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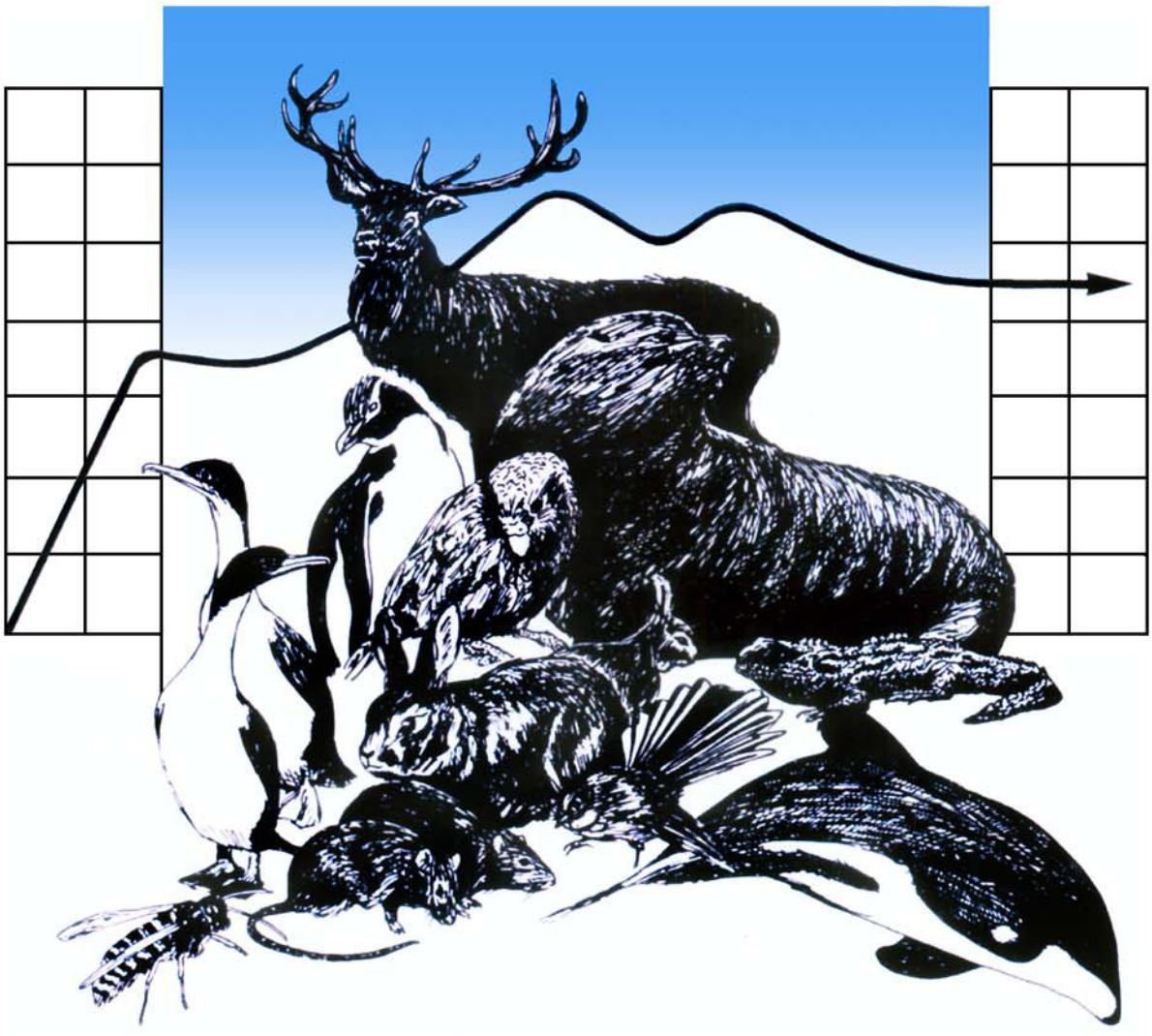

WILDLIFE MANAGEMENT

The abundance of Bottlenose dolphin (Tursiops truncatus) in the Bay of Islands, New Zealand:

Photo-identification results from summer surveying during 2011

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Picture by Tom Brough, 2011

A project completed for the fulfilment of WILM403: Wildlife management placement, Post-Graduate Diploma of Wildlife management, University of Otago.

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Contents

Abstract:

Bottlenose dolphins (Tursiops truncatus) are found in three distinct populations around the New Zealand coastline. One of those populations, the North Island population, regularly uses the area known as the Bay of Islands on the Northern East coast of the North Island. The population has been the subject of ongoing population monitoring since the early 90's, which is important due to the presence of an intense commercial dolphin watching industry; An industry that has been shown to have negative consequences upon the behavioural budget of the dolphins. This study aims to utilize mark-recapture technique to provide a new population estimate of dolphins utilizing the Bay of Islands during the summer months of 2011. A POPAN model was employed using the software MARK which provided a population abundance estimate of 78 (95%CI 77.41-81.82). This estimate provides evidence that the previously observed population decline is continuing. Reasons for the decline are discussed, including the ongoing disturbance from the dolphin watching industry.

Introduction:

Bottlenose dolphins (*Tursiops truncatus)* are found throughout the world's oceans from warm tropical seas to the temperate oceans of the high latitudes (Leatherwood & Reeves 1983). Often inhabiting coastal areas, bottlenose dolphins are one of the more familiar dolphins with many populations experiencing high exposure to human activities (Constantine, 2004). Due to the relative ease of encounters in many locations, bottlenose dolphins have attracted a large amount of research effort throughout the world, and thus comparatively much is known about their various populations' demographics, ecology and behaviour (Constantine & Baker, 1999).

Bottlenose dolphin in New Zealand waters inhabit three discontinuous coastal regions with little mixing between the genetically distinct populations found therein (Tezanos-Pinto et al., 2008). The three 'Super populations' are found in Fiordland and the Marlborough sounds of the South Island, and along the East

coast of the North Island (with some sightings in the far North-West)(Tezanos-Pinto, 2009) . In addition to genetic evidence of isolation (Tezanos-Pinto et al., 2008), extensive photo-identification surveys have taken place in Fiordland (Williams et al., 1993; Haase & Schneider, 2001; Currey et al., 2007), the Marlborough Sounds (Merriman 2007) and the Bay of Islands/Hauraki gulf (Constantine, 2002; Tezanos-Pinto, 2009; Berghan et al., 2008) which indicate very little overlap between the three populations (Brager & Sneider, 1998; Constantine, 2002).

The use of photo-identification techniques to assess dolphin population abundance has been used extensively in New Zealand with a range of species including Bottlenose dolphins (Wilson et al., 1993), Hectors/Mauis dolphins (Bejder & Dawson, 2001), Common dolphins (Neumann et al., 2003) , and Orca (Visser, 2000). Common forms of population abundance assessment using photo-identification include population censusing and the use of the various models that employ mark-recapture theory to produce an abundance estimate. Undertaking a population census is generally only applicable should each individual be uniquely identifiable and observable (100% detection) (Lettink & Armstrong, 2003), which is often not the case in dolphin populations due to the occurrence of animals without distinguishing features (often young animals), and the highly mobile nature of dolphin populations (Hammond et al., 1990). Mark-recapture is more applicable for assessment of dolphin population abundance because the technique takes into account those dolphins that are 'unmarked' or not observed (Hammond et al., 1990). Mark-recapture deduces population abundance (along with other key population parameters such as survival) from the ratio of marked to unmarked individuals and the individual catch histories of each marked animal in a population (Jolly 1965; Seber 1965). This ratio is later extrapolated to a population estimate of marked individuals to gain a total population of marked and unmarked individuals (Wilson et al.,1999; Read et al., 2003). A range of models have been developed that account for a variety of population 'types' and sampling methods. Each model has associated with it a number of assumptions that must be addressed in order for the population

assessment to be accurate, however should the assumptions be met, mark-recapture can be a very powerful tool for researchers (Lettink & Armstrong, 2003).

The ongoing assessment of dolphin population abundance is vital to ensure the long term viability of the often unique and isolated populations (Lettink & Armstrong, 2003). Two of the three bottlenose dolphin populations of New Zealand are the subject of extensive dolphin watching/swimming operations which have been shown to have serious consequences upon the behavioural budget of the dolphins in Fiordland (Lusseau, 2003; Lusseau, 2002;) and the Bay of Islands (Constantine & Baker, 1999; Constantine et al., 2004). In particular, individuals in both populations have experienced significant decline in resting behaviour in the presence of tour boats in favour of travelling behaviour (Lusseau, 2003; Constantine et al., 2004). It has been suggested that the extensive changes in the dolphins' behavioural budgets may contribute to the observed population declines of the Fiordland and North Island populations (Lusseau et al., 2006). Long term disturbance from tour boats has been shown to result in a decline in relative abundance of Bottlenose dolphins in Shark bay Australia, a relatively large and genetically diverse population (Bejder et al., 2006). It is likely that a population decline would be more evident and the effects more serious in smaller, more confined populations with less genetic diversity, such as the Bottlenose dolphin populations of New Zealand (Chilvers & Corkeron, 2003; Bejder et al., 2006;).

The Bay of Islands is an important habitat for the North Island Bottlenose population with dolphins being present on most days (Constantine, 2002). The bay is also the home of the most intensive dolphin watching and swimming operations in the North Island with up to eight permitted boats running twelve trips per day (Pers obs), plus a high volume of recreational and non-permitted commercial encounters. Using photo-identification mark-recapture techniques, Constantine (2002) estimated the number of individual dolphins utilizing the Bay of Islands at 446 (95% CI = 418-487). It was suggested that the Bay of

Islands is included within the home range of the majority of dolphins in the North Island population (Constantine, 2002). A more recent study discovered a decline in the relative abundance of dolphins using the Bay of Islands from 204 (CV=0.03) in 1998 to 126 (CV=0.02) in 2004, a decline of 38% (Tezanos-Pinto, 2009). Interestingly, dolphins are still found commonly within the area due to a shift from a scenario in which many dolphins use the bay irregularly to a few individuals using the bay regularly (Tezanos-Pinto, 2009).

The present study aims to continue the ongoing assessment of dolphin abundance in Bay of Islands using mark-recapture technique. Survey time has been limited to the summer months of 2011 and thus the study is only an indication of the abundance of dolphins utilizing the Bay of Islands during this time. Based on personal observation of commercial and recreational boat traffic over the summer months of 2010/11, it is hypothesized that the continued decline of individual bottlenose dolphins using the bay is evident in the ensuing population estimate.

Materials/Methods:

Study area:

The Bay of Islands is a large bay on the Northern East coast of New-Zealand (35.14 S, 174.06 E). The bay is open to the North and is bound by two peninsulas; Cape Brett to the East and Cape Wikiwiki to the North West. The bay is ancient submerged river delta and has a wide range of habitat from estuarine, coastal to open ocean. The average depth within the bay is approximately 15m but depths of over 40m are common. Average sea surface temperature 17°C (Tezanos-Pinto, 2009), with summer surface temperature inside the sheltered bays reaching up to 23°C in summer (Pers. Obs).

Surveys:

Surveys were conducted using a 5.1m aluminium stabicraft vessel powered by a 60hp four-stroke yamaha outboard motor. Ten days of survey effort were carried out between January and April 2011

and were highly weather dependant. Surveys were non-systematic although the majority of the bay was attempted to be covered during each day (weather conditions depending) to ensure every dolphin in the bay was included within the survey for a given day. Time on and off the water was recorded as the moment leaving and returning to the boat ramp. Dolphins were found either by liaising with commercial operators using vhf radio (which also helped to ensure all dolphins in the bay were included in each days survey) or by conducting visual surveys using binoculars.

Photo-identification :

Dolphin groups were approached if there were less than three other boats viewing the dolphins. When dolphins were encountered the GPS position was recorded, as well as a minimum, best and maximum group size, and any other relevant information. The group composition in terms of number of adults, juveniles, calves and neonates was also recorded.

The dolphins were approached by matching the same course of travel and slowing the vessel to less than 5 knots, the space between the dolphins and the research vessel was gradually closed until the vessel was appropriately placed for photo-identification. Photo identification was undertaken using a Cannon 400D digital camera with a Tamron 200-400mm zoom lens. A side profile of the dorsal fin of each animal in the group was taken for identification with no preference for marked or unmarked individuals. The distinguishing nicks and notches along the anterior edge of the bottlenose dorsal fin are generally the same on each side therefore it was deemed unnecessary to attempt to get photos of both sides of the dorsal fin (Read et al., 2003). Photo-identification continued until all animals in the group were accounted for with at least one photo at which time the encounter was broken off by changing the vessels course relative to the dolphins.

Processing:

At the end of each sampling day, all photos were uploaded on to a laptop computer and catalogued under date and group encounter time. All information relative to each encounter was inserted into a spreadsheet summarising effort and group size/composition. Photos were then graded according to: focus and clarity, percentage of dorsal fin showing, angle of fin and sharpness, with only the best quality photographs being retained. A 'capture' was considered as the occurrence of any individual in a photograph of good quality; therefore one photograph could contain multiple 'captures' if there were more than one dolphin in a picture. Photos of more than one dolphin were then cropped so that multiple captures could be accounted for individually. All photos of clean fins were put in a separate folder whilst photos of identifiable individuals were matched against the updated Bay of Islands Bottlenose Dolphin Catalagoe (BIBDC). The catalogue contains a total of 746 pictures of 546 uniquely identifiable individuals. An identifiable individual is characterized by the occurrence of nicks and notches along the anterior edge of the dorsal fin which are significant enough to distinguish the animal as unique (Wilson et al., 1999; Chilvers & Corkeron, 2003;Read et al., 2003) . Bottlenose dolphins also possess non-permanent scaring marks such as tooth rakes which are not considered in photo-identification due to their non-permanent nature (Tezanos-Pinto, 2009).

Matching photographs against the BIBDC was completed by one researcher independently to eliminate bias due to variation in researcher skill. However after matching was completed, all matches were checked independently by another researcher.

An excel spreadsheet was created to summarise the capture history of all individuals across all Ten sampling days. The total number of captures per individual, per day was entered into the spreadsheet along with the total number of 'unmarked' captures per day. Unmarked captures are those animals without any distinguishing marks on their fins or animals that were not included within the BIBDC.

Capture histories in mark-recapture format were then produced which are based solely upon the presence or absence of a marked individual across all sampling periods. Presence is denoted with a '1' and absence with a '0'.

Mark-rate:

To account for the number of unmarked individuals in a population it is necessary to work out the relative proportion of marked individuals. This is undertaken using the equation:

$$MR = \frac{Mc}{Tc}$$

Where Mc is the total number of marked captures across all sampling days, and Tc is the number of total captures across all sampling days.

Population estimate:

The population assessment for dolphins using the Bay of Islands between January and April 2011 was conducted using the software MARK. MARK provides various models to obtain abundance estimates as well as other key demographic features (Lettink & Armstrong, 2003; Cooch & White, 2011). The dolphins using the Bay of Islands may be considered an open population with high amounts of immigration/emigration with the larger North Island populations. Therefore it was important an abundance estimate was employed that took into account the open nature of the Bay of Islands dolphins.

The POPAN programme that has been incorporated into MARK utilizes a re-parametization of the traditional Jolly-Seber open population model to obtain an abundance assessment (Scharz & Arnason), 1996). Like most models of population assessment in MARK the key input data is the total capture history of all individuals encountered. The key difference of POPAN is that the programme includes a new parameter which postulates a hypothetical 'Super-population' (N) that essentially consists of all

animals that could be born(or immigrated) into the population between sampling periods (Cooch & White, 2011). As with Jolly-Seber models the parameter Pent is used (probability of entry of new individuals), however POPAN models Pent as the probability of new entrants from the defined 'Super-population' being encountered during sampling (Scharz & Arnason, 1996). In this manner, POPAN accounts for animals not actually seen during sampling but with an associated probability of being seen (Cooch & White, 2011). The key parameters of capture and survival probability are estimated as in the Jolly-Seber model (Arnason & Scharz, 1995). A key advantage of the POPAN programme is that parameters can be constrained by time and ran as different models to assess which has the best fit to the data available, thus increasing model accuracy (Sharz & Arnason, 1996;Tezanos-Pinto, 2009). The various models applied to the data where the following:

{Phi(t) p(t) pent(.) N(.) PIM}
{Phi(t) p(t) pent(.) N(t) PIM}
{Phi(t) p(.) pent(t) N(.) PIM}
{Phi(t) p(.) pent(t) N(t) PIM}
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{Phi(.) p(.) pent(t) N(t) PIM}
{Phi(.) p(.) pent(.) N(.) PIM}
{Phi(.) p(.) pent(.) N(t) PIM}

Where Phi is survival probability, p is capture probability , pent is the probability of entries and N is the Super-population size. (PIM is code for the production of a parameter matrix).

***(*t) indicates time dependence whilst (.) indicates time independence.**

MARK contains AICc, an inbuilt variation of AIC (Akaike's Information Criterion, Aikake 1973) to assess the best model for the available data. AICc assesses the number of paramaters in combination with the maximum likelihood for each model, the lowest AICc value being the associated with the best model (Tezanos-Pinto, 2009; Cooch & White, 2011).

POPAN provides an estimate of the total number of marked animals in the population (Arnason &

Scharz, 1996, 1999). Thus to account for the unmarked individuals in the population, the final population estimate of dolphins in the Bay of Islands was found with the equation:

$$N = N' + N'(1 - MR)$$

Where N is the total estimated population size of marked and unmarked individuals, N' is the population estimate of marked individuals from the POPAN model, and MR is mark rate.

Results:

Encounters:

Over the ten sampling days carried out in this study a total of 1034 photo-identification frames of good quality were taken of 63 uniquely identifiable Bottlenose dolphins. The greatest number of marked individuals encountered during one survey was 35 on the 11th April, whilst the least marked individuals encountered per day was 4 on the 15th of March (Figure 1).

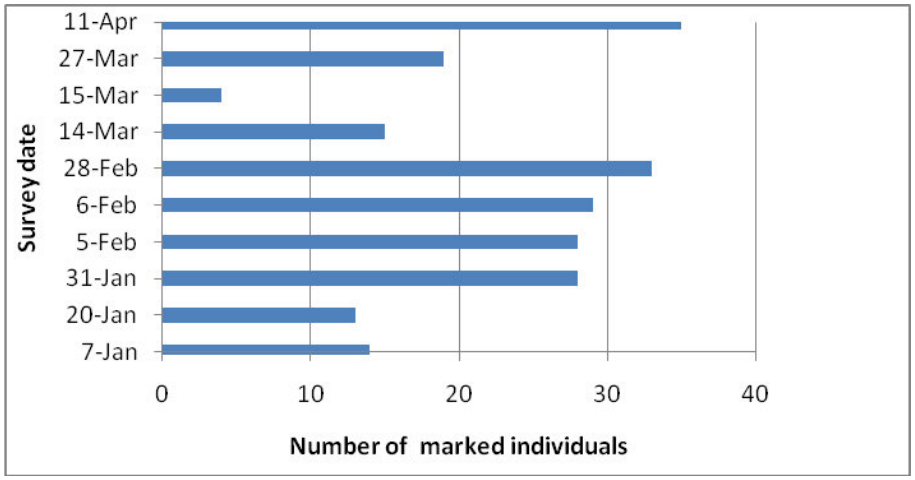

Figure 1: A summary of the number of marked individuals encountered on each sampling day during the study.

New dolphins continued to be encountered on every survey as indicated by the lack of a plateau on the discovery curve shown below (figure 2). The greatest amount of 'new' dolphins encountered on any survey day was 16 on the 31st of January, whilst no new individuals were encountered on the 27th of March.

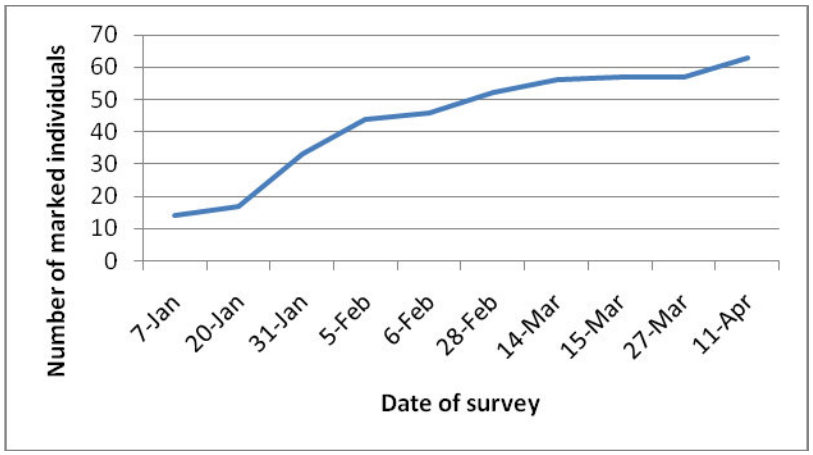

Figure 2: A discovery curve depicting the rate of encounter of new individuals across all survey days.

Mark-rate:

A total of 1253 photo-identification frames were taken of dolphin dorsal fins over the course of this study. Of these, 219 frames were of unmarked individuals. This provides a mark-rate for this study of 0.83.

New marked individuals:

A total of 8 individuals were identified as having significant distinguishing features yet were not present in the BIBDC. Upon the first encounter with these individuals they were treated as 'unmarked', and were subsequently added to the catalogue so that if further encounters were obtained they would be treated as 'marked' animals. Five of these dolphins; BOI 546, 547, 548, 549 and 550 were resighted at least once in subsequent surveys.

Population estimation:

The most parsimonious POPAN models were those that rendered survival (Phi) and capture (p) probability as time dependant, and the probability of entries (pent) as time independent. (Table 1). This is indicated by the low AICc value of 524.3105. The difference between the best and second best models is high, indicating that Phi and p are highly variable across time. Note that the effect of time

dependence upon Super-population size remains non-influential across all models. This is likely because N is not a product of a factor concerned with maximum likelihood like the other parameters and thus time is inconsequential (Cooch & White,2011).

Model	AICc	Delta AICc	AICc Weights	Model Likelihood	Num. Par	Deviance
{Phi(t) p(t) pent(.) N(.) PIM}	524.3105	0	0.5	1	21	23.5167
{Phi(t) p(t) pent(.) N(t) PIM}	524.3105	0	0.5	1	21	23.5167
{Phi(t) p(.) pent(t) N(.) PIM}	19712.78	19188.4725	0	0	20	19214.44
{Phi(t) p(.) pent(t) N(t) PIM}	19712.78	19188.4725	0	0	20	19214.44
{Phi(.) p(.) pent(t) N(.) PIM}	19722.57	19198.2555	0	0	12	19242.96
{Phi(.) p(.) pent(t) N(t) PIM}	19722.57	19198.2555	0	0	12	19242.96
{Phi(.) p(.) pent(.) N(.) PIM}	23777.48	23253.1663	0	0	4	23315.21
{Phi(.) p(.) pent(.) N(t) PIM}	23777.48	23253.1663	0	0	4	23315.21

Table 1: Results from the run of the eight POPAN models using different degrees of parameter time dependence.

The Gross population estimate from the model {Phi(t) p(t) pent(.) N(.) PIM} is 66 marked individuals (95%CI 62.22-69.34).

When scaled for the proportion of marked individuals as indicated by the mark rate (0.82) we reach a final population estimate of 78 (95%CI 77.41-81.82) marked and unmarked individuals.

Discussion:

Model assumptions:

The assumptions of the POPAN model are the same as for the traditional Jolly-Seber model (Arnason & Schwarz, 1995). The main assumptions being:

- No mark loss and correct identification of marks.

The survey period of this study was deemed short enough to not be concerned with mark change, the only method of mark loss possible for mark-recapture techniques of bottlenose dolphins (Read et al., 2003; Hammond et al., 1990). Mark matching was double checked by an independent observer to

ensure they were correctly identified.

- Homogeneity of capture probability for all animals alive just before sample.

Previous study has determined that there are no factors that influence the likelihood of capture for different bottlenose dolphin individuals to the extent where the assumption is jeopardized (Tezanos-Pinto, 2009; Bejder et al., 2006).

- Homogeneity of survival for all animals in the population just after sample.

The time between surveying days was deemed short enough to allow for homogeneity of survival across the sampling period.

As all assumptions for the open population model are met, the estimate is deemed reliable.

Population estimate:

The discovery curve (figure 2) shows that new individuals have been steadily encountered on each sampling day throughout the study (demonstrated by the absence of a plateau in the discovery curve. This indicates that surveying has not been sufficient to account for all individuals that may use the bay over an annual period. However this study provides an accurate assessment of the abundance of dolphins from the North Island population utilizing the Bay of Islands during the busy months. It is crucial to determine the extent of the effects of disturbance upon dolphin populations when the level of disturbance is greatest (Bejder et al., 2006; Lusseau et al, ref). Therefore much weight can be attributed to an assessment of population abundance during the summer months in the Bay of Islands if the population is deemed to be at risk from the impacts of tourism.

The amount of marked individuals encountered across all sampling days in this study is significantly lower (63 individuals) than the most recent previous survey of 2005 (84 individuals) (Tezanos-Pinto, 2009). Tezanos-Pinto (2009) conducted a far greater number of surveys across multiple years and

seasons, thus the population estimate in that study may be considered more precise and accurate than the current estimate. Tezanos-Pinto estimated the total population size of dolphins utilizing the Bay of Islands between 2003-2005 as 126 individuals (CV 0.02). However this result may not be directly comparable to the current study due to the limited temporal survey coverage associated with the current study, particularly the lack of seasonal data. Seasonal data was shown to be an important consideration in the models used to produce population estimations in the Bay of Islands (Tezanos-Pinto, 2009), as well as in the study of Bottlenose dolphin populations elsewhere in New Zealand (Williams et al., 1993; Merrimen, 2007; Berghan et al., 2008).

Tezanos-Pinto (2009) also pooled seasonal data to produce population estimates of seasonal windows throughout her study. The most recent seasonal population estimate was for the summer-autumn of 2005 with a population estimate of 98 (95%CI 87-108) (Tezanos-Pinto, 2009). As this result is directly comparable to the abundance estimate of the current study we can determine that there has been a 20% decline in the abundance of dolphins using the bay from summer 2005 to the summer of 2011.The previous population estimate also indicated a decline in the abundance of dolphin using the bay from 204 (CV 0.03) in 1998 to 126 (CV 0.02) in 2004, a decline of 30% (Tezanos-Pinto, 2009). The current study provides evidence of a continuation of the population decline that has been previously observed.

There is evidence to suggest that the decline in the population of Bay of Islands' users is a combination of increased adult mortality and emigration (Tezanos-Pinto, 2009). It is possible that increased emigration is a product of a change in home range selection due to a change in biotic or abiotic conditions or increased disturbance (Tezanos-Pinto, 2009). It is not possible to discount the effects of possible change in biotic conditions upon the current population as such change was not accounted for in this or any previous study. However, there has been significant study focussing on the effects of increased disturbance upon the population with the most significant source of behaviour disrupting

practise having been identified as the commercial tourism fleet (Constantine & Baker, 1997; Constantine et al., 2004). Tezanos-Pinto (2009), found the Bay of Islands was being used more frequently but by fewer individuals, indicating the abdication of the area by other possibly more sensitive individuals. This result is analogous to trends identified in Shark bay, Australia, where a large proportion of sensitive bottlenose dolphins migrated from an area experiencing high tourism disturbance resulting in population decline (Bejder et al., 2006). Additionally, resident bottlenose dolphins in Milford sound have residence patterns which are determined by the distribution of boat traffic (largely tourism) within the fiord (Lusseau, 2005). The bay experiences a variety of types of use from primary industries to tourism. It is possible that the effects of cumulative disturbance from a variety of sources are particularly significant for this relatively small population of dolphins in busy coastal area (Chilvers & Corkeron, 2003).

The observed decline in abundance of dolphins using the bay may also be indicative of a decline in the larger North Island population (Tezanos-Pinto, 2009).Without a range wide assessment of the population abundance for the greater North Island population it is not possible to discount this possibility. It is suggested that survey effort is applied to other areas of significance along the East coast of the North Island such as the Hauraki gulf, Tauranga and Doubtless bay (Constantine, 2002) to determine the state of the larger North Island population and/or to account for the possible emigration of Bay of Islands users.

Regardless of the method of decline, the fact the population of Bay of Islands' users continues to decline has serious connotations for the level of commercial use and the effectiveness of current management. Attempts to mitigate the disruptive effect of the commercial dolphin industry in the Bay of Islands include; the creation of a 'dolphin lunch hour' where tourism vessels are unable to approach dolphins between 1200 and 1300, the creation of dolphin resting areas that are off limits to tourism vessels, and

maximum of three vessels being permitted with a dolphin group at one time. Additionally, vessels are only permitted to swim with the dolphins should the group consist entirely of adults (Department of Conservation, pers comm.). There has been no study to assess effectiveness of such measures but in light of the continuation of population decline it is likely that such measures are ineffective. It is suggested that management be reviewed to pursue a precautionary approach and impose more substantial protection measures for the dolphins using the Bay of Islands. Coupled with ongoing research, precautionary management may ensure the ongoing viability of this important population.

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