Distribution and abundance of Maui's dolphins (*Cephalorhynchus hectori maui*) along the North Island west coast, New Zealand

DOC SCIENCE INTERNAL SERIES 93

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Published by
Department of Conservation
P.O. Box 10-420
Wellington, New Zealand

DOC Science Internal Series is a published record of scientific research carried out, or advice given, by Department of Conservation staff, or external contractors funded by DOC. It comprises progress reports and short communications that are generally peer-reviewed within DOC, but not always externally refereed. Fully refereed contract reports funded from the Conservation Services Levy (CSL) are also included.

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ISSN 1175-6519

ISBN 0-478-22360-9

This report originated from work carried out under Department of Conservation investigation no. 3537. It was prepared for publication by DOC Science Publishing, Science & Research Unit; editing by Jaap Jasperse and layout by Ruth Munro. Publication was approved by the Manager, Science & Research Unit, Science Technology and Information Services, Department of Conservation, Wellington.

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ABSTRACT

A subspecies of Hector's dolphin, *Cephalorhynchus hectori maui* (Maui's dolphin), occurs along the west coast of North Island, New Zealand. Previous studies and records indicated a small population size (134 individuals), a recent decline in the population (based on genetic data), and a change in the distribution of this subspecies. We conducted aerial surveys for Maui's dolphin between Paraparaumu and North Cape during the summers of 2000/01 and 2001/02, primarily to determine its current distribution. Dolphins were recorded between Kaipara Harbour and Kawhia Harbour, with most sightings between the Manukau Harbour and Port Waikato. A population estimate potentially constrained by availability and perception bias suggests that the population could be as small as 75 individuals (CI = 48–130). We conclude that strong conservation actions, including the immediate reduction of fisheries-related mortality to zero, might allow this population to recover.

Keywords: Hector's dolphin, Maui's dolphin, distribution, abundance, west coast North Island, aerial survey

Ferreira, S.M.; Roberts, C.C. 2003: Distribution and abundance of Maui's dolphins (*Cephalorhynchus hectori maui*) along the North Island west coast, New Zealand. *DOC Science Internal Series 93*. Department of Conservation, Wellington. 19 p.

1. Introduction

Hector's dolphin, *Cephalorhynchus hectori* (Van Beneden, 1881), is endemic to New Zealand. Two allopatric subspecies have been described recently (Baker et al. 2002): *C. hectori hectori* from South Island waters, and *C. hectori maui* from the west coast of the North Island. A few sightings of the species have been recorded along the east coast of the North Island (Russell 1999), but the status of any permanent population on that coast is unknown. The species is considered to have been distributed along the entire west coast of New Zealand when the coastline was continuous in the Pleistocene glacial periods (Pichler 2002; Baker et al. 2002). The post-glacial opening of Cook Strait separated a northern population and confined it to the North Island, while the dolphin population around the South Island became fragmented into three regional populations (Pichler 2002): west coast South Island, east coast South Island and south coast South Island.

The reasons for the range fragmentation of Hector's dolphins are not well understood but it has been suggested that natal fidelity, ecological preference, and strong philopatry could have contributed to such fragmentation (Dawson & Slooten 1993; Pichler & Baker 2000). A mitochondrial DNA study (Pichler et al. 2001) suggests that the North Island population has been isolated from the South Island populations for up to 16 000 years. The North Island population now represents a morphologically and genetically distinct subspecies of Hector's dolphin with a unique haplotype (Pichler et al. 1998; Baker et al. 2002). Prior to 1987, haplotypes from other regions were occasionally recorded in the North Island population, but after 1987 only North Island haplotypes have been recorded (Pichler & Baker 2000). This reduction in genetic diversity suggests a decrease in population size of the North Island subspecies of Hector's dolphin. The only available population estimate for *C. hectori maui* is 134 dolphins in 1985 (Dawson & Slooten 1988).

In recent years, one of the major contributing factors to the decline of the Maui's dolphin subspecies has been fishing-induced mortality (Martien et al. 1999). Pollution is thought to be another, less-significant contributing factor to mortality: the near-shore habitat favoured by Hector's dolphins exposes them to a variety of pollutants and contaminants such as organochlorines and heavy metals (Baker 1978). Plastic debris also constitutes a potential threat (Laist 1987).

The fishing-induced mortality has contributed to both a decrease in population size, and a reduction in genetic diversity of the North Island subspecies (Pichler 2002). For instance, comparison of historic and contemporary genetic diversity suggests a severe decline in abundance of the North Island population (Pichler & Baker 2000). In addition, Pichler (2002) evaluated diversity at nuclear loci using six micro-satellite markers and recorded that three of those were fixed with low diversity for the other loci. More importantly, indirect evidence, using Tajima's D-statistic as measure of expected mtDNA diversity, suggests that the North Island population has undergone a *recent* (e.g. last few generations) population decline (Pichler 2002). Because of the evidence of decline, the IUCN

(2000) classified the population as ‘critically endangered’, while the species was declared ‘threatened’ during 2001 under the provisions of the New Zealand Marine Mammals Protection Act (1978).

As the main cause of Hector’s dolphin demise appears to be fisheries-related, management options in the past have focused on aspects of the fisheries. For instance, a recreational set-net ban is currently in place along the west coast of the North Island, but commercial set-net regulations gazetted by the Minister of Fisheries during 2001 were annulled by the New Zealand High Court during May 2002, primarily as a result of insufficient and incorrect information. Provisions under the Fisheries Act (1996) allow management regulations ranging from gear restrictions to complete fishing bans and may include the setting of maximum allowable levels of fisheries related mortality (‘MALFIRMs’: Wade & Angliss 1997; Wade 1998). MALFIRMs are calculated using a reliable population estimate and an estimate of maximum population growth rate. Furthermore, information on the distribution of a particular species and the location of interactions with fisheries are also necessary in making management decisions leading to the implementation of regulations. Management using such a legislative structure therefore requires two key components: the distribution of a population and robust population abundance estimates.

Prior to 1998, the distribution of Hector’s dolphins in North Island waters was primarily based on stranding records and public sightings (Baker 1978, 1981; Russell 1999). However, since 1998 there have been intensive and systematic observations by a boat-based study (Russell 1999) and genetic studies (Pichler 2002) which have provided additional information on the dolphin’s distribution. Some concerns over the use of public (i.e. non-systematic) sightings to describe both the past and present distribution of North Island Hector’s dolphin have been raised, despite the species’ distinctive size, colour and external morphology. The primary objective of our study was to assess the current distribution of dolphins using a systematic methodology without the constraints that are common to boat-based surveys, and reports of strandings and sightings. A secondary objective was to attempt to estimate the population size of North Island Hector’s dolphin, while acknowledging the constraints of a survey primarily designed for determining the range of the population.

2. Material and methods

The survey was carried out using aerial survey techniques. Based on previous studies, we expected two gradients of dolphin distribution and abundance. First, distribution and abundance should vary north and south along the coast of the North Island (Russell 1999). Secondly, we expected that distribution and abundance should vary with offshore distances (Dawson & Slooten 1988). We also expected seasonal variation based on Dawson & Slooten’s (1988) observations along the east coast of the South Island, and therefore restricted the surveys to between December and March of the 2000/01 and 2001/02 summers. Some additional flights were also conducted during October 2001.

Following consultation with experienced researchers (Steve Dawson, pers. comm.[1]; Jenny Brown, pers. comm.[2]; Gregory Stone, pers. comm.[3]), our survey consisted primarily of longitudinal flights parallel to the coast line at various distances offshore.

We used prominent landmarks and divided the west coast of the North Island into eight zones of unequal size (Fig. 1). In each of these zones, transects parallel to the coastline along the total length of a zone were established at various distances offshore. Effort was variable across zones and offshore distances (Table 1).

A number of flights at 45° to the coastline were also conducted up to 5 nautical miles (9.3 km) offshore in the Manukau–Port Waikato Zone where, historically, most strandings and sightings have been recorded (Russell 1999).

2.1 SURVEY PLATFORM AND PROTOCOL

We utilised aerial rather than boat-based survey techniques primarily to allow us to cover large areas along the west coast of the North Island efficiently. The survey platform was a four-seater Cessna 172 with high wings, low noise, good forward vision and the ability to fly safely at slow airspeeds. The survey crew comprised a commercial pilot and a recorder/flight controller in the two front seats. Two observers, located in the rear seats, made observations of dolphins from both sides of the aircraft at all times while on a survey transect.

Surveys were conducted at 75 knots in surface wind-speeds of less than 10 knots, at a height of 180 m (600 ft) above sea level. Surveys were not conducted in sea conditions with an estimated swell height of greater than 3 m. Conditions (wind-speed and direction, swell height and direction, turbidity, percentage cloud cover and glare) were recorded every 5 minutes and a survey-flight terminated when protocol conditions (wind-speed and swell height) were violated.

The co-ordinates of transects were determined by a global positioning system (GPS) and recorded on a laptop computer using Ozi-Explorer moving map software. This facilitated download of transects and way-point observations made onto Arcview, a Geographical Information System.

The front seat recorder/flight controller was responsible for recording additional data into a notebook including time, species, perpendicular downward angle from the horizontal to the sighting, way-point references, group size, number of calves, initial sighting cue, behaviour and other comments such as fishing activities. Voice-activated headphones linked the survey team, while sightings, time and behavioural information were also recorded onto voice-activated tape recorders.

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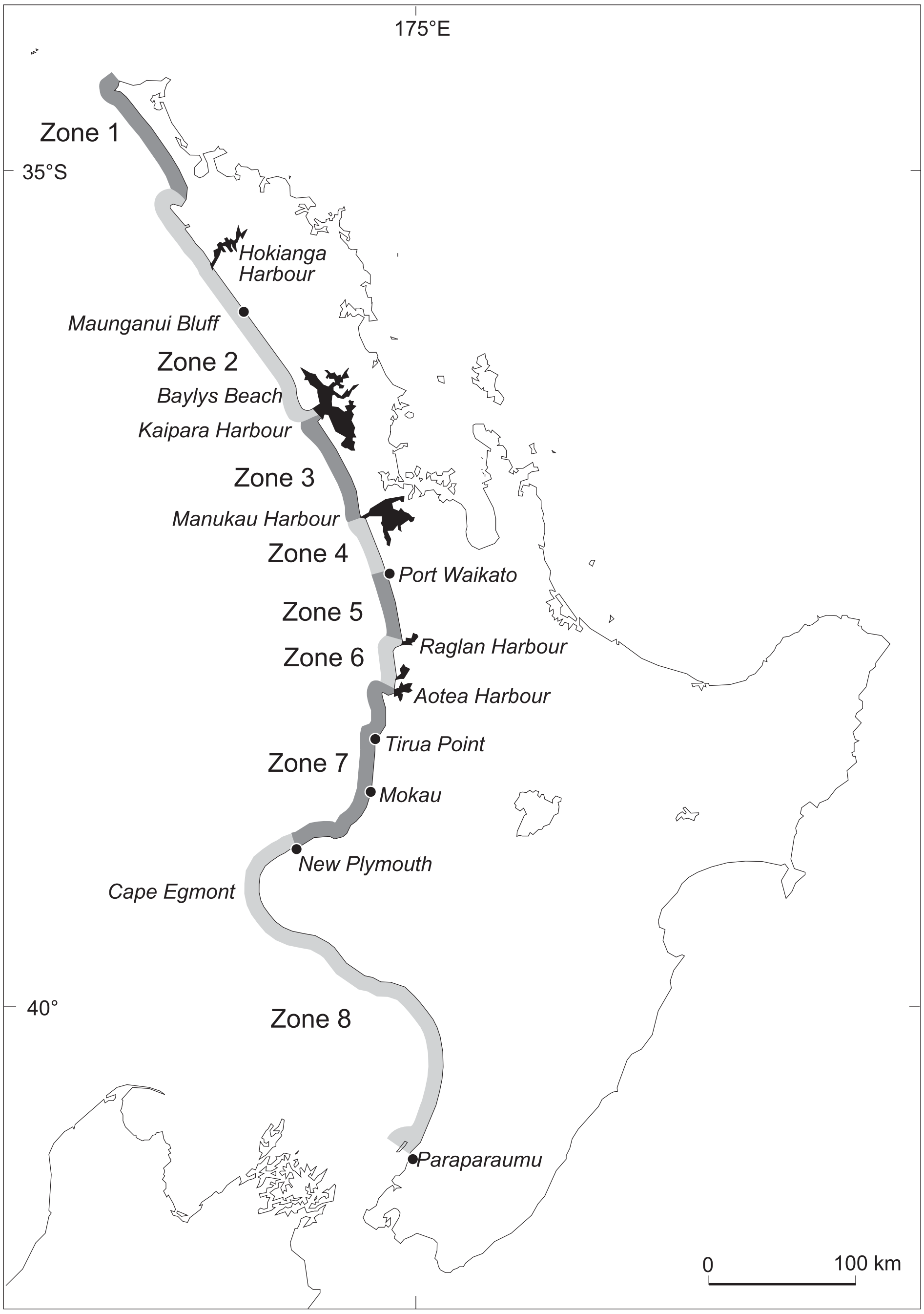
2 University of Canterbury, Christchurch, New Zealand.

3 New England Aquarium, Boston, USA.

Figure 1. Maui's dolphin survey zones along the west coast of the North Island of New Zealand. The zones were defined as follows: Zone 1: Cape Reinga–Ahipara, Zone 2: Ahipara–Kaipara North Head, Zone 3: Kaipara North Head–Manukau North Head, Zone 4: Manukau North Head–Port Waikato South Bank, Zone 5: Port Waikato South Bank–Raglan North Head, Zone 6: Raglan North Head–Kawhia North Head, Zone 7: Kawhia North Head–New Plymouth, and Zone 8: New Plymouth–Paraparaumu.



When a Hector's dolphin was sighted, the angle from the horizontal to it was recorded. The flight path along the transect was interrupted approximately 10 seconds after the angle-reading was recorded using an inclinometer and the aircraft circled back towards the location of the sighting, to join the flight path along the transect at a point approximately 1 km before the point from which the sighting occurred. This resulted in a 'racetrack' flight pattern. The number of dolphins was recorded when the first sighting was made, and when circling and passing a second time. In this way the total pod size could be determined accurately. Note that no additional sightings were recorded during this exercise.

TABLE 1. SURVEY EFFORT DURING THE SUMMERS OF 2000/01 AND 2001/02.
n represents the number of transects in a zone. The number in brackets represents the number of transects. n.a. = not applicable.

ZONE	AREA (km^2)	EFFORT (km)	*n*	EFFORT (km) AT VARIOUS OFFSHORE DISTANCES							
				400–600 m	800–1000 m	1500 m	2500 m	4500 m	5500 m[1]	7500 m	9500 m
Summer of 2000/01											
Cape Reinga – Ahipara	1012.7	216.0	2	108.0 (1)	108.0 (1)	–	–	–	–	–	–
Ahipara – Kaipara	1917.5	538.9	4	184.5 (1)	170.0 (2)	–	–	–	–	184.5 (1)	–
Kaipara – Manukau	822.9	931.0	14	166.2 (2)	598.6 (10)	–	166.2 (2)	–	–	–	–
Manukau – Port Waikato	353.7	1332.5	34	313.5 (8)	627.0 (16)	78.4 (2)	39.2 (1)	78.4 (2)	156.8 (4)	–	39.2 (1)
Port Waikato – Raglan	482.2	624.5	12	140.1 (2)	312.2 (6)	52.0 (1)	52.0 (1)	104.1 (2)	–	–	–
Raglan – Kawhia	382.9	156.4	4	39.1 (1)	117.3 (3)	–	–	–	–	–	–
Kawhia – New Plymouth	1454.1	620.3	5	156.8 (1)	463.5 (4)	–	–	–	–	–	–
New Plymouth – Paraparaumu	3047.1	540.0	2	270.0 (1)	270.0 (1)	–	–	–	–	–	–
45° offshore surveys	353.7	–	–	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Summer of 2001/02											
Cape Reinga – Ahipara	1012.7	–	–	–	–	–	–	–	–	–	–
Ahipara – Kaipara	1917.5	548.9	4	184.5 (1)	274.5 (2)	–	90.0 (1)	–	–	–	–
Kaipara – Manukau	822.9	357.4	5	274.3 (4)	83.1 (1)	–	–	–	–	–	–
Manukau – Port Waikato	353.7	460.1	21	303.4 (17)	156.8 (4)	–	–	–	–	–	–
Port Waikato – Raglan	482.2	312.2	6	208.2 (4)	104.1 (2)	–	–	–	–	–	–
Raglan – Kawhia	382.9	156.4	4	78.2 (2)	78.2 (2)	–	–	–	–	–	–
Kawhia – New Plymouth	1454.1	627.0	4	313.5 (2)	313.5 (2)	–	–	–	–	–	–
New Plymouth – Paraparaumu	3047.1	–	–	–	–	–	–	–	–	–	–
45° offshore surveys	353.7	572.4	44	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

[1] Flight in October.

2.2 DATA ANALYSIS

We recognised that a number of factors related to Hector's dolphin biology and habitat can influence the detection and visibility of dolphins (e.g. duration of surfacing, pod sizes, the small size of Hector's dolphin, the turbidity of the water and sea conditions). Availability and perception biases are potential sources in variation of observations (Marsh & Sinclair 1989). Slooten et al. (2002) estimated availability bias, i.e. the proportion of time a dolphin is visible at the water surface when a survey team passes over, as 0.463 (*CV* = 4.23%). By contrast, our protocol was directed at ensuring that we counted the exact number in a group. We are confident that, for those sightings noted, we accurately recorded the number of dolphins comprising a sighting.

We remained concerned about those groups of dolphins where all may have been under water and not available for sighting when the survey team passed over. Slooten & Dawson (1994) recorded long dives of 1–1.5 minutes, but during those dives, dolphins were almost continuously visible from the air, except in extremely turbid waters. In addition, our flight speed was relatively slow, so observers had a reasonable amount of time to scan the surface per unit area. This would have reduced the probability of dolphins being missed. We therefore did not make any corrections for availability bias as we believe it to be negligibly small.

Perception bias, i.e. sightings missed due to glare, fatigue or inattention by observers (Marsh & Sincair 1989), was also considered; it was estimated by Slooten et al. (2002) as 0.962, *CV* = 2.26%. Our protocol involved the same two survey-teams in both years, working with breaks every 30 minutes to maximise experience and minimise fatigue. For the present analysis we consider that perception bias would have a negligibly small effect on the probability of observing dolphins at 65 m from the transect (the nearest distance to the transect that observers could scan the surface due to the aircraft design).

Future surveys could benefit from evaluating our assumptions that availability and perception bias are negligible.

We corrected for unequal survey effort in each zone in our analysis of distribution by multiplying the frequency of sightings by a correction factor. The correction factor weighted frequencies of sightings according to the area of a zone and the distance flown in that zone, and reflected the distance flown per unit area (correction factor = 1/(Effort/Area)). The area of a zone is the area contained between along-shore boundaries and 10 nautical miles offshore. We used the weighted frequencies of sightings in our comparison between zones, summers, distance offshore and comparison with stranding frequencies since 1980. We corrected stranding frequencies for each zone by expressing them as the number of strandings per 100 km^2. For offshore comparisons, we also calculated expected weighted sightings in a zone as the sum of the weighted sightings, divided by the sum of the sightings and multiplied by the number of sightings in a zone.

The GPS locations recorded for each sighting were used to define distribution. The mean and variance of the distance between all sightings were estimated. We then added the 95% upper confidence limit of the mean distance between sightings to the north of the most northern record and the south of the most southern record to define part of the coast that contains most of the Maui's dolphin population. In addition, this distribution (defined by aerial surveys) was compared with the distribution defined by recent stranding records since 1980, collated from published (Russell 1999) and unpublished (Kirsty Russell, pers.comm.[4]) records.

Abundance estimation was conducted for each zone using distance-sampling techniques (Buckland et al. 1993). First we developed a detection function using 67 sightings available after right truncation at 1020 m (following Buckland et al. 1993) and left truncation at 65 m to estimate the effective half strip width. Left truncation at 65 m was necessitated by the inability to observe dolphins closer than 65 m from the transect line due to aircraft design. We explored three models (Hazard/Cosine, Hazard/Simple polynomial and Hazard/Hermite polynomial) and used Akaike's Information Criterion (Akaike 1973) to select the models. We used the χ^2 Goodness of Fit test to evaluate model fit (Buckland et al. 1993).

Expected group size was estimated as the mean of the observed group sizes recorded for each sighting. Group size (2.53 ± 0.23, estimated mean ± SE) and the effective half strip width (203.9 m) were estimated using all 67 sightings. We estimated abundance within each zone by estimating density and calculating abundance using the area comprising a zone.

3. Results

A total of 139 dolphins were recorded during 58 sightings made on longitudinal transects parallel to the coast. A further 26 dolphins (12 sightings) were recorded as part of the 45° offshore surveys conducted during 2001/02 (Table 2). Note that four sightings comprising nine dolphins were made during a flight conducted in October 2001. The frequency of sightings on flights parallel to the coast were dependent on zones but independent of the summer in which the survey was conducted (*G*-test for independence: $G_1 = 4.45$, $p = 0.03$). Nearly three times as many sightings were made per unit effort per unit area in the Manukau–Port Waikato Zone than in the two adjacent zones (Kaipara–Manukau and Port Waikato–Raglan) (Table 3). Seventy-nine percent of the pooled sightings (86.5% of all individual dolphins) for the two summers along flights parallel to the coast were in the Manukau–Port Waikato Zone (Fig. 2). The strandings in each zone since 1980 were proportionally associated with the number of observation in each zone during the present study (Paired *t*-test: $t_7 = 0.01$, $p = 0.99$) (Table 3).

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[4] University of Auckland, Auckland, New Zealand.

TABLE 2. SIGHTINGS OF MAUI'S DOLPHINS RECORDED DURING AERIAL SURVEYS CONDUCTED IN THE SUMMERS OF 2000/01 AND 2001/02.

	2000/01		2001/02	
ZONE	SIGHTINGS	DOLPHINS	SIGHTINGS	DOLPHINS
Cape Reinga–Ahipara	0	0	–	–
Ahipara–Kaipara	0	0	0	0
Kaipara–Manukau	4	6	1	3
Manukau–Port Waikato	26	75	20[a]	45
Port Waikato–Raglan	2	2	4	6
Raglan–Kawhia	0	0	1	2
Kawhia–New Plymouth	0	0	0	0
New Plymouth–Paraparaumu	0	0	–	–
45° offshore surveys	–	–	12	26

[a] Includes four sightings recorded during October 2001.

TABLE 3. FREQUENCY OF OCCURRENCE AND CORRECTED DISTRIBUTION INDEX OBTAINED DURING THE AERIAL SURVEY IN COMPARISON WITH THE FREQUENCY OF STRANDINGS AND CORRECTED STRANDING INDEX SINCE 1980 (RUSSELL 1999; KIRSTY RUSSELL, UNIVERSITY OF AUCKLAND, NEW ZEALAND, PERS. COMM.).

ZONE	SIGHTINGS	WEIGHTED SIGHTINGS	STRANDINGS	WEIGHTED STRANDINGS
Cape Reinga – Ahipara	0	0	1	0.10
Ahipara – Kaipara	0	0	3	0.16
Kaipara – Manukau	5	3.19	5	0.61
Manukau – Port Waikato	46	9.06	7	1.98
Port Waikato – Raglan	6	3.08	1	0.21
Raglan – Kawhia	1	1.22	1	0.26
Kawhia – New Plymouth	0	0	8	0.55
New Plymouth – Paraparaumu	0	0	2	0.07

Frequency of sightings decreased with distance offshore with most sightings (87.3%) within 1500 m of the shore (Fig. 3). The furthest sighting from the shore was recorded at 6.2 km during October 2001. Note that correction for survey effort suggested that more sightings were recorded at distances greater than 800 m offshore (*G*-test for Goodness of Fit: $G_4 = 16.34$, $p < 0.01$), a figure higher than expected from our observed uncorrected sightings.

We defined the current range of the Maui's dolphin population using our estimate of mean distance (± SD) between all sightings of 29.5 ± 16.9 km. The range of dolphins observed during the aerial survey was estimated to stretch between a point 62.6 km north of our most northern sighting, i.e. Moremonui Gully north of Baylys Beach to 62.6 km south of our most southern sighting, i.e. 10 km south of Tirau Point. In terms of prominent land-marks, the area (up to 7.4 km or 4 nautical miles offshore) between Manganui Bluff and Mokau will include most of the present distribution of Maui's dolphins.

Figure 2. Distribution of Maui's dolphin sightings during surveys conducted in the summers of 2000/01 and 2001/02. The four furthest offshore sightings in Zone 4 (Manukau to Port Waikato) were recorded during October 2001.

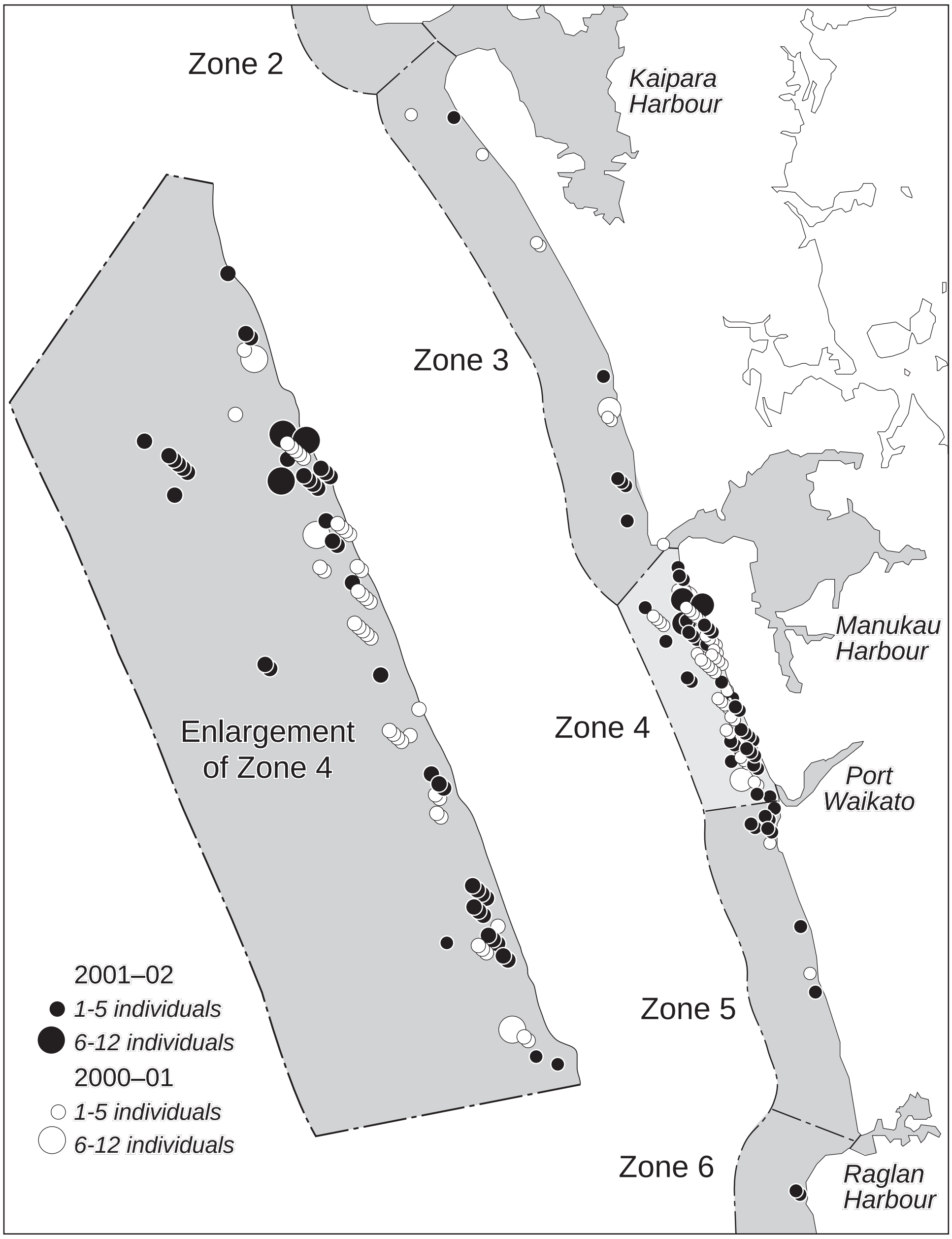
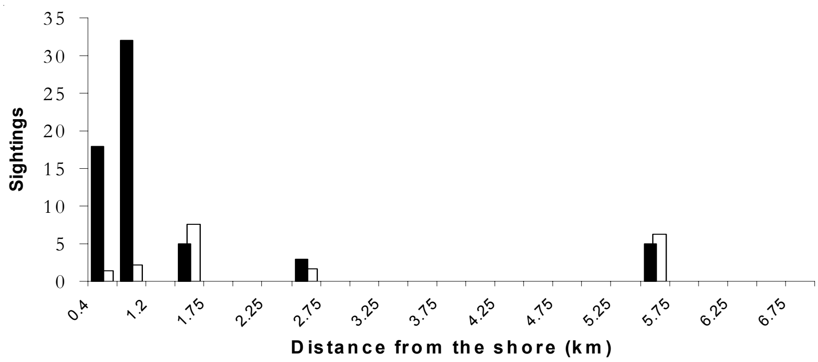


Figure 3. Frequency of occurrence of Maui's dolphin sightings at different distances from the shore (solid bars). Open bars represent weighted sightings corrected for survey effort. Note that the observations furthest from the shore were recorded during October 2001.



For abundance estimation, the detection function, using 67 sightings that were available after truncation, was modelled by a Hazard-rate Hermite-polynomial model (AIC = 883.74) and represented the data well (Goodness of Fit test: χ^2 = 8.30, d.f. = 5, p = 0.15) (Fig. 4). Using this detection function, the Maui's dolphin population was estimated as 75 individuals (CV = 23.63%) with the lower 95% confidence interval 48 individuals and the upper 95% confidence interval 130 individuals. The largest proportion of the population (68%) resides in the Manukau–Port Waikato Zone (Table 4).

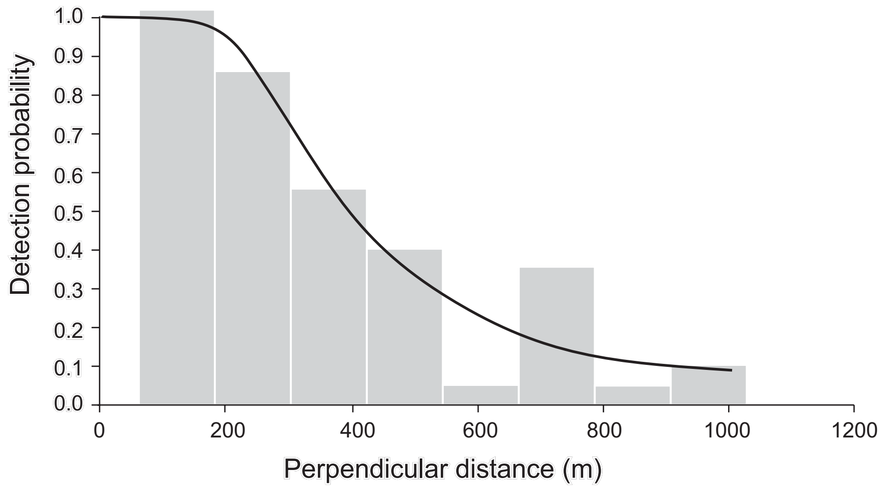


Figure 4. Detection function fitted for distance data collected during the summers of 2000/01 and 2001/02 (n = 67 sightings). The effective half-strip width was estimated as 203.9 m.

TABLE 4. ESTIMATES OF TOTAL MAUI'S DOLPHIN POPULATION SIZE WITHIN ZONES. Sightings (n) exclude those that were truncated as part of the estimation of the detection function and those recorded along 45° transects. n, number of sightings; N, estimated population size; CV, coefficient of variation; LCI, lower 95% confidence interval; UCI, upper 95% confidence interval.

SURVEY ZONES	n	N	CV	LCI	UCI
Cape Reinga–Ahipara	0	0	–	–	–
Ahipara–Kaipara	0	0	–	–	–
Kaipara–Manukau	5	10	48.83	4	25
Manukau–Port Waikato	44	51	24.74	32	83
Port Waikato–Raglan	6	10	45.29	4	23
Raglan–Kawhia	1	4	101.09	1	19
Kawhia–New Plymouth	0	0	–	–	–
New Plymouth–Paraparaumu	0	0	–	–	–
Total	56	75	23.63	48	130

4. Discussion

The remaining Maui's dolphins constitute a small population restricted to a fraction of their former wider distribution along the west coast of the North Island (prior to the 1960s regular sightings were recorded as far south as Paraparaumu (Larry Paul, NIWA, pers.comm.)). Our results show that dolphins are now primarily observed between Manganui Bluff and Mokau with the majority of observations between Manukau and Port Waikato. Stranding records since 1990 have been concentrated in the area from Port Waikato to Kaipara Harbour (Russell 1999). Russell reported a change in strandings distribution since 1970, with most recent dolphin strandings occurring further north.

Russell (1999) speculated on the reasons for the change in distribution of strandings. It may reflect:

- a change in the distribution of the population, or
- that the localities of strandings are independent of the locality of death, or
- that not all strandings are reported, or
- that only a proportion of dead dolphins wash ashore.

We will address two of the speculations—that there has been a true shift in dolphin distribution and that strandings are independent of location of death—as there is limited information regarding the other two speculations.

Our results suggest that it is unlikely that there are large-scale movements of dolphins from point of death to sites of stranding, as the population distribution determined by our and other aerial surveys coincides with the distribution of strandings reported in recent years.

Based on the available information, it is most likely that the distribution of the population has changed. Duffy & Williams (2001) conducted a preliminary aerial survey between Urenui, North of New Plymouth, and Tirau Point during April 1999 and recorded no dolphins. Historically, most strandings occurred between Cape Egmont and Tirau Point (Russell 1999). Only one stranding has been recorded in this area since 1990. Our survey recorded no dolphins in the Urenui to Tirau Point area surveyed by Duffy & Williams (2001). Furthermore, Duffy & Williams (2001) collated 11 reports of sightings between Cape Egmont and Tirau Point between 1950 and 1990. Eight sightings were recorded since 1990, all north of Mokau (Duffy & Williams 2001). It is, therefore, apparent that dolphins were previously recorded south of Mokau, but during recent years and during the present survey no dolphins were recorded here. So the distribution of Maui's dolphin has changed in a manner that corresponds with previously recorded changes in stranding data (Russell 1999).

Our survey results also permit comment on the type of distributional change that has occurred in recent years. The distribution of Maui's dolphins could have changed through a complete shift of an entire population from south to north, which is one way to interpret Russell's (1999) stranding data, but this seems unlikely. Cawthorn (1988) collated sightings along the entire west coast of the North Island, and these indicate that the historic distribution was likely to have encompassed most of the North Island west coast. Russell's (1999) speculation that not all strandings are reported or observed is probably correct.

Was the distribution uniform or clumped along the coast? Hector's dolphin (both subspecies) are often recorded in turbid waters near river mouths and estuaries (Abel et al. 1971; Baker 1972, 1978; Mörzer-Bruyns & Baker 1973) suggesting a preference for this type of habitat. Dawson & Slooten (1988) suggested that the most significant factor influencing distribution appears to be water depth. Our own observations between Manukau and Port Waikato certainly indicate a relatively uniform distribution with no preferences for turbid waters associated with river mouths or harbour entrances in particular, although there appeared to be some association with turbid waters irrespective of river mouth or harbour entrances. Such turbid waters are characteristic of most of the North Island west coast (pers. obs., C.C. Roberts). The change in distribution of Maui's dolphins indicated by our survey has most likely resulted from the former distribution of the population contracting. Martien et al. (1999) and Pichler & Baker (2000) indicated that the range had been restricted and that the reduction was a result of fisheries-related mortality.

Offshore distribution was less well defined by our survey, primarily because of low and variable survey effort. Nonetheless, most dolphins were observed within 1500 m of the shore. Our results conform well to the offshore distribution recorded by Dawson & Slooten (1988) for Hector's dolphin along the east coast of the South Island. Note that weighted frequencies of sightings were higher than expected for greater distances from the shore. This suggests that some dolphins may spend considerable time during summer further offshore. In addition, the furthest observations offshore (5.75 km) were recorded during a flight in October 2001. It is likely, therefore, that seasonal offshore movement as recorded by Dawson & Slooten (1988) could also characterise Maui's dolphins.

The population between the Wanganui River and the Kaipara Harbour was estimated in 1985 by Slooten & Dawson (1988), using boat-based strip surveys during which 22 dolphins were sighted, to comprise 134 individuals. The 95% confidence interval for that survey was 46–280 (see Martien et al. 1999). Cawthorn (1988) speculated that the population between Wanganui River and Ninety Mile Beach could be 400 during 1988, based on incidental sightings from various sources.

The population was assumed to have been at carrying capacity during 1970, estimated by Martien et al. (1999) as 437. Using this estimate, the prediction for the North Island dolphin population during 2002 was 39 individuals. This assumes a constant rate of change of –0.07 since 1970 (estimated from the population estimates during 1970 and 1985, $N_t = N_0 e^{rt}$: Caughley 1977). It is likely, however, that the assumption of a constant rate of change inherent in the model has been violated during recent years. For instance, seven dolphin strandings have been recorded during the period 2000–02 between Kawhia and Manukau Harbours, with at least two a result of human activities and others demonstrating net-marks (pers. obs., C.C. Roberts). Our abundance estimate, though constrained by availability and perception bias, suggests the population to comprise between 48 and 130 individuals (Table 4).

5. Conclusions

We have determined the distribution of Maui's dolphin on the North Island's west coast from systematic aerial surveys and compared it with estimates of the historic distribution. There is a clear reduction in the range since earlier surveys and assessments of the number and distribution of the dolphins. The population is small and, based on the number of recent strandings, is likely to be declining. Extreme conservation and management measures are therefore required to save Maui's dolphin from extinction. Due to the small population size, any fishing method or other human-related factor that has contributed to mortality in the past should be considered a current or potential threat. Furthermore, the immediate reduction of fisheries-related mortality and other human-related mortality to zero must be considered pivotal to the survival of this endemic, isolated subspecies of Hector's dolphin.

6. Acknowledgements

We appreciate the commitment from Jo Ritchie, Chris Wild and Natalie Patenaude for diligent participation as observers. Rod Miller is thanked for his accurate flying and participation in the survey. Roger Stevenson, Craig Atchinson and Gregory Stone provided advice on flight patterns and aircraft limitations, while Dan Blok assisted with the download of GIS information from laptop computers. Chris Wild provided assistance with GIS analyses. Paul Wade, Geoff Given, Ian Wilkinson, Simon Childerhouse and Alan Baker provided valuable comments on a draft of the manuscript. Lynette Clelland provided editorial suggestions.

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