Line-transect survey of Hector's dolphin abundance between Farewell Spit and Motunau

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CONTENTS

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ABSTRACT

This report summarises the results of line-transect surveys undertaken in 1999/2000 to quantify the abundance of Hector's dolphins (*Cephalorhynchus hectori*) in the coastal area between Farewell Spit and Motunau, along the north-east coast of the South Island, New Zealand. A total of 23 sightings were recorded in 766 km of trackline. Greatest dolphin densities were found within Queen Charlotte Sound, Cloudy and Clifford Bays, and between Cape Campbell and Motunau, South Island, New Zealand. No sightings were reported within Golden Bay or Tasman Bay, within Pelorus Sound, or seaward of the Marlborough Sounds. The total corrected abundance estimate for the survey area (to 4 n.m. offshore) is 285 dolphins (95% CI = 137–590). The total abundance estimate, summing the two previous surveys and the current survey (Farewell Spit to Long Point) is 1882 dolphins (95% CI = 1246–2843).

Keywords: Hector's dolphins, *Cephalorhynchus hectori*, abundance estimates, South Island, New Zealand.

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1. Introduction

The third of an on-going programme of line-transect surveys to estimate abundance of Hector's dolphins (*Cephalorhynchus hectori*) was completed between December 1999 and February 2000, covering the area from Farewell Spit to Motunau (north-east coast of the South Island, New Zealand; Figs 1, 2). The first survey encompassed the area between Motunau and Timaru during the summer of 1998 (Dawson et al. 2000). The second survey extended coverage from Timaru to Long Point in the 1998/99 summer (DuFresne et al. 2001). Surveys of the west coasts of the North Island and South Island will complete a population survey for Hector's dolphins. There are occasional sightings in other areas, but these are too infrequent to allow abundance estimation by any standard survey method.

Current and accurate abundance estimates are a basic requirement for management. Effective conservation management is of key importance for Hector's dolphin due to their slow population growth and limited distribution (Dawson & Slooten 1988), genetically different sub-populations (Pichler et al. 1998), and mortality in gillnet fishing (Dawson 1991).

2. Methods

2.1 FAREWELL SPIT–MOTUNAU LINE TRANSECT SURVEY

The line-transect survey methods used were the same as for the previous two surveys, and we used the same correction factor for dolphin attraction and missed sightings (Dawson et al. 2000, DuFresne et al. 2001). We used the same vessel (RV *Catalyst*) which is equipped with a purpose-built observer platform, providing a 6 m eye height. *Catalyst* has a cruising speed of 9–10 knots and a minimum working depth of 2 m.

The survey design consisted of transect lines laid out across factors known to influence Hector's dolphin density (Figs 1, 2). As in our previous line-transect surveys, transects were placed at 45° to the coast to account for dolphin movement alongshore (Slooten & Dawson 1994) and declining density with distance offshore (Dawson & Slooten 1988).

Transect line spacing was decided mainly on the basis of existing data on dolphin distribution (Dawson & Slooten 1988), and reports of recent sightings. As in the previous two surveys, the goal was to put most survey effort into areas of relatively high density because these will contribute most to the overall abundance estimate. Inshore transects (from the coast to 4 nautical miles (n.m.) offshore) were spaced at 8 n.m. apart between Farewell Spit and Cape Koamaru, as previous information indicated very low dolphin densities in this

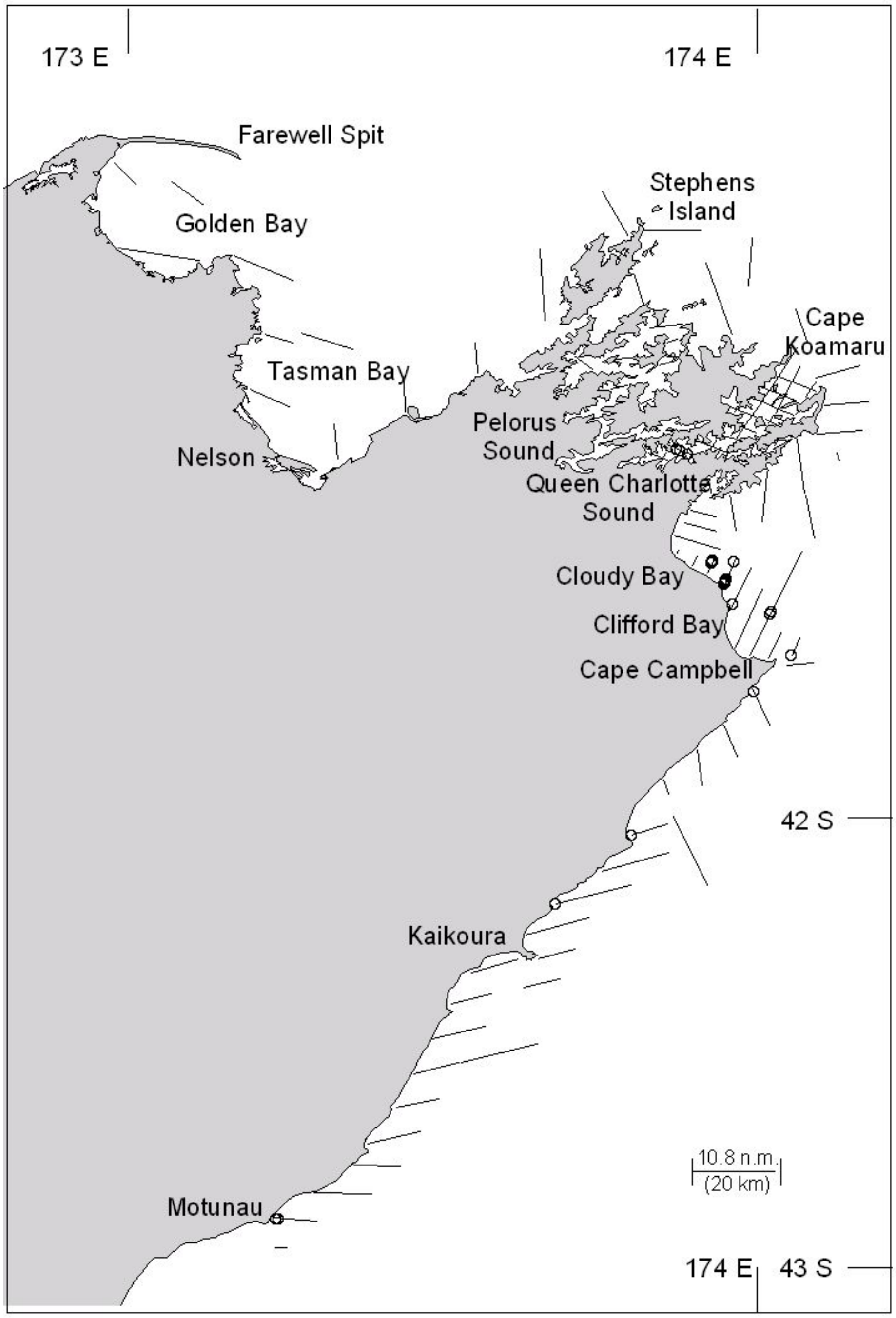

Figure 1. Transect lines and sightings between Farewell Spit and Motunau.

area. Lines were spaced 4 n.m. apart within Pelorus sound, between Cape Koamaru and Port Underwood, and from Cape Campbell to Motunau.

In Queen Charlotte Sound, two replicate sets of transects were carried out, which reduced the line spacing from 4 n.m. originally, to 2 n.m. Dolphins are known to occur in Queen Charlotte Sound, and were sighted off-effort while carrying out the first set of transect lines. Yet, densities were so low that two sets of transect lines were needed to make any sightings. Sponsorship from Clifford Bay Mussel Farms Ltd allowed us to double our effort in Cloudy Bay and Clifford Bay. We included the adjacent Port Underwood in this high effort area. In the offshore zone (4–10 n.m. offshore), transect lines were spaced approximately 30 n.m. apart.

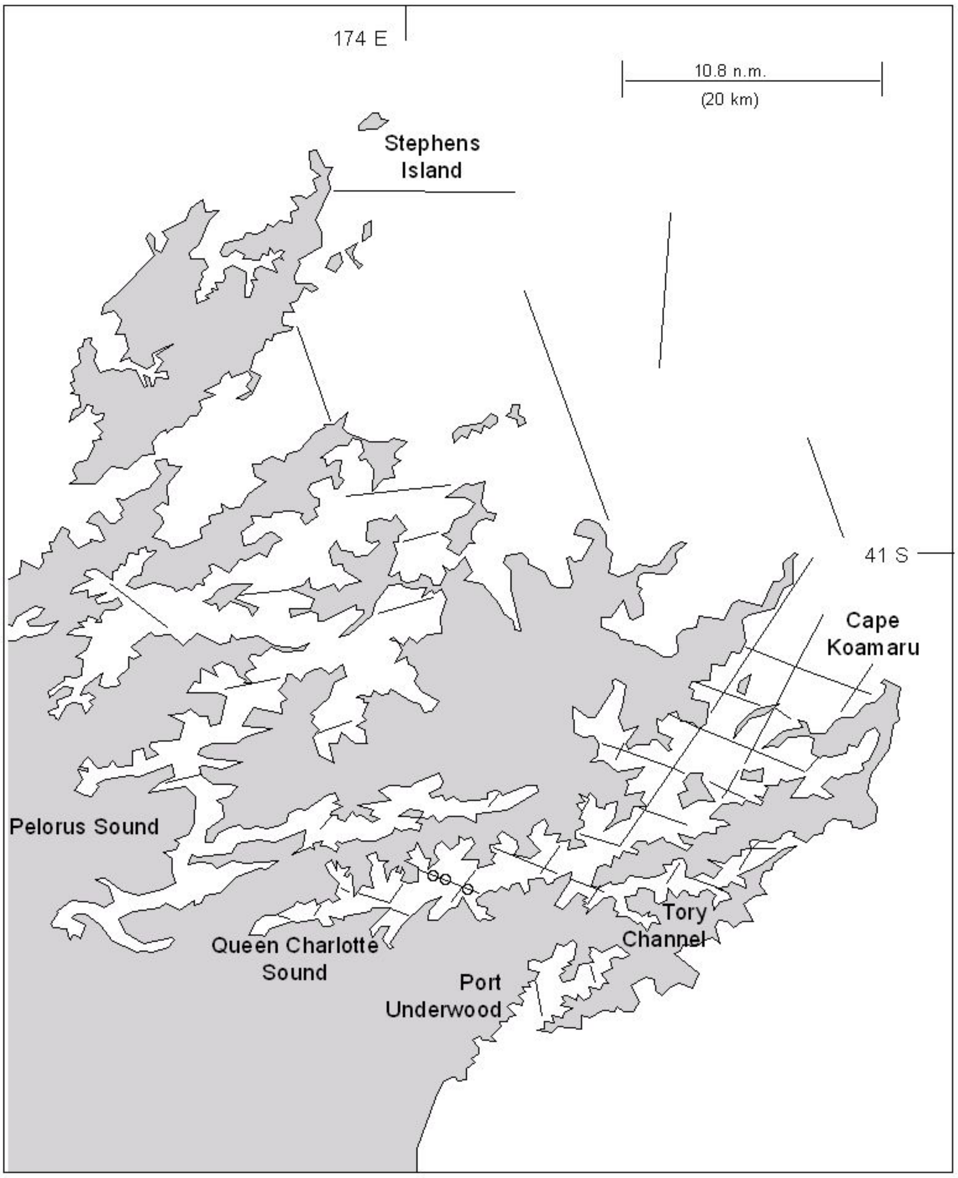

Figure 2. Transect lines and sightings within the Marlborough Sounds.

Survey areas (strata) were (see Figs 1, 2):

(a) Farewell Spit to Stephens Island (transect lines 8 n.m. apart).

(b) Outer Sounds (Stephens Island to Cape Koamaru, 8 n.m. line spacing).

(c) Pelorus Sound (4 n.m. line spacing).

(d) Queen Charlotte Sound (including Tory Channel, 2 n.m. line spacing).

(e) Cape Koamaru to Port Underwood (4 n.m. line spacing).

(f) Cloudy/Clifford Bay (including Port Underwood, 2 n.m. line spacing).

(g) Cape Campbell to Motunau (4 n.m. line spacing).

(h) Offshore zone (4–10 n.m. offshore) from Farewell Spit to Motunau (30 n.m. line spacing).

2.2 FIELD METHODS

To minimise the chance of missing sightings, survey effort was restricted to sea conditions of Beaufort 3 or less and swell heights of < 2 m. Transect lines were run down-swell to minimise pitching movement on the observer platform.

Observer training was conducted over seven days during which 95 sightings were made. This intensive training was done for two reasons. First, the Motunau–Timaru survey demonstrated that at least one week of observer training was required to ensure high data quality. Secondly, it was important to ensure that the scanning behaviour of the current observer crew was as close as possible to that of the previous surveys.

Three observers were on watch at any one time, one each searching left and right and one in the centre acting as recorder. Observers used 7 × 50 Fujinon marine binoculars to minimise the chance of reactive movement by the dolphins before detection. There were five crew on the observer team, and observers rotated every 30 minutes to avoid fatigue. Sightings were entered in real time into a palmtop computer on the sighting platform. This computer was linked to a GPS navigator.

The binoculars had built-in reticle scales and compasses, which were used to measure the downward angle from the land, or horizon to the sighting (used to calculate sighting distance) and the sighting angle. The corresponding distance to land was measured using RADAR.

2.3 DATA ANALYSIS: ABUNDANCE ESTIMATION

Hector's dolphin abundance was estimated using distance sampling methods (Buckland et al. 1993) and the program Distance 3.5 (Thomas et al. 1998). Within each stratum, Hector's dolphin abundance (N) was estimated as:

$$N = A\ n\ s/\{2\ L\ ESW\ g(0)\} \qquad (1)$$

where A is the size of the study area, n is the number of groups seen, s is the expected group size, L the length of transect line surveyed, ESW the effective half strip width, and $g(0)$ the probability of seeing a group directly on the transect line.

ESW was estimated separately for the Marlborough Sounds strata (strata c and d above) and the open coast strata (strata a, b, e, f, g, and h above). Buckland et al. (1993) recommend gaining 60–80 sightings in order to fit a detection function reliably, and therefore estimate *ESW*. It was recognised from the onset that with realistic levels of survey effort, it was extremely unlikely that sufficient sightings would be observed within the Marlborough Sounds and along the open coast alone. Therefore, additional transect lines were run in Akaroa Harbour in order to complete the 'Sounds' detection function. Extra open coast transects were run south of Banks Peninsula to supplement the survey data for a robust 'open coast' *ESW* estimation. These sites were chosen because they have similar sighting conditions to the actual survey strata and reliable medium to high dolphin densities, allowing the extra sightings to be made in a cost-effective way.

Using Distance 3.5 (Thomas et al. 1998) a hazard key function with cosine adjustments (Sounds strata) and a uniform key function with cosine adjustments (open coast strata) were fitted to perpendicular distance data to estimate *ESW*. Akaike's Information Criterion was used to select among models fitted to the data. Potential model choices were: hazard/cosine, hazard/polynomial, half-normal/cosine, half-normal/hermite, and uniform/cosine. Perpendicular sighting distances were truncated at 5%, as recommended by Buckland et al. (1993), and binned manually for $f(0)$ estimation. Sightings for which range (radial distance) was estimated by eye were removed before $f(0)$ estimation, but were used for density estimation.

The coefficient of variation (CV) of the uncorrected abundance estimates (N_S) were calculated from the CV of each variable in Equation 1:

$$\mathrm{CV(N)} = \sqrt{\{\mathrm{CV}^2(n) + \mathrm{CV}^2(s) + \mathrm{CV}^2(ESW)\}} \qquad (2)$$

The CV(n) was estimated empirically as recommended by Buckland et al. (1993):

$$\mathrm{CV}(n) = \sqrt{\{\mathrm{var}(n)/n^2\}} \qquad (3)$$

where: $\mathrm{var}(n) = L \sum l_i(n_i/l_i - n/L)^2/(k - 1)$ (4)

where l_i was the length of transect line i, n_i was the number of sightings on transect i, and k was the total number of transect lines within that stratum.

The CV(s) was estimated from the standard error of the mean group size. The CV(ESW) was estimated using the Distance 3.5 bootstrapping option. This process incorporates uncertainty in model fitting and model selection.

Abundance estimates (N_S) were then corrected using the correction factor (c) generated from the 1999 survey (DuFresne et al. 2001). The corrected abundance estimates (N_U) were calculated by:

$$N_U = c\, N_S \qquad (5)$$

The CVs of the corrected abundance estimates (N_U) were estimated by:

$$\mathrm{CV}(N_U) = \sqrt{\{\mathrm{CV}^2(c) + \mathrm{CV}^2(N_S)\}} \qquad (6)$$

where: $\mathrm{CV}(c) = \mathrm{SE}(c)/c$ (7)

Upper and lower 95% confidence intervals (CI) for N_U were calculated using the Satterthwaite degrees of freedom procedure outlined in Buckland et al. (1993). This procedure assumes a log-normal distribution, using:

$$\mathrm{CI_L} = N_U/C$$

and $\mathrm{CI_U} = N_U\, C$ (8)

where: $C = \exp\{t_{df}(0.025) \sqrt{\log_e (1 + \mathrm{CV}^2(N_U))}\}$ (9)

and: $\mathrm{df} = \mathrm{CV}^4(N_U)/\{\mathrm{CV}^4(c)/(B - 1) + \mathrm{CV}^4(N_S)/\mathrm{df_S}\}$ (10)

where B is the number of bootstrap samples, and $\mathrm{df_S}$ is the Satterthwaite degrees of freedom for the uncorrected abundance estimate (N_S). The Satterthwaite degrees of freedom ($\mathrm{df_S}$) were calculated by:

$$\mathrm{df_S} = \mathrm{CV}^4(N_S)/\{\mathrm{CV}^4(n)/(k - 1) + \mathrm{CV}^4(ESW)/n\} \qquad (11)$$

(See Buckland et al. (1993) for a detailed explanation of this procedure.)

The CV for the total corrected abundance estimate (N_U) for Farewell Spit to Motunau was calculated by:

$$CV(N_U) = SE(N_U)/N_U \quad (12)$$

where: $$SE(N_U) = \sqrt{\{SE^2(N_1) + SE^2(N_2) + \ldots SE^2(N_i)\}} \quad (13)$$

3. Results

3.1 SURVEY EFFORT AND SIGHTINGS

On the Farewell Spit to Motunau survey, 23 sightings were recorded with a survey effort of approximately 414 n.m. (766 km) (Table 1). Overall, R.V. *Catalyst* covered nearly 4000 n.m. (7400 km).

3.2 ABUNDANCE ESTIMATES FOR 2000 FAREWELL SPIT–MOTUNAU SURVEY

To estimate ESW, sightings from Akaroa Harbour and South of Banks Peninsula were used to supplement sightings for the Sounds and open coast strata, respectively. The ESW was estimated from 70 sightings after truncation for the 'Sounds' stratum and 89 sightings after truncation for the open coast (Figs 3, 4). Both comfortably fulfil Buckland et al.'s (1993) recommendation of the minimum number of sightings to be used for estimating ESW.

Because of the irregular dolphin densities, the variety of transect spacings needed to efficiently sample the survey area, and the contrast between the Marlborough Sounds and the open coastline, eight levels of stratification were warranted (Table 1). Hector's dolphin sightings were made in four strata. A summary of abundance estimation calculations for these strata is given in Table 2. An abundance estimate was not calculated for the offshore zone due to the small number of sightings. The two sightings made in the offshore zone were

TABLE 1. SURVEY EFFORT AND SIGHTINGS (FAREWELL SPIT–MOTUNAU).

STRATUM		SURVEY EFFORT (km)	NO. OF SIGHTINGS	SIGHTINGS/ km
Farewell Spit–Stephens Island	(a)	120.23	0	0
Outer Sounds	(b)	48.16	0	0
Pelorus Sound	(c)	32.35	0	0
Queen Charlotte Sound	(d)	124.43	3	0.024
Cape Koamaru–Port Underwood	(e)	67.74	0	0
Cloudy/Clifford Bay	(f)	89.25	13	0.146
Cape Campbell–Motunau	(g)	191.64	5	0.026
Offshore (4–10 n.m.)	(h)	92.62	2	0.022

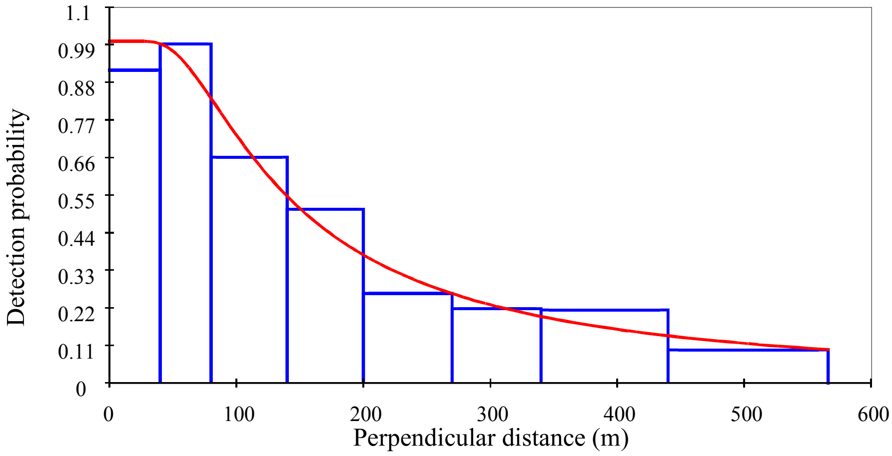

Figure 3. Sightings v. distance and the fitted detection function for strata inside Sounds (hazard/cosine, n = 70, GoF = 0.952).

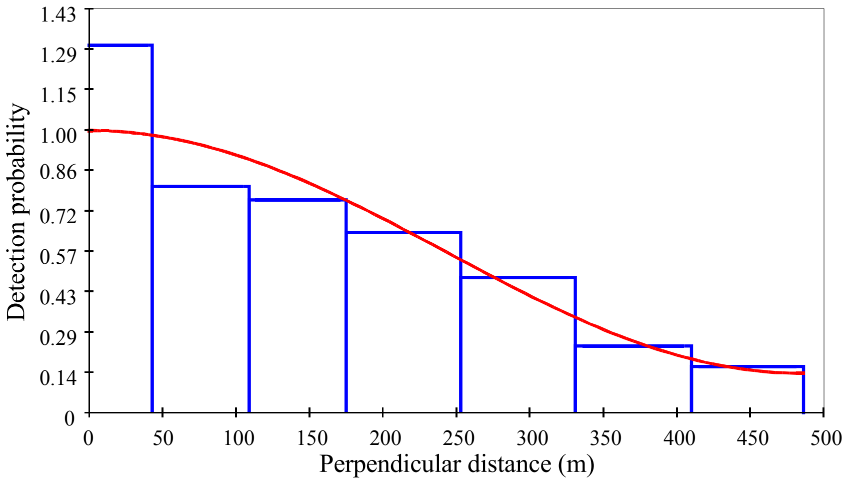

Figure 4. Sightings v. distance and the fitted detection function for open coast strata (uniform/cosine, n = 89, GoF = 0.837).

close together, in the area of greatest dolphin density (Cloudy/Clifford Bay), on the boundary of the inshore and offshore zone.

The abundance estimates include the correction factor (c = 0.5032) for dolphin attraction and missed sightings on the trackline (DuFresne et al. 2001). Table 3 contains a combined corrected abundance estimate for the entire area surveyed thus far from Farewell Spit to Long Point.

TABLE 2. ABUNDANCE ESTIMATES (FAREWELL SPIT-MOTUNAU).

STRATUM		GROUPS SEEN	*ESW* (m)	N_U	%CV(N_U)	CI_L	CI_U
Queen Charlotte Sound	(d)	3	213.7	20	100.48	4	110
Cloudy/Clifford Bay	(f)	13	276.9	162	55.43	56	474
Cape Campbell-Motunau	(g)	5	276.9	102	58.22	34	305
Study Area		21		285	38.55	137	590

ESW effective half strip width; N_U estimated abundance (corrected); %CV(N_U) percentage coefficient of variation; CI_L lower 95% confidence interval; CI_U upper 95% confidence interval.

TABLE 3. ABUNDANCE ESTIMATES (FAREWELL SPIT–LONG POINT).

Estimated abundance (corrected), N_U	1882
Percentage coefficient of variation, CV(N_U)	21.28
Lower 95% confidence interval, CI_L	1246
Upper 95% confidence interval, CI_U	2843

4. Discussion

The abundance estimates from this survey are not strictly comparable to past estimates, due to differences in survey methods. This is the first set of line-transect surveys for Hector's dolphins. The only other systematic boat survey was carried out during 1984/85 (Dawson & Slooten 1988). It used a much smaller boat, smaller team of observers and very different methods for correcting for the proportion of dolphins missed. Nevertheless, the two estimates are similar. The 1984/85 abundance estimate was approximately 612 dolphins for the Farewell Spit to Motunau area (to 5 n.m. offshore; Dawson & Slooten 1988). This falls within the range of the 95% confidence interval for the new abundance estimate (137–590). It is not possible to infer any population trend, or lack thereof, by comparing the two estimates.

Special care should be taken when comparing abundance estimates for individual strata. For example, the 1984/85 survey estimated the abundance from Cape Campbell to Motunau to be approximately 282 dolphins (Dawson & Slooten 1988), much higher than this survey's estimate of 102 individuals but within the 95% confidence interval (34–305). Within Queen Charlotte Sound, our abundance estimate was 20 dolphins (Table 2). Dolphin-watching tour operators reported that the number of dolphin sightings in this area was lower during the 1999/2000 summer than in previous years, from approximately 40 dolphins in previous years to only 17–23 dolphins during the 1999/2000 summer (L. Battersby[1], pers. comm.). The 1984/85 survey also indicated a higher density, of 48 Hector's dolphins in Queen Charlotte Sound.

Low densities of Hector's dolphins, approximately 65 individuals (95% CI 39–96), were recorded in Golden Bay and Tasman Bay in the 1984/85 survey (Dawson & Slooten 1988). We found no Hector's dolphins in this area on our line-transect survey, though occasional sightings have been made this year (Cairney, pers. comm.). Our transect lines in Golden Bay and Tasman Bay were fairly wide apart (8 n.m.) due to the low densities of dolphins, a large sampling area, and time and funding constraints. It was not practical or cost-effective to increase survey effort in this low-density area, which often has somewhat difficult weather conditions. Our results are sufficient to demonstrate that abundance here is very low. If a more fine-grained abundance estimate is desired for this area, it could be done by manipulating transect spacing. For

[1] Owner/operator of dolphin-watching operation in Queen Charlotte Sound, Marlborough.

example, an effective design would be to start with transect lines 4 n.m. apart, then add lines spaced 2 n.m. (adding new lines between the transect lines already covered) and even 1 n.m. if necessary, to obtain an abundance estimate with the desired level of precision.

Overall, the population estimate from this survey fell within the confidence interval of the last population estimate. Care should be taken in comparing abundance estimates for smaller regions.

5. Acknowledgements

This survey was funded principally by Department of Conservation contract SCO-3075. A portion of this contract was funded by a Conservation Services Levy from the commercial fishing industry. Clifford Bay Mussel Farms Ltd funded an increase in the number of transect lines in the Cloudy Bay, Clifford Bay area. Significant contributions to equipment used in the survey were made by the New Zealand Whale and Dolphin Trust and the University of Otago. The survey vessel was made available by Liz Slooten and Steve Dawson. We are very grateful for the help of Ellie Dickson, Guen Jones, and Will Rayment, who were fine observers and cheerful crew members. Akaroa Harbour Cruises and Dolphin Encounters provided much-appreciated field support. Daryl Coup wrote the sightings programme we used to collect data in the field. Otago University's Department of Surveying very helpfully provided access to Arc/View for plotting transect lines and sightings.

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