# Distribution of Maui's dolphin (*Cephalorhynchus hectori maui*)

2000–2009

DOC RESEARCH & DEVELOPMENT SERIES 322

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*Te Papa Atawhai*

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## 2000–2009

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A B S T R A C T

Maui's dolphin (*Cephalorhynchus hectori maui*) is a highly endangered subspecies that is only found off the coast of New Zealand. Reliable distribution data are highly important for the protection and management of this cetacean. Several Maui's dolphin surveys have been carried out in recent years. This report aims to synthesise these distribution data into one accessible document, which should assist managers in determining boundaries for the protection areas needed to halt population decline. Recent systematic offshore surveys of Maui's dolphin distribution indicate that the subspecies is regularly found between Kaipara Harbour to the north, and Kawhia Harbour to the south, while opportunistic and alongshore survey sightings indicate that Maui's dolphins are occasionally seen further south. The surveys also indicate that while many sightings of Maui's dolphins occur within the current 4 nautical mile (7.4 km) gillnet-fishing restricted area boundary, there have been reliable sightings of Maui's dolphins outside this area. These offshore sightings happen particularly, but not exclusively, during winter months. Verified sightings by members of the public can also provide useful information on distribution. Several sightings reported by members of the public have also occurred near New Plymouth, which is south of the current protected area. Maui's dolphins have been reported by members of the public in several of the North Island harbours, including Kaipara, Raglan, and especially Manukau. Passive acoustic monitoring of Manukau Harbour suggests that Maui's dolphins regularly use the areas near or beyond the current protected area of outer Manukau Harbour. Given the highly endangered status of this subspecies, proposals for protected areas need to consider not only the core home range area, but also those areas occasionally visited by the animals. These considerations should apply to both offshore and alongshore boundaries.

Keywords: Maui's dolphin, *Cephalorhynchus hectori maui*, aerial surveys, distribution


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# 1. Introduction

Maui's dolphin, *Cephalorhynchus hectori maui*, is arguably one of the most endangered cetacean populations in the world (Dawson et al. 2001; Slooten et al. 2006); it is classified as critically endangered by IUCN (Reeves et al. 2008) and nationally critical under the New Zealand Threat Classification System (Baker et al. 2010). Formally recognised as a genetically distinct subspecies of the more abundant Hector's dolphin (Baker et al. 2002), the most recent and robust population estimate puts the total abundance of Maui's dolphin at just 111 (95% confidence interval = 48–252; Slooten et al. 2006).

With such a low estimated abundance, it is paramount that the entire population be protected throughout its range. The potential biological removal (PBR[1]) for Maui's dolphins would be just one dolphin every 6.4 years (Slooten et al. 2006). Even though the PBR method is not a recommended management tool for very small populations (Wade 1998), it is nonetheless a useful way of giving population estimates some context. In this case, it is clear that Maui's dolphins have a very low potential for sustainable human-induced mortality, making good knowledge of their distribution vital for designing effective management regimes.

Maui's dolphins are restricted in their range to the west coast of the North Island. The most serious documented and quantifiable human threat to Maui's dolphins is bycatch mortality in set nets (Dawson et al. 2001). To reduce fisheries-related mortality, amateur and commercial set netting has been prohibited between Maunganui Bluff and Pariokariwa Point to 4 nautical miles (n.m.) offshore, and inside the entrance to Manukau Harbour since 2003 (see Fig. 1 for location and extent of closure area, and for all place names mentioned in the text).

Several systematic sighting surveys of Maui's dolphins have been conducted since 2003. These have either produced robust population estimates (e.g. Slooten et al. 2006) or simply examined current distribution patterns (e.g. Slooten et al. 2005). More recently, attempts have been made to investigate habitat use in some of the key North Island harbours (e.g. Manukau), using T-PODs—passive acoustic data loggers (Scali et al. 2008). Additionally, the Department of Conservation (DOC) holds records of a number of sightings made by members of the public. WWF also holds a sightings database, but this information was not available at the time of publishing.

Following the release of the draft Threat Management Plan (TMP) for Hector's and Maui's dolphins in 2007 (MFish & DOC 2007), DOC has sought to compile all known and reliable distribution and sighting data from the last several years into one accessible document. The goal was to undertake a thorough review of distribution data, pulling together all sources of information from the last decade or so to support decision-makers.

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[1] Potential biological removal was developed in the USA as a tool for setting limits on human-induced mortality of marine mammal populations. It is a generic tool, and one which is relatively straightforward to apply. Uncertainty factors can be applied that are representative of species status and management goals.

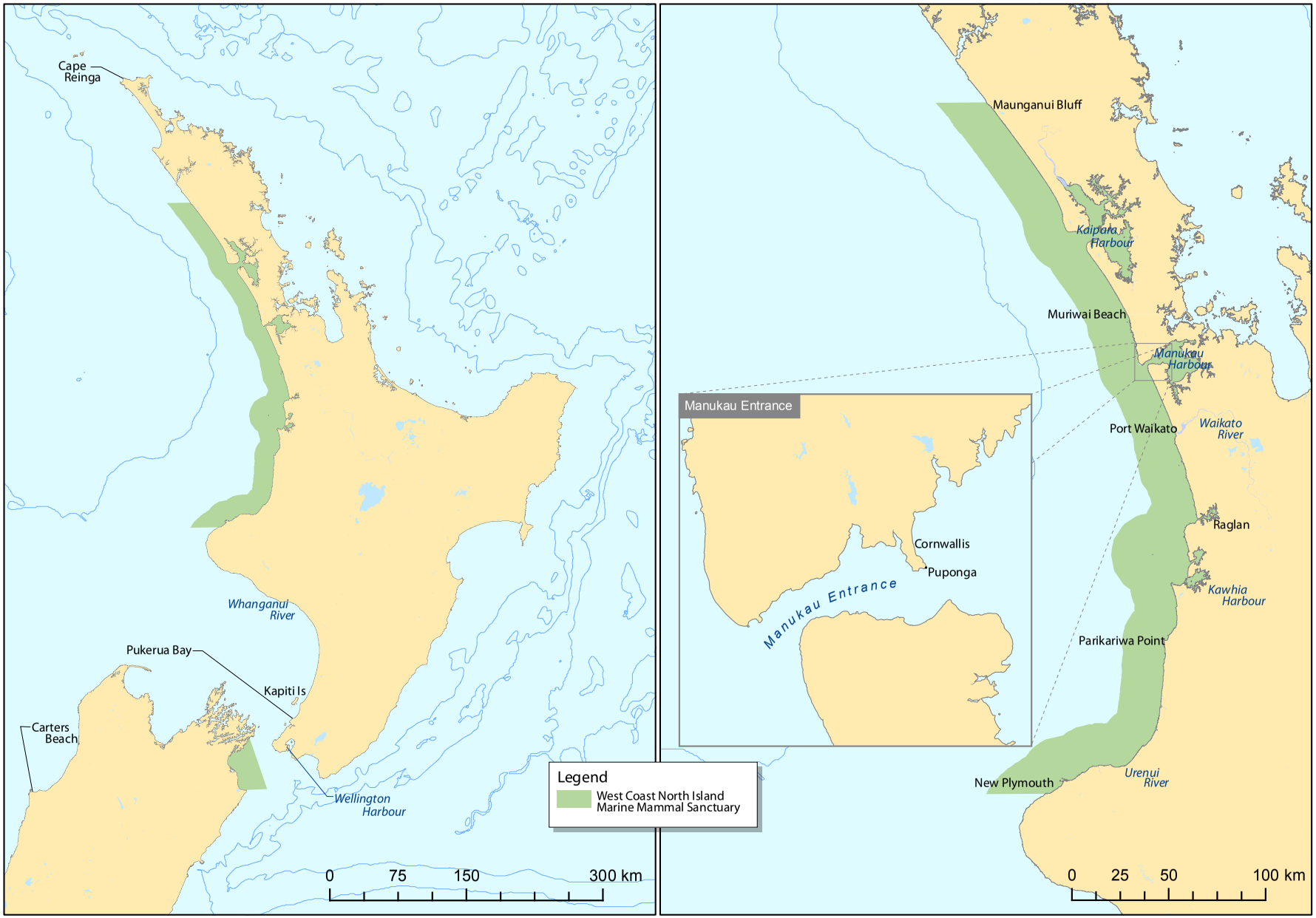


Figure 1. Location and extent of Maui's dolphin protected area; and place names mentioned in the report text.

After extensive consultation on the draft TMP, a raft of new measures designed to protect Hector's and Maui's dolphins were announced and came into effect on 1 October 2008. However, these measures were subsequently challenged via a judicial review—during which distribution data (particularly offshore distribution) played a key role. Following this, a number of interim relief measures were put into place. Two of the new protection measures were subsequently referred back to the Ministry of Fisheries for reconsideration[2]. The remaining measures were upheld by the court[3].

The goal of this report is to produce an overall distribution plot based on systematic and reliable opportunistic sighting data. There is no attempt to estimate the abundance of Maui's dolphin, as this has already been achieved (Slooten et al. 2006), or to review any previous abundance estimates (e.g. Ferreira & Roberts 2003).

# 2. Methods

## 2.1 DATA SOURCES

In consultation with DOC, several data sources were compiled. These are summarised in Table 1. For the purpose of plotting sightings to show distribution, data were separated into several groups, often determined by the survey method and/or survey design. This was because the extent of the offshore distribution of Maui's dolphin was of particular interest: alongshore surveys would not result in any offshore sightings, and plotting sightings from alongshore and offshore surveys on the same plot would unfairly weight the plots towards sightings close to shore. Since DOC already maintains a database of public sightings, these were not included in the compiled file, though sightings were plotted if appropriate information (i.e. latitude/longitude) was available.

Differences in effort allocation between different surveys were not formally taken into consideration. However, reliability was considered where possible. Where issues of reliability were known or thought to exist, the sightings in question were identified. In interpreting results, greatest weight was given to sightings from dedicated surveys using experienced observers.

T-POD data were not included in this analysis, but are briefly discussed.

## 2.2 SIGHTING PLOTS

Data were plotted using ESRI ArcMap 9.3.1.

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[2] These were the extension of the set net ban on the west coast of the North Island from 4 n.m. to 7 n.m.; and a ban on netting for butterfish in an area of the east coast of the South Island.

[3] More information on the protection measures and the judicial review can be found at: www.fish.govt.nz/en-nz/Environmental/Hectors+Dolphins/default.htm, and www.fish.govt.nz/en-nz/Press/Press+Releases+2010/February10/High+Court+rules+on+dolphin+legal+challenge.htm, respectively.

TABLE 1. SOURCES OF DISTRIBUTION DATA FOR MAUI'S DOLPHIN.

| AUTHOR(S) AND/OR SOURCE | SEASON | DISTANCE OFFSHORE | YEAR | AREA COVERED |
|---|---|---|---|---|
| Ferreira & Roberts (2003) | Summer | 5 n.m. | 2000/01 & 2001/02 | Paraparaumu – North Cape |
| Slooten et al. (2005) | Summer, Winter | 5 or 10 n.m. | 2004 | New Plymouth – Maunganui Bluff |
| Slooten et al. (2006) | Summer | 5 or 10 n.m. | 2004 | New Plymouth – Maunganui Bluff |
| Scali (2006) | Winter | 10 n.m. | 2006 | Carters Beach – Muriwai |
| Rayment & Du Fresne (2007) | Spring | 10 n.m. | 2007 | Carters Beach – Muriwai |
| Childerhouse et al. (2008) | Winter | 10 n.m. | 2008 | Carters Beach – Muriwai |
| Stanley (2009) | Winter | 10 n.m. | 2009 | Baylys Beach – Kawhia Harbour |
| DOC (unpubl. data) | Various | Various | Various | Sightings made during various alongshore alongshore surveys, in addition to recent harbour-focussed efforts |
| DOC (unpubl. data) | Various | Various | Various | Opportunistic sightings reported by members of the public |

# 3. Results

## 3.1 DESCRIPTION OF COMPILED DATA

Some of the data used in this report have previously been analysed and published. Specifically, readers are directed to Ferreira & Roberts (2003) and Slooten et al. (2005, 2006) for complete descriptions of data sources 1–3 in Table 1. Although these data are plotted here, the listed publications provide greater detail and more in-depth analysis.

Ferreira & Roberts (2003) conducted aerial surveys between Paraparaumu and North Cape to determine the distribution and estimate the abundance of Maui's dolphin. The survey design utilised alongshore transects flown at various distances offshore (between 0.3 n.m. and 5 n.m. offshore), in addition to transects at 45° to the coast and to a distance of 3 n.m. (5.5 km) offshore, between Manukau and Port Waikato. A total of 58 sightings were made during the alongshore surveys, and a further 26 were made during the offshore surveys.

Slooten et al. (2005) conducted summer (14–31 January) and winter (26 June – 18 July) aerial surveys during 2004. The surveys were designed to assess the distribution of Maui's dolphin and, more particularly, to look for seasonal distributional patterns. These surveys utilised transect lines at 45° to the coast in order to sample both alongshore and offshore density gradients. Several subsequent surveys (Scali 2006; Rayment & Du Fresne, 2007; Childerhouse et al. 2008; Stanley 2009) have used the same basic design principles. The compiled spreadsheet provided for this report listed 13 winter and 24 summer sightings from the 2004 surveys.

More recent offshore surveys (Scali 2006; Rayment & Du Fresne 2007; Childerhouse et al. 2008; Stanley 2009) followed essentially the same survey protocol as the Slooten et al. (2005) surveys, using the same basic survey design and either a Partenvia P-68 (with bubble windows for rear observers; 2006, 2007 and 2008 surveys), or a Britten Norman Islander (2009 survey). For all surveys,

four observers were used (two front and two rear). Observer experience differed between the surveys. In particular, there were differences in the observer experience of the teams on the 2006 and 2007/2008 surveys, with the 2007/2008 team made up of highly experienced Maui's and Hector's dolphin observers. The 2006 survey leader felt that some of the sightings were unreliable, possibly because of observer inexperience (S. Scali, University of Otago, pers. comm.). These sightings are included in the plots, but tagged as 'unreliable'. Furthermore, those sightings considered unreliable have not been used in forming conclusions about the offshore distribution of Maui's dolphin. A recent judicial review[4] of the Threat Management Plan included considerable discussion on the reliability of the 2006 data, and readers are directed to paragraph 120 (and others before and after this paragraph). The 2009 observer team consisted of several experienced marine mammal observers.

The 2006 offshore survey resulted in seven on-effort and two off-effort sightings of Maui's dolphins; while the 2007 survey (Rayment & Du Fresne 2007) resulted in 13 on-effort and four off-effort sightings. Three sightings from the 2007 offshore survey were duplicates (seen by both front and rear observers). During the 2008 offshore survey, a total of seven Maui's dolphin groups were sighted while on-effort (one sighting was a duplicate, seen by both front and rear observers), and a further three sightings were made off-effort (Childerhouse et al. 2008). The 2009 offshore survey resulted in eight on-effort and three off-effort sightings of Maui's dolphins.

DOC carried out a number of dedicated surveys for Maui's dolphins between 2006 and 2009 (DOC, unpubl. data[5]; Webster & Edwards 2008). These surveys were conducted from a variety of survey platforms, including fixed wing planes, helicopters and boats. These surveys were conducted in February and March 2006, February 2007, March 2008, and February and March 2009. The 2006 surveys extended from Manukau Harbour north to Cape Reinga (Te Rerengawairua) (three surveys), and south to New Plymouth (three surveys) or Kapiti Island (one survey). In 2007, opportunistic boat surveys were carried out, in addition to helicopter surveys between Pariokariwa Point and Oakura. For the helicopter surveys, transect lines were plotted at 45° to the coast, placed 0.5 n.m. apart, and extended to 5 n.m. (9.3 km) offshore. During 2008, fixed wing aerial surveys were flown parallel to the coast at 300, 600 or 900 m offshore, between Manukau and New Plymouth (Webster & Edwards 2008). During 2009, alongshore surveys were conducted at various distances offshore between Urenui River and Sugar Loaf (February 2009), and between Raglan and Sugar Loaf (March 2009). These surveys were carried out by suitably experienced DOC field staff. There were 25 sightings of Maui's dolphins in 2006 and 2007: 14 in summer 2006 (plane) and 11 in summer 2007 (6 from boat and 5 from helicopter). The 2008 alongshore surveys, which extended south towards New Plymouth, sighting dolphins near the southern limit of the current fisheries closure area, resulted in 23 sightings of Maui's dolphin. No dolphins were seen south of the current closure area (Webster & Edwards 2008). Few Maui's dolphins were seen during the 2009 surveys, with just one group seen during the February surveys, and none during March.

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[4] The New Zealand Federation Of Commercial Fishermen Incorporated And Ors V The Minister Of Fisheries and Anor HC WN CIV-2008-485-2016 [23 February 2010].

[5] These surveys have been carried out primarily by the Auckland Area Office, where all data are held.

Most of the survey work described in the previous paragraphs focussed on the open coast, though during DOC's 2008 surveys the plane also flew into Manukau Harbour as far as Cornwallis (the maximum distance into the harbour that was permitted due to airspace restrictions). In 2008, a number of boat- and land-based surveys for Maui's dolphins were conducted in Manukau Harbour (Edwards 2008). A total of 229 hours over 32 days were spent surveying, but no Maui's dolphins were sighted. There are several possible reasons to explain the lack of sightings, including: dolphins were not present during the surveys; dolphins were present, but not seen; or dolphins entered the harbour during hours of darkness or during rough weather. The surveys provided good coverage of Manukau Harbour, so it is reasonable to conclude that if dolphins had been present, there was a reasonable chance of them being spotted by the observers.

DOC has recently compiled a database of Maui's dolphin sightings, strandings and acoustic detections (these are a combination of research and public sightings). At the time of writing, there were a total of 549 records in this database, dated between 1870 and 2009. Four sightings had no date given. Of the remaining 504, 100 were made prior to 2000. In other words, approximately 80% of the sightings have been reported in the past 8 years. This is not surprising, as this period coincides with high levels of public awareness and media attention towards Maui's dolphins. Unfortunately, many sightings do not have latitude/longitude (i.e. GPS coordinates)—while those that are provided with land-marks are still included, detailed distribution plots are best when precise location data are provided.

## 3.2 SIGHTING PLOTS

### 3.2.1 Offshore surveys

Ferreira & Roberts (2003) reported that nearly three times as many dolphins were sighted between Manukau and Port Waikato as between adjacent areas of Kaipara–Manukau and Port Waikato–Raglan. No sightings were made north of Kaipara or south of Kawhia. Most sightings were made within 0.8 n.m. (1.5 km) of shore, with the furthest offshore sighting recorded at 3.35 n.m. (6.2 km) (Fig. 2).

Sightings made during the University of Otago 2004 summer survey (Slooten et al. 2005) were nearly all (six out of nine) within 1 n.m. (1.85 km) of shore, whereas just one-third (three out of nine) of sightings were further offshore during the winter survey (Fig. 3). Maximum offshore sighting distance was similar during both surveys, at 3.09 n.m. (5.7 km) and 3.33 n.m. (6.17 km) for summer and winter, respectively. The northernmost sightings were made just south of Kaipara Harbour, while the southernmost sightings were made between Raglan and Kawhia. Highest sighting rates (63%) occurred between Manukau Harbour and Raglan.

Irrespective of reliability issues, the sightings from the 2006 aerial survey provide little in the way of a clear pattern, with sightings widely distributed between Muriwai and Carters Beach, and out to a distance of nearly 10 n.m. (18.5 km) offshore (Fig. 4). If those sightings considered to be 'unreliable' are discarded, the furthest offshore sighting was made 'off effort' at a distance of about 7 n.m. offshore from Muriwai.

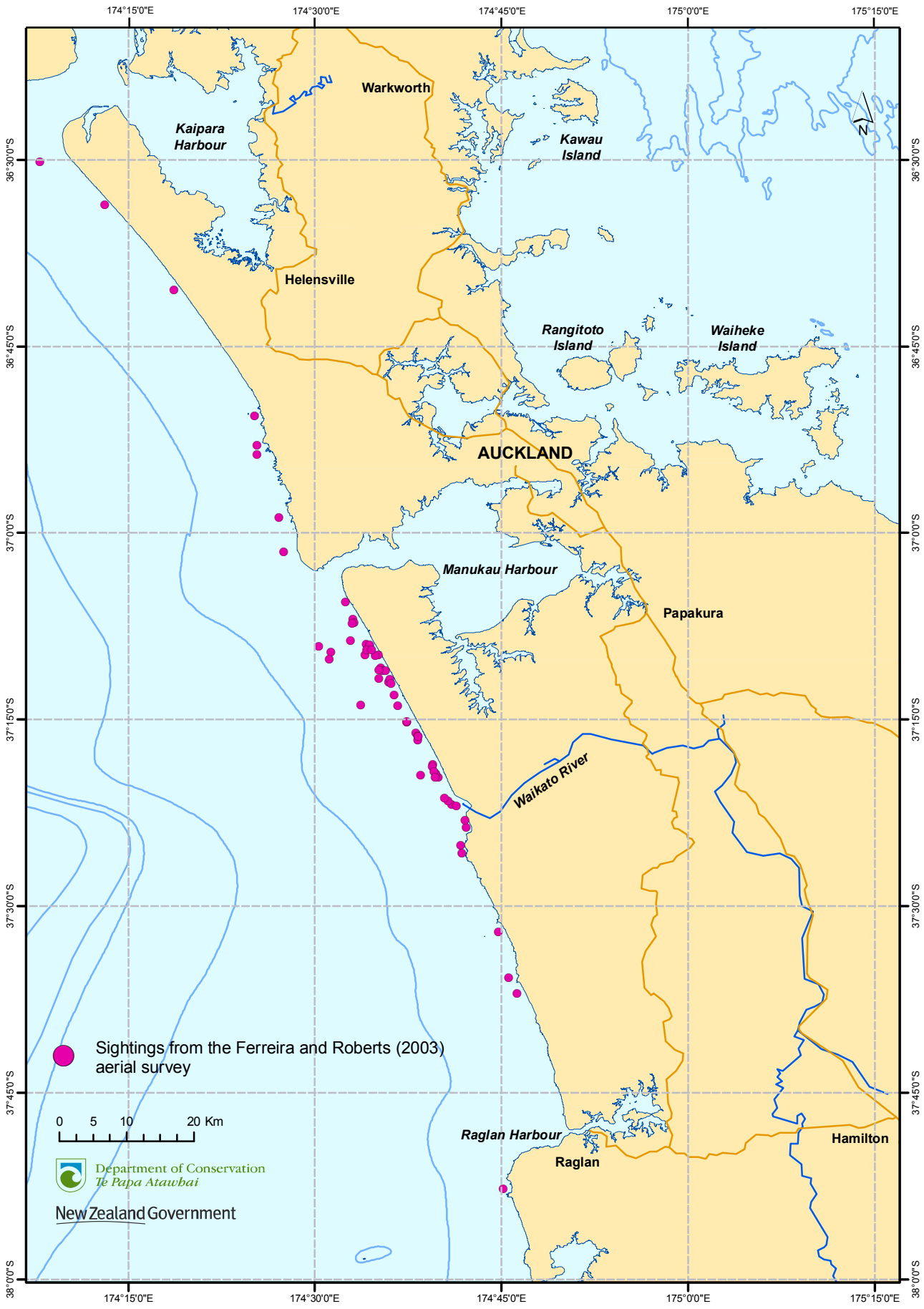


Figure 2. Sightings of Maui's dolphins from the Ferreira & Roberts (2003) aerial survey.

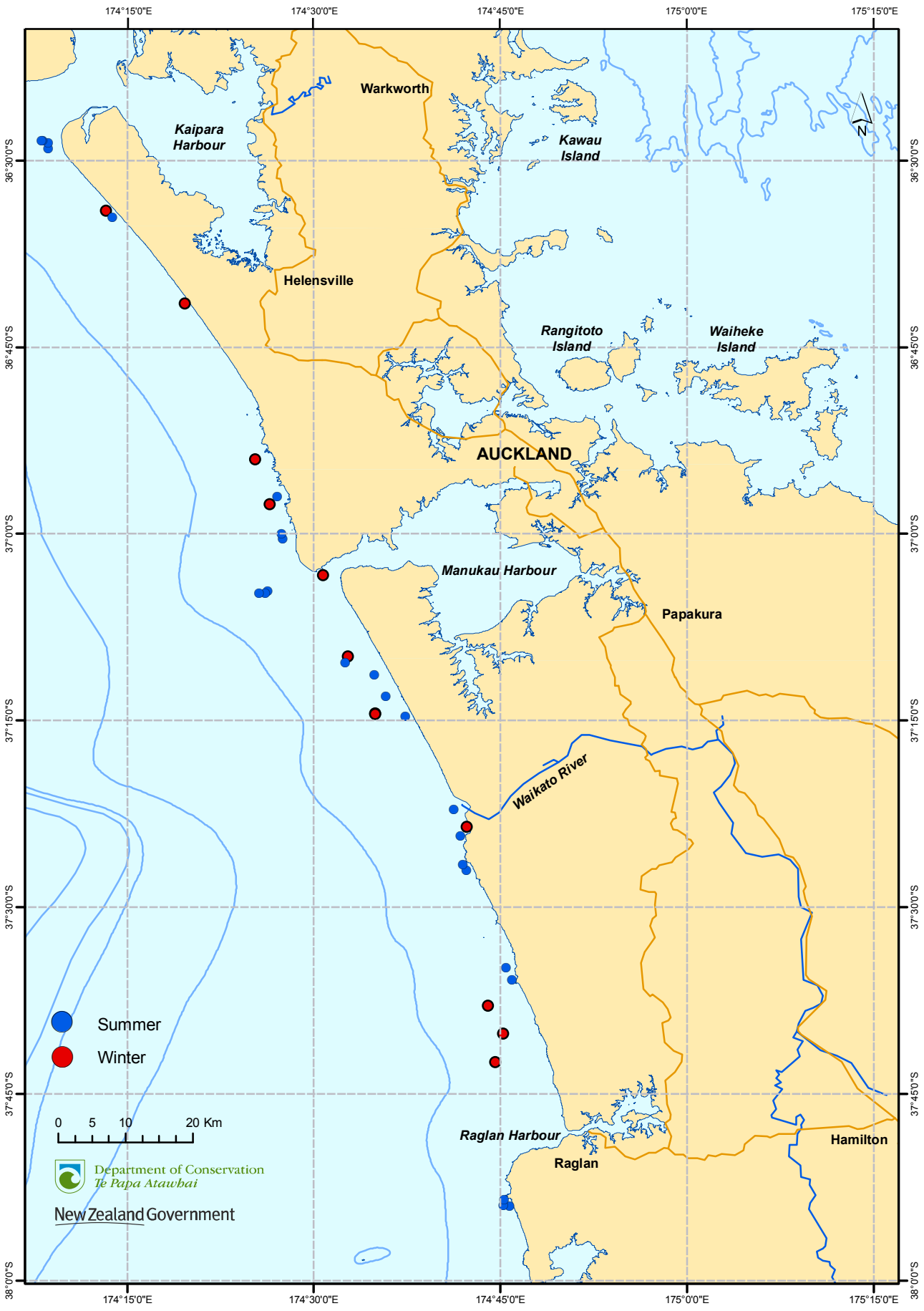


Figure 3. Sightings of Maui's dolphins from the University of Otago summer and winter aerial surveys, 2004.

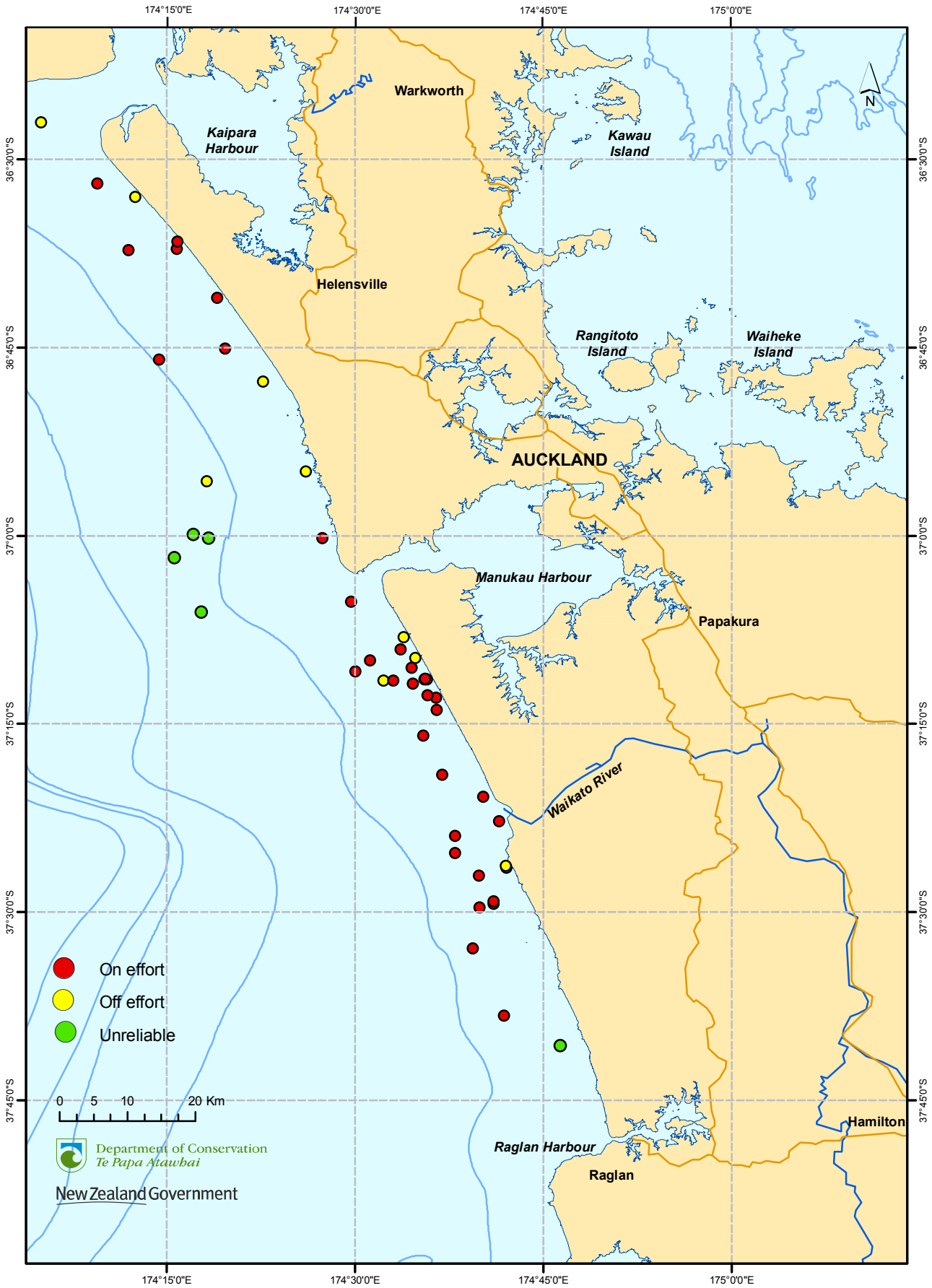


Figure 4. Sightings of Maui's dolphins made during systematic, offshore aerial surveys, 2006–2009.

The alongshore distribution of sightings from the 2007 aerial survey indicate a high concentration of sightings between Manukau Harbour and the Waikato River (Fig. 4). However, there were also a number of sightings (seven, including two off-effort) south of the Waikato River. There were no on-effort sightings north of Manukau Harbour; however, one off-effort sighting was made near Muriwai Beach, approximately 1.2 n.m. (2.2 km) offshore. Most on-effort sightings (11 out of 13) were made within 3 n.m. (5.6 km) of shore; however, one sighting was just beyond the 4 n.m. (7.4 km) boundary of the current gillnet fisheries restricted area, which is 4.05 n.m. (7.5 km) offshore, near Carters Beach.

Sightings from the 2008 survey were split almost equally between north (five sightings) and south (four sightings) of Manukau Harbour (Fig. 4). Only one sighting was made further than 4 n.m. (7.4 km) offshore during the 2008 survey (4.3 n.m. or 7.96 km).

The 2009 survey recorded a total of 12 sightings of Maui's dolphins (eight on-effort and three off-effort). These were distributed between the mouth of Kaipara Harbour and just north of the Waikato River mouth (Fig. 4). While most sightings were within roughly 2 n.m. (3.7 km) of shore, one sighting was made at 6.18 n.m. (11.4 km) offshore.

Data from the most recent systematic offshore surveys (2006, 2007, 2008 and 2009), together with the results from the Slooten et al. (2005; 2006) surveys, indicate that Maui's dolphins at least occasionally use waters beyond 4 n.m. (7.4 km). However, the majority of the sightings were concentrated within 4 n.m. (7.4 km), and between Manukau and Raglan, with occasional sightings further north, towards Kaipara.

### 3.2.2 Alongshore sightings

The alongshore sightings came from helicopter, plane or boat surveys carried out in 2006 (14 sightings), 2007 (11 sightings), 2008 (4 sightings) and 2009 (1 sighting) (Fig. 5). Despite these surveys extending at least as far north as Muriwai and at least as far south as Raglan (the northernmost point in any survey was Cape Reinga; the southernmost Kapiti Island), well over half of the sightings were between Manukau Harbour and the Waikato River mouth. The southernmost sightings from the alongshore surveys were located approximately 60 km northeast of New Plymouth, and approximately 9.2 n.m. (17 km) northeast of Pariokariwa Point (the southern limit of the set net closure area). The northernmost sighting was roughly 0.9 n.m. (1.7 km) offshore from Piha Beach.

### 3.2.3 Opportunistic sightings

The overall pattern of GPS-marked opportunistic (public) sightings is similar to that from the systematic surveys (Fig. 6). An important caveat with any public sightings database is that clusters of sightings tend to occur near centres of high human activity—making the obvious cluster of reported sightings in the Manukau Harbour area unsurprising. Of those sightings within Manukau Harbour, most are in the outer region (i.e. west of Cornwallis).

The DOC database also contains sightings from Kaipara (6 sightings), Raglan (3 sightings), New Plymouth (1 sighting) and Wellington (1 sighting) Harbours. The majority of harbour sightings were located in Manukau (62 sightings).

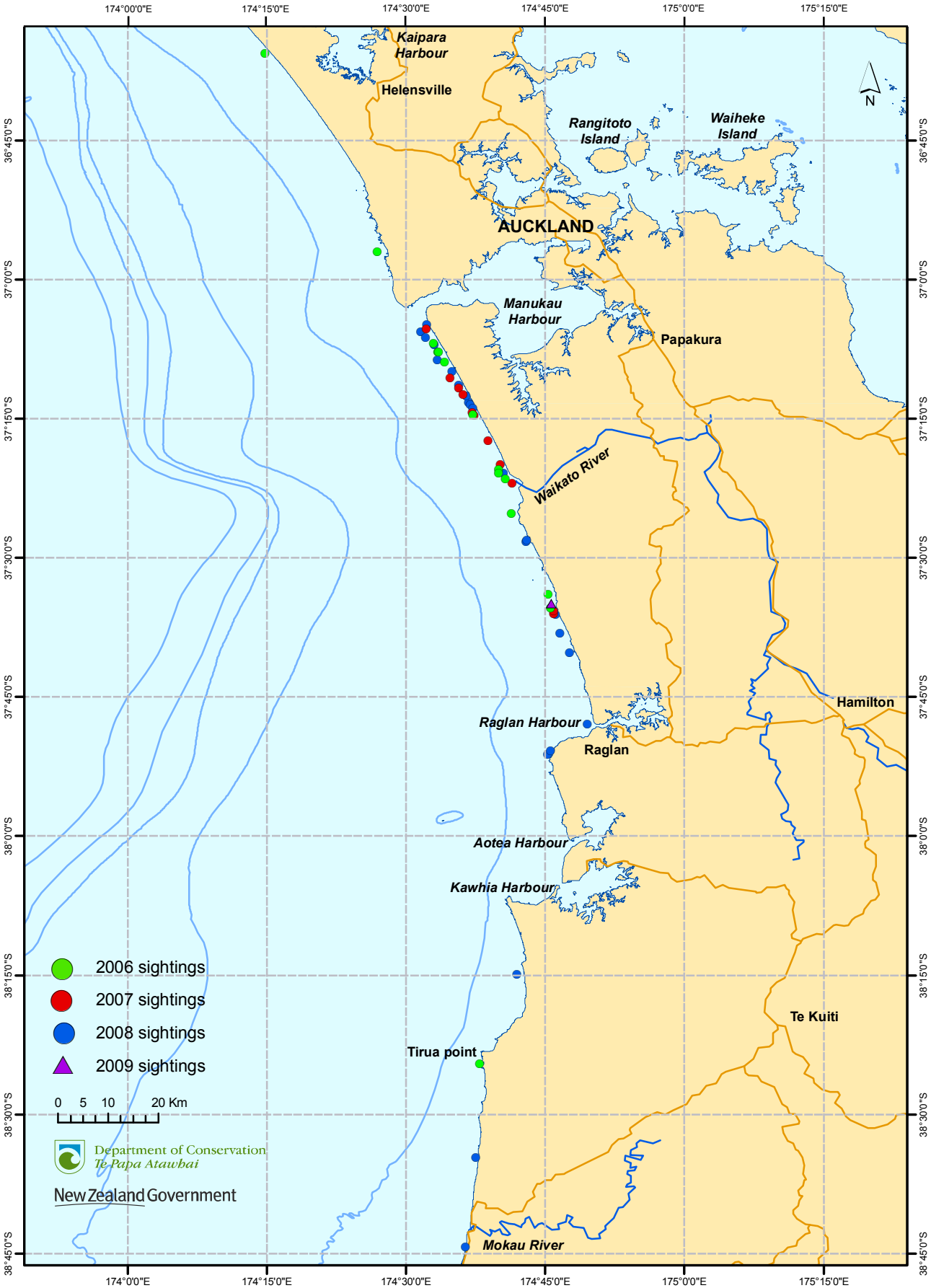


Figure 5. Sightings of Maui's dolphins made during DOC alongshore surveys (helicopter, fixed wing plane and boat), 2006–2009.

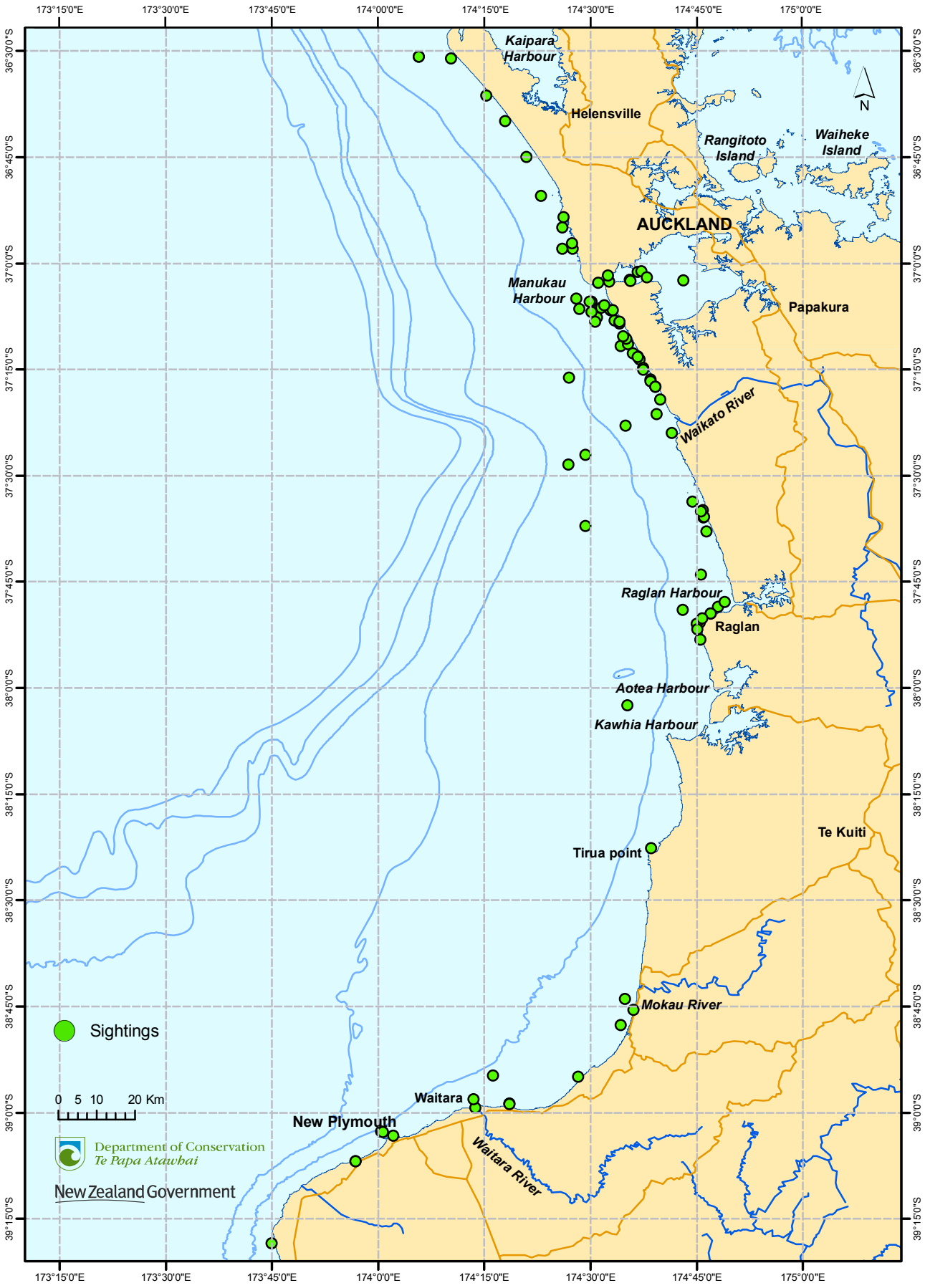


Figure 6. Opportunistic sightings of Hector's dolphins, held in DOC database (only those sightings with GPS locations are plotted).

For many of the public sightings, precise locations (GPS) were not provided, so it is sometimes difficult to know whether a record came from within a harbour or just outside the harbour.

Four of the public sightings occurred between about 8.75 n.m. and 14 n.m. (16.2–25.9 km) offshore, all between Manukau and Raglan. These sightings were all recorded during September and October 2002. Only some of these four sightings have been verified by DOC staff, so they should be treated with some caution; however, the sightings occurred between the 50-m and 100-m isobaths, which is within the known depth range of Hector's dolphins (Rayment et al. 2006; Slooten et al. 2006).

The other clusters of public sightings to note are those occurring south of Kawhia Harbour, in the New Plymouth area (Fig. 7). These sightings are particularly interesting because they are further south than sightings from recent systematic surveys that have also covered that area (Ferreira & Roberts 2003; Slooten et al. 2005). In particular, eight sightings of Maui's dolphin were reported near New Plymouth during January 2004. These sightings were made by commercial and recreational fishers, and surfers. More recently, there have only been sporadic sightings in the area (four between 2005 and 2007). The cluster of sightings near New Plymouth (in 2004) may have coincided with an excursion of some Maui's dolphins beyond their normal home range. Alternatively, there may be a resident group of Maui's dolphins in the area that are not often seen.

In late 2009 and early 2010, there were several public sightings in the Taranaki/New Plymouth area (many of which were verified by DOC staff members through interviews). A further sighting of six dolphins off the New Plymouth coast had not been verified by DOC staff at the time of writing. The most interesting of the recent public sightings was the one made just south of Pukerua Bay. After interviewing the member of the public, DOC staff were confident that this was a Maui's dolphin. Although there is often an assumption that *C. Hectori* species sightings on the west coast of the North Island are Maui's dolphin—which are only know from a restricted range on the west coast of the North Island—rather than Hector's dolphins, this is not always the case. A recent sighting of either a Hector's or Maui's dolphin in Wellington Harbour was biopsied and was shown to have mitochondrial haplotypes consistent with Hector's dolphin (Rebecca Hamner, University of Auckland, pers. comm.). Additionally, a beach-cast animal found at Peka Peka Beach (on the Kapiti Coast, well south of the current known distribution of Maui's dolphin) was also found to have mitochondrial haplotypes found in both east coast and west coast (South Island) Hector's dolphin populations (Hamner et al. 2009).

### 3.2.4 Additional data

DOC has recently produced comprehensive plots of Maui's dolphin sightings in four categories: research surveys, verbal location sightings, GPS location sightings, and all sightings combined. These data included all sightings in the database up to March 2008. These plots are available on the DOC website (www.doc.govt.nz/conservation/native-animals/marine-mammals/dolphins/mauis-dolphin/docs-work/recent-work/), so are not reproduced here.

The research survey plot includes all sightings from 1985 through 2008 (with the exception of those from research by Kirsty Russell when at the University of Auckland). These sightings are clearly concentrated between Kaipara and Raglan.


Figure 7. Sightings of Hector's dolphins, 1920–2010.

Sightings on the verbal locations plot are, not surprisingly, concentrated around areas of high human activity, namely Kaipara Harbour, Manukau Harbour, the Waikato River mouth and Raglan Harbour. Only four of the sightings in Manukau Harbour were near or beyond the boundary of (i.e. further in the harbour than) the current protected area. Most Manukau records were situated between Cornwallis and the Manukau Heads.

The plots of GPS locations and all sightings combined show a similar pattern of a high concentration of sightings between Manukau and Raglan, and to a lesser extent south to Kawhia and north to Kaipara.

Further information about the use of Manukau Harbour by Maui's dolphins comes from a study utilising T-PODs, or passive acoustic data loggers (Scali et al. 2008). T-PODs work by recording echolocation click trains, and are an excellent way of monitoring for the presence of cetaceans in all weather conditions and at all times of the day. The DOC database contains some 51 acoustic detections of Maui's dolphins logged by a T-POD located near Puponga Point, just inside the current closure area. These detections occurred between January 2005 and November 2006. T-PODs do not give precise locations of animals (for reference, the detection radii for Hector's dolphins are c. 200 m (Rayment et al. 2009); a similar radius could be expected for Maui's dolphin), but these detections do suggest that Maui's dolphins are at least utilising the areas near the protected area boundary, and indeed may be ranging further into Manukau Harbour.

### 3.2.5 Survey design and effort variation

It is worth considering the differences in survey design and effort allocation amongst the various surveys.

The 1985 boat research studies (Dawson & Slooten 1988) surveyed the area between 18.5 km (10 n.m.) south of the Wanganui River and Kaipara Harbour, and did not cover any offshore areas. Some of the later research surveys have similarly concentrated on alongshore surveys.

Ferreira & Roberts (2003) covered an extensive section of the coastline (DOC surveys 2000–2002), but did not go any further offshore than 5 n.m. (9.3 km). In the Otago aerial surveys of 2004 (Slooten et al. 2005), survey extent and effort varied between summer and winter: areas north of Kaipara and south of Raglan were only covered during the summer survey, and greater survey effort was put into the area between Muriwai and Raglan during the summer survey. Essentially, these surveys were designed so that the central area of Muriwai to Raglan had the most survey effort, in terms of density of transects between 0 n.m. and 5 n.m. (9.3 km), and distance offshore surveyed (10 n.m. or 18.5 km). The areas north to Kaipara and south to Kawhia were also surveyed out to 10 n.m., but without the same high density of inshore (0–5 n.m. or 9.3 km) lines. The winter 2004 survey focussed only on Muriwai to Raglan, and the recent aerial surveys of 2006, 2007, 2008 and 2009 similarly focussed on this area.

Consequently, although sightings on the research survey plots are clearly concentrated between Manukau and Raglan, this is likely to result from a combination of true distribution of the dolphins and disproportionate survey effort in comparison with those areas to the north and south.

# 4. Discussion

The most reliable and complete data for assessing the distribution of Maui's dolphins come from the recent dedicated surveys (e.g. Slooten et al. 2005; Rayment & Du Fresne 2007; Childerhouse et al. 2008; Stanley 2009). Though there are some acknowledged issues with reliability of some data from the Scali (2006) survey, this dataset is also a useful contribution. Interpreting the data from these aerial surveys is straightforward because survey effort is even throughout the survey areas. Furthermore, these surveys were designed according to robust survey design principles (Buckland et al. 2001) to cover extensive offshore and alongshore areas.

Perhaps the biggest limitation of these data is the fact that the alongshore extent of the surveys covered only the central alongshore range of Maui's dolphin distribution in the case of the Scali (2006), Rayment & Du Fresne (2007) and Childerhouse et al. (2008) surveys. Though this is arguably the most important area to cover in assessing offshore distribution, especially when funding constraints are considered, it does (to an extent) limit conclusions.

Supplementary sightings are provided by alongshore research surveys and the DOC sightings database, both of which largely confirm the results from the systematic surveys described above—though also highlight the potential importance of the Taranaki region, which does not clearly come out of the systematic surveys. Additionally, passive acoustic surveys using T-PODs have provided more data on harbour usage (Scali et al. 2008).

While most sightings are within 4 n.m. (7.4 km) of the coast, Maui's dolphins have been sighted recently at least as far offshore as 7 n.m. (12.96 km). This is a key result, as it suggests that to maximise efficacy, the spatial extent of protection measures needs to extend at least 7 n.m. offshore.

The combined results of these surveys indicate that Maui's dolphins utilise the coast at least between Kaipara Harbour and Kawhia. The high concentration of sightings in this area (especially between Manukau and Raglan) will be, in part, due to this area receiving the highest observer effort over the past several years. However, it is also the case that some surveys (Ferriera & Roberts 2003; Slooten et al. 2005; Webster & Edwards 2008) have extended well to the south of Raglan, Kawhia and even the southern limit of the current closure area; and have seen few Maui's dolphins. This could mean one of two things: these areas are beyond the core range of Maui's dolphins, but are visited occasionally by the dolphins; or there are animals resident in these more southern areas, but surveys miss them because they are present in such low numbers. Whichever of these interpretations is correct, the management response should be no different: Maui's dolphins are critically endangered, and should be protected throughout their entire range.

# 5. Recommendations

Maui's dolphins are arguably one of the most endangered cetacean populations in the world (Slooten et al. 2006), with a documented history of gillnet bycatch (Dawson et al. 2001). When considering protection requirements, it is vital that total protection and removal of all fisheries-related mortality be the primary goal. A PBR or some other form of quota-based bycatch management is inappropriate for this subspecies, given its already dangerously low population size and the extreme difficulties encountered in monitoring commercial and recreational fisheries.

Protected areas (or time/area fisheries closures) will offer the most reliable, complete and immediate protection for Maui's dolphin, but need to consider the full range of known and likely habitat of the subspecies. An additional buffer zone beyond areas of known utilisation would help to ensure full protection of Maui's dolphin.

Additional and regular surveys will help to refine our understanding of Maui's dolphin distribution, and to monitor the success of any new management regimes. Outside the west coast harbours, aerial surveys offer the most comprehensive solution, as large areas can be covered relatively quickly, ensuring equal survey effort throughout, and covering both alongshore and offshore areas. Of particular importance is the southern extreme of the distribution, since this is the most likely site for genetic exchange with Hector's dolphin from the north coast of the South Island.

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