of common dolphins between November 2010 and May 2013, in the ECBOP, New Zealand.

Distinctiveness	Rating description	Illustration
Not distinct/ Unmarked	The absence of notches/nicks or the presence of very small commonly observed notches/nicks on the trailing edge, the absence of marks/scars on the fin, and a uniform colouration of the dorsal fin; unable to identify and compare the individual to the catalogue even on an excellent quality photograph	
Distinct	The presence of small to large notches/nicks on the trailing edge, and/or the presence of marks/scars on the fin, and/or some recognizable details in the pigmentation; able to identify and compare the individual to the catalogue	
Very distinct	The presence of medium to large uniquely shaped notches/nicks on the trailing edge, and/or notches on the anterior edge of the dorsal fin, and/or the presence of marks/scars on the fin, and/or very unique pigmentation; able to identify and compare the individual to the catalogue even on a poor quality photograph	

Appendix 5

Monthly summary of surveys by platform and area, between November 2010 and May 2013, in the ECBOP, New Zealand.

		Tauranga						Whakatane				
		RV	Tourism vessels									
		A.Moana	CatchupIII	G.Galaxsea	Guardian	Orca	Sub-total	Diveworks	PeeJayIV	PeeJayV	Sub-total	Total
2010	November	6										6
	December	6			1		1					7
2011	January	3		4	5	4	13					16
	February	4		8	17	8	33					37
	March	2		8	11	1	20					22
	April	4		4	6	6	16					20
	May	6		4		1	5					11
	June	5										5
	July	3										3
	August	2										2
	September	3		4			4					7
	October	5										5
	November	4							1	5	6	10
	December	7		2			2	2		1	3	12
2012	January	13		14	13	2	29			1	1	43
	February	8		5		8	13	7	1	1	9	30
	March	2		4		4	8					10
	April	10		1			1					11
	May	4										4
	June	8										8
	July	7										7
	August	3		1			1					4
	September	3		3			3					6
	October	4										4
	November	5		3			3					8
	December	8		6	7		13					21
2013	January	3		15	13		28					31
	February	4	2	13	16	4	35					39
	March	7	2	3	7	2	14					21
	April	1		2	3		5					6
	May				1		1					1
	Total	150	4	104	100	40	248	9	2	8	19	417

Appendix 6

Monthly summary of the independent marine mammal encounters, between November 2010 and May 2013, in the ECBOP, New Zealand.

		Common dolphins	Bottlenose dolphins	Bottlenose dolphins + False killer whales	Killer whales	Pilot whales	Minke whales	Blue whales	Brydes whales	Unidentified whales	New Zealand Fur seals	Total
2010	November				5						1	6
	December	5										5
2011	January	17			1							18
	February	45			1						2	48
	March	28									9	37
	April	9			1						6	16
	May	1									12	13
	June	1									2	3
	July	1									2	3
	August										1	1
	September						1	1			18	20
	October										10	10
	November	1				1					3	5
	December	9		1			1	3			5	19
2012	January	34		2	1						2	39
	February	22	1	1		1					26	51
	March	11									2	13
	April	12									2	14
	May	3									10	13
	June	2	1								7	10
	July	2								1	7	10
	August										9	9
	September						1		1		11	13
	October										5	5
	November	3			1			1			3	8
	December	19				1		1				21
2013	January	22									5	27
	February	29	3		1		1				4	38
	March	16									7	23
	April	8										8
	May	2										2
Total		302	5	4	11	3	4	6	1	1	171	508

Appendix 7

Monthly summary of independent common dolphin encounters by platform, between November 2010 and May 2013, in the ECBOP, New Zealand. The number of focal follows conducted by the research vessel is shown in parentheses.

		Tauranga						Whakatane			
		RV	Tourism vessels								
		A. Moana	Catchup III	G. Galaxsea	Guardian	Orca	Sub-total	Diveworks	PeeJay V	Sub-total	Total
2010	November										
	December	4 (4)			1		1				5
2011	January	1 (1)		6	8	2	16				17
	February	5 (4)		9	24	7	40				45
	March	3 (1)		11	13	1	25				28
	April	1 (1)			5	3	8				9
	May	1 (1)									1
	June	1 (1)									1
	July	1 (1)									1
	August										
	September										
	October										
	November								1	1	1
	December	2 (1)		3			3	3	1	4	9
2012	January	5 (6)		18	8	2	28		1	1	34
	February	4 (3)		4		6	10	7	1	8	22
	March	1 (1)		4		6	10				11
	April	12 (7)									12
	May	3 (3)									3
	June	2									2
	July	2 (2)									2
	August										
	September										
	October										
	November	3 (2)									3
	December	5 (5)		7	7		14				19
2013	January	2 (3)		8	12		20				22
	February	3 (2)		10	11	5	26				29
	March	3 (4)	2	4	5	2	13				16
	April	1 (1)		4	3		7				8
	May				2		2				2
	Total	65 (52)	2	88	99	34	223	10	4	14	302

Appendix 8

Resighting history for 29 common dolphins encountered more than once in the ECBOP, New Zealand, between December 2010 and November 2012

ID	02/12/10	31/12/10	12/01/11	15/01/11	26/01/11	28/01/11	30/01/11	02/02/11	03/02/11	07/02/11	13/02/11	14/02/11	15/02/11	23/02/11	26/02/11	27/02/11	03/03/11	03/04/11	13/04/11	05/01/12	06/01/12	15/01/12	19/01/12	21/01/12	05/03/12	22/05/12	23/11/12	Time between sightings (days)	Time between sightings (months)
002	•														•													86	2.87
008		•		•																								15	0.50
056				•					•																			19	0.63
057				•										•		•												39+4= 43	1.43
059				•				•																				18	0.60
063					•				•																			8	0.27
075						•						•												•				17+341= 358	11.93
080						•				•					•													10+19= 29	0.96
094								•					•															13	0.43
104								•						•														21	0.70
111								•		•										•								5+332= 337	11.23
120							•	•																				3	0.10
130							•			•																		8	0.27
134							•	•																				3	0.10
138							•			•																		8	0.27
150							•			•																		8	0.27

Appendix 8 *(continued)*

ID	02/12/10	31/12/10	12/01/11	15/01/11	26/01/11	28/01/11	30/01/11	02/02/11	03/02/11	07/02/11	13/02/11	14/02/11	15/02/11	23/02/11	26/02/11	27/02/11	03/03/11	03/04/11	13/04/11	05/01/12	06/01/12	15/01/12	19/01/12	21/01/12	05/03/12	22/05/12	23/11/12	Time between sightings (days)	Time between sightings (months)
158									•						•													23	0.77
203													•				•											16	0.53
264										•					•													19	0.63
293																			•							•		405	13.50
364										•						•												20	0.67
367												•		•			•								•			9+8+368= 385	12.83
368												•													•			385	12.83
370												•		•														9	0.30
412														•	•													3	0.10
430														•			•											8	0.27
508																	•							•				324	10.80
534																		•			•							278	9.27
542																					•	•						9	0.30