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New Zealand marine mammals and commercial fisheries

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EXECUTIVE SUMMARY

Incidental captures of marine mammals occur across different fisheries worldwide, affecting a range of cetacean and pinniped species. As bycatch assessments are often hampered by scarcity of data of the number and identity of captured individuals, risk assessments provide a systematic approach to identifying and evaluating potential impacts of fishing-related mortalities, while also accounting for uncertainty.

The present study forms the basis for a risk assessment of the interactions between different commercial fisheries and marine mammals in New Zealand waters. Considering the 35 marine mammal (sub)species that inhabit New Zealand waters, population data relevant to the risk assessment process were summarised for each of the 10 mysticetes, 22 odontocetes (including dolphins and beaked whales), and three pinnipeds. Existing bycatch data were used to characterise the different types of interactions between these marine mammals and trawl, longline, setnet, and pot/trap fisheries.

There were few bycatch records of baleen whales in New Zealand, with observed entanglements involving Bryde's, humpback and southern right whales. Data from other regions show that the majority of recorded bycatch incidents were entanglements and injuries in static gear, predominantly involving species and populations that reside in coastal waters. Although the New Zealand Bryde's whale population is resident in coastal northern North Island waters, the main threat identified for this species was not fisheries-related, but vessel collision, particularly in Hauraki Gulf.

For toothed cetaceans, bycatch documentation showed that direct interactions with fishing operations often lead to immediate mortality, particularly for small-sized dolphins, as captured individuals are unable to free themselves and drown in fishing gear. Furthermore, the coastal distributions of many dolphin species and their attraction to fishing vessels expose them to the risk of fisheries bycatch. Consistent with data from elsewhere, almost all toothed cetacean species have featured in bycatch reports in New Zealand, involving trawl, longline and gill/set-net fisheries. In addition to bycatch in trawl and gill/set-net fisheries, there have been documented Hector's dolphin entanglements in lobster fishing gear. Lobster pot gear has also been implicated in the bycatch of bottlenose dolphin and long-finned pilot whale in other regions.

For pinnipeds, trawl fisheries were the most significant source of mortality, with high numbers of New Zealand fur seal and New Zealand sea lion incidentally captured in these fisheries in New Zealand waters. New Zealand fur seal were also frequently bycaught in surface-longline fisheries.

Data reviewed here led to the identification of different fisheries-marine mammal interactions, and will inform the next step in the risk assessment process involving marine mammals and commercial fisheries in New Zealand.

1. INTRODUCTION

Incidental captures of marine mammals occur across a wide range of fisheries worldwide, affecting a range of cetacean and pinniped species in coastal and pelagic environments (Read 2008). Interactions between marine mammals and commercial fisheries can be significant, in particularly in inshore waters, with the outcome dependent on the marine mammal species and the type of fishing gear and fishery involved. The latter include gill- and set netting, longlining, trawling, and purse seining, with incidental captures also recorded in pot and trap fisheries (Wickens 1995, Fertl & Leatherwood 1997, Campbell et al. 2008, Hamer et al. 2012, Reeves et al. 2013). As a consequence, most marine mammal species have featured in global bycatch records, including 61 (of 74) recognised species of odontocetes, 13 (of 14) mysticete species, eight (of 14) species of otariid seals and sea lions, and 15 (of 18) phocid seal species (Reeves et al. 2013). For some of these species, bycatch has been identified as a critical source of mortality, limiting population growth and contributing to or causing the decline of (sub)populations (Woodley & Lavigne 1991).

Recognising the significant impact of bycatch on a number of cetacean species in passive fishing gear, the International Whaling Commission conducted a symposium and workshop in 1990 on bycatch involving nets and traps, resulting in a summary of global fishery and bycatch data (Perrin et al. 1994). Subsequent reviews have updated this information (Reeves et al. 2013), and also focused on other fisheries, including trawling (Fertl & Leatherwood 1997, Zollett & Rosenberg 2005) and longlining (Hamer et al. 2012), with the bycatch of pinnipeds in active and passive fishing gear also receiving some research attention (Woodley & Lavigne 1991, Wickens 1995, Hamer et al. 2013). A number of studies have attempted to identify the extent of bycatch for individual (sub)species (e.g., common dolphin bycatch - Thompson et al. 2013a) and on regional and global scales (Read et al. 2006, Zollett 2009, Carretta et al. 2012).

One of the main limitations of bycatch assessments is the scarcity or lack of data of the number and identity of species involved. In many countries, marine mammal bycatch is not reported or systematically recorded, even though anecdotal and ad hoc observations indicate that it occurs (see examples in Reeves et al. 2013). Some countries (e.g., United States, Australia, New Zealand) place government fisheries observers on-board commercial fishing vessels to obtain reliable records of incidental captures of non-target species such as marine mammals, but few fisheries have 100% observer coverage. Small-vessel fisheries in particular are often characterised by limited capacity to accommodate on-board observers, while contributing a significant proportion to the total fishing effort, including in New Zealand waters.

In addition, fisheries interactions are unlikely to be observed when pelagic species are involved, as the latter occur predominantly in offshore waters and are relative rare in coastal areas, such as most baleen whale species (National Marine Fisheries Service 2012). Although these pelagic species are deemed to have few interactions with fishing operations, any offshore entanglement or capture on unobserved fishing vessels is likely to be undetected as the interactions occur too far from shore for individuals to become stranded (Heyning & Lewis 1990). The likelihood of observing fisheries mortalities are further reduced by balaenopterid carcasses sinking initially and only refloating at a later stage if bloating occurs (Cassoff et al. 2011). For these reasons, a proportion of bycatch is likely to be un- or under-reported.

Bycatch assessments are further hampered by an unknown proportion of animals that may have been incidentally captured in gear, but went unnoticed as the carcass was lost when gear was hauled, or the animal managed to free itself although with severe injuries or with some gear still attached (Ross & Isaac 2004, Northridge et al. 2010, Kindt-Larsen et al. 2012). The latter interactions may cause subsequent mortality, when entangled or ingested gear causes injuries and systemic infections, interferes with foraging causing starvation, or becomes increasingly constrictive (Moore et al. 2004, Knowlton et al. 2012). As these subsequent mortalities from fisheries interactions are not acute but "cryptic", they are generally not accounted for in bycatch records. Some of these cryptic mortalities may get recorded in

strandings data, when animals wash up with gear still attached. In most cases, however, it is impossible to assign the gear involved to a particular fishery, even when the materials used or the locations of entangled animal sightings or strandings clearly implicate commercial fisheries.

This difficulty is exacerbated by derelict gear that continues to entangle or trap marine organisms (known as "ghost fishing") after it is lost or abandoned (Macfadyen et al. 2009). Fishing gear entanglement has been confirmed as a significant source of injury and mortality for many marine mammal populations in a number of regions, such as northern right whale *Eubalaena glacialis* and humpback whale *Megaptera novaeangliae* in the northwestern Atlantic Ocean (Clapham et al. 1999).

The limited availability of quantitative bycatch data makes it difficult to determine the potential impacts of incidental captures on marine mammal populations. Nevertheless, information on bycatch mortality is crucial for the management of commercial fisheries that may impact on protected species, such as marine mammals. One way to address the difficulty of limited data in the management and mitigation of protected species bycatch is to apply a risk assessment approach to a fisheries context. Risk assessments are increasingly being used as management tools in fisheries worldwide, to assess adverse ecological effects arising from fishing activities, including the risk of stock depletion of non-target species (i.e., bycatch of protected, threatened and endangered species, such as seabirds and marine mammals)(Astles et al. 2006, Goldsworthy & Page 2007, Sharp et al. 2011).

Based on scientific data and accounting for uncertainty, the risk assessment process provides a systematic approach for fisheries management to characterise, quantify, and evaluate potential impacts. In addition to identifying risks posed by human activities, risk assessments highlight areas that require additional information, thereby enabling the prioritisation of data collection and monitoring programmes. As a consequence, risk assessments are considered valuable management tools, particularly when available data are limited and resources are managed under uncertainty (Hunsaker et al. 1990). The latter include the management of capture fisheries, where risk assessments are becoming a common technique to minimise the risk of undesirable events, such as overexploitation of stock (Francis & Shotton 1997, Sethi 2010).

In a New Zealand fisheries context, ecological risk assessments have had limited application to date (but see Campbell & Gallagher 2007). For protected species bycatch, recent risk assessments have focused on the risk of commercial fisheries to seabird populations in New Zealand waters (Richard & Abraham 2013a, 2013b), while a risk assessment concerning Maui's dolphin *Cephalorhynchus hectori maui* included bycatch mortality with other human-caused threats (Currey et al. 2012). These risk assessments were based on a mortality limit, the "Potential Biological Removal" (PBR), developed under the United States Marine Mammal Protection Act for the assessment of fisheries' impacts on marine mammal populations (Wade 1998). Wade (1998) defined the PBR as the "maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population". Determining the PBR for a population relies on biological data including the minimum population size and the maximum population growth for the species and populations concerned. The PBR value is then compared to the estimated number of human-caused mortalities to identify marine mammal populations that may be at risk of depletion.

The current study is intended to support a risk assessment of commercial fisheries to marine mammal populations in New Zealand's Exclusive Economic Zone (EEZ). It presents a review of available information that is relevant to the risk assessment process, including population data of marine mammal populations found in New Zealand waters. Also considered are bycatch data and other information that allow the identification of the types of interactions that may occur between marine mammals and different commercial fisheries.

2. METHODS

The current review presents data collated from a number of sources, with biological data of marine mammal populations including information on their distribution, population status (i.e., the population size and population trends, both globally and in New Zealand waters), age at first reproduction, maximum growth rate, breeding locations and seasonality, and longevity. The primary sources of these biological data were the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (IUCN 2012) and published books on marine mammals (i.e., Jefferson et al. 2008, Perrin et al. 2009), with information also sourced from scientific papers, theses, and "grey literature" reports and documents.

Data on the distribution of marine mammals within New Zealand's EEZ were collated for the period between January 1970 and January 2013 from sightings and strandings databases. Four data sets of cetacean sightings were used to describe and map the distribution patterns of cetaceans in New Zealand waters: (1) sightings collated and administered by Department of Conservation (DoC) (Department of Conservation 2012b), (2) incidental sightings of cetaceans recorded by transiting ships between New Zealand and overseas ports collated by M. Cawthorn (Cawthorn 2009), (3) observations of cetaceans collected by New Zealand government inshore fisheries observers (Centralised Observer Database, COD), and (4) a data set of opportunistic at-sea cetacean sightings recorded by scientists from the National Institute of Water and Atmospheric Research (NIWA)(L. Torres, unpublished data) (see spatial distributions of species or species group sightings by season and dataset in Appendix A, and details of the frequency of cetacean sightings by species, month, season, data set, and year in Appendix B).

Sightings compiled in the DoC data set were from multiple sources, including members of the public, scientific research, and DoC employees. The time period of the 5853 sightings held by DoC ranged from 1970 to 2013, though most sightings were recorded between 1999 and 2012. Sightings in this data set are divided into two time periods, before and after 2011. All sightings in the latter period have been validated by DoC (one to five, high to low confidence), whereas the application of this validation system to the earlier sightings data is on-going. For this reason, the DoC data used in the current analysis included sightings before 2011 without a validation score, whereas only sightings with a confidence rating between one and three were included from the subsequent period. The data collated by Cawthorn (2009) were collected by ship captains trained by the author, with all sightings also verified by M. Cawthorn. These data consisted of 1737 sightings that were collected between 1979 and 1999, with most data recorded between 1980 and 1987. The cetacean sightings recorded in COD encompassed 3475 records by trained fisheries observers on-board inshore fishing vessels between 2009 and 2011. All of the 111 at-sea sightings by NIWA scientists were verified (L. Torres), either through photos or videos taken in the field, or by verbal descriptions of the observations. The time period of the NIWA sightings ranged from 2007 to 2013.

Information on marine mammal interactions with fisheries was sourced from government fisheries observer data (COD), and also included other records of interactions with fisheries, such as Hector's dolphin captures (Starr & Langley 2000) and large whale entanglements (International Whaling Commission 2012) that occurred within New Zealand waters.

A systematic literature search was conducted to obtain additional information on the interactions between marine mammals and commercial fisheries in New Zealand. When there were little or no data from this region, studies from elsewhere (including reviews) were considered for related species, and for species and populations that also occur outside of New Zealand's EEZ. This information was included to illustrate the types of interaction that may occur between particular species and fisheries; it was not intended to provide a comprehensive assessment of marine mammal bycatch on a global scale.

The literature search used internet search engines and electronic literature databases, including Aquatic

Sciences and Fisheries Abstracts, Science Direct, Google, Google Scholar, and National Library of New Zealand. The following keywords were used individually and in various combinations: "bycatch", "by-catch", "incidental", "entangle*", "injury", "mortality", "marine mammal", "whale", "dolphin", "pinniped", species (common and scientific) names (e.g., blue whale *Balaenoptera muculus*) and different fisheries (e.g., longlining, trawling). The initial search was narrowed by refining the search terms if a large number of records was returned.

The following literature and data review presents available information for each marine mammal (sub)species, including summary tables of population data and fisheries interactions.

3. MARINE MAMMAL POPULATIONS IN NEW ZEALAND

New Zealand waters are inhabited by a wide range of marine mammals, including the endemic subspecies Hector's and Maui's dolphins (*Cephalorhynchus hectori hectori* and *C. hectori maui*) and New Zealand sea lion (*Phocarctos hookeri*) (Childerhouse & Gales 1998, Currey et al. 2012). A recent assessment of the conservation status of marine mammal species in New Zealand considered all taxa that have been recorded in New Zealand's Exclusive Economic Zone (EEZ) since 1800 (Baker et al. 2010a). This assessment followed the New Zealand Threat Classification System manual (see Townsend et al. 2008) and distinguished between resident, migrant and vagrant taxa, based on their occurrence and breeding status in New Zealand waters. Accordingly, migrant taxa do not breed in New Zealand waters, but regularly visit this region as part of their normal life cycle, with at least 15 individuals known or presumed to occur here each year. Migratory species with less than 15 individuals each year are considered vagrant, and this category also includes taxa that are unexpectedly found in New Zealand waters.

From a total of 56 marine mammal taxa (species, subspecies, and unnamed forms or types), 36 taxa were considered to be resident or migrant in New Zealand's EEZ (Baker et al. 2010a). These taxa included 10 species/subspecies of baleen whale, 23 taxa of toothed whale (including dolphins and nine species of beaked whale), and three pinniped species (Table 1).

All of these taxa were included in the present review, but the Kermadecs form of bottlenose dolphin (distinguished by Baker et al. 2010a) was not considered separately. Information from Kermadec Islands indicate that there are no resident bottlenose dolphin populations in this area, and that visiting individuals are not distinctly different to bottlenose dolphin observed around mainland New Zealand (R. Constantine, University of Auckland, pers. comm.).

Since the assessment by Baker et al. (2010a), a review of pinniped taxonomy resurrected the genus *Arctophoca*, and renamed New Zealand fur seal *Arctocephalus forsteri* as *Arctophoca australis forsteri* (Berta & Churchill 2012). This new species name was used for New Zealand fur seal in the present review.

Another 20 species were considered vagrant by Baker et al. (2010a), and these 14 species of toothed whale and six pinniped species were not included in the present study: Arnoux's beaked whale *Berardius arnuxii*, ginkgo-toothed whale *Mesoplodon ginkgodens*, lesser/pygmy beaked whale *Mesoplodon peruvianus*, dwarf sperm whale *Kogia sima*, Fraser's dolphin *Lagenodelphis hosei*, types B–D of killer whale *Orcinus orca*, melon-headed whale *Peponocephala electra*, spectacled porpoise *Phocoena dioptrica*, pantropical spotted dolphin *Stenella attenuata*, striped dolphin *Stenella coeruleoalba*, rough-toothed dolphin *Steno bredanensis*, Risso's dolphin *Grampus griseus*, Antarctic fur seal *Arctocephalus gazella*, subantarctic fur seal *Arctocephalus tropicalis*, leopard seal *Hydrurga leptonyx*, Weddell seal *Leptonychotes weddellii*, crabeater seal *Lobodon carcinophagus*, and Ross seal *Ommatophoca rossi*.

Table 1: Marine mammal taxa included in the present review of interactions between marine mammals and commercial fisheries in New Zealand waters.

Group	Common name	Scientific name	IUCN threat status	New Zealand threat status
Baleen whales	Antarctic blue whale	*Balaenoptera musculus intermedia*	Criticially endangered	Migrant
	Pygmy blue whale	*Balaenoptera musculus brevicauda*	Endangered	Migrant
	Antarctic minke whale	*Balaenoptera bonaerensis*	Data deficient	Not threatened
	Dwarf minke whale	*Balaenoptera acutorostrata*	Least concern	Not threatened
	Bryde's whale	*Balaenoptera brydei*	Data deficient	Nationally critical
	Fin whale	*Balaenoptera physalus*	Endangered	Migrant
	Sei whale	*Balaenoptera borealis*	Endangered	Migrant
	Humpback whale	*Megaptera novaeangliae*	Least concern	Migrant
	Southern right whale	*Eubalaena australis*	Least concern	Nationally endangered
	Pygmy right whale	*Caperea marginata*	Data deficient	Data deficient
Toothed whales	Sperm whale	*Physeter macrocephalus*	Vulnerable	Not threatened
	Pygmy sperm whale	*Kogia breviceps*	Data deficient	Data deficient
	Bottlenose dolphin	*Tursiops truncatus*	Least concern	Nationally endangered
	Common dolphin	*Delphinus delphis*	Least concern	Not threatened
	Dusky dolphin	*Lagenorhynchus obscurus*	Data deficient	Not threatened
	Hector's dolphin	*Cephalorhynchus hectori hectori*	Endangered	Nationally endangered
	Maui's dolphin	*Cephalorhynchus hectori maui*	Critically endangered	Nationally critical
	Hourglass dolphin	*Lagenorhynchus cruciger*	Least concern	Data deficient
	False killer whale	*Pseudorca crassidens*	Data deficient	Not threatened
	Killer whale Type A	*Orcinus orca*	Data deficient	Nationally critical
	Long-finned pilot whale	*Globicephala melas*	Data deficient	Not threatened
	Short-finned pilot whale	*Globicephala macrorhynchus*	Data deficient	Migrant
	Southern right whale dolphin	*Lissodelphis peronii*	Data deficient	Not threatened
Beaked whales	Andrews' beaked whale	*Mesoplodon bowdoini*	Data deficient	Data deficient
	Cuvier's beaked whale	*Ziphius cavirostris*	Least concern	Data deficient
	Dense-beaked whale	*Mesoplodon densirostris*	Data deficient	Data deficient
	Gray's beaked whale	*Mesoplodon grayi*	Data deficient	Data deficient
	Hector's beaked whale	*Mesoplodon hectori*	Data deficient	Data deficient
	Strap-toothed whale	*Mesoplodon layardii*	Data deficient	Data deficient
	Spade-toothed whale	*Mesoplodon traversii*	Data deficient	Data deficient
	Shepherd's beaked whale	*Tasmacetus shepherdi*	Data deficient	Data deficient
	Southern bottlenose whale	*Hyperoodon planifrons*	Least concern	Data deficient
Pinnipeds	New Zealand fur seal	*Arctophoca australis forsteri*	Least concern	Not threatened
	New Zealand sea lion	*Phocarctos hookeri*	Vulnerable	Nationally critical
	Southern elephant seal	*Mirounga leonina*	Least concern	Nationally critical

Cetacean sightings in the period between January 1970 and January 2013 included a range of taxa across the different data sources (Table 2). Records included generic sightings of blue, minke, and beaked whales, and also data of other baleen whale species and of toothed cetaceans.

Table 2: Number of cetacean sightings within New Zealand's Exclusive Economic Zone for the period between January 1970 and January 2013 by species and data set. Data sources included Department of Conservation (DOC; Department of Conservation 2012b), Cawthorn (2009), opportunistic at-sea sightings (NIWA), and the Centralised Observer Database (COD).

Taxa	DOC	Cawthorn	NIWA	COD	Total
Blue whales	67	45	2		114
Minke whale	27	29	3	1	60
Bryde's whale	570	6		1	577
Fin whale	16	45	1	2	64
Sei whale	29	50	1	1	81
Humpback whale	404	122	6	6	538
Southern right whale	326	39		1	366
Pygmy right whale	1				1
Sperm whale	175	303	10	7	495
Pygmy sperm whale	2				2
Bottlenose dolphin	268	101	5	68	442
Common dolphin	1 561	454	27	652	2 694
Dusky dolphin	280	157	9	284	730
Hector's dolphin	720	64	31	2 419	3 234
Maui's dolphin	589				589
Hourglass dolphin	4	1			5
False killer whale	24	2	1		27
Killer whale	401	124	5	18	548
Pilot whales	350	178	7	15	550
Southern right whale dolphin	5				5
Beaked whales	28	17	1		46
Southern bottlenose whale	4				4
Total	5 853	1 737	111	3 475	11 176

3.1 Baleen whales - Mysticetes

Baleen whales are characterised by the lack of functional teeth, as they feed via a specialised feeding apparatus consisting of baleen plates which are used to filter small marine animals (mostly zooplankton, and also small fish) from the water column (Bannister 2009). Most baleen whale species have a widespread distribution (including cosmopolitan species) and migrate considerable distances between low-latitude summer feeding grounds and winter breeding areas at higher latitudes. Their feeding grounds are generally associated with areas of high productivity, such as Antarctic waters in the Southern Hemisphere, where large concentrations of zooplankton (i.e., krill) are present in summer.

Feeding mostly occurs in surface waters (within 100 m of the surface), and most baleen whale species are oceanic, spending limited periods of time in coastal regions. In contrast to many other cetaceans, baleen whales are seldom found in large aggregations. Although they congregate on feeding and breeding grounds, they are often solitary (or in small groups) during migrations. Owing to their widespread distribution and primarily oceanic lifestyle, population data of many baleen whale species are limited, with abundance data generally restricted to particular geographical areas and regional assessments (e.g., Leaper et al. 2008). Furthermore, most population surveys have been conducted at baleen whale feeding grounds, so that the locations of calving grounds remain largely unknown for several species, such as blue and sei whales in the Southern Hemisphere.

Table 3: Population information of baleen whale (sub)species that inhabit New Zealand waters (n.d., no data).

Common name	General distribution	Global population size	General NZ distribution	NZ population size	Age at first reproduction	Max. population growth
Antarctic blue whale	Southern Hemisphere (Jefferson et al. 2008)	South of 60°S: 1700 individuals (95% c.i.: 860–2900) [1996] (Branch et al. 2004)	Migrant (McDonald 2006); Taranaki Bight (Torres 2013)	n.d	Both sexes: 5–15 years (8–10 years) (Sears & Perrin 2009)	7.3%/year (95% c.i. 1.4–11.4%) (Branch et al. 2004)
Pygmy blue whale	Southern Hemisphere, northern Indian Ocean (Jefferson et al. 2008)	4000 individuals [1970s] (Jefferson et al. 2008)	Migrant (McDonald 2006); Taranaki Bight (Torres 2013)	n.d	Both sexes: 5–15 years (8–10 years) (Sears & Perrin 2009)	n.d
Antarctic minke whale	Southern Hemisphere (Reilly et al. 2008b)	Antarctica: 338 000 individuals (CV: 0.079) [1991–2004] (Reilly et al. 2008b)	Migrant	n.d	Females: 7–8 years, males: 8 years (Perrin 2009b)	n.d
Dwarf minke whale	Global (Reilly et al. 2008a)	n.d	Northern NZ	n.d	Females: 6 years, males: 7 years (Perrin 2009b)	n.d
Bryde's whale	Global, tropical and warm-temperate waters (Jefferson et al. 2008)	n.d	Northern North Island, i.e., Hauraki Gulf (Baker & Madon 2007, Wiseman et al. 2011)	Hauraki Gulf: 46 (CV 0.08) – 159 (CV 0.35) individuals [2003–2006] (Wiseman 2008)	About 7 years (Kato & Perrin 2009)	n.d
Fin whale	Global (Reilly et al. 2008f)	Antarctica: 4300 (CV: 0.46) – 8800 individuals (CV: 0.56) (Leaper et al. 2008)	Migrant (Reilly et al. 2008f)	n.d	Females: 7–8 years, males: 6–7 years (Aguilar 2009)	5.5% (Reilly et al. 2008f)
Sei whale	Global (Reilly et al. 2008c)	Southern Hemisphere and North Pacific Ocean: 70 000 individuals (Horwood 2009)	Migrant (Reilly et al. 2008c)	n.d	10 years (Reilly et al. 2008c)	2.7% (Reilly et al. 2008c)
Humpback whale	Global (Reilly et al. 2008i)	Antarctica, south of 60°S: 41 800 individuals (CV: 0.11)[1992–2004]; (Reilly et al. 2008i) > 50 000 in Southern Ocean (Leaper et al. 2008)	Migrant, coastal areas throughout mainland NZ	73 migrating individuals [2011] (Department of Conservation 2012a); Oceania: 4329 (95% c.i.: 3345 to 5313) individuals [2005] (Constantine et al. 2012)	5–10 years (Clapham 2009)	SW Pacific Ocean: 10.6% (95% c.i.: 0.5%) [1987–2004] (Noad et al. 2006)

(Continued on next page)

Table 3: (*continued*)

Common name	General distribution	Global population size	General NZ distribution	NZ population size	Age at first reproduction	Max. population growth
Southern right whale	Southern Hemisphere (Reilly et al. 2008h)	7 500 individuals [1997]; >15 000 individuals (early 2000s) (Kenny 2009)	Subantarctic wintering grounds; coastal waters mainland NZ (Carroll et al. 2013b)	2169 (95% c.i.: 1836–2563) individuals [1995–2009] (Carroll et al. 2013a)	NZ: females: 7.7–9.1 years, males: 3–6 years (Carroll 2011)	4.6% Carroll (2011); females 5% (95% confidence limit: 7 to 9%), males 7% (95% confidence limit: 5 to 9%) (Carroll et al. 2013a)
Pygmy right whale	Southern Hemisphere (Reilly et al. 2008g)	n.d	Coastal and pelagic areas throughout NZ (Kemper et al. 2013)	n.d	n.d	n.d

Similar to other cetaceans, baleen whales are long-lived, although there are few data available on their maximum age. Age determination of this group of cetaceans is difficult, as they lack teeth so that longevity data are often based on repeated sightings of known individuals over a considerable period of time (Kenny 2009). Other baleen whale ageing techniques include analyses of growth increments in ear plugs and baleen, chemical analysis of eye globes (aspartic acid racemization), and assessment of female reproductive tissue (ovarian corpora counts) to ascertain age estimates, but these techniques have only been applied to few species, e.g., fin and bowhead whales (Lockyer 1972, George et al. 1999, 2011, Lubetkin et al. 2008).

Baleen whales in New Zealand waters are represented by 10 species/subspecies, encompassing three of the four extant global baleen whale families, including "rorquals" or balaenopterids (8 species/subspecies), right whales (1 species), and pygmy right whale (1 species) (see summary of population data in Table 3).

3.1.1 Blue whales

There are two (of a total of three) subspecies of blue whale in the Southern Hemisphere, with Antarctic blue whale *Balaenoptera musculus intermedia* and pygmy blue whale *Balaenoptera musculus brevicauda* both occurring in New Zealand waters (Branch et al. 2007b, Jefferson et al. 2008, Torres 2013). These two southern subspecies are generally distinguished by differences in maximum length, average length at sexual maturity, and proportional length of the tail region, making field identifications difficult and some sighting records uncertain (Branch et al. 2007a). For this reason, a number of studies do not distinguish between subspecies (e.g., Miller et al. 2013, Olson et al. 2013).

There is some geographical separation between the two subspecies during austral summer, when Antarctic blue whale are predominantly south of 55 degrees South, whereas pygmy blue whale are considered uncommon beyond this latitude in the Southern Ocean (Branch et al. 2007a). In winter, there is some overlap in the distributions of the two subspecies, as Antarctic blue whale migrate north and occur sympatrically with pygmy blue whale (Jefferson et al. 2008). Part of the Antarctic blue whale population migrates to waters in southern Africa and other northern areas in winter, with some individuals remaining in Antarctica over winter (Branch et al. 2007b). At the same time, recent studies suggest that not all Antarctic blue whale migrate to Antarctic feeding grounds in summer, with a number of individuals remaining north of the Polar Front throughout the year (Samaran et al. 2010).

Pygmy blue whale have a resident population in the northern Indian Ocean, with other groupings including a population between northern New Zealand and the equator (Branch et al. 2007b). Throughout their range, blue whales are prevalent in areas of cold current upwellings, as they feed almost exclusively on euphausiids that are often concentrated in these productive areas (Jefferson et al. 2008, Reilly et al. 2008e).

Global blue whale populations were severely depleted by whaling (e.g., less than 3% of pre-whaling levels for Antarctic blue whale), and the current population status of all subspecies is poorly known, with total blue whale estimates varying between 10 000 and 25 000 individuals (Clapham et al. 1999, Reilly et al. 2008e). For Antarctic blue whale, a recent study estimated the population in the Southern Ocean south of 60 degrees South at 1700 individuals (95% credible interval: 860–2900) in 1996, with an estimated population increase of 7.3%/year (95% credible interval: 1.4–11.4%)(Branch et al. 2004). The present (and past) population size of pygmy blue whale is unknown, with the most recent estimate of 4000 individuals in the 1970s (Jefferson et al. 2008).

Blue whales reach sexual maturity between 5–15 years of age, although 8–10 years is more common for

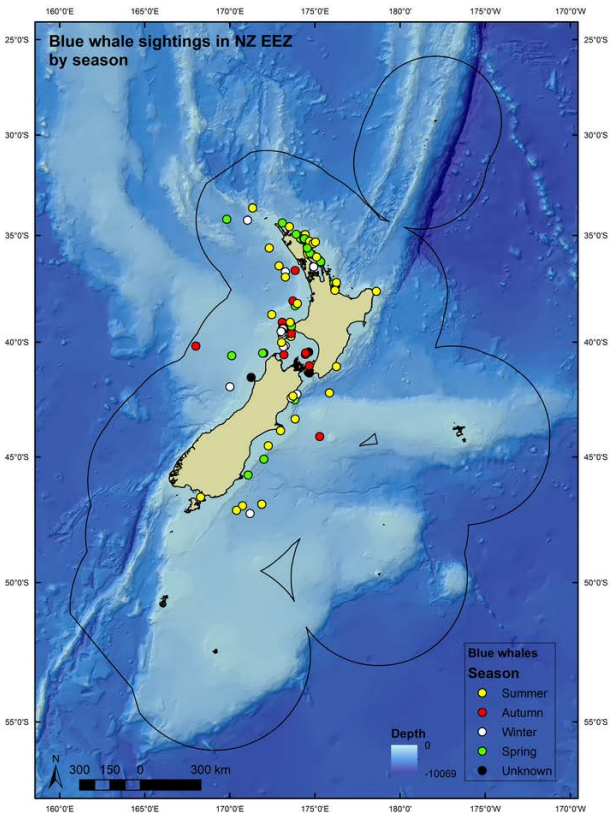

Figure 1: Distribution of blue whale (*Balaenoptera musculus*) sightings in New Zealand waters between 1970 and 2013. (Reported sightings are from a variety of sources and need to be considered as indicative only, as identifications may not be correct.)

both sexes (Sears & Perrin 2009). Calving occurs every 2–3 years in winter after a gestation period of 10–12 months. Blue whales live for at least 40 years, with suggestions that they may reach 80–90 years of age.

Sightings and strandings data (since 1970) indicate the occurrence of blue whales (subspecies not distinguished) around most of mainland New Zealand, particularly on the North Island west coast and South Island east coast, with concentrations in eastern Northland and in the Taranaki region (Figure 1). Blue whales were sighted in New Zealand waters in all seasons.

Recordings of blue whale song in Hauraki Gulf in 1997 indicate that blue whale migrate seasonally through the New Zealand region, and the sound of blue whales in New Zealand is distinct compared with that in other regions (McDonald 2006). In addition, whaling records indicate that blue whale catches northwest of New Zealand were common, including pelagic catches of pregnant female blue whales in northern New Zealand waters, on North Island's and northern South Island's west coast (Branch et al. 2007a, 2007b). Blue whales have also been recorded in New Zealand's subantarctic region (Sears & Perrin 2009).

Recent records, including photo-identifications and sound recordings, confirm the presence of blue whales throughout New Zealand waters, but also do not distinguish between the two subspecies (Miller et al. 2013, Olson et al. 2013). Between January and March 2013, New Zealand blue whale records included recordings of blue whale calls and 12 sightings (of a total 18 individuals) around South Island, with the latter including six sightings of a loose aggregation of 10–11 individuals off the west coast

(Miller et al. 2013). The remaining South Island sightings involved seven individuals at three different sites on the South Island east coast. Blue whale calls were recorded all around South Island to 53 degrees South in the Southern Ocean.

Photo-identifications distinguished 18 different blue whale individuals in coastal waters around North and South islands between 2004 and 2013 (Olson et al. 2013). These data encompassed photo-identifications across five different months throughout the year, with records including nine individuals off South Island's west coast, five individuals off South Island's east coast, one individual each in Cook Strait and off Kaikoura, and a mother-calf pair in Hauraki Gulf. There was also another photo-identification of a single blue whale in southern South Island waters. The authors considered blue whale sounds and distribution patterns as evidence that there may be a distinct New Zealand blue whale population; blue whale sounds recorded in this region are unique compared with sound recordings of other populations, and there is a discontinuity in the spatial distribution of blue whale sightings between New Zealand and other southeast Pacific Ocean regions (Olson et al. 2013).

In addition to the general distribution of blue whales in New Zealand waters, evidence compiled from different data sources suggests that both or either subspecies use South Taranaki Bight, with sightings of groups of several blue whales observed in this area (Torres 2013).

3.1.2 Minke whales

Similar to blue whales, there are two sympatric species of minke whale in the Southern Hemisphere that are difficult to distinguish in the field (Jefferson et al. 2008). Antarctic minke *Balaenoptera bonaerensis* and dwarf minke *Balaenoptera acutorostra* have only been recognised as separate species since 2000, and the latter species also occurs in the Northern Hemisphere where it is referred to as common minke whale (Reilly et al. 2008a, 2008b, International Whaling Commission 2013). Because of the taxonomic ambiguity, and difficulties identifying the two congeners, there is a lack of general biological data regarding southern minke whales.

Antarctic minke whale are considered abundant throughout the Southern Ocean south of 60 degrees South in summer, whereas their winter distribution is not well-known; part of the population seems to be remaining in the Southern Ocean (Reilly et al. 2008b). Surveys conducted in this region provided a general estimate of 338 000 individuals (CV: 0.079) of Antarctic minke whale in 1991–2004; this species has undergone an apparent decline and is currently undergoing a new population assessment by the International Whaling Commission (IWC)(International Whaling Commission 2013).

Dwarf minke whale are relatively uncommon south of 60 degrees South, but their distribution overlaps with that of Antarctic minke whale in summer, although the former species generally occurs in shallower water in coastal areas and over the continental shelf (Jefferson et al. 2008, Perrin 2009b). There are no abundance estimates available for dwarf minke whale in the Southern Hemisphere, as most quantitative sighting data do not distinguish this species from Antarctic minke whale.

Minke whales are usually single or in small groups, but may form feeding aggregations of over 400 individuals at higher latitudes (Perrin 2009b). Both species have similar life history parameters, with Antarctic minke whale reaching sexual maturity at seven to eight years in females and eight years in males. The reproductive cycle of this species is considered to be annual, based on a pregnancy rate of 90%, with a peak in births in July and August. Female and male dwarf minke whale reach sexual maturity at six and seven years of age, respectively, with a gestation period of 10–11 months also suggesting an annual reproductive cycle.

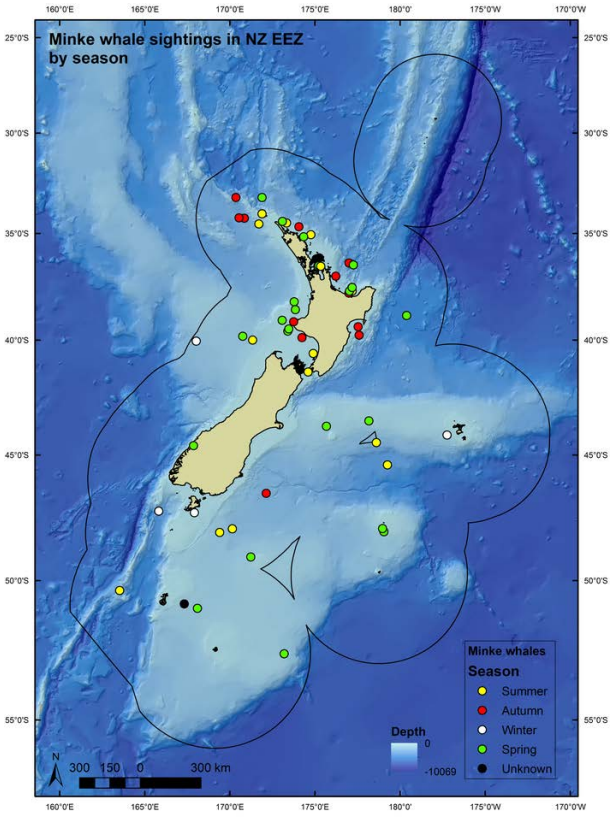

Figure 2: Distribution of minke whale (*Balaenoptera bonaerensis* or *Balaenoptera acutorostrata*) sightings in New Zealand waters between 1970 and 2013. (Reported sightings are from a variety of sources and need to be considered as indicative only, as identifications may not be correct.)

In New Zealand, sightings and strandings data indicate the distribution of minke whales (species not distinguished) throughout mainland New Zealand to subantarctic waters, but mostly in northern New Zealand (Figure 2). Between 1970 and 2013, there were few sightings in winter.

3.1.3 Bryde's whale

The global taxonomic status of Bryde's whale is uncertain, but Bryde's whale in New Zealand waters have been confirmed as *Balaenoptera brydei* based on genetic analysis, as they share haplotypes with conspecifics in the North Pacific and Indian oceans (Jefferson et al. 2008, Wiseman 2008).

Bryde's whale have a worldwide distribution, but are the most resident balaenopterid species, and do not undertake long-distance migrations between tropical and high-latitude regions. Instead, they are restricted to tropical and warm-temperate waters, forming resident populations in some areas, including north-eastern New Zealand (Jefferson et al. 2008, Baker & Madon 2007). Global Bryde's whale abundance is considered to be increasing, although there are no global population estimates (Reilly et al. 2008d). There are, however, some regional population estimates available, although not for the Southern Hemisphere. There have been no recent (in the past 25 years) population assessments in the Southern Hemisphere, and previous abundance estimates are based on methods that have become outdated (Reilly et al. 2008d).

The lack of data, the taxonomic uncertainty regarding potential subspecies or congeners, and mis-

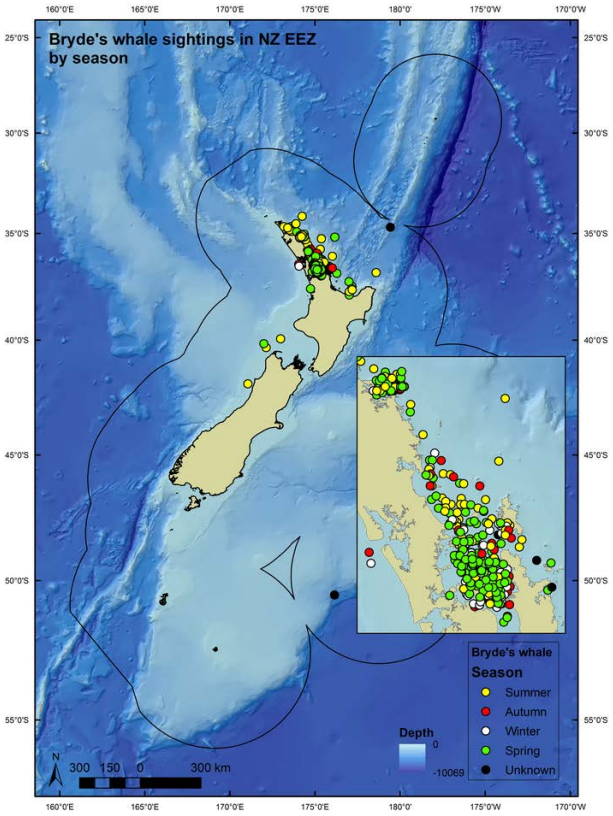

Figure 3: Distribution of Bryde's whale (*Balaenoptera brydei*) sightings in New Zealand waters between 1970 and 2013. (Reported sightings are from a variety of sources and need to be considered indicative only, as identifications may not be correct.)

identifications with sei whale hamper Bryde's whale population assessments.

This species reaches sexually maturity at an average age of slightly less than seven years (Kato & Perrin 2009). Calving occurs throughout the year after a 11–12-month gestation period, with a calving interval of two years (Jefferson et al. 2008).

Bryde's whale are usually solitary or in small groups of 2–3 individuals, and surface-feed year-round on schooling fish and associated species (Jefferson et al. 2008, Wiseman 2008).

In New Zealand, the distribution of Bryde's whale is concentrated in northern North Island waters, in particular in Hauraki Gulf (Baker & Madon 2007, Wiseman et al. 2011). There were significantly higher Bryde's whale densities in the inner than upper gulf, and this area has been identified as an important breeding area. Mark-recapture models based on sightings data revealed abundance estimates for Hauraki Gulf ranging from 46 (CV: 0.08; open population model) to 159 (CV: 0.35; closed population model) individuals between March 2003 and February 2006; it is unknown how genetically isolated this population is (Wiseman 2008).

Sightings data confirm that this species is concentrated in the northern North Island area, with sightings recorded across all seasons, but the majority of sightings in spring and summer (Figure 3).

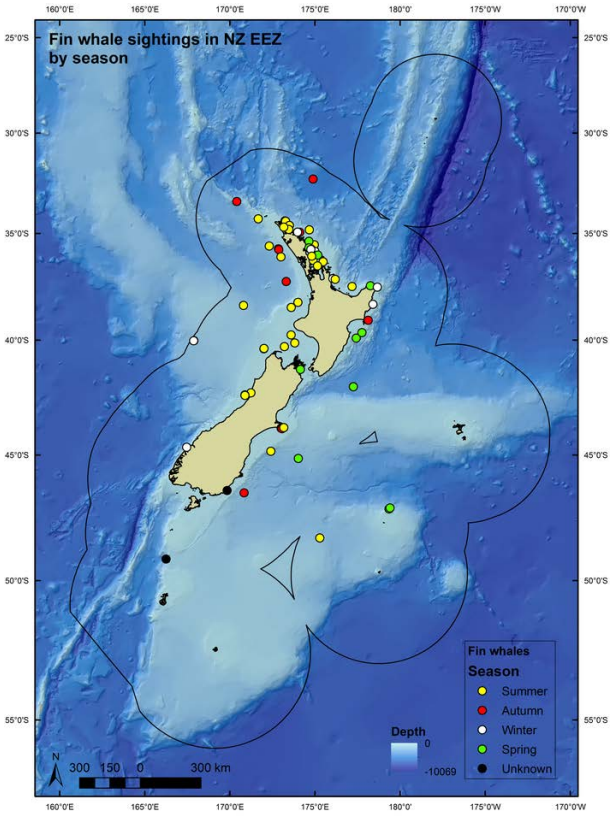

Figure 4: Distribution of fin whale (*Balaenoptera physalus*) sightings in New Zealand waters between 1970 and 2013. (Reported sightings are from a variety of sources and need to be considered indicative only, as identifications may not be correct.)

3.1.4 Fin and sei whales

Fin *Balaenoptera physalus* and sei whales *Balaenoptera borealis* are two cosmopolitan baleen whale species that pass through New Zealand waters on their seasonal migrations between the tropics and their summer feeding grounds in the South Pacific and Antarctica (Reilly et al. 2008f, 2008c). Both species have a worldwide distribution, with Southern Hemisphere populations residing in South Pacific Ocean waters between 45 and 65 degrees South during summer. Sei whale remain largely between the sub-tropical and Antarctic convergences, while the distribution of fin whale extends further south. The respective winter distributions of these two species are largely unknown.

Both fin and sei whales experienced global population declines between 70% and 80% during commercial whaling, and most of the decline was attributed to decreases in the Southern Hemisphere (Reilly et al. 2008f, 2008c). The global population trends of both fin and sei whales are unknown.

Owing to the lack of up-to-date published assessments, the IUCN panel assessed sei and fin whale populations in different regions, including in the Southern Hemisphere, using conventional population assessment methods (e.g., deterministic age-structured model and linear density-dependence)(Reilly et al. 2008f, 2008c). Fin whale abundance in this region was estimated at 15 178 individuals in 1983, and this IUCN assessment was based on an age at first reproduction of eight years and a net recruitment rate of 0.055, with the latter rate considered over-optimistic. The assessment showed a gradual increase in different fin whale populations including the Southern Hemisphere population in the period to 2007. The most recent population estimates for this species in Antarctica (i.e., south of 60 degree South) ranged

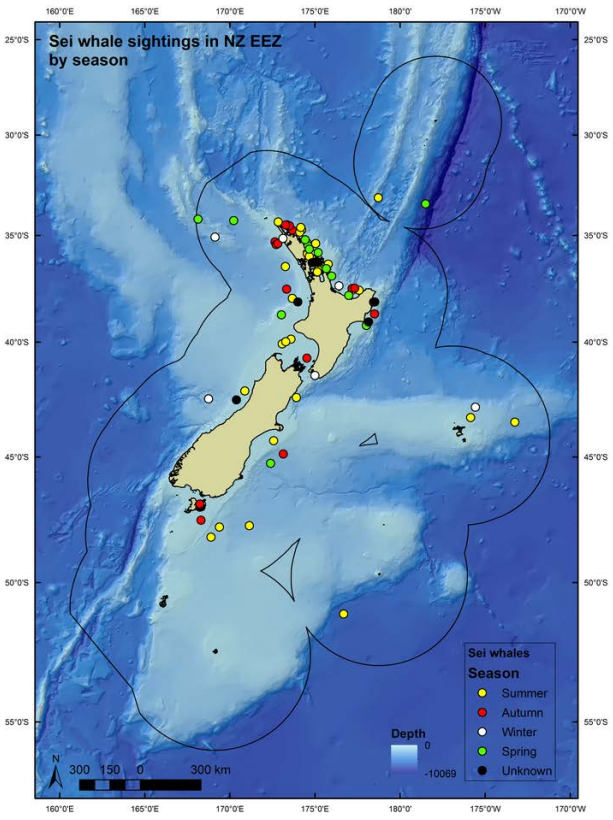

Figure 5: Distribution of sei whale (*Balaenoptera borealis*) sightings in New Zealand waters between 1970 and 2013. (Reported sightings are from a variety of sources and need to be considered indicative only, as identifications may not be correct.)

between 4300 (CV: 0.46) and 8800 individuals (CV: 0.56)(Leaper et al. 2008).

For sei whale, the IUCN assessment was based on a population estimate of 11 000 individuals in the Southern Hemisphere in 1979 (Reilly et al. 2008c). Parameters used in this assessment included an age at first reproduction of 10 years, and a maximum rate of population increase of 0.0266 (or 2.7%), revealing a slight increase in the period to 2007. The current population size estimate of this species is 70 000 individuals in the Southern Hemisphere and North Pacific Ocean (Horwood 2009).

Fin and sei whales are generally found in offshore, deep waters beyond the continental slope (Aguilar 2009, Horwood 2009). Both species are mostly solitary during migrations, but may also occur in pairs and groups of several individuals, including larger feeding groups of 20–100 individuals in productive areas. Fin whale feed almost exclusively on krill in the Southern Hemisphere, but consume a wide range of prey species elsewhere, similar to sei whale.

Age at sexual maturity for fin whale in the Southern Hemisphere is seven to eight years for females and six to seven years for males, with the age at first reproduction indicated at nine years of age (Aguilar 2009). The gestation period is about 11 months, with an inter-calving interval of about two years.

For sei whale, age at sexual maturity is about 10 years for both sexes; this age at sexual maturity has declined by about two to three years in most areas following commercial exploitation and population depletion (Horwood 2009). Longevity has been estimated to be about 80–90 years for fin whale, based on resightings of known individuals, with no available maximum age estimate for sei whale.

Both species are considered migrant in the New Zealand region, with relatively few sightings between 1970 and 2013 (Figure 4, 5). Sighting records of both species were concentrated in northern New Zealand, in particularly the North Island east coast.

3.1.5 Humpback whale

Humpback whale *Megaptera novaeangliae* is another cosmopolitan species that migrates between winter breeding grounds at low latitudes and summer feeding areas at high latitudes in both hemispheres (Leaper et al. 2008, Reilly et al. 2008i). Unlike the predominantly oceanic baleen whale species such as fin and sei whales, humpback whale spend considerable time in coastal regions in continental shelf waters, although their exact migration routes are unknown (Jefferson et al. 2008).

In the Southern Hemisphere, humpback whale have a circumpolar distribution in the Southern Ocean, from where they migrate to discrete breeding areas in tropical waters (Clapham 2009). The IWC distinguishes seven breeding populations (or breeding stocks) in the Southern Hemisphere, with a total population estimate of 41 800 individuals (CV: 0.11) for humpback whale feeding south of 60 degrees South between 1992 and 2004 (adjusted for non-surveyed parts of this survey area; see Reilly et al. (2008i)).

In most areas for which data are available, humpback whale populations show an increase, but there has been concern about discrete, small subpopulations for which data are lacking, including subpopulations in the South Pacific Ocean and parts of Oceania (IWC breeding stocks E and F)(Reilly et al. 2008i). The population increase in the Southwest Pacific Ocean was estimated at 10.6% (95% c.i.: 0.5%) between 1987 and 2004 (Noad et al. 2006). In other Southern Hemisphere regions, including Atlantic and Indian oceans, estimated rates of increase range from 4.6% to 10.1% per year (Reilly et al. 2008i).

The age at sexual maturity of humpback whale ranges from five to ten years, depending on the population (Clapham 2009). Breeding in this species is strongly seasonal, with mating and calving occurring in winter, involving a gestation period of 11.5 months. Although annual calving has been recorded, a 2-year inter-calving period is more common (Clapham 2009). The maximum age of humpback whale is not well-known, but likely to exceed 50 years (Jefferson et al. 2008).

Humpback whale in the Southern Hemisphere feed almost entirely in Antarctica, where they predominantly feed on krill (Jefferson et al. 2008).

Humpback whale move through New Zealand waters from May to October during their seasonal migrations between Antarctic and tropical waters, with sightings also evident at other times (Figure 6). Humpback whale sightings are frequently in coastal regions, including Cook Strait, where annual surveys of humpback whale migrating through the area have been conducted by Department of Conservation since 2004 (Department of Conservation 2012a). In 2011, 73 humpback whale individuals were recorded during this winter survey.

These whales are part of the Southwest Pacific Ocean population, or IWC breeding stock E, and have been genetically linked to individuals breeding off northeastern Australia, New Caledonia, and Tonga (Constantine et al. 2007, Olavarría 2008). Of 34 humpback whale that were identified in New Zealand waters between 1994 and 2004, subsequent resightings included two individuals in New Caledonia, one individual in Tonga, and another individual within New Zealand waters in different years (Constantine et al. 2007). Although there appears to be a close link between migrating humpback whales in New Zealand and the New Caledonia breeding grounds, the main wintering area for the New Zealand component of breeding stock E remains unknown.

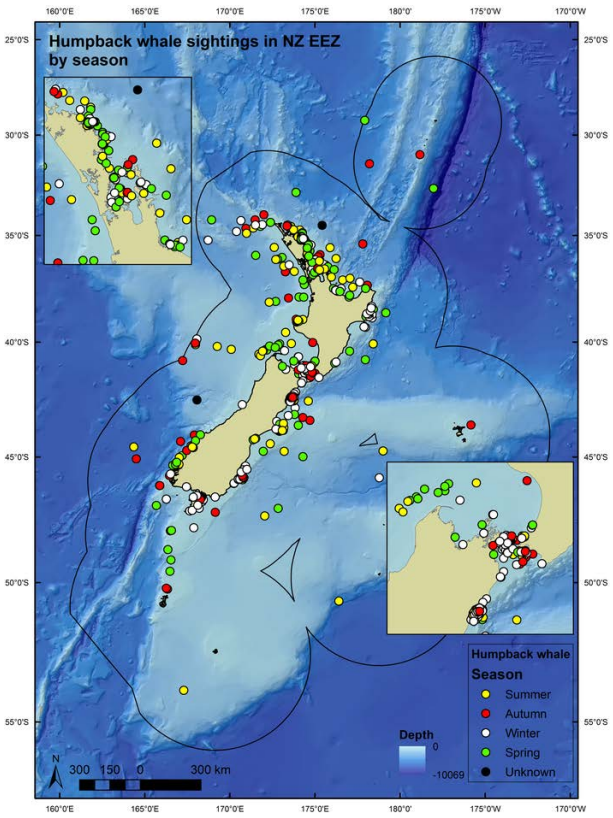

Figure 6: Distribution of humpback whale (*Megaptera novaeangliae*) sightings in New Zealand waters between 1970 and 2013. (Reported sightings are from a variety of sources and need to be considered indicative only, as identifications may not be correct.)

A recent study of humpback whale at the Oceania breeding grounds used data from fluke photo-identifications and microsatellite genotypes to provide the first abundance estimate for this region (Constantine et al. 2012). Using a superpopulation model, the abundance estimate for Oceania was a total 4329 (95% c.i.: 3345 to 5313) humpback whale in 2005, including resident and migrating individuals. Based on this estimate, humpback whale in Oceania represent the least abundant breeding population in the Southern Hemisphere. Furthermore, in contrast to other regions where data indicate that humpback whale populations are recovering from the impact of commercial whaling, there was no significant trend in abundance in Oceania.

3.1.6 Southern right whale

There are three separate species of right whale globally, with geographically isolated populations in the North Atlantic Ocean, North Pacific Ocean, and the Southern Hemisphere (Reilly et al. 2008h).

In the Southern Hemisphere, southern right whale *Eubalaena australis* have a circumpolar distribution, with annual migrations between high-latitude feeding areas and low-latitude winter calving and breeding grounds (Kenny 2009). These breeding areas are in nearshore waters off southern Australia, New Zealand (i.e., Auckland and Campbell islands), South America (Atlantic Ocean), and southern Africa (mainly South Africa)(Reilly et al. 2008h).

The estimated population size of southern right whale was 7500 individuals in 1997, and the population

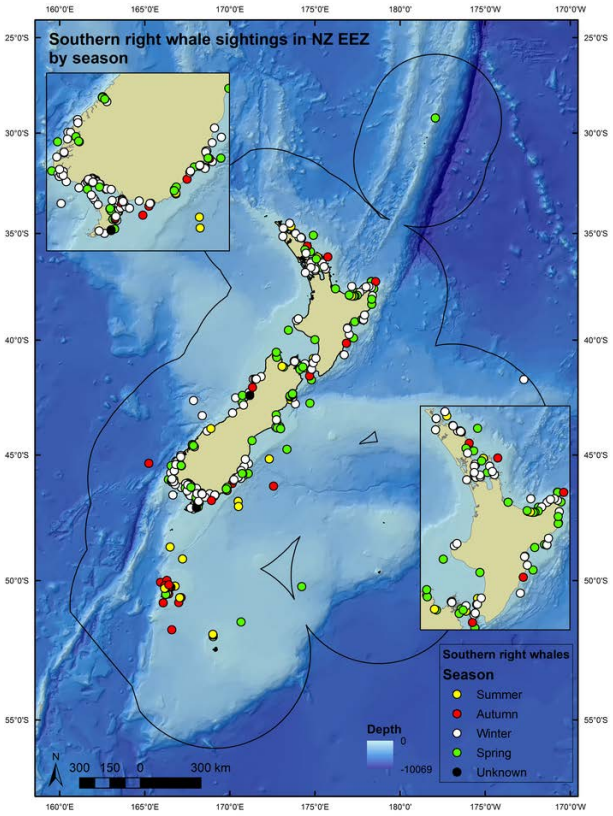

Figure 7: Distribution of southern right whale (*Eubalaena australis*) sightings in New Zealand waters between 1970 and 2013. (Reported sightings are from a variety of sources and need to be considered indicative only, as identifications may not be correct.)

trend of this species is considered to be increasing, with a doubling time of 10–12 years (Reilly et al. 2008h). Based on an annual increase of 7–8%, the current population has been estimated at over 15 000 individuals (Kenny 2009).

Female southern right whale reach sexual maturity after four years of age (7.7–9.1 years for the New Zealand population, Carroll 2011), but the average age of calving is about 9–10 years; the age of sexual maturity of males in the New Zealand population is 3–6 years (Carroll 2011). Calving occurs between June and October, after a gestation period of 10–13 months, with a calving interval of 3–7 years.

Estimated rates of southern right whale population increase vary across regions, with a relatively high rate of 8.1% (4.48–11.83%) estimated for southwestern Australia, and between 6.8 and 14% in the South Atlantic Ocean (see Carroll 2011). In comparison, the rate of increase for New Zealand southern right whale has been estimated at 4.6%.

There are few data on the longevity of southern right whale, but anecdotal data of a northern right whale female that was identified in the North Atlantic Ocean and repeatedly resighted indicates that this species may live for at least 70 years (Kenny 2009).

Although this species feeds generally on zooplankton at or just below the surface, there are indications that individuals may undertake feeding dives of 10–20 minutes also (Jefferson et al. 2008, Kenny 2009).

Southern right whale have a discrete subantarctic New Zealand population, with Auckland Islands

considered the main wintering ground of this species in New Zealand waters (Carroll 2011). Sightings of this species (including groups and cow-calf pairs) have also been documented throughout the entire coastline of mainland New Zealand, i.e., in winter, as this species re-colonises former sites (Carroll et al. 2013b). This species exhibits some matrilineal site fidelity to calving grounds, resulting in genetic differences across different Southern Hemisphere calving grounds, including New Zealand (Carroll et al. 2011a).

The size of the New Zealand subantarctic southern right whale population was estimated to be about 900 individuals in 1998, based on capture-recapture modelling that used data from photo-identification surveys and genetic samples (Carroll et al. 2011b). In addition, southern right whale have been regularly sighted since 1988 around mainland New Zealand, which has been attributed to the species' return to historical calving sites in coastal waters (Carroll et al. 2013a, 2013b). There were 11 sightings of cow-calf pairs between 1991 and 2002, with 28 cow-calf pairs sighted between 2003 and 2010 in coastal North Island and South Island waters. These data indicate that coastal waters around mainland New Zealand are increasingly being used by southern right whale, i.e., by cow-calf pairs and reproductive groups.

Sightings between 1970 and 2013 confirm the occurrence of southern right whale along New Zealand's coastline, with most sightings documented in winter and spring (Figure 7). While these coastal areas are important for calving in winter, southern right whale move to offshore feeding areas in summer, and the locations of these winter feeding grounds are largely unknown. Recent research using habitat models and predictive maps based on historical whaling data identified offshore foraging areas of southern right whale in New Zealand waters, highlighting the importance of the Chatham Rise area, i.e., in summer (Torres et al. 2013). Chatham Rise waters are characterised by the Subtropical Front, associating the habitat suitability of the wider Chatham Rise area with the foraging of southern whale in highly productive areas.

The most recent abundance estimate of southern right whale in New Zealand waters was 2169 (95% confidence limit: 1836 to 2563) individuals for the period from 1995–2009, which was based on a combined superpopulation model fitted to male and female data sets (Carroll et al. 2013a). Considering males and females separately in this modelling resulted in an abundance estimate of 1162 (95% confident limit: 921 to 1467) female southern right whale, with a corresponding annual increase of 5% (95% confidence limit: 7 to 9%). In comparison, the estimated abundance of male southern right whale was 1007 (95% confidence limit: 794 to 1276) individuals, with an estimated annual increase of 7% (95% confidence limit: 5 to 9%).

3.1.7 Pygmy right whale

Pygmy right whale *Caperea marginata* are a little-known baleen whale species that occurs in New Zealand waters, but is naturally rare or difficult to detect (Reilly et al. 2008g, Kemper et al. 2013). All records of this species have been from the Southern Hemisphere, with the majority based on strandings and only few sightings of live animals. This species has a circumpolar distribution between 30 and 55 degrees South; it is present in coastal and oceanic waters, with concentrations in highly productive areas where plankton is abundant, such as the Subtropical Convergence (Jefferson et al. 2008).

Pygmy right whale do not seem to undertake long-distance migrations, but seasonal inshore shifts of individuals have been related to the availability of food in spring and summer (Jefferson et al. 2008, Kemper 2009). The population status of pygmy right whale is largely unknown, and there are no available population estimates. Other biological data are similarly lacking, including the mating season, gestation period, calving interval, and longevity.

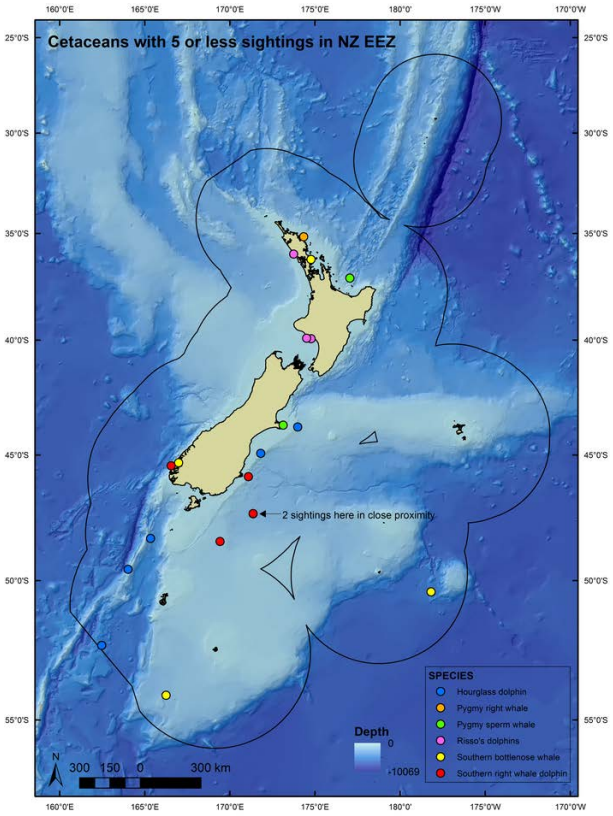

Figure 8: Distribution of sightings of pygmy right whale *Caperea marginata*, pygmy sperm whale *Kogia breviceps*, hourglass dolphin *Lagenorhynchus cruciger*, Risso's dolphin *Grampus griseus*, southern right whale dolphin *Lissodelphis peronii*, and southern bottlenose whale *Hyperoodon planifrons* in New Zealand waters between 1970 and 2013. All of these cetacean species were recorded in less than five sightings. (Reported sightings are from a variety of sources and need to be considered indicative only, as identifications may not be correct.)

A recent study examined the distribution of pygmy right whale in relation to areas of high productivity in Australia and New Zealand, and identified "hotspots" where this species has been repeatedly recorded over a period of at least 50 years between 1884 and 2007(Kemper et al. 2013). Records of events relating to pygmy right whale included strandings, entanglements, and other sightings, with 58 events documented from New Zealand waters including pelagic areas (i.e., 40–750 km offshore). This study revealed three coastal hotspots within New Zealand's EEZ, including Cook Strait, the Waikato region and Stewart Island, where plankton appeared to be abundant. Pygmy right whale also occurred north of Northland, on the North and South Island west coast (including off Fiordland), Hawke's Bay, Canterbury, Foveaux Strait, and around Chatham Islands.

Stranding records indicate that between one and nine pygmy right whale strand in New Zealand waters per year (Kemper et al. 2013). Sightings data since 1970 also included a record of this species, on the east coast of Northland (Figure 8).

3.2 Toothed whales - Odontocetes

In contrast to baleen whales, toothed whales have a single blow hole (not two), teeth, and use specialised echolocation (Hooker 2009). The teeth allow age determinations via growth layers that are deposited

internally. In some species, such as sperm whale and beaked whales, dentition is reduced, as they feed predominantly on squid (presumed to be captured by suction).

This group of cetaceans encompasses a diverse range of species, from large-sized sperm whale that are renowned for their deep foraging dives to small, gregarious delphinids, such as bottlenose and dusky dolphins. Also included in this group are 21 species of beaked whale (Ziphiidae), which are largely pelagic, open-ocean cetaceans, that feed on deep-water squid and fish, and forage at considerable depths (Mead 2009).

Similar to baleen whales, toothed whales are found across a range of marine habitats in all world oceans (Hooker 2009). While mysticetes are characterised by long distance migrations and movement, few toothed cetacean species exhibit a similar distributional range, although sperm whale also have a global distribution. This species and killer whale have the most extensive geographical distribution amongst toothed cetaceans, while other species, i.e., a number of delphinids, have a more restricted distribution, often forming resident populations in coastal and inshore habitats. For some toothed whale genera, the warm tropical waters at the equator form a distributional boundary, resulting in northern and southern hemisphere species pairs, e.g., right whale dolphin and bottlenose whale.

Some delphinid species that occupy coastal and offshore regions exhibit considerable morphological variation between the two habitats, mostly in relation to their size and colour (Hooker 2009). This differentiation has led researchers to distinguish between oceanic versus coastal “forms” or “ecotypes”, although this distinction is often not based on taxonomic differences or genetic evidence.

All toothed whale species are predators, and their target prey generally encompass a diversity of organisms, which varies dependent on the odontocete involved. Prey species include fish, crustaceans, squid, birds, and also other marine mammals. Several toothed whale species have been shown to follow the movement of their prey, such as long-finned pilot whale that follow squid and mackerel into continental shelf waters in summer and autumn (Taylor et al. 2008a). Other examples include dolphins that exhibit diurnal variation in foraging depth, with their feeding associated with the deep scattering layer that moves to the water surface at night.

New Zealand waters are inhabited by 22 toothed whale (sub)species, including nine species of beaked whale (see summary of population data in Table 4). In addition to the latter group, there are two species of sperm whale, and 10 delphinid species, with endemic Hector’s dolphin consisting of two subspecies.

Table 4: Population information of toothed cetacean (sub)species that inhabit New Zealand waters (n.d., no data).

Common name	General distribution	Global population size	General NZ distribution	NZ population size	Age at first reproduction	Max. population growth
Sperm whale	Global, widespread (Whitehead 2002)	360 000 individuals [1999] (Whitehead 2002)	Throughout NZ Transient and resident males at Kaikoura (Gaskin & Cawthorn 1967a, Childerhouse et al. 1995)	136 individuals [1998] (Jaquet et al. 2000)	Females: 10 years, males: late 20s (Whitehead 2009)	1% (Whitehead 2002)
Pygmy sperm whale	Global, tropical to warm-temperate waters (Jefferson et al. 2008)	n.d	Throughout NZ	n.d	South Africa: 2.5–5.0 years (Jefferson et al. 2008)	n.d
Bottlenose dolphin	Global, tropical to temperate waters (Hammond et al. 2012c)	600 000+ individuals (Wells & Scott 2009, Hammond et al. 2012c)	Throughout NZ incl. offshore waters and Kermadec Islands; three separate, coastal subpopulations in Bay of Islands, Marlborough Sounds and Fiordland (Baker et al. 2010a)	Inshore: 900–1000 individuals (Baker et al. 2010a); Bay of Islands: 483 (95% c.i.: 358 to 653; superpopulation) individuals (Tezanos-Pinto et al. 2013); Marlborough Sounds: 211 (95% c.i.: 195 to 230) individuals (Merriman et al. 2009); Doubtful Sound: 205 (95% c.i.: 192 to 219) individuals (Currey et al. 2009a); offshore: 163 individuals (Zaeschmar et al. 2013)	Females: 5–13 years, males 9–14 years (Jefferson et al. 2008, Wells & Scott 2009)	Decline in two NZ subpopulations: Bay of Islands, Doubtful Sound
Common dolphin	Atlantic and Pacific oceans; tropical and temperate waters (Hammond et al. 2012a)	4 million individuals (Hammond et al. 2012a)	Throughout NZ, but more commonly in northern regions and Cook Strait (Bräger & Schneider 1998, Stockin et al. 2008)	n.d	Eastern Pacific Ocean: females 6–8 years, males 7–12 years (Jefferson et al. 2008)	Unknown population trend (Hammond et al. 2012a)
Dusky dolphin	Southern Hemisphere (Hammond et al. 2008a)	n.d	Continental shelf and slope (Würsig et al. 2007)	Kaikoura: 12 000 individuals (Markowitz et al. 2004) NZ female population size: 15 000–17 000 (Harlin et al. 2003)	New Zealand: females and males about 7–8 years (Würsig et al. 2007); Peru: females 4.5–5.0 years, males 3.8–4.7 years (Waerebeek & Würsig 2009)	n.d

(Continued on next page)

Table 4: (*continued*)

Common name	General distribution	Global population size	General NZ distribution	NZ population size	Age at first reproduction	Max. population growth
Hector's dolphin	Endemic to NZ	Endemic to NZ	South Island, NZ (Dawson 2009)	7270 individuals (CV: 16.2%) (Slooten et al. 2004)	Females: 7–9 years, males: 6–9 years (Slooten 1991)	1.8–4.9% (Slooten & Lad 1991)
Maui's dolphin	Endemic to NZ	Endemic to NZ	North Island west coast, NZ (Dawson 2009)	55 individuals (95% c.i.: 48 to 69) [2010–11] (Hamner et al. 2012)	Females: 7–9 years, males: 6–9 years (Slooten 1991)	1.8–4.9% (Slooten & Lad 1991)
Hourglass dolphin	Southern Hemisphere, circumpolar (Hammond et al. 2008b)	South of Antarctic Convergence 144 300 individuals (CV 0.17) [1976/77–1987/88] (Jefferson et al. 2008)	n.d	n.d	n.d	n.d
False killer whale	Indian, Pacific and Atlantic oceans, tropical to warm-temperate waters (Jefferson et al. 2008, Baird 2009)	No global estimate 39 800 individuals (CV: 64%) in the eastern tropical Pacific Ocean (Jefferson et al. 2008)	Few records; Bay of Islands (Visser et al. 2010), Hauraki Gulf (Zaeschmar et al. 2012)	n.d	Sexual maturity: 8–14 years (Baird 2009)	n.d
Killer whale Type A	Cosmopolitan; equator to polar regions	No global data, but global estimate: 50 000+ individuals for all types (Taylor et al. 2008c, Ford 2009)	Throughout NZ, three subpopulations: North Island, South Island, both mainland islands (Visser 2000b)	117 individuals (95% CI 64-167)[1997] (Visser 2000b)	Females: 12–14 years, males: 15 years (Ford 2009)	n.d
Long-finned pilot whale	Southern Hemisphere (Taylor et al. 2008a) Pacific Ocean: 14°S to Antarctica at 68°S (Taylor et al. 2008a, Olson 2009)	No global estimate; 200 000 individuals south of the Antarctic Convergence in summer (Taylor et al. 2008a)	Throughout NZ, with a preference for temperate waters (Taylor et al. 2008a)	n.d	Sexual maturity: females: 8 years, males: 12 years (Olson 2009)	n.d
Short-finned pilot whale	Global, tropical to warm-temperate waters (Olson 2009)	No global estimate (Taylor et al. 2011)	Throughout NZ, with a preference for tropical waters (Taylor et al. 2011)	n.d	Sexual maturity: females: 9 years, males: 13–16 years (Olson 2009)	n.d

(Continued on next page)

Table 4: (*continued*)

Common name	General distribution	Global population size	General NZ distribution	NZ population size	Age at first reproduction	Max. population growth
Southern right whale dolphin	Southern Hemisphere, circumpolar in sub-antarctic and cool-temperate waters 30–65°S (Lipsky 2009, Hammond et al. 2012b)	n.d	n.d	n.d	Sexual maturity in *Lissodelphis borealis*: females at 9.7 years, males at 9.9 years (Lipsky 2009)	n.d

3.2.1 Sperm whale

The largest toothed whale species, sperm whale *Physeter macrocephalus* has a global distribution and occurs in almost every marine region from the equator to higher latitudes (Whitehead 2002, Jefferson et al. 2008). Their wide geographical distribution, long-distance movement, and lack of clear genetic differences prevent the identification of population boundaries on a global scale, although a genetically distinct subpopulation has been identified in the Mediterranean Sea (Taylor et al. 2008e, Sciara et al. 2012).

Sperm whale are predominantly found in waters deeper than 1000 m in the open ocean and above the continental slope, where they conduct relatively long, deep dives to several hundred metres to prey on deep-water cephalopods and fishes (Gaskin & Cawthorn 1967a, Jaquet & Whitehead 1999). Their foraging dives extend to 600 m depth and deeper, lasting about 45 minutes, with short surface intervals of several minutes between repeated dives (Whitehead 2009). This extensive foraging behaviour means that sperm whale spend considerable periods of time under water, with adult sperm whale spending over 70% of their time foraging. Their main target species are meso- and bathypelagic cephalopods, including commercial species, and their distribution has been related to biologically productive areas that support high cephalopod biomass (Jaquet & Gendron 2002). Furthermore, changes in their spatial distribution and relative abundance over different spatial scales and over time appear to correspond to variation in the abundance of their prey species (Whitehead & Kahn 1992, Jaquet & Gendron 2002).

This species is characterised by differences in the social organisation and geographical distribution of males and females, with the latter usually residing in tropical and warm-temperate waters at latitudes below $40-50\,^{\circ}$latitude, where sea surface temperatures remain above $15\,^{\circ}$C (Whitehead 2009). Females and immature individuals form mixed groups, and males leave these groups at the beginning of sexual maturity (at about 10–20 years of age) to move to higher latitudes, where they remain solitary or occur in small groups with similar-sized males.

Sperm whale have undergone large-scale exploitation during two phases of commercial whaling, including "open-boat" whaling in the late 18th and early 19th centuries, and modern whaling in the early 20th century (Whitehead 2002). Extensive whaling during the latter period in particular has been detrimental for the sperm whale population, and ten years after the end of commercial exploitation in 1999, the global population estimate was 360 000 individuals (CV: 0.36)(Whitehead 2002). This population estimate is about 32% of the species' population size before the start of commercial whaling, estimated at 1 110 000 individuals.

Sperm whale are characterised by a low birth rate, slow growth and slow maturation, resulting in a low maximum rate of increase, which has been estimated at about 1% per year (Whitehead 2002). Many regional populations have shown few signs of recovery, including that in the southeast Pacific Ocean. Similarly, systematic surveys in other areas of the Southern Hemisphere have revealed no significant increase in the population between 1978 and 1992 in the Southern Ocean, where sperm whale were heavily exploited during commercial whaling.

The age of first reproduction for female sperm whale is 10 years, whereas males do not become active breeders until they are in their late 20s (Whitehead 2009). Single calves are born after about 14–16 months of gestation, with calving occurring predominantly in summer and autumn (Jefferson et al. 2008). The inter-calving period varies across areas, and also depends on the level of exploitation and age of females; it is about five years in unexploited populations (Whitehead 2009). As the reproductive rate decreases with increasing female age, only few females calve after they have reached 40 years of age. The maximum age of sperm whale is at least 50 years (Whitehead 2009).

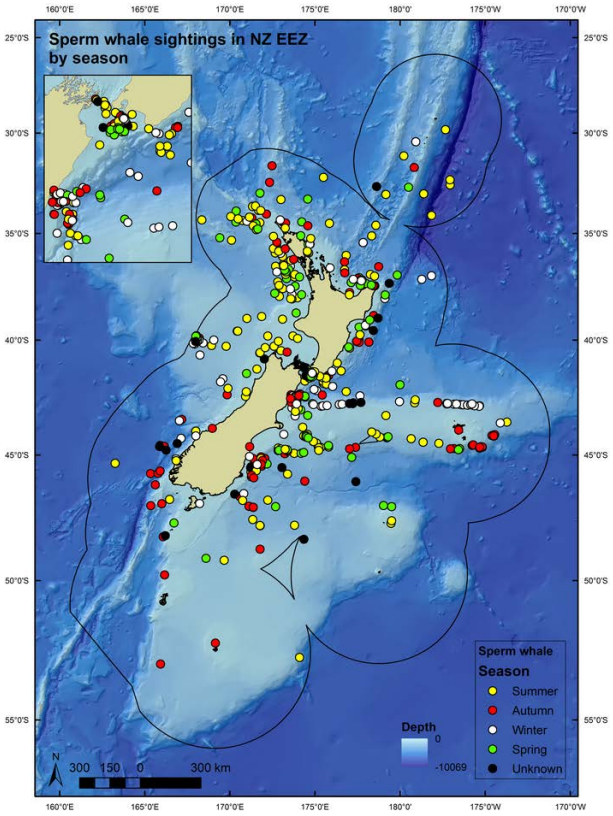

Figure 9: Distribution of sperm whale (*Physeter macrocephalus*) sightings in New Zealand waters between 1970 and 2013. (Reported sightings are from a variety of sources and need to be considered indicative only, as identifications may not be correct.)

Sperm whale occur in New Zealand waters in offshore and nearshore regions, and are widely distributed from northern areas around Kermadec Islands to subantarctic waters and Chatham Islands (Gaskin 1973). There were a large number of sperm whale sightings between 1970 and 2013, dispersed throughout most of New Zealand's EEZ (Figure 9).

During commercial whaling, this species was targeted in shore-based and pelagic operations in New Zealand, and was the primary target of coastal whaling in Cook Strait (Gaskin & Cawthorn 1967a). Early New Zealand studies were based on sightings and catch record data from whaling activities, in addition to survey data from this period (e.g., Gaskin & Cawthorn (1967a), Gaskin (1970)). These studies document the presence of different social sperm whale groupings on the east coast of North Island, ranging from solitary males and male pairs to nursery schools and schools of bachelor males and of immatures. Subsequent strandings and sightings data confirm the presence of different life stages of male and female sperm whale from other areas around New Zealand, including sightings off the west coast of southern South Island, strandings of harem/nursery herds in North Island locations (near Kaipara Harbour, including Muriwai Beach and at Gisborne) and strandings of bachelor herds at different locations throughout North and South islands (Webb 1973, Stephenson 1975, Brabyn 1991, Brabyn & McLean 1992).

Stomach content analysis of commercially caught individuals and of stranded sperm whale revealed a variety of squid species, confirming the importance of cephalopods in the sperm whale diet in New Zealand, while several fish species seemed to be regionally important (Gaskin & Cawthorn 1967b, Gómez-Villota 2008). The latter included groper or hapuku *Polyprion oxygeneios*, orange roughy

Hoplostethus sp., ling *Genypterus blacodes*, an unidentified eel species, and hake *Jordanidia solandri*.

Recent research has been largely focused in the Kaikoura region, where a male population is present year-round, while transient sperm whale also migrate through the area. The close proximity of sperm whale to the Kaikoura coast (i.e., within 10 nautical miles or 18.5 km) has been attributed to the narrow continental shelf and high productivity of this area, resulting from almost permanent current upwelling and convergence (Gaskin & Cawthorn 1967a, Childerhouse et al. 1995). Since the early 1990s, sperm whale off Kaikoura have been the subject of a number of studies ranging from photogrammetry techniques, photo-identification and acoustic surveys, to examinations of their diving behaviour and echolocation (Childerhouse et al. 1995, 1996, Jaquet et al. 2000, Douglas et al. 2005, Miller & Dawson 2009).

The Kaikoura sperm whale population resides in a relatively small area (10 by 15 nautical miles) with other, transient males passing through briefly, and few sightings of females or nursery groups (Childerhouse et al. 1995). In general, these sperm whale occur in water deeper than 200 m (mostly between 500 and 1500 m depth), and data from different seasons between 1990 and 1998 identified 136 individuals in the area (Jaquet et al. 2000). Although there was no significant difference in sperm whale abundance between summer and winter, there was a significant shift in their distribution between these two seasons, suggesting a seasonal change in prey species. Furthermore, the diving behaviour of the whales also revealed seasonal differences, with longer dives, longer surface intervals and greater distances travelled between dives in summer than in winter. Overall, the sperm whale at Kaikoura spend about 83% of their time under water (Jaquet et al. 2000).

3.2.2 Pygmy sperm whale

Little is known about pygmy sperm whale *Kogia breviceps*, a deep-water species that occurs in tropical and warm-temperate regions (McAlpine 2009, Taylor et al. 2012). At-sea sightings of this species are rare, and its distribution and range are largely unknown, although records – predominantly strandings data – exist from a wide range of locations, including New Zealand waters. This species is considered relatively uncommon, although lack of global abundance data and of population trends prevent an accurate assessment of its status; mis-identifications with its congener dwarf sperm whale *Kogia sima* also make abundance estimates difficult (Taylor et al. 2012).

Pygmy sperm whale are oceanic and are mainly found in waters on the continental shelf or further offshore (Jefferson et al. 2008). Studies in South Africa indicate that individuals reach sexual maturity at 2.5 to 5.0 years of age, and females appear to calve annually (Taylor et al. 2012). The maximum known age of pygmy sperm whale is 23 years (Taylor et al. 2012).

This species feeds primarily on cephalopds and deep-sea fishes and crustaceans (Jefferson et al. 2008).

In New Zealand, pygmy sperm whale are the most frequently recorded species in strandings data, with 364 individuals reported in 297 stranding events between 1873 and 2001 (Beatson 2007). These stranding records show that pygmy sperm whale are distributed around North and South islands, and are relatively abundant on the east coast of North Island, with the majority of strandings occurring in Hawke's Bay. Most of the strandings involved live animals, with females outnumbering males; the involvement of calves in half of the female stranding events in Hawke's Bay suggests that this area may be important for breeding.

Pygmy sperm whale sightings in New Zealand's EEZ since 1970 also include records from Canterbury and Bay of Plenty (Figure 8).

A study of pygmy sperm whale diet found predominantly meso-pelagic cephalopod species in the stomach contents of stranded individuals, including deep-water (i.e., more than 500 m depth) and also shallow-water (less than 100 m depth) species (Beatson 2007). The majority of the identified prey species undertake diurnal vertical migrations, suggesting that pygmy sperm whale follow this migration pattern in their feeding dives, or feed primarily at night, when their target species are close to the water surface.

3.2.3 Bottlenose dolphin

Bottlenose dolphin *Tursiops trunactus* are widespread and abundant in a diversity of tropical and temperate marine habitats (Hammond et al. 2012c). This species occurs in shallow coastal regions, including inshore waters, estuaries and lagoons; in many of these inshore areas, bottlenose dolphin form resident populations with a long-term multi-generational home range. Although bottlenose dolphin is considered a coastal species, its distribution does extend to some offshore areas, i.e., around oceanic islands (Jefferson et al. 2008). Some of this geographical separation has been attributed to different populations or ecotypes, distinguishing "inshore" and "offshore" forms, although this differentiation may not be based on taxonomic differences (Jefferson et al. 2008, Baker et al. 2010a).

The global population size of bottlenose dolphin is estimated at a minimum of 600 000 individuals, with an unknown population trend (Wells & Scott 2009, Hammond et al. 2012c). Their age at sexual maturity varies greatly dependent on the region, with females reaching sexual maturity between five and 13 years of age and males between nine and 14 years of age (Jefferson et al. 2008, Wells & Scott 2009). The gestation period is approximately one year, with a calving interval of three to six years, while the maternal investment for calves generally lasts until the birth of the next calf. Females have a prolonged reproductive lifespan, and give birth and raise calves successfully until they are about 48 years old. The longevity of females is over 57 years compared with 48 years for males.

Bottlenose dolphin feed on a wide range of fish and squid species, with fish prey including benthic and pelagic species (Wells & Scott 2009). Bottlenose dolphin exhibit considerable plasticity in their foraging behaviour and prey choice, which has been related to the availability of different prey species and the vertical migration of mesopelagic prey. In shallow habitat, bottlenose dolphin dive for short periods of time, with longer dives, reaching depths of over 500 m, conducted in deep-water habitats (Wells & Scott 2009).

Bottlenose dolphin are present throughout New Zealand's EEZ, with three separate coastal, regional subpopulations in Bay of Islands, Marlborough Sounds and Fiordland (Baker et al. 2010a). These subpopulations are genetically distinct, with little or no maternal gene flow or exchange among them. The total population estimate for the inshore bottlenose dolphin populations in New Zealand is about 900–1000 individuals, with fewer than 1000 mature individuals. Population estimates for the different subpopulations include 483 (95% c.i.: 358 to 653) individuals for Bay of Islands (Tezanos-Pinto et al. 2013), 211 (95% c.i.: 195 to 230) individuals for Marlborough Sounds (Merriman et al. 2009), and 205 (95% c.i.: 192 to 219) individuals for Fiordland (Currey et al. 2009a). The subpopulation in Marlborough Sounds (extending to Westport) is considered semi-resident, with high migration rates and an unknown number of transient animals (Merriman et al. 2009).

Apart from the three regional subpopulations, bottlenose dolphin are widespread throughout New Zealand, including offshore sightings such as in the subantarctic, and Chatham and Kermadec islands regions in the period between 1970 and 2013 (Figure 10).

Two of the regional subpopulations are currently undergoing (apparent) population declines, with high rates of calf mortality reported in Bay of Islands and Fiordland (Currey et al. 2011, Tezanos-Pinto et

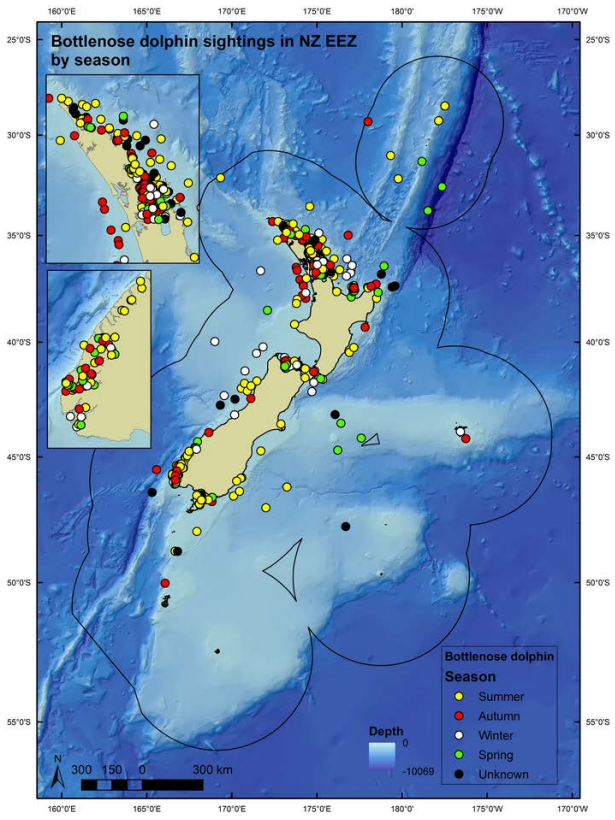

Figure 10: Distribution of bottlenose dolphin (*Tursiops truncatus*) sightings in New Zealand waters between 1970 and 2013. (Reported sightings are from a variety of sources and need to be considered indicative only, as identifications may not be correct.)

al. 2013). In Bay of Islands, data from photo-identification studies revealed that the bottlenose dolphin subpopulation had a significant rate of decline between 1997–1999 and 2003–2006 (Tezanos-Pinto et al. 2013). Although dolphin abundance and emigration rates were highly variable throughout the study period, the annual rate of decline was 7.5%, with the regional abundance decreasing from 240 individuals (95% c.i.: 99 to 581) in October 1997 to 21 individuals in October 2004 (95% c.i.: 14 to 31) and September 2005 (95% c.i.: 15 to 28). The survival rate in this subpopulation was estimated at 0.928 (95% c.i.: 0.911 to 0.942).

The Fiordland subpopulation is further subdivided into three discrete local units, inhabiting northern Fiordland, Doubtful Sound and Dusky Sound (Currey et al. 2011). Although adult survival in Doubtful Sound remained constant (survival rate for 1990–2008: 0.937, 95% c.i.: 0.917–0.953), the bottlenose dolphin subpopulation underwent a substantial decrease in abundance; this subpopulation experienced a 34–39% decline to 56 individuals (95% c.i.: 55 to 57) in 2008 (Currey et al. 2008, 2009b). The two important factors that appeared to contribute to this decline were a decrease in juvenile survival (1–3 yr old) in the period before 2002, with a reduction in calf survival in the subsequent period (Currey et al. 2011). Also in Fiordland, in adjacent Dusky Sound, an abundance survey conducted in February 2008 resulted in an estimate of 102 bottlenose dolphin (CV: 0.9%; 95% c.i.: 100 to 104)(Currey et al. 2008), while the population estimate for northern Fiordland was 47 (CV: 14.9%; 95% c.i.: 35 to 63) bottlenose dolphin in 2003 (Currey et al. 2009a).

A recent estimate of offshore bottlenose dolphin suggested a minimum population size of 163 individuals (Zaeschmar et al. 2013).

3.2.4 Common dolphin

There are two species of common dolphin currently recognised worldwide, short-beaked *Delphinus delphis* and long-beaked common dolphin *Delphinus capensis* (Hammond et al. 2012a). The former species is widely distributed and abundant throughout tropical and temperate zones of the Atlantic and Pacific oceans, including New Zealand waters (Perrin 2009a, Hammond et al. 2012a).

Abundance data for common dolphins are generally missing, but the global population size has been estimated at over four million, with an unknown population trend (Hammond et al. 2012a). Short-beaked common dolphin are considered an oceanic species that exhibits seasonal and inter-annual shifts in distribution in some areas, such as off California/United States (Forney & Barlow 1998). Some of the seasonal inshore-offshore migrations have been related to changes in prey availability and environmental conditions, including in New Zealand (Neumann 2001).

Life history parameters, including the age at sexual maturity and calving interval, vary across regions, which has been attributed to possible density-dependent effects or sampling bias (Perrin 2009a). In the eastern Pacific Ocean, males reach sexual maturity between seven and 12 years and females between six and eight years of age. Gestation lasts for 10–12 months with an inter-calving period of three years in this region (Jefferson et al. 2008). The maximum age of this species has been estimated at 30 years for both males and females in the western North Atlantic Ocean (Perrin 2009a).

This species feeds on small schooling fishes and squids, including epi-pelagic species, and diurnal movement in some areas has been associated with the deep scattering layer vertically migrating towards the surface in the dark and common dolphin feeding mostly at night (Evans 1994, Rossman 2010).

Common dolphin in New Zealand is distributed along the entire coastline of the main islands, i.e., in northern regions and Cook Strait (Bräger & Schneider 1998, Stockin et al. 2008). Sightings data between 1970 and 2013 include a large number of records throughout the New Zealand region, including offshore areas and subantarctic waters (Figure 11).

There are no abundance estimates available for the New Zealand common dolphin population, and data on growth and reproduction are similarly lacking (Stockin et al. 2008). Studies conducted in Hauraki Gulf and Bay of Islands revealed seasonal differences in the distribution of this species, including inshore-offshore movement related to variation in the availability of prey and nutrient upwelling (Neumann 2001, Meynier et al. 2008).

In Hauraki Gulf, common dolphin are present year-round, with groups at times exceeding 50 individuals (Stockin et al. 2008). These groups contain a considerable number of immatures and calves, suggesting that Hauraki Gulf may be an important calving and nursery area. Calving seems to peak in later spring to summer in Hauraki Gulf, Bay of Islands, and Bay of Plenty.

A recent study of common dolphin in New Zealand indicated high genetic variability, which is consistent with common dolphin populations in other regions (Stockin et al. 2013). Sampling of individuals from three putative "populations" in New Zealand indicated some genetic differentiation between coastal and oceanic putative populations, but genetic differences were only significant between individuals from Hauraki Gulf and from elsewhere. This study also sought to clarify the taxonomic status of New Zealand common dolphin, as morphological differences, observed group sizes and occurrence in oceanic waters implied that some individuals may be long-beaked common dolphin *Delphinus capensis* (Stockin et al. 2013). The findings from genetic analyses were inconclusive, leading the authors to suggest that individuals of both morphotypes may be present in New Zealand waters, even though there are no genetic differences that would clearly distinguish the two species.

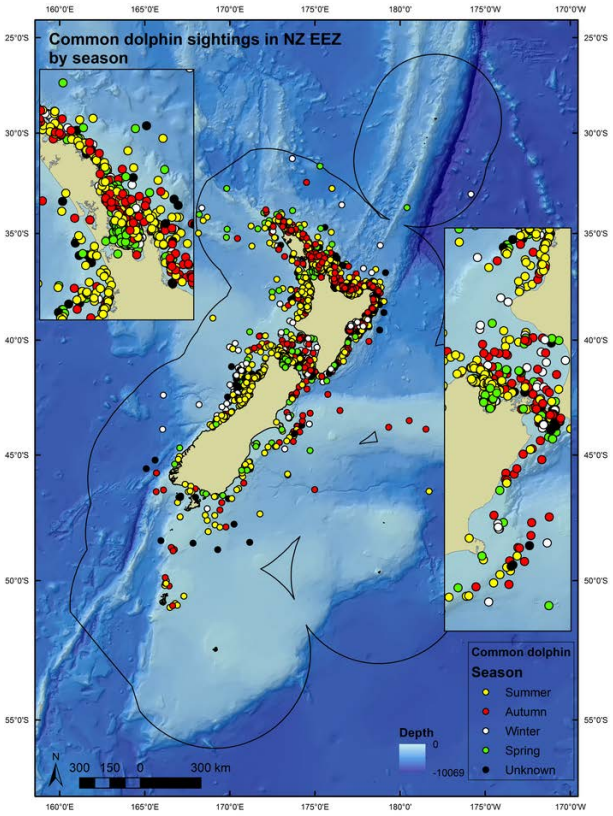

Figure 11: Distribution of common dolphin (*Delphinus delphis*) sightings in New Zealand waters between 1970 and 2013. (Reported sightings are from a variety of sources and need to be considered indicative only, as identifications may not be correct.)

3.2.5 Dusky dolphin

Dusky dolphin *Lagenorhynchus obscurus* is a Southern Hemisphere species with a broad distribution and genetically distinct populations (possibly subspecies) on the west coast of South America, southwestern Africa, and New Zealand (Hammond et al. 2008a). Abundance estimates are only available for a small proportion of the species' range, preventing a global population assessment and determination of the population trend.

Dusky dolphin are coastal delphinids that occur in waters above the continental slope and shelf, usually at less than 2000 m depth (Würsig et al. 2007). In New Zealand, this species exhibits some inshore-offshore shifts in abundance, moving into deeper waters in some areas (Brownell & Cipriano 1999, Hammond et al. 2008a).

Sightings data show that this species is present in New Zealand waters year-round (Figure 12). Between 1970 and 2013, there were comparatively few sightings in North Island areas, revealing a prevalence of dusky dolphin in southern areas, including Stewart Island and around subantarctic islands. As is common for many dolphin species, dusky dolphin are gregarious, with groups of 12 or more individuals commonly encountered, extending to schools of 100s to 1000s of individuals in the open ocean. In New Zealand waters, dusky dolphin also occur frequently in multi-species associations, in particular with common dolphin (Markowitz et al. 2004).

This species has been the focus of a number of studies in Marlborough Sounds and Kaikoura (see Würsig

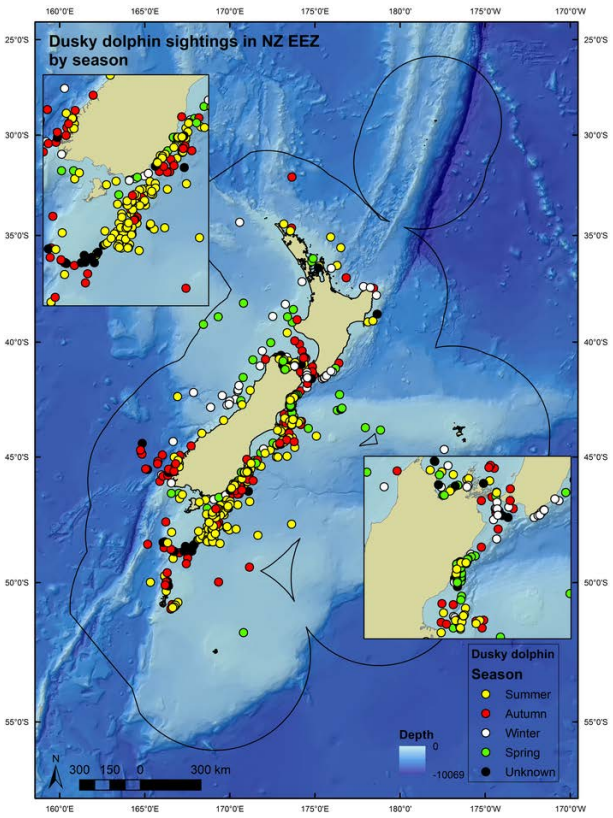

Figure 12: Distribution of dusky dolphin (*Lagenorhynchus obscurus*) sightings in New Zealand waters between 1970 and 2013. (Reported sightings are from a variety of sources and need to be considered indicative only, as identifications may not be correct.)

et al. 2007). Foraging is considered to be mostly at relatively shallow depths, but may extend to 130 m deep. In Marlborough Sounds, dusky dolphin feed during the day on the northern edge of South Island, whereas around Kaikoura, they typically feed at night, targeting prey associated with the deep-scattering layer. A number of individuals use both areas (Würsig et al. 2007).

Off Kaikoura, small groups of mother-calf pairs show a clear preference for shallow habitats, with these nursery groups occurring significantly more frequently in shallow waters (less than 20 m depth) than in deeper areas (Weir et al. 2008). This habitat preference was not observed in other dusky dolphin groups in this area, suggesting that nursery groups seek refuge in inshore waters, as possible predator avoidance strategy of sharks and killer whale.

Abundance in the Kaikoura area has been estimated at 12 000 individuals, with about 2000 dusky dolphin present at any one time (Markowitz et al. 2004). Based on genetic analysis, the estimated effective female population size for all of New Zealand is 15 000–17 000 (Harlin et al. 2003).

Based on data from Peru, sexual maturity of female dusky dolphin has been estimated at 4.5 and 5.0 years, compared with males reaching sexual maturity between 3.8–4.7 years of age (Waerebeek & Würsig 2009). Calves are born after a gestation period of about 13 months, with an inter-calving period of about 16 months that includes a 12-month lactation period, and a rest period of just under 4 months.

In New Zealand waters, sexual maturity of both males and females has been estimated at about seven to eight years of age, and most of the calving occurs in later winter and early spring (August to October)

(Würsig et al. 2007, Waerebeek & Würsig 2009). Off Kaikoura, calving peaks between November and January, following a gestation period of about 11.4 months, with a lactation period of 18 months (Würsig et al. 2007).

Dusky dolphin feed on a diversity of prey, and their foraging dives vary accordingly, such as the targeting of southern anchovy close to the surface in shallow waters, and feeding on midwater and benthic prey such as squid, hake, and lanternfishes in other areas (Hammond et al. 2008a).

3.2.6 Hector's dolphins

Hector's dolphin *Cephalorhynchus hectori* are endemic to New Zealand, and include the North Island subspecies Maui's dolphin *Cephalorhynchus hectori maui* and its South Island counterpart Hector's dolphin *Cephalorhynchus hectori hectori* (Dawson 2009).

Hector's dolphin were formally distinguished as two subspecies in 2002, based on differences in morphology and mitochondrial DNA haplotypes, and the absence of gene flow between populations (Baker et al. 2002).

Both subspecies occur in coastal waters, generally within the 100-m depth contour (Dawson et al. 2004). The distribution of Maui's dolphin is restricted to the North Island's west coast, primarily between Manukau Harbour and Port Waikato (about 40 km of coastline) (Dawson 2009, Oremus et al. 2012). Although the small remnant population of this subspecies is found along 300 km of coastline, surveys indicate that it is largely concentrated within 139 km of its distribution (Oremus et al. 2012, Hamner et al. 2013). This limited along-shore range reflects a considerable reduction in the historical distribution of this subspecies within the past 100 years (Dawson et al. 2001). Historical sightings data suggest that Maui's dolphin used to be distributed throughout most of North Island, with early strandings data (since 1970) including a number of beachcast and stranded individuals in northwestern North Island, between Dargaville and Wanganui. Recent modelling of the distribution of Maui's dolphin on the North Island west coast used sightings data from a number of systematic surveys to describe the species' spatial range (see Currey et al. 2012). This modelling study confirmed that Maui's dolphin density was highest within 2 nautical miles (3.7 km) from the shore, and between Manukau Harbour and Port Waikato along the North Island's coastline.

Reported sightings of this subspecies in the period between 1970 and 2013 also included records from different North Island areas, with most observations on North Island's west coast (Figure 13a). During a 2013 risk assessment, the distribution of Maui's dolphin was evaluated, with the panel concluding that the current distribution of Maui's dolphin is restricted to North Island's west cost (Figure 13b)(Currey et al. 2012).

The Hector's dolphin subspecies is present in South Island waters, with three regional populations on the east, west and south coasts, respectively (Dawson et al. 2004, Slooten et al. 2004). There is limited movement across the different areas, resulting in limited gene flow among the three South Island populations of this subspecies (Hamner et al. 2012).

Sightings data of the Hector's dolphin subspecies between 1970 and 2013 show a large number of records around Banks Peninsula on the South Island's east coast, and between Westport and Greymouth on the west coast, with the majority of observations recorded during summer (Figure 14). There were also documented sightings of this subspecies in different coastal North Island areas.

Both subspecies show limited home ranges and along-shore movement (generally less than 50 km);

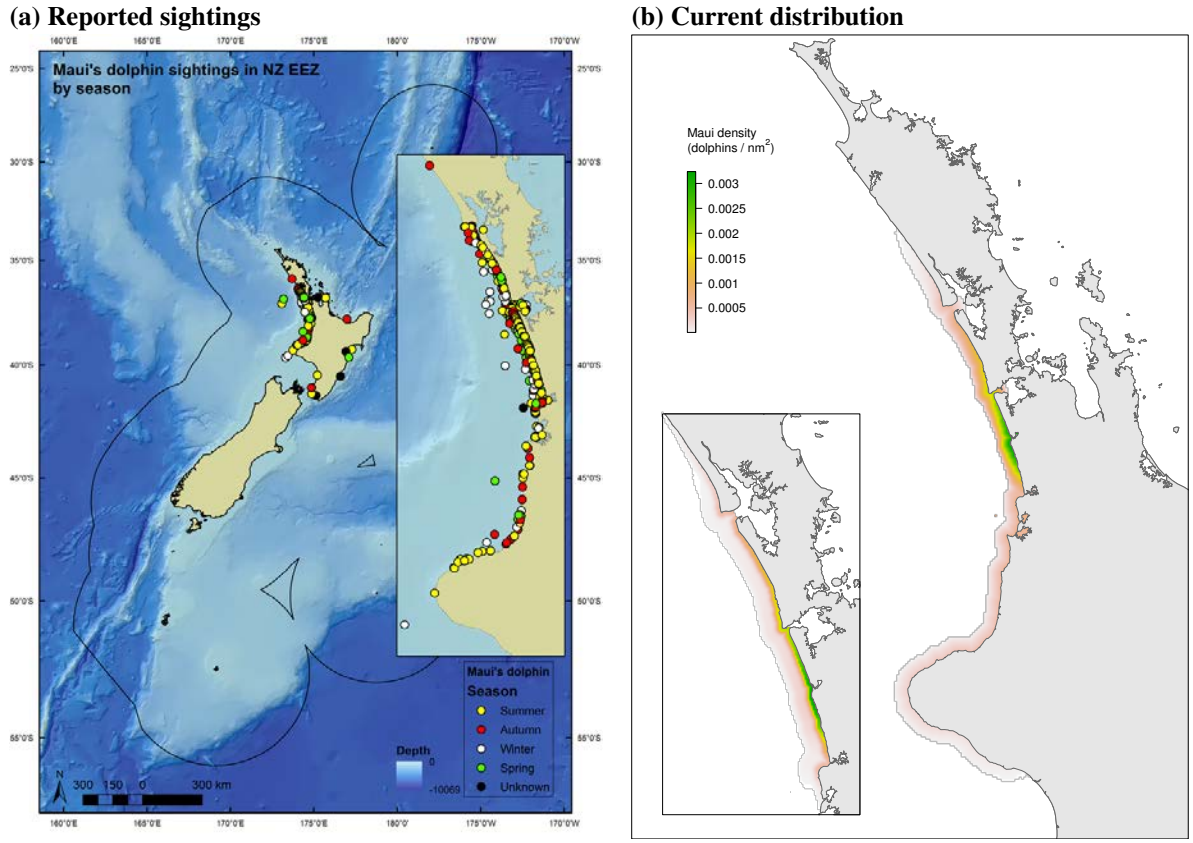

Figure 13: Distribution of Maui's dolphin (*Cephalorhynchus hectori maui*) (a) sightings in New Zealand waters between 1970 and 2013. (Reported sightings are from a variety of sources and need to be considered indicative only, as identifications may not be correct.) (b) current distribution of Maui's dolphin (from Currey et al. 2012). The colours indicate the expected number of dolphin per square nautical mile.

travel over distances greater than 100 km is rare (Bräger et al. 2002, Rayment et al. 2009, Oremus et al. 2012). Nevertheless, genetic monitoring revealed four Hector's dolphin individuals within Maui's dolphin North Island habitat, providing evidence of long-distance dispersal (more than 300 km) of the southern subspecies, or "natural translocation" (Hamner et al. 2013). Furthermore, genetic sampling between 2010 and 2012 confirmed the presence of two Hector's dolphin individuals on the North Island's southwest coast, an area that was previously considered outside the presumed range of the southern subspecies. Although these data indicate the occurrence of southern Hector's dolphin migrants in North Island waters, there has been no evidence of interbreeding between the two subspecies (Hamner et al. 2013).

Based on a combination of aerial and boat-based line-transect surveys conducted between 1998 and 2001, the total population size of South Island Hector's dolphin has been estimated at 7270 (CV: 16.2%) individuals, including an estimated 5388 (CV: 20.6%) individuals on the South Island west coast (Slooten et al. 2004). A similar population survey of Maui's dolphin, conducted in 2004 resulted in an estimated population size of 111 (95% c.i.: 48 to 252) individuals (Slooten et al. 2006). Another population study of this northern subspecies used genetic samples of living and beachcast (dead) Maui's dolphin collected between 2001 and 2007 to inform capture-recapture models to obtain abundance estimates (Baker et al. 2013). This study resulted in an estimated Maui's dolphin population size of 87 (95% c.i.: 59 to 158) individuals for the multi-year period, or 69 (95% c.i.: 38 to 125) individuals at the midpoint of this study in 2003.

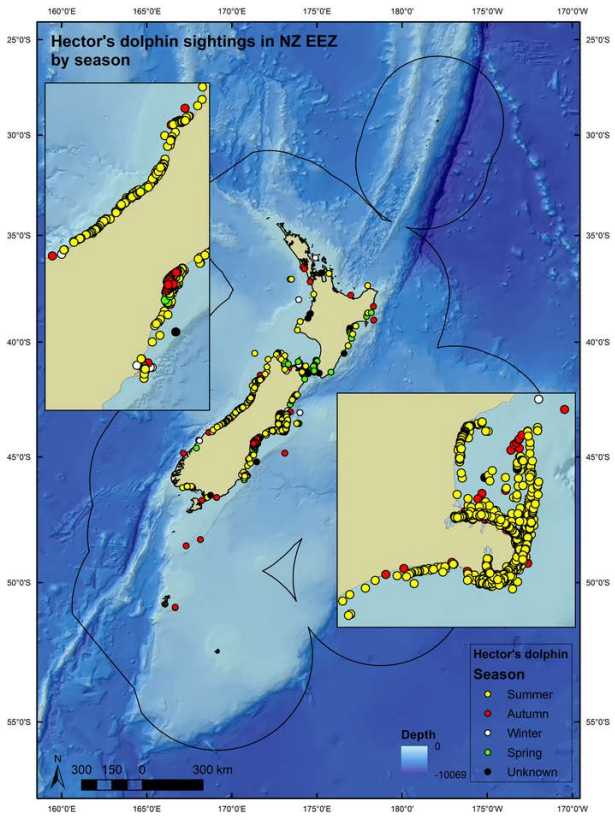

Figure 14: Distribution of Hector's dolphin (*Cephalorhynchus hectori hectori*) sightings in New Zealand waters between 1970 and 2013. (Reported sightings are from a variety of sources and need to be considered indicative only, as identifications may not be correct.)

Subsequently, based on DNA profiling and capture-recapture models, Hamner et al. (2012) estimated the abundance of Maui's dolphin over one year old at 55 individuals (95% c.i.: 48 to 69) for 2010–11. They also used genetic data to estimate the effective population size for the same period, resulting in an estimated 69 breeding adults in the parental generation, although the uncertainty around this estimate was large (95% c.i.: 31 to 641 breeding adults).

Hector's dolphin males reach sexual maturity at six to nine years of age, while females calve for the first time when they are between seven and nine years old (Slooten 1991). Gestation lasts for 10–11 months, and the inter-calving period is two to four years (Dawson 2009).

The maximum observed age of this species has been estimated at 20 years for males and 19 years for females, based on tooth sectioning (Slooten 1991). More recent age estimates based on repeated sightings of identified individuals were 22 years for males and 21 years for females (Rayment et al. 2009). This species is characterised by low population growth, with a relatively high age at first reproduction (i.e., in view of its lifespan) and long inter-calving period. Estimated maximum population growth rates for this species vary between 1.8 and 4.9% (Slooten & Lad 1991). A recent study of Maui's dolphin used data from microsatellite genotyping in open-population capture-recapture models to estimate an upper limit of recruitment of 11% (Baker et al. 2013). This value, considered by the authors as the "maximum feasible rate of annual population increase", does not appear to include overall survival, and was based on little to no juvenile mortality, a calving interval of two years, and an age at first calving of seven years. The value decreased to less than 5.8% when based on a calving interval of four years, an age of first calving of nine years, and neonatal survival of 0.8 (Baker et al. 2013).

3.2.7 Hourglass dolphin

A congener of dusky dolphin, hourglass dolphin *Lagenorhynchus cruciger* is another Southern Hemisphere species with a circumpolar distribution (Hammond et al. 2008b). This species is mainly found at higher latitudes between 45 and 68 degrees South in the subantarctic region of the South Pacific Ocean (Goodall 2009). Hourglass dolphin are largely oceanic, predominantly in deep, offshore waters, with few data from relatively shallow waters or from strandings (Jefferson et al. 2008).

They are regularly sighted throughout their range, but population data are largely missing, so that their life history remains largely unknown. The presence of calves has been documented in January and February, with small groups (up to eight individuals), and larger group sizes of 60 individuals also recorded. Surveys conducted south of the Antarctic Convergence between 1976–77 and 1987–88 resulted in a population estimate of 144 300 individuals (CV: 0.17) for this area (Jefferson et al. 2008).

Their diet includes small fish including myctophids, squids, crustaceans (Hammond et al. 2008b, Jefferson et al. 2008).

There have been only few sightings of hourglass dolphin in New Zealand's EEZ between 1970 and 2013 (Figure 8). These sightings were on the South Island east coast (off Canterbury), and in subantarctic waters, including below 50 degrees South.

3.2.8 False killer whale

False killer whale *Pseudorca crassidens* have a widespread distribution in tropical to warm-temperate zones in the Indian, Pacific and Atlantic oceans, with some records from cold temperate waters also (Jefferson et al. 2008, Baird 2009). They are naturally uncommon throughout their range. They are mostly found in deep, offshore waters, but may occasional move to continental shelf and shallow areas.

There are no global abundance data or population trends available for this species, but some regional abundance estimates document 39 800 individuals (CV: 64%) in the eastern tropical Pacific Ocean and 16 000 individuals (CV: 26%) in coastal waters of China and Japan (Jefferson et al. 2008).

False killer whale are typically found in groups, generally including 20 to 100 individuals, with observed mass strandings involving up to 800 individuals (Taylor et al. 2008d). This cetacean species feeds predominantly on cephalopod and fish species, including tuna, and also other cetacean species (Baird 2009).

Little is known about false killer whale biology and life history parameters, with most information derived from stranded individuals. Males and females reach sexual maturity at about 8–14 years of age, although males may possibly mature later than females (Baird 2009). Maximum longevity is 57 years for males and 62 years for females.

This species' reproductive biology is also largely unknown. The reproductive rate appears to be low, based on a calving interval of almost seven years that was observed in one population (Baird 2009).

There have been few records of false killer whale in New Zealand's EEZ, and sightings data are mostly from northeastern North Island, with few records from other areas (Figure 15). The majority of these sightings occurred in summer and autumn. Visser et al. (2010) observed killer whale attacking false killer whale in Bay of Islands in 2010. The group of false killer whale consisted of approximately 50–60 individuals, including about 15 calves. Other opportunistic sightings of false killer whale in New Zealand

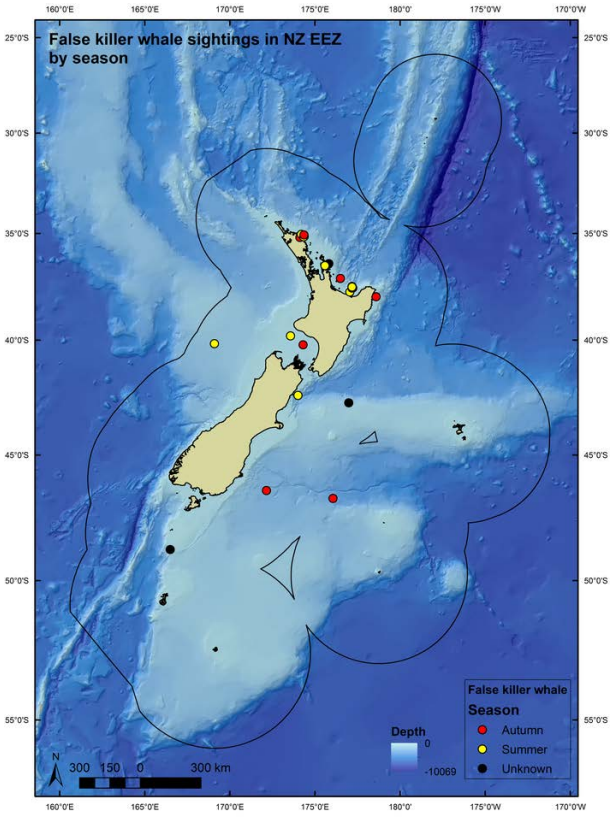

Figure 15: Distribution of false killer whale (*Pseudorca crassidens*) sightings in New Zealand waters between 1970 and 2013. (Reported sightings are from a variety of sources and need to be considered indicative only, as identifications may not be correct.)

waters were feeding associations with bottlenose dolphin in Hauraki Gulf, with about 30 and 100 false killer whale feeding with 60 and 150 bottlenose dolphin, respectively in two separate incidents in 2011 (Zaeschmar et al. 2012, 2013).

3.2.9 Killer whale

Killer whale *Orcinus orca* are considered the most cosmopolitan cetacean species, as their distribution is widespread in all marine regions from the equator to polar waters (Taylor et al. 2008c). Currently a single species, their taxonomic status is under review, and the separation of different species or subspecies is likely in a number of regions.

In the Southern Hemisphere, different morphological forms are referred to as "types" A to D, although the different types have not been formally described as separate species to date (Pitman & Ensor 2003, Baker et al. 2010a). Only killer whale type A is considered resident in New Zealand, with types B to D most common in the Southern Ocean and around Antarctica. These latter killer whale types are only occasionally sighted in New Zealand waters. Killer whale are common in coastal waters and in areas of high productivity, and at high latitudes (Taylor et al. 2008c). Although global data are lacking, as there are no data for high Northern Hemisphere latitudes and large oceanic areas of the South Pacific, South Atlantic and Indian oceans, the global abundance of killer whale has been estimated at a minimum of 50 000 individuals for all types (Taylor et al. 2008c, Ford 2009). This estimate was derived from vessel-based sightings surveys and population counts conducted in different regions. The latter included vessel

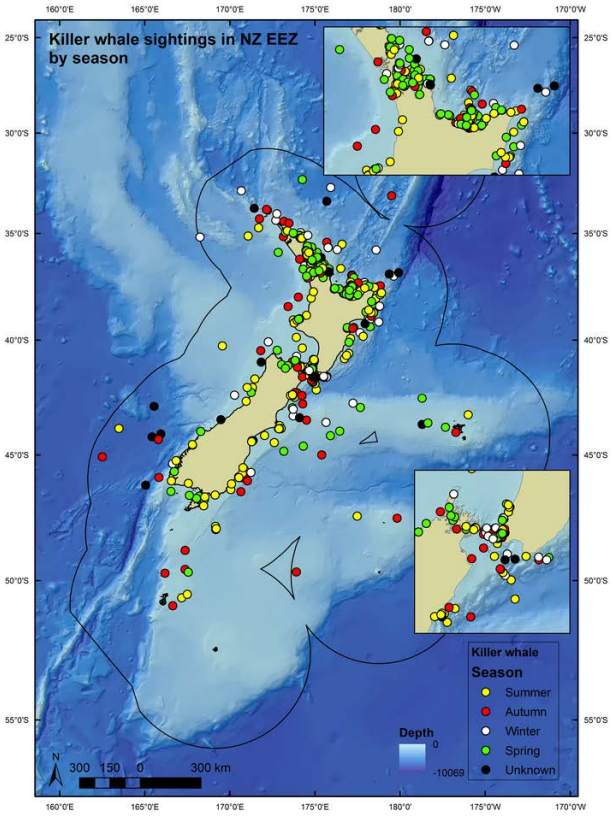

Figure 16: Distribution of killer whale (*Orcinus orca*) sightings in New Zealand waters between 1970 and 2013. (Reported sightings are from a variety of sources and need to be considered indicative only, as identifications may not be correct.)

surveys in the Southern Ocean, which resulted in a regional estimate of a minimum of 25 000 killer whale (Ford 2009). The overall population trend of this species is unknown; it seems to be increasing in some populations for which data are available, while other populations such as on the northwest coast of United States and British Columbia/Canada and in the Strait of Gibraltar are threatened or endangered (Ford 2009).

Males reach sexual maturity at about 15 years of age, whereas females produce their first viable calf when they are about 12 to 14 years old, with the female reproductive lifespan estimated to be about 25 years (Ford 2009). Calving follows a gestation period of 15–18 months, and is diffusely seasonal with high neonate mortality (43%) within the first six months. The calving interval is on average five years, with females producing an average of five calves before they become reproductively senescent. The life expectancy of killer whale (at age 0.5 following high neonate mortality) is approximately 30 years for males and 50 years for females, with a maximum longevity of 50–60 years and 80–90 years, respectively (Ford 2009).

Studies of killer whale have shown that this species is organised in a number of different social groups, including temporary aggregations of over 20 individuals, and also small, stable units and "resident societies" (Ford 2009). The latter are based on matrilines, with individuals linked by their maternal descent, with these groups usually consisting of a female, her male and female offspring, and the latter's offspring, encompassing up to four generations. The bonds within the matrilineal groups are strong and permanent, with no known movement from resident matrilines.

Killer whale are apex predators that feed on a variety of prey, including marine mammals, seabirds and a diversity of fish species (Ford 2009). In New Zealand waters, prey species of killer whale include a range of elasmobranchs, e.g., demersal shark and ray species, and also marine mammals and fish species (Visser 2007).

Killer whale in New Zealand have been the focus of a number of studies, including research on their population size, distribution, their prey species, and anecdotal observations of different behavioural aspects such as their home range, predation on false killer whale, and interactions with longline fisheries (Visser 1999, 2000a, 2000b, Visser et al. 2010).

The resident population of killer whale type A in New Zealand is relatively small, consisting of an estimated 117 individuals (95% c.i.: 65–167) in 1997 (Visser 2000b). Since then, the number of individuals recorded in photo-identification surveys reached 132 in 2006 (Visser 2007). While some of the identified individuals have not been resighted for considerable lengths of time (over 5 years), resightings after extended periods of time have occurred, such as that of a known individual after 29 years (Visser 2007).

Killer whale are regularly sighted in New Zealand waters with records along the coastline of North and South islands, Chatham Islands and also from offshore and subantarctic waters (Figure 16).

The New Zealand killer whale population is considered stable (Baker et al. 2010a), with calves and juveniles present throughout the year (Visser 2000b). Based on their distribution, Visser (2000b) suggested that there are three killer whale type A subpopulations in New Zealand, including one off North Island, one off South Island, and a third subpopulation that moves between the two regions.

3.2.10 Long-finned and short-finned pilot whales

There are two species of pilot whale globally, with both long-finned and short-finned pilot whales (*Globicephala melas* and *Globicephala macrorhynchus*) occurring in New Zealand waters (Taylor et al. 2008a, 2011). The two species are difficult to distinguish at sea, but their general distributions differ to some extent, with short-finned pilot whale preferring warm temperate to tropical waters, whereas their long-finned congener is prevalent in cold-temperate waters (Olson 2009). Nevertheless, their distributions overlap in some regions, including in the Southern Hemisphere, i.e., the South Pacific Ocean and New Zealand waters.

In New Zealand waters, pilot whale sightings occurred throughout all seasons, with a large number of sightings from northern to southern waters, including offshore areas and around subantarctic islands (Figure 17). Long-finned pilot whale commonly strand in New Zealand, including mass strandings in a number of locations throughout North and South islands, and also Chatham Islands (O'Callaghan et al. 2001).

Long-finned pilot whale are currently recognised as three sub-species, with *Globicephala melas edwardii* occurring in the Southern Hemisphere (Taylor et al. 2008a). This subspecies appears to be isolated from the Northern Hemisphere subspecies, with its distribution in the Pacific Ocean extending from 14 degrees South to Antarctica at 68 degrees South (Taylor et al. 2008a, Olson 2009).

Although there are no global abundance data or population trends available for long-finned pilot whale, this species is considered relatively common and abundant, with over 750 000 individuals estimated to be present in the North Atlantic Ocean (in 1987, 1989) and an estimated 200 000 individuals occurring south of the Antarctic Convergence in summer (Taylor et al. 2008a).

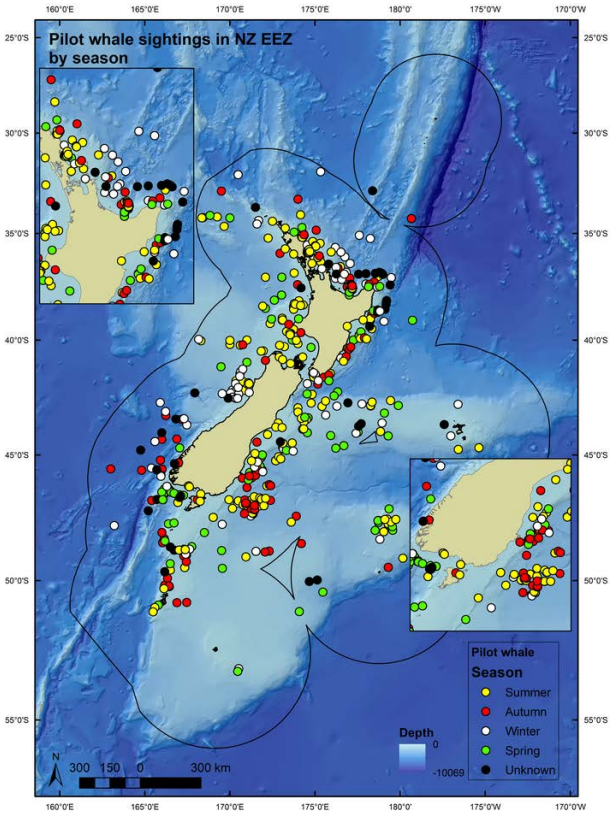

Figure 17: Distribution of pilot whale (*Globicephala* sp.) sightings in New Zealand waters between 1970 and 2013. (Reported sightings are from a variety of sources and need to be considered indicative only, as identifications may not be correct.)

Short-finned pilot whale inhabit deep, offshore habitats, occurring at high densities above the outer continental shelf and continental slope (Taylor et al. 2011). As for long-finned pilot whale, there are no global population estimates available for this species, although abundance data exist for some regions. These data range from 1000 individuals on the United States west coast to 500 000 individuals in the Eastern Tropical Pacific Ocean (Jefferson et al. 2008).

Pilot whales have a long lifespan and delayed maturity, with female and male long-finned pilot whale reaching sexual maturity at eight and 12 years, respectively (Olson 2009). In comparison, male short-finned pilot whale reach sexual maturity when they are 13 to 16 years old, whereas females are sexually mature at about 9 years. Female short-finned pilot whale are post-productive when they reach 40 years of age (Jefferson et al. 2008). The gestation period is 12 months in long-finned pilot whale, and slightly longer at about 15–16 months in short-finned pilot whale. In both species, the calving interval is comparatively long, with three or more years between calves (Olson 2009). The longevity of pilot whales varies between genders, with females living for over 60 years, compared with 35 to 45 years for males (Olson 2009).

Pilot whales feed predominantly on cephalopods, i.e., squid, with a number of fish species (e.g., mackerel, cod, and dogfish) also included in the diet of long-finned pilot whale (Olson 2009). Both species are known to forage at depth, reaching several hundred metres of water depth. Some of their feeding behaviour has been related to the movement of their vertically migrating prey, with pilot whales conducting relatively shallow dives during the day (to about 16 m depth), with deeper dives at dusk and dawn (up to 600 m depth)(Olson 2009). Long-finned pilot whale have also been shown to exhibit

some inshore movement in summer and autumn when they follow their target prey into coastal areas and continental shelf waters (Taylor et al. 2008a).

3.2.11 Southern right whale dolphin

There are two species of right whale dolphin globally, with the northern and southern congeners *Lissodelphis borealis* and *Lissodelphis peronii*, respectively (Lipsky 2009). The southern species *Lissodelphis peronii* has a circumpolar distribution in the Southern Hemisphere, occurring predominantly in subantarctic and cool-temperate waters between 30 and 65 degrees South (Lipsky 2009, Hammond et al. 2012b).

Southern right whale dolphin are predominantly oceanic, occurring in deep, offshore waters (Lipsky 2009). They are only rarely encountered in near-shore waters, generally in coastal regions that are characterised by a steep continental slope and deep waters close to shore. This species is gregarious and often sighted in groups of up to 1000 individuals.

Life history data for this species are largely lacking, including information of its distribution, population size, and population biology (Jefferson et al. 2008). In its northern congener, *Lissodelphis borealis*, males reach sexual maturity at 9.9 years and females at 9.7 years of age (Lipsky 2009). The gestation period in northern right whale dolphin is about 12 months, with a inter-calving period of two years. Northern right whale dolphin live to at least 42 years (Jefferson et al. 2008).

Southern right whale dolphin feed on a variety of fish and squid. The prevalence of lanternfish (myctophids) in this dolphin species' diet suggests that southern right whale dolphin dive to considerable depth, exceeding 200 m (Jefferson et al. 2008).

There have been few records of this species in New Zealand's EEZ, with records generally based on strandings and opportunistic sightings (Visser et al. 2004). These data include a stranding of three southern right whale dolphins in 1952 (Lipsky 2009), and observation of a group of over 500 individuals about 15 km southeast of Kaikoura in water depths of over 1500 m (Visser et al. 2004).

Of the few sightings of southern right whale in New Zealand since 1970, all records were in southern waters, including off Otago and further south on the South Island's east coast and off Fiordland (Figure 8).

3.3 Beaked whales

Beaked whales are a group of cetaceans that has received little research, partly owing to their pelagic, open-ocean lifestyle, in addition to a number of beaked whale species being relatively uncommon. Furthermore, beaked whales are difficult to detect at sea, as they are relatively cryptic without conspicuous features above the water surface. As a consequence, many aspects of their distribution and life history remain unknown, so that data on their global distribution, population size and trends, and general life history are scarce. There are only few abundance estimates available, including an estimate for the eastern Pacific Ocean, where the abundance of beaked whales in the genus *Mesoplodon* was estimated at 32 678 individuals (Taylor et al. 2008b). Most beaked whales included in this estimate were considered to be pygmy beaked whale *Mesoplodon peruvianus* or dense-beaked whale *Mesoplodon densirostris*.

Beaked whales are renowned for their deep-diving ability, with their diet presumed to be consisting largely of deep-water squid and fish species.

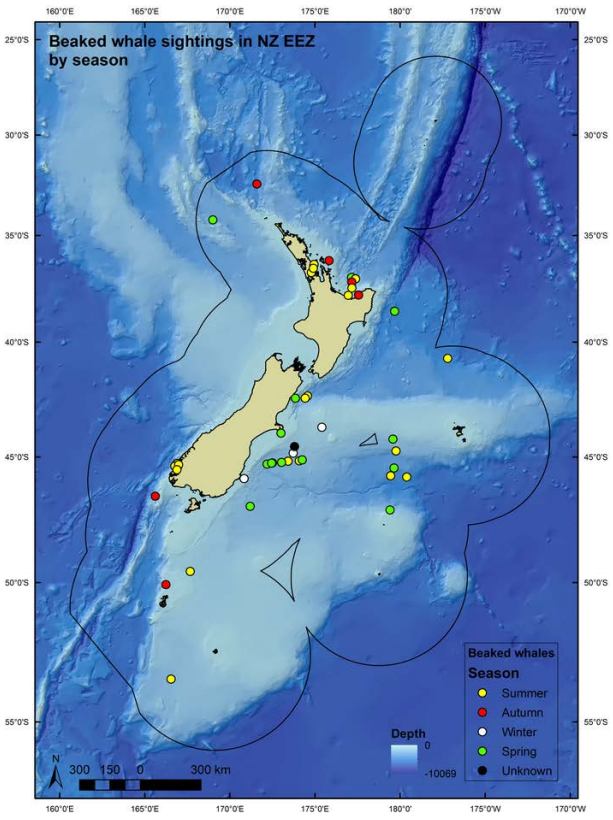

Figure 18: Distribution of beaked whale (species not identified) sightings in New Zealand waters between 1970 and 2013. (Reported sightings are from a variety of sources and need to be considered indicative only, as identifications may not be correct.)

New Zealand has been identified as a "hotspot" of beaked whale diversity, with the relatively high number of beaked whale species in this region making it difficult to distinguish them by their external characteristics only, particularly at sea (MacLeod & Mitchell 2005, Thompson et al. 2012).

In their assessment of marine mammal species within the New Zealand threat classification scheme, Baker et al. (2010a) included 11 species of beaked whale, with a further three species listed as vagrant. All of the assessed beaked whale species were considered data deficient in the threat ranking, and all but Cuvier's beaked whale *Ziphius cavirostris*(also known as "goose-beaked" whale) and southern bottlenose whale *Hyperoodon planifrons* are currently considered data deficient in the IUCN threat ranking (see Baker et al. (2010a)).

Records of beaked whales in New Zealand waters are largely from strandings data, and the most dominant species in the strandings database (i.e., recorded in more than 250 stranding events since 1970) is Gray's beaked whale *Mesoplodon grayi* (Department of Conservation 2013b). Other species featuring relatively frequently in stranding records in New Zealand (i.e., more than 70 stranding events) include Cuvier's beaked whale *Ziphius cavirostris* and strap-toothed whale *Mesoplodon layardii*. Most sightings and strandings of species in the genus *Mesoplodon* have been east and south of South Island, with a potential hotspot in the area between South Island and Chatham Islands.

Furthermore, stranding records of Andrews' beaked whale *Mesoplodon bowdoini* and Cuvier's beaked whale *Ziphius cavirostris* include females with a calf, indicating that these species breed in New Zealand waters (MacLeod & Mitchell 2005).

A particulary rare species, spade-toothed whale *Mesoplodon traversii* is only known from six records worldwide, of which five records are from New Zealand, including mandibles and skulls from Chatham and White islands, and a stranded male and female from Bay of Plenty (Thompson et al. 2012).

Sightings data from New Zealand do not distinguish different beaked whale species, with generally few records between 1970 and 2013 (Figure 18). Sightings were mostly from waters east of South Island, with few data from more southern and northern areas.

3.4 Pinnipeds

There are three pinniped species inhabiting New Zealand waters, including New Zealand fur seal, endemic New Zealand sea lion (both members of the family Otariidae, "eared" seals) and southern elephant seal (family Phocidae, "true" or "earless" seals)(see summary of population data in Table 5).

Otariid seals are typically long-lived (about 15–20 years), and sexual maturity is delayed as is characteristic for pinnipeds (Berta 2009, Boness 2009). This pinniped family is also characterised by sexual bimaturation, with males maturing more slowly than females. Their reproductive biology is based on an annual breeding cycle, with the birth of a single pup followed by mating each year. Pupping and mating occur in breeding colonies, and males compete for control of these colonies to gain access to females.

Elephant seals follow a similar breeding pattern, with a single pup produced per reproductive cycle. In contrast to otariid seals, however, elephant seals do not feed while lactating, but remain on land and fast during a short lactation period (Berta 2009). This reproductive strategy means that foraging trips by female elephant seals are not dependent on pups that need tending on land at regular intervals.

3.4.1 New Zealand fur seal

New Zealand fur seal are native to New Zealand and Australia, and are widely distributed along the coastline of New Zealand's main islands (Harcourt 2001, Goldsworthy & Gales 2008). This species also inhabits subantarctic and offshore islands, including Chatham, The Snares, Campbell, Antipodes, and Bounty islands in the New Zealand region.

Following subsistence hunting and exploitation by commercial sealers, New Zealand fur seal came close to extinction in the nineteenth century (Lalas & Bradshaw 2001). Through the implementation of protection measures, the population has recovered and is currently expanding into its former range (Bradshaw et al. 2000). Breeding colonies of fur seal in New Zealand extend from mostly southern locations to northern areas, with rocky shorelines providing preferred haul-out and rookery habitat (Harcourt 2001, Bouma et al. 2008).

This species has been the focus of a number of New Zealand studies on its distribution, re-colonisation patterns, population biology, foraging behaviour and diet (e.g., Taylor 1996, Lalas & Murphy 1998, Mattlin et al. 1998, Bradshaw et al. 2000, Boren 2010). Some of these studies include regional abundance surveys and multi-year (pup) counts, but there are no current (within the past 30 years) abundance data for the entire population (Goldsworthy & Gales 2008, Baird 2011). Nevertheless, the 2008 IUCN assessment considered the population trend to be increasing, with an estimated 200 000 individuals for the total New Zealand fur seal population in Australia and New Zealand, and about half of this population in either country (Goldsworthy & Gales 2008).

Table 5: Population information of pinniped species that inhabit New Zealand waters (n.d., no data).

Common name	General distribution	Global population size	General NZ distribution	NZ population size	Age at first reproduction	Max. population growth
New Zealand fur seal	NZ and southern Australia (Goldsworthy & Gales 2008)	No recent abundance data; estimated at about 200 000 individuals (Goldsworthy & Gales 2008)	NZ mainland, offshore and subantarctic islands (Harcourt 2001)	No recent total abundance data; estimated at about 100 000 individuals (Goldsworthy & Gales 2008)	Females: 4–6 years, males 5–9 years (Dickie & Dawson 2003)	Regional annual estimates 5%–47% (Harcourt 2001, Boren et al. 2006b)
New Zealand sea lion	Endemic to NZ (Childerhouse & Gales 1998)	Endemic to NZ	Auckland and Campbell islands; southern South Island, including Stewart Island (Gales & Fletcher 1999)	11 000–13 000 (Ministry for Primary Industries 2012)	Females: 3–4 years, males: 5 years (Childerhouse 2008, Gales 2012)	Declining (Gales 2012)
Southern elephant seal	Southern Hemisphere, circumpolar (Hindell & Perrin 2009)	650 000 individuals [mid-1990s] (Campagna 2008)	Migrant; pelagic; Antipodes and Campbell islands (Baker et al. 2010a)	250–260 individuals (Baker et al. 2010a)	Females: 3–5 years, males: 4 years (Campagna 2008)	n.d

As the New Zealand fur seal population is generally considered to be expanding, migrating animals colonise new areas and haul-outs become breeding colonies (Bradshaw et al. 2000). As a consequence, identification of distinct subpopulations can be difficult, as evident in a genetic study of New Zealand fur seal population structure (Robertson & Gemmell 2005) . This study analysed genetic samples of fur seal at seven New Zealand colonies, including Cape Palliser (southern North Island), Wekakura Point, Cape Foulwind and Open Bay Islands (South Island west coast), and Ohau Point, Horseshoe Bay and Nugget Point (South Island east coast). There were low levels of genetic differentiation, indicating moderate levels of gene flow and an expanding fur seal population. The increase in gene flow across breeding colonies reduces genetic differences across subpopulations, making it increasingly difficult to assign individuals to their colony of origin. For this reason, genetic sampling allowed only about 42% of individuals to be assigned to their colonies of origin, compared with about 70% of individuals that were assigned to their respective west coast or east coast regions (Robertson & Gemmell 2005). Consistent with a broader regional differentiation, genetic sampling that included Bounty Islands showed that 77% of pups could be correctly assigned to this colony of origin, indicating a distinct subpopulation at this location (B. Robertson, University of Otago, unpubl. data).

Several regional studies have used pup counts to estimate New Zealand fur seal abundance at breeding colonies (Lalas & Harcourt 1995, Taylor et al. 1995, Lalas & Murphy 1998). Although annual pup counts do not provide absolute pup numbers, they can be used to assess population trends if they are conducted consistently across years (Lalas 2007). As pups are restricted to land, pup counts provide a more reliable assessment method than single counts of all individuals, even though some pups may die before surveys are conducted, and some live pups may be missed (Lalas & Bradshaw 2001). This potential, negative bias can be addressed by using mark-recapture techniques to estimate absolute pup numbers. In New Zealand, mark-recapture methods have been used to obtain fur seal pup abundance estimates at different South Island colonies (e.g., Lalas & Harcourt 1995, Bradshaw et al. 1999, Boren et al. 2006b). In turn, pup census data can be used to estimate the size of the fur seal population at a colony, usually involving a multiplier (e.g., 3.5–5.3, see Hamilton & Baker 2010) that is informed by several population parameters, such as age at first reproduction, the reproductive rate, and age-related mortality (Lalas & Bradshaw 2001).

Fur seal abundance data are available for a number of New Zealand locations, including the South Island west coast, the subantarctic, Fiordland, Nelson/Marlborough, Kaikoura, Banks Peninsula, and Otago regions, including the Catlins. Some of these abundance surveys are dated (i.e., conducted over 15 years ago) but provide the only available data for some regions, such as Bounty Islands. In contrast, there are on-going, long-term monitoring programmes in other regions, such as Otago and parts of the South Island west coast (Department of Conservation unpubl. data, Lalas 2007).

A recent assessment of the impact of commercial fisheries on New Zealand fur seal populations on the South Island west coast and at Campbell and Bounty islands considered population data from a variety of sources, including ground and aerial surveys, and pup mark-recapture studies (Hamilton & Baker 2010). This assessment included an unpublished long-term data set of fur seal abundance at three South Island west coast locations, at Wekakura Point, Cape Foulwind, and Taumaka Island/Open Bay Islands (Department of Conservation unpubl. data). Also included were population data from an aerial census, conducted in January 2009 on the South Island west coast (excluding Fiordland), including the three long-term monitoring sites (Baker et al. 2010b). Based on the aerial survey, the total population size of New Zealand fur seal on the South Island west coast was estimated at 18 503 (c.i.: 17 886 to 19 120 individuals). Comparison of data from aerial and ground surveys at the three long-term monitoring sites, however, showed that the aerial census returned markedly lower abundance data than the concurrent ground counts (461 compared with 1442 pups across the three sites). This finding suggests that the aerial counts may underestimate the total size of the fur seal population on the South Island west coast (Baker et al. 2010b).

Incorporating data from these aerial surveys and from other sources including unpublished pup count data from Fiordland in their assessment, Hamilton & Baker (2010) estimated that the fur seal population of the entire South Island west coast ranged between 24 360 and 36 880 individuals.

At the three west coast colonies that have been monitored since the early 1990s, population data indicate a decline in fur seal abundance (see Hamilton & Baker 2010). At Wekakura Point, Cape Foulwind and Taumaka Island, pup production has decreased in the period between 1992–1998 and 2001–2007. The reason for this decline is unknown, but this population trend is in stark contrast to other areas.

In northwestern South Island (Nelson/northern Marlborough), fur seal have become re-established since 1970, with new rookeries and haul-outs evident at different southern Cook Strait locations (Taylor et al. 1995). In this area, fur seal have greatly expanded their distribution and population size, with a high annual pup production rate of of 23% on average between 1970–71 and 1994. In the 1993–94 breeding season, about 500 pups were born, leading to an estimated population size of 2410 individuals.

On the South Island east coast, a mark-recapture study was used to estimate pup abundance at two sites each at Kaikoura (Ohau Point and Lynch's reef) and at Banks Peninsula (Horseshoe Bay and Te Oka Bay) (Boren et al. 2006b). This study was conducted over four breeding seasons between 2002 and 2005, and also used earlier data to establish trends in pup production at Kaikoura over a longer period (16 years). Since pups were first sighted at Kaikoura in 1990, the population has grown at an exponential rate of over 32% per year, reaching densities of about 600 pups in 2005. The colony at Te Oka Bay also exhibited exponential growth at 47% over 5 years, with almost 300 pups born in 2005. These high population growth rates were in part explained by observations of adults immigrating from nearby colonies. At the other Banks Peninsula site, Horseshoe Bay, the colony seemed to be at carrying capacity, with about 200 pups per year, while suitable breeding habitat was spatially restricted at Lynch's Reef, where eight to 12 pups were born each year.

Some of the high population increase in the Otago region has also been attributed to extrinsic growth via immigration (Lalas 2007). Research at different Otago Peninsula sites confirmed that female fur seal are philopatric and return to natal sites to breed, with young breeders initiating new breeding colonies close to established breeding sites as densities at the latter colonies increase (Bradshaw et al. 2000).

Data from long-term monitoring at Otago Peninsula revealed an average annual rate of increase of 30% in the period from the 1970s to 1998 (Lalas 2007). In the Catlins area, population growth was on average 19% per year between 1994 and 1996–97 (Lalas & Murphy 1998). Subsequent survey data revealed a recent reduction in the annual rate of increase in the Otago region, indicating that the population may have reached carrying capacity, with preliminary estimates based on pup production data indicating a stable population size of 20 000 to 30 000 fur seal in 2008 (Lalas 2007).

For the subantarctic region, Taylor (1996) used aerial pup counts to estimate the abundance of New Zealand fur seal at Bounty Islands at 21 500 individuals in January 1994. The rate of population increase was relatively low for this species, at 4.9% per year between the early 1900s to the 1980s (Taylor 1996). Comparing the 1994 population estimate with earlier data indicated that abundance continued to increase although at a slower rate than previously established, at about 2.1% per year. At Antipodes Islands, the abundance of New Zealand fur seal was estimated at about 2000 individuals in 1985, with mostly yearlings and older juveniles present and few breeding individuals (Taylor 1992b).

Other early fur seal abundance estimates are based on counts of varying reliability with sometimes only a "rough idea of numbers" for the period between January 1970 and February 1973 (Crawley & Wilson 1976). These estimates include 1000 individuals at Auckland Islands, 1150 individuals at The Snares, 2100 individuals at Chatham Islands, and 3150 individuals at Stewart Island. These estimates are

included here, but not considered further owing to the lack of systematic data collection.

As the New Zealand fur seal population is expanding into northern areas, breeding colonies have also been recorded from North Island locations (Bouma et al. 2008). Since the early 1990s, fur seal have established breeding colonies at Cape Palliser (Wairarapa) and Sugar Loaf Islands (Taranaki), with the most northern breeding site in the Waikato region, at Gannet Island. In 2007, there were four pups born at this breeding site (Bouma et al. 2008).

New Zealand fur seal become sexually mature when females are four to six years old and males five to nine years (Dickie & Dawson 2003). Pupping occurs from mid-November to January, with the majority of pups born in December (Harcourt 2001). Mating occurs about seven to eight days after pups are born, with the annual breeding cycle including the weaning of pups when they are about 10 months old. The maximum age of New Zealand fur seal has been determined as 12 years for males and 22 years for females, based on tooth sections (Dickie & Dawson 2003).

Fur seal feed on a variety of prey species, mostly cephalopods and fishes, such as arrow squids (*Nototodarus* spp.), octopus, a variety of lanternfishes (myctophids), hoki (*Macruronus novaezelandiae*), and jack mackerel (*Trachurus* spp.) (Harcourt 2001, Boren 2010). The diversity of their diet is reflected in the foraging behaviour, as New Zealand fur seal conduct foraging dives in different water masses and at different depths, ranging from inshore to continental shelf and oceanic waters, and from the surface to over 300 m water depth (Goldsworthy et al. 2003).

Females stay close to breeding sites during summer following pupping, and during that time their foraging does not greatly extend beyond the continental shelf; in autumn and winter, they forage at greater distances from breeding colonies and in deeper waters (Harcourt 2001). Adult males forage in continental slope waters, whereas juveniles conduct their foraging dives in oceanic waters.

3.4.2 New Zealand sea lion

New Zealand sea lion *Phocarctos hookeri* are endemic to New Zealand, with the main breeding colonies in the subantarctic region, on Auckland and Campbell islands (Childerhouse & Gales 1998). The former island group in particular is an important breeding site, supporting more than 70% of the total pup production (Ministry for Primary Industries 2012).

Pups are also occasionally born at haul-out sites in southern South Island, most frequently on Otago Peninsula, where a small sea lion population is currently re-colonising mainland New Zealand (McConkey et al. 2002). Pupping has also been reported on Stewart Island (Ministry for Primary Industries 2012).

The distribution and abundance of New Zealand sea lion were greatly reduced by subsistence hunting and commercial sealing, and this species has recovered to some extent after being close to extirpation due to exploitation. Their historical range included the North and South islands in addition to subantarctic islands (Childerhouse & Gales 1998). Although their current distribution is restricted, haul-out sites are more widely distributed than breeding colonies (Gales & Fletcher 1999). These haul-out sites are mostly used by adult and sub-adult males, and include sites at Macquarie Island, Stewart Island, islands in Foveaux Strait and Otago Peninsula. Individual sea lion have also been sighted at other South Island locations.

The current population estimate of New Zealand sea lion is approximately 11 000–13 000 individuals (Ministry for Primary Industries 2012). Pup counts are regularly carried out on Auckland Islands (e.g.,

Chilvers et al. 2007), and these data form the basis for estimating the Auckland Islands population size. The most recent estimate of this population was in 2009, with an estimated 12 065 individuals (90% c.i.: 11 160 to 13 061) (Ministry for Primary Industries 2012). The pup count data and Bayesian population models (used to estimate sea lion population size) indicate a decline of 23% in the Auckland Islands population between 1995 and 2009.

The population decline in recent years has been related to a period of decline in pup production on Auckland Islands (40% between 1998 and 2010)(Childerhouse & Gales 1998, Gales 2012, Ministry for Primary Industries 2012). This decline has been linked to a series of three epizootic (bacterial) disease outbreaks in 1998, 2002, and 2003, causing high mortality of pups (and also of individuals in other age classes). The drop in pup production in 2002 was also attributed to the failure of philopatric females to return to breeding areas, with possible reasons including indirect and direct fisheries interactions (Robertson & Chilvers 2011).

In addition to the subantarctic breeding colonies, a small population of New Zealand sea lion has established itself on Otago Peninsula since 1994 (McConkey et al. 2002, Robertson & Chilvers 2011). This population produces about four to five pups a year, with 45 pups born between 1994 and 2010 (less than 0.001% of the annual pup production), and female pups remaining and breeding in this region (Augé et al. 2011, Robertson & Chilvers 2011). Pups have also been born on Stewart Island, with 25 pups tagged in March 2012 (Ministry for Primary Industries 2012).

Male New Zealand sea lion reach sexual maturity at five years of age, but usually do not have access to females until they are about eight to ten years old and hold territories (Boness 2009, Gales 2012). Females are sexually mature when they are between three and four years old; the average age of reproductive females is 10.75 years (Childerhouse 2008). Pups are born in summer after a gestation period of 12 months, with females usually pupping within two to three days of returning to breeding sites between early December and early January (Chilvers et al. 2005). Seven to ten days after pupping, sea lion mate again, following an annual breeding cycle.

The lifespan of New Zealand sea lion has been estimated to be at least 23 years for males and 26 years for females (Childerhouse 2008).

New Zealand sea lion prey on a variety of benthic and pelagic species, including vertebrates and invertebrates, such as hoki, opalfish, rat-tails, and octopus and squids (Gales 2012, Meynier et al. 2010).

Their feeding behaviour involves extensive foraging trips and dives to considerable depths (in excess of 600 m), with differences in foraging noted between males and females and between different regions (Chilvers et al. 2005, Chilvers 2009, Augé et al. 2011, Leung et al. 2012). For example, male juvenile sea lion at Auckland Islands undertake foraging trips to the 500-m depth contour of the shelf, travelling over 100 km, whereas female juveniles forage mostly within 50 km of Auckland Islands (Leung et al. 2012). In the Otago region, satellite-tracking showed that female sea lion feed in coastal and mid-shelf waters within the narrow continental shelf, in contrast to females at Auckland Islands that feed mostly at the edge of the continental shelf or above the continental slope (Augé et al. 2011).

3.4.3 Southern elephant seal

In contrast to fur seals and sea lions, elephant seals have a predominantly pelagic lifestyle, spending considerable periods of time in offshore waters (Campagna 2008, Hindell & Perrin 2009). Globally, there are two species of elephant seal, with a northern and a southern species found in the respective hemispheres. Both species are renowned for their long-distance movement and deep-diving abilities,

spending up to seven months per year at sea.

During this pelagic phase, elephant seal are solitary, while they form groups when on land, where they breed, pup and moult (Campagna 2008). Southern elephant seal *Mirounga leonis* have a nearly circumpolar distribution in the Southern Hemisphere, with breeding sites on subantarctic islands, and separate feeding areas for males and females (Hindell & Perrin 2009). There is no recent population estimate throughout the species' entire distributional range, but the global population estimate in the mid-1990s was approximately 650 000 individuals (Campagna 2008).

Female southern elephant seal reach sexually maturity at 3–5 years and males at 4 years of age, but few individuals start breeding before they are 10 years old (Campagna 2008). Furthermore, natural mortality rates are high, with 90% of males and females dying before they are 10 and 14 years old, respectively. Pups are only nursed for 23 days.

The estimated size of the New Zealand southern elephant seal population is about 250–260 individuals, a decrease from a previous 1990s estimate of 420 individuals (Baker et al. 2010a). The small New Zealand population is considered part of a large Australasian population based at Macquarie Island, with breeding in New Zealand waters mostly restricted to small areas on Antipodes and Campbell islands.

4. MARINE MAMMAL INTERACTIONS WITH COMMERCIAL FISHERIES IN NEW ZEALAND

A substantial proportion of marine mammal interactions with fisheries involve passive fishing gear, particularly gill and set nets, but also traps and pots (Read et al. 2006). In addition, incidental captures and entanglements of marine mammals also occur in fishing operations using mobile gear, such as trawling, purse seining and longlining (Wise et al. 2007). Interactions with trawl fisheries result in the bycatch of a variety of marine mammal species, often causing mortality, with at least 25 cetacean species and 20 pinniped species affected globally (Woodley & Lavigne 1991, Fertl & Leatherwood 1997, Zollett & Rosenberg 2005).

For some species, incidental captures have been related to the sharing of common resources, as fisheries exploit the same target species as marine mammals in a particular area, or target different species in the same area. In addition, some marine mammal species are attracted to fishing vessels (e.g., trawlers and longlining vessels), owing to the increased food availability, as they feed on fish and discarded bycatch around vessels, and also forage on captured fish (Wickens 1995, Jaiteh et al. 2012). The latter interaction known as "depredation" has been documented for a number of species, especially delphinids such as bottlenose dolphin that routinely swim in and out of active trawl nets to feed, with pinnipeds also known to enter and exit moving nets (Browne et al. 2005, Jaiteh et al. 2012). Incidental captures of baleen whales in longlining gear have also been occasionally reported, although this bycatch has been attributed to individuals becoming entangled inadvertently during their natural foraging activities and movement through areas that contain longlining gear (Gilman et al. 2006).

The most exceptional marine mammal-fisheries interaction on a global scale involves the bycatch of dolphins in the tuna purse-seine fishery in the eastern tropical Pacific Ocean (ETP)(Joseph 1994, Bratten & Hall 1996, Gerrodette 2009). Although incidental captures of marine mammals (both cetaceans and pinnipeds) have been documented in other purse-seine fisheries (Neilson 2006, Hamer et al. 2008, Carretta et al. 2012), dolphins are intentionally targeted in ETP purse-seine operations to detect and capture yellow-fin tuna (*Thunnus albacares*). Since the start of this fishery in the late 1950s, these "dolphin sets" have resulted in the incidental mortality of an estimated six million dolphins, even though large numbers of dolphins are released alive (Gerrodette 2009). The main dolphin species involved in these incidental captures are spotted (*Stenella attenuata*), spinner (*Stenella longirostris*) and common

(*Delphinus* spp.) dolphins (Gerrodette & Forcada 2005). Since the 1980s, management measures have led to more than a 99% reduction in incidental captures, but some dolphin populations are still failing to show signs of recovery; the repeated capture and live release of many individuals is considered to also contribute to the impact on regional dolphin populations (Gerrodette & Forcada 2005). The current bycatch level in the ETP tuna fishery is still significant, with 1500 dolphins caught per year (Gerrodette 2009).

The present report presents a synthesis of available information of incidental captures and mortalities of the 35 marine mammal taxa that reside in or migrate through New Zealand waters. Bycatch information was obtained from a variety of sources, including government fisheries observer and strandings data, scientific reports and publications, theses, ad hoc observations and anecdotal accounts, and also individual reports and studies of incidental captures involving different marine mammal species. For species for which little or no data were available from New Zealand, information on related species and from elsewhere was included to describe the nature and extent of potential interactions that may arise when a species' spatial distribution overlaps with that of commercial fisheries.

Data are summarised according to the three main groupings of marine mammals taxa occurring in the New Zealand region, including mysticete, odontocete, and pinnipeds.

Government fisheries observer data for the period between 1992–93 and 2011–12 show that interactions between marine mammals and commercial fisheries in New Zealand waters involved a range of cetacean and pinniped species (see summary of data from the Centralised Observer Database (COD) in Table 6). Observer coverage varied between different fisheries over this period; it was 7.5% in trawl fisheries, 3.6% in surface-longline fisheries, 10.6% in bottom-longline fisheries, and 0.5% in set-net fisheries. Observed captures occurred in trawl, surface-, bottom-longline, and set-net fisheries involving different target species, with most captures reported from trawl fisheries. There were no observed marine mammal captures in other commercial fisheries. Baleen whales were only identified in one observed capture (humpback whale).

Most observed bycatch of cetaceans was of common dolphin, with 152 incidental captures recorded for this period by government fisheries observers. For pinnipeds, there were significant numbers of observed New Zealand fur seal captures in trawl and also surface-longline fisheries, with a total observed bycatch of 3595 individuals between 1992–93 and 2011–12. The majority of observed fur seal captures in trawl fisheries involved mortalities (2607 bycatch mortalities compared with 289 live captures), whereas most of the observed captures in surface-longline fisheries involved live releases (643 live captures compared with 34 mortalities), although the post-escape survival of captured fur seal is generally unknown. New Zealand sea lion were also mostly captured in trawl fisheries, with 296 (of a total 297) observed captures involving trawling compared with one capture in surface longlines.

Other than marine mammal species that reside in or migrate through New Zealand waters, there were three observed incidental captures of leopard seal, all involving trawl fisheries.

In addition to the government fisheries observer data, there was a designated observer programme on the South Island east coast in the 1997–98 fishing year, implemented by Department of Conservation (Starr & Langley 2000). This programme was focused solely on monitoring Hector's dolphin bycatch, and involved observers by the (then) New Zealand Seafood Industry Council (NZSeaFiC). Under this programme, there were eight observed incidental captures of Hector's dolphin in set nets (six mortalities and two live releases), and one observed Hector's dolphin bycatch mortality in trawl fisheries (Table 6).

Earlier records of cetacean bycatch in New Zealand waters are presented in some of the annual progress reports to the IWC (e.g., Cawthorn 1992). These research reports include incidental captures that were

Table 6: Total number of marine mammal captures in commercial fisheries as reported by government observers (recorded in the Centralised Observer Database, COD) between the 1992–93 and 2011–12 fishing years in New Zealand's Exclusive Economic Zone. In addition to government observers, observer effort involved New Zealand Seafood Industry Council (NZSeaFIC) observers in trawl and set-net fisheries on the South Island east coast in the 1997–98 fishing year. This observer programme was focused on Hector's dolphin captures, with one observed capture in trawl fisheries and eight observed Hector's dolphin captures in set-net fisheries reported by NZSeaFIC observers. The captures reported by observers included both animals that were killed, and animals that were released alive. The fisheries involved were trawl, surface-longline (SLL), bottom-longline (BLL) and set-net (SN) fisheries. Effort data are number of tows for trawling, thousands of hooks for longlining, and kilometres of net for set netting.

Species	Fishery				Total
	Trawl	SLL	BLL	SN	
New Zealand fur seal	2901	678	4	12	3595
New Zealand sea lion	297	1			298
Common dolphin	155	2			157
Long-finned pilot whale	21	2	3	1	27
Bottlenose dolphin	22	1			23
Dusky dolphin	8	2		5	15
Hector's dolphin	1			13	14
Whale (unspecified)		7			7
Leopard seal	3				3
Humpback whale		1			1
Pinniped (unspecified)	1				1
Sperm whale		1			1
Dolphin (unspecified)		1			1
Elephant seal	1				1
Total effort	2 507 106	101 780	909 277	561 347	
Observed effort	146 872	19 132	62 549	1 958	
Observed (NZSeaFIC)	433			260	
% Observed	5.88	18.80	6.88	0.40	

reported to the predecessor of the Ministry for Primary Industries and the Department of Conservation, and also captures documented by government fisheries observers (after the implementation of the observer programme in 1986) (Cawthorn 1988).

Documented incidental captures before April 1992 include an unidentified baleen whale and also three long-finned pilot whale caught in a gillnet, several dolphin species that were captured across different types of fisheries, and an unidentified beaked whale that was captured in trawl fisheries (Table 7)(see Cawthorn 1981, 1982, 1983, 1986, 1988, 1990, 1991, 1992, 1993). In addition, bycatch records for the year from May 1980 to May 1981 also included observed captures of an estimated 120 to 150 individuals of dusky, common and Hector's dolphins (reported as species combination without individual breakdown) in deep-set set nets around Kaikoura, and an estimated six Hector's dolphin in set nets in shallow coastal waters around Banks Peninsula (Cawthorn 1982). Some of the reported incidents include information of the capture location, with incidental captures of Hector's dolphin in North Island locations (e.g., off Taranaki and Waiheke Island) indicating the involvement of the Maui's dolphin subspecies (Cawthorn 1979, 1982).

Subsequent records of cetacean bycatch in New Zealand waters included in the IWC reports involve a range of species, from baleen and beaked whales to a number of dolphin species (Table 8) (Donoghue 1994, 1995, 1996). As these later reports generally lack the exact date, fishing method, and location of the capture events, it is not possible to reconcile the bycatch records with incidental captures recorded in

Table 7: Incidental captures of cetaceans in commercial fisheries in New Zealand waters as reported in annual research progress reports to the International Whaling Commission between June 1979 and April 1992. The fisheries involved were trawl, set-net (SN), lobster pot (pot), purse-seine (PS) and unspecified fisheries.

Species	Fishery				
	Trawl	SN	Pot	PS	Unspecified
Unidentified baleen whale		1			
Common dolphin	73		3	11	
Dusky dolphin	3	5			4
Hector's dolphin	2	30			1
Unidentified dolphin	1				
Killer whale	1				
Pilot whale		3			
Unidentified beaked whale	1				

the fisheries observer database (COD), even though they cover part of the same time period (i.e., from January 1993 to March 1995). Nevertheless, this information is presented here as it includes bycatch data of species not recorded in COD, including sei, killer, and Gray's beaked whales (Donoghue 1994, 1995).

Table 8: Incidental captures of cetaceans in commercial fisheries in New Zealand waters as reported in annual research progress reports to the International Whaling Commission between January 1993 and March 1995. The fisheries involved were trawl and unspecified fisheries.

Species	Fishery	
	Trawl	Unspecified
Humpback whale		1
Sei whale		1
Unidentified whale		2
Bottlenose dolphin		22
Common dolphin	17	36
Dusky dolphin		1
Hector's dolphin	2	11
Killer whale		1
Pilot whale		8
Gray's beaked whale		2

The strandings database, administered by Department of Conservation (Department of Conservation 2013b), also contains records of stranded or beachcast marine mammals that showed signs of entanglement (i.e., through evidence in the form of scars and injuries, or attached gear) (Table 9). Although these data do not generally allow distinction between commercial and recreational fisheries, identification of the type of fishery involved, or any kind of quantification of entanglement incidents, they provide an indication of the species involved. Some strandings clearly identify species, while other records only use generic terms.

Overall, there were few records of entanglements involving stranded baleen whales, with one to two stranded individuals with entanglements for unspecified blue, dwarf minke, Bryde's, and humpback whales. There were markedly more entanglement records amongst odontocetes, with generally higher numbers of stranding events and of the individuals involved in strandings. The highest number of

strandings associated with entanglements was 45 Hector's dolphin (subspecies not specified), followed by 28 common dolphin and 18 dusky dolphin. Although there was only one record each for long-finned and short-finned pilot whales, the former species had the highest number of stranding records, with 280 stranding events involving 7852 individuals.

Amongst beaked whales, there were frequent stranding events of Gray's beaked whale (252 events invovling 391 individuals), with 91 and 84 stranded inviduals of strap-toothed whale and Cuvier's beaked whale, respectively. Strandings of this group of cetaceans only included 2 records of entanglement, with one Cuvier's and one Gray's beaked whale.

Similarly, there was only one stranded New Zealand fur seal (of a total 14 stranded individuals) with signs of entanglement.

Table 9: Summary of marine mammal strandings in New Zealand, recorded in the Department of Conservation strandings database between 1970 and 2013. Included are the total number of stranding events (Strandings), the number of individuals involved, the number of individuals that showed signs of entanglement, and the status of individuals that stranded (alive, dead). Stranding records of blue whale, Hector's dolphin, pilot whale and *Mesoplodon* sp. did not distinguish (sub)species.

Species	Strandings	Individuals	Entanglements	Alive	Dead
Blue whale (unspecified)	8	8	1	0	6
Pygmy blue whale	3	3	0	0	3
Antarctic minke whale	17	17	0	10	7
Dwarf minke whale	85	85	1	34	36
Bryde's whale	33	34	2	5	26
Fin whale	7	7	0	0	2
Sei whale	4	4	0	0	3
Humpback whale	20	20	2	2	15
Southern right whale	2	2	0	0	2
Pygmy right whale	49	50	0	11	36
Balaenoptera sp.	16	16	0	1	13
Sperm whale	211	422	1	31	127
Pygmy sperm whale	355	441	0	154	131
Bottlenose dolphin	157	323	6	52	87
Common dolphin	478	2301	28	88	323
Dusky dolphin	107	137	18	19	73
Hourglass dolphin	3	4	1	0	3
False killer whale	16	322	0	7	5
Hector's dolphin	249	260	45	9	194
Killer whale Type A	45	67	1	19	18
Long-finned pilot whale	280	7852	1	104	127
Short-finned pilot whale	12	149	0	4	8
Southern right whale dolphin	16	100	0	3	5
Toothed whale (unspecified)	4	4	0	0	4
Pilot whale (unspecified)	21	576	1	4	12
Andrews' beaked whale	19	24	0	1	16
Cuvier's beaked whale	82	84	1	17	47
Dense-beaked whale	3	3	0	0	3
Gray's beaked whale	252	391	1	58	153
Hector's beaked whale	12	13	0	2	7
Strap-toothed whale	78	91	0	20	43
Spade-toothed whale	1	2	0	1	0
Shepherd's beaked whale	17	17	0	1	14
Southern bottlenose whale	24	31	0	8	7
Mesoplodon sp.	60	73	0	15	32

4.1 Baleen whales - Mysticetes

For large-sized baleen whales, the majority of fisheries interactions typically relates to entanglement in fishing gear, mostly involving static gear (gill and set nets, trap and float lines), with fewer records regarding longlines, trawl nets, purse seines and other gear (Fertl & Leatherwood 1997, Johnson et al. 2005)(see summary of baleen whale interactions with commercial fisheries in Table 10). As baleen whales feed on zooplankton and small fishes, they are not attracted to fishing operations like toothed whales and pinnipeds; however, they may forage in the same highly productive areas that also support commercial fisheries.

Table 10: Reported interactions between baleen whales and fisheries (SLL, surface longlining; BLL, bottom longlining; n.d., no data).

Common name	Scientific name	Fishing method	Global bycatch	New Zealand bycatch
Dwarf minke whale	*Balaenoptera acutorostrata*	Trawl	Fertl & Leatherwood (1997), Song et al. (2010)	n.d
		Gill/set/drift net	Waerebeek & Reyes (1994), Song et al. (2010), Benjamins et al. (2011), Kot et al. (2012)	n.d
		Pots/traps	Northridge et al. (2010), Song et al. (2010), Benjamins et al. (2011), Kot et al. (2012)	n.d
		Purse seine	Waerebeek & Reyes (1994), Song et al. (2010)	n.d
		Unspecified	Groom & Coughran (2012)	n.d
Bryde's whale	*Balaenoptera edeni/brydei* sp	SLL	Forney & Kobayashi (2007)	n.d
		Gill/set/drift net	Shark nets - Mëyer et al. (2011)	n.d
		Pots/traps	Groom & Coughran (2012)	n.d
		Purse seine	Western and Central Pacific Fisheries Commission (2012)	n.d
		Unspecified	Cassoff et al. (2011), Hoop et al. (2012)	Lloyd (2003)
Fin whale	*Balaenoptera physalus*	Gill/set/drift net	Sciara et al. (2003)	n.d
		Pots/traps	Sciara et al. (2003)	n.d
		Purse seine	Amandè et al. (2010)	n.d
		Unspecified	Waring et al. (2010), Hoop et al. (2012); drifting longline (Sciara et al. 2003)	n.d
Sei whale	*Balaenoptera borealis*	Purse seine	Romanov (2002), Western and Central Pacific Fisheries Commission (2012)	n.d
		Unspecified	Waring et al. (2010), Hoop et al. (2012)	Donoghue (1995)
Humpback whale	*Megaptera novaeangliae*	SLL	Waring et al. (1990), Forney & Kobayashi (2007)	NZ observer data
		Gill/set/drift net	Johnson et al. (2005), Félix et al. (2006), Carretta et al. (2012)	n.d
		Pots/traps	Johnson et al. (2005), Carretta et al. (2012), Groom & Coughran (2012)	Lloyd (2003); Department of Conservation (unpubl. data); Department of Conservation (2013b)
		Purse seine	Volgenau et al. (1995), Neilson (2006), Amandè et al. (2010), Waring et al. (2013)	n.d
		Unspecified	Johnson et al. (2005), Groom & Coughran (2012)	Donoghue (1995)
Southern right whale	*Eubalaena australis*	Trawl	*Eubalaena glacialis* - Waring et al. (1990)	n.d
		BLL	*Eubalaena glacialis* - Vanderlaan et al. (2011)	n.d
		SLL	*Eubalaena glacialis* - Vanderlaan et al. (2011)	n.d
		Gill/set/drift net	*Eubalaena glacialis* - Johnson et al. (2005), Vanderlaan et al. (2011)	n.d
		Pots/traps	Groom & Coughran (2012); *Eubalaena glacialis* - Johnson et al. (2005), Vanderlaan et al. (2011)	n.d
		Purse seine	*Eubalaena glacialis* - Johnson et al. (2005)	n.d
		Unspecified	n.d	Lloyd (2003)

Entanglements are particularly common in coastal species that co-occur with commercial fisheries (Song et al. 2010, Hoop et al. 2012). Lines, netting, and other materials get wrapped around the body of the affected animal, frequently in the tail region, i.e., the leading edges of the flukes and the caudal peduncle, causing characteristic scarring (Hamilton et al. 1998). Owing to their size and strength, baleen whales are often able to break free from fishing gear after becoming entangled, so that immediate fisheries-related mortalities such as drowning are relatively rare (Clapham et al. 1999). Nevertheless, immediate bycatch fatalities do occur, often involving smaller-sized minke whales and juveniles (Northridge et al. 2010, Song et al. 2010). Furthermore, fishing gear that remains attached to the whales can cause serious injuries and subsequent mortality, with fatal gear entanglements confirmed as a significant source of mortality for some baleen whale populations, such as humpback and northern right whales in the western North Atlantic Ocean (Volgenau et al. 1995, Knowlton et al. 2012). The generic nature of fishing gear makes it often difficult to assign these mortalities to a specific fishery (Johnson et al. 2005).

A study of large whale entanglements in the western North Atlantic Ocean used an extensive data set to identify commercial fisheries that pose a particular risk to populations off Newfoundland and Labrador, Canada (Benjamins et al. 2011). This assessment included 1209 records (including spatial information) of large whale entanglements in different fisheries between 1979 and 2008. Most of the entanglements involved two baleen whale species, humpback whale (about 80% of records) and minke whale (*B. acutorostrata*, 15%), with entanglements of fin, killer, bowhead and North Atlantic right whales also documented. Over 600 of these entanglements resulted in live releases, compared with the mortality of 267 entangled whales, indicating that around a quarter of all reported entanglements (24%) resulted in fatalities.

The gear involved was identified in 1123 entanglements, and consisted mostly of gill and drift nets, traps and pots, and rope without identifying fishing gear, but attached to floats, marker buoys and anchors. Over the study period, there were discernible differences in the spatial distribution of entanglements and the types of gear involved, which seemed to be related to the implementation of a moratorium on Atlantic cod in 1992. The moratorium and the closure of other fisheries at the same time such as pelagic gillnet fisheries targeting Atlantic salmon, caused a shift in fisheries, such as the expansion of snow crab and other pot trap fisheries (e.g., lobster) in deep inshore and offshore waters. These changes were evident in the entanglement data, including an increase in the number of entanglements recorded offshore, entanglements in pot gear becoming more common, and records of humpback whale entanglements decreasing after 1992 (Benjamins et al. 2011).

The fishing gear involved in right whale and humpback whale entanglements studied in another part of the western North Atlantic Ocean was also predominantly "fixed gear", defined as bottom or sink gillnets and pots, set on the seafloor and in the water column, with connecting lines extending to the water surface (Johnson et al. 2005).

A Danish seine was implicated in the mortality of an entangled North Atlantic right whale (Johnson et al. 2005), and weir and purse-seine gear (combined category) was identified in nine non-fatal humpback whale entanglements observed in the Gulf of Maine between 1975 and 1990 (Volgenau et al. 1995). Other baleen whale species involved in interactions with purse-seine fisheries include Bryde's and sei whales in the tropical western and central Pacific Ocean, with some of these interactions resulting in mortality (Western and Central Pacific Fisheries Commission 2012). Observers in this tuna fishery also recorded interactions with unspecified baleen whales, i.e., individuals that were partially or fully encircled by the purse-seine nets, with 21 individuals involved in 18 non-fatal interactions in 2009.

Within New Zealand waters, there have been few observed incidents of baleen whales becoming entangled, and these entanglements have also involved aquaculture operations (Lloyd 2003). The species involved in the entanglements with fishing gear were southern right whale and humpback whale, with

all reported incidents involving lobster pots and lines. On average, large whale entanglements in New Zealand waters have been estimated at two individuals per year since 2000 (International Whaling Commission 2012).

4.1.1 Blue whales

Blue whales are seldom included in bycatch data, and there has been no observed bycatch of either subspecies in New Zealand waters between 1992–93 and 2011–12 (Table 6). There were 11 blue whale stranding events in the strandings data, including three records of pygmy blue whale and eight records without identification of the blue whale subspecies (Table 9). Only one of the pygmy blue whale strandings included signs of entanglement, which was an individual that had died recently.

There are generally few data on fisheries interactions involving blue whales. These baleen whales are most common in offshore waters with occasional sightings in coastal areas (National Marine Fisheries Service 2012, Torres 2013).

Owing to their predominantly offshore distribution, they are considered unlikely to interact with fisheries, while any incidents that do occur may remain unnoticed (Heyning & Lewis 1990, Zollett 2009). Furthermore, species identifications of blue whale subspecies can be ambiguous as it is difficult to distinguish them at sea (Jefferson et al. 2008).

There were no recorded blue whale mortalities between 1970 and 2009 included in a recent study on human-caused mortality of baleen whales in the Northwest Atlantic Ocean (Hoop et al. 2012). Similarly, there was no observed blue whale bycatch in United States marine mammal stock assessments for the Northwest Atlantic Ocean and Gulf of Mexico between 2004 and 2008 (Waring et al. 2010). The only fishery considered to pose a threat to large baleen whales (including blue whales) in United States waters of the North Pacific Ocean is the offshore drift gillnet fishery (Carretta et al. 2012). These fisheries target sharks and swordfish in the Baja California/Mexican region of the Pacific Ocean and have been identified as a potential threat to baleen whales, while observer coverage in these offshore fisheries has been too low to detect mortalities.

4.1.2 Minke whales

New Zealand fisheries observers did not record any Antarctic minke or dwarf minke whale bycatch between 1992–93 and 2011–12 (Table 6). There were 85 stranding events of dwarf minke whale in the strandings database, including one recently dead individual with signs of entanglement (Table 9). There were no records of entanglement of Antarctic minke whale.

Dwarf (or common) minke whale *Balaenoptera acutorostrata* are relatively small-sized baleen whales, and this characteristic, together with their wide distribution that often extends into coastal habitats make this species susceptible to fisheries interactions in both hemispheres (Kot et al. 2012).

Fisheries impact on dwarf minke whale include direct mortalities and non-acute entanglements, with injuries from ropes and other fishing gear often persisting and adversely affecting individuals (Kot et al. 2009). Necropsies of stranded minke whale in the Northwest Atlantic Ocean revealed detailed information on the causes of death for some of the lethal entanglements, including impaired foraging and starvation, systemic infection, and asphyxia from drowning (Cassoff et al. 2011). This species was the second most commonly reported large whale species (15%, after humpback whale) affected by nearshore fisheries in eastern Canada between 1979 and 2009 (Benjamins et al. 2011, Kot et al. 2012),

with entanglement in fishing gear highlighted as the presumed leading cause of death for this species in United States and Canadian waters (Hoop et al. 2012). Interactions with fishing gear mostly involved crab pots, cod traps and gillnets, with buoy lines and end or anchor lines in gillnet systems frequently implicated in incidental entanglements.

Lethal and non-acute entanglements of dwarf minke whale have also been reported from other regions, including Scotland/United Kingdom, where entanglements in lines and ropes used with creels (a type of crustacean pot) have been identified as the cause of death for several minke whale (and other baleen whale species)(Northridge et al. 2010). Observer data of baleen whale entanglement in Western Australia included one record of dwarf minke whale, although the gear involved could not be identified (Groom & Coughran 2012). In South Africa, entanglements in lobster pots and shark nets between 1981 and 2009 included 10 minke whale (Mëyer et al. 2011), with bycatch mortalities in South America including a neonatal female and a juvenile male minke whale in artisanal gillnet fisheries in central Peru, with another individual (presumably *Balaenoptera acutorostrata*) drowning in purse-seine nets (Waerebeek & Reyes 1994). United States fisheries observers reported the incidental capture (and live release) of a dwarf minke whale in tuna longline fisheries in the Atlantic Ocean (Waring et al. 1990).

Although dwarf minke whale bycatch has been reported in trawl fisheries (Fertl & Leatherwood 1997), data predominantly indicate the involvement of stationary gear. Dwarf minke whale entanglements in South Korean waters confirm this pattern: most entanglements (about 96% of a total 214 recorded entanglements between 2004 and 2007) involved three types of gear (at similar proportions): set nets, gillnets, and pots (Song et al. 2010). The remainder involved bottom trawls, purse seines, and other trawls. All of the minke whale entanglements resulted in mortality, which was attributed to the relatively small size of this baleen whale and its inability to free itself from attached fishing gear compared with larger species. The majority of incidents (87%) occurred in relatively shallow, coastal waters at water depths between 10 and 220 m within 10 n. m. (18.5 km) of the coast, with significantly smaller (i.e., shorter) individuals captured in these coastal areas compared with deeper, offshore waters. Bycaught individuals were also significantly smaller in set nets than in pots and gillnets. With an estimated 100–150 individuals becoming entangled in the East Sea of Korea each year, the minke whale population in this region has been predicted to continue to decrease and become extinct in the next few decades owing to entanglement in fishing gear (Song et al. 2010).

This species' frequent occurrence in coastal waters and the concomitant risk posed by stationary fishing gear, particularly vertical lines in the water column, has led to research into minke whale behaviour around fishing gear and gear detection (Kot et al. 2012).

4.1.3 Bryde's whale

Similar to other large whale species, i.e., those in coastal waters, Bryde's whale in New Zealand are potentially susceptible to injuries and mortality resulting from entanglement in fishing gear, although available data imply that these types of interaction are rare. There are no entanglement records between 1992–93 and 2011–12 that identify this species in the fisheries observer data.

There were 34 Bryde's whales recorded in 33 stranding events, with two individuals showing signs of entanglement (Table 9). Most documented Bryde's whale mortalities where the cause of death has been identified have been related to ship collision (in Hauraki Gulf), with only three incidents of entanglements reported; two of these entanglements occurred in aquaculture operations (Lloyd 2003, Wiseman 2008).

In other regions, bycatch and entanglement records of Bryde's whale (both subspecies) indicate that few individuals are incidentally captured in fisheries, with entanglements documented for longlining and net

fisheries. Forney & Kobayashi (2007) used observer data from 1994–2004 to estimate the bycatch of cetaceans in longline-fisheries in the central North Pacific Ocean, and reported one incidental capture of Bryde's whale (*Balaenoptera edeni*). This bycatch was observed in the shallow-set swordfish component of the fishery and noted as a non-serious injury. Based on the total and observed fishing effort, the estimated bycatch rate of Bryde's whale in longline fisheries in this region was 0.4 individuals per 1000 sets, with an estimated 0.3 individuals per 1000 sets bycaught in longlines targeting swordfish.

Other records of Bryde's whale include entanglement mortalities in fisheries in United States and Canada, but the fisheries involved were not identified (Cassoff et al. 2011, Hoop et al. 2012). These unspecified fishing gear entanglements included two Bryde's whale mortalities in the Northwest Atlantic Ocean in over 40 years of data (1970–2009). There was one non-fishing related record of Bryde's whale mortality in shark nets in South Africa for the period between 1981 and 2009, indicating that this species is potentially susceptible to captures in nets (Mëyer et al. 2011).

There are occasional reports of incidental captures of Bryde's whale in purse-seine fisheries, such as in the tropical western and central Pacific Ocean (Western and Central Pacific Fisheries Commission 2012). Between 2007–2009, there were three observed Bryde's whale interactions in the tropical purse-seine fishery in this region, based on 19 136 observed sets. These interactions, defined as animals becoming fully or partially encircled in the net, resulted in an observed mortality rate of 0.1 Bryde's whale per 1000 sets, with an estimated mortality of 4 individuals in 2009 (derived from observer data and total number of sets fished).

Bryde's whale do also get occasionally captured in pot and trap fishing gear, which may immobilise the animal involved or greatly reduce its mobility. Examination of observer records from Western Australia between 1982 and 2010 revealed the capture of one Bryde's whale in rock lobster gear, which had anchored the captured baleen whale (Groom & Coughran 2012).

4.1.4 Fin and sei whales

There was one incidental capture of sei whale in an unspecified fishery in New Zealand waters between 1 April 1993 and 31 March 1994 (see Table 8) (Donoghue 1995), but there was no observed bycatch of fin or sei whale recorded in the observer database (COD) for the period between 1992–93 and 2011–12 (Table 6).

There were several stranding events of these species in the strandings data, including seven fin whale and four sei whale stranding events, without any stranded individuals showing signs of entanglement (Table 9).

Data on fisheries interactions involving fin and sei whales are relatively scarce. Similar to blue whales, fin and sei whales are predominantly found in oceanic waters, and generally occur only occasionally in inshore waters (National Marine Fisheries Service 2012). Their offshore distribution makes them less likely to interact with fishing operation, and incidents that do occur may not be recorded (Heyning & Lewis 1990, Zollett 2009). Furthermore, species identifications are not always certain, as some of the species can be easily confused at sea (Jefferson et al. 2008). As a consequence, there have been relatively few records of bycatch mortality and of non-lethal entrapment and entanglement in fishing gear concerning these oceanic baleen whales.

In their assessment of human-caused mortality of baleen whales in the Northwest Atlantic Ocean in the 40-year period between 1970 and 2009, Hoop et al. (2012) identified entanglement as the cause of death for 26 fin and five sei whales. United States marine mammal stock assessments for the Northwest Atlantic

Ocean and Gulf of Mexico between 2004 and 2008 included observed fisheries-related entanglements of 0.6 sei whale per year (2 serious injuries, 1 mortality over the reporting period) and of 1.2 fin whale (three serious injuries, three mortalities) (Waring et al. 2010). The fisheries involved were not identified.

There has been no reported bycatch of sei whale in United States waters of the North Pacific Ocean, and the only fishery considered to pose a threat to this and other large baleen whales in this region is the offshore drift gillnet fishery (Carretta et al. 2012). An early Pacific Ocean study focused on the southern California offshore drift gillnet fishery during the 1980s and estimated an annual mortality of approximately 73 rorquals, which may have included sei whale (Heyning & Lewis 1990).

In the European purse-seine fishery targeting tuna (yellowfin *Thunnus albacares*, bigeye *Thunnus obesus*, and skipjack *Katsuwonus pelamis*) in the Atlantic Ocean, observers reported the bycatch of one fin whale that was released alive (Amandè et al. 2010). Incidental captures of sei whale in tuna purse-seine fisheries have been documented by observers in the western and central Pacific Ocean, with two incidents involving two individuals in 2007–2009, and two incidents involving four individuals in 2010 (Western and Central Pacific Fisheries Commission 2012). None of the interactions resulted in mortality, and based on fishing effort, the corresponding encounter rates were 0.10 and 0.18 encounters per 1000 sets for the two time periods, respectively. In the western Indian Ocean, purse-seines are set on whale-associated schools of skipjack, yellowfin and bigeye tunas, resulting in baleen whale captures including fatalities (Romanov 2002). Between 1986–92, there was one observed bycatch mortality of sei whale in the western Indian Ocean tuna fishery, with observers present on 494 sets during this period.

In the Mediterranean Sea, fin whale entanglements have been linked to driftnet fisheries, while entrapment in other types of fishing gear are considered rare (Sciara et al. 2003). Anecdotal data of fin whale entanglement and mortality between 1986 and 1999 included two individuals that were killed in drift nets, and two separate incidents of a juvenile entangled in drifting longline and in a tuna gillnet; fin whale in coastal areas in this region also become occasionally trapped in traditional tuna trap fisheries during spring.

4.1.5 Humpback whale

In the New Zealand region, fisheries observer data included one humpback whale capture between 1992–93 and 2011–12, which occurred in surface longlines (Table 6).

The strandings database included two humpback whale stranding events (of a total of 20) that involved entanglement, including one live stranding, and one decomposed carcass (Table 9).

Incidents of humpback whale entanglements have also been recorded by Department of Conservation (unpublished data), with nine documented entanglements between 1993 and 2006, two of which involved the same individual. These entanglements include the drowning of a juvenile humpback whale in mooring line (unspecified) in Bay of Plenty, and one individual entangled in netting (unspecified) in Pigeon Bay. The remaining five records refer to individuals that were entangled in lobster pot fishing gear ("craypot lines") around Kaikoura; some of the entangled animals were freed or partially freed (with one person getting killed while attempting to free a humpback whale in 2003).

Humpback whale entanglements, often involving lobster or other pot fisheries, are also frequently reported in other regions. This species was the most prevalent of four large baleen whale species becoming entangled in Western Australia, with 56 (89%) observed entanglements involving humpback whale (Groom & Coughran 2012). The most common gear type was rock lobster gear (29 humpback whale entanglements), followed by eight entanglements with ropes, seven with rope and floats, and one

each in an octopus pot, shark fishing gear, and a sea anchor. Interactions with fixed gear have also been highlighted as causing substantial humpback whale injury and mortality in the western North Atlantic Ocean (Johnson et al. 2005). In 2003, 65% of observed humpback whale *Megaptera novaeangliae* had entanglement scars, with the presence of new scarring occurring at an average annual rate of about 12% (Robbins 2009). Humpback whale in southeastern Alaska showed a similar proportion of individuals with entanglement scarring, with 71% of the population affected, and an 8% rate of increase in new scarring between 2002 and 2003 (Neilson et al. 2009).

Although a wide range of specific gear types was involved in the entanglement of 31 humpback whale (and 31 northern right whale) in the northwestern Atlantic Ocean, the majority (89%) of entanglements was attributed to pot and gillnet gear (Johnson et al. 2005). Similarly, 11 at-sea observations of entangled humpback whale involved pot and trap fishing gear off the United States west coast, with seven entanglements involving unknown gillnet fisheries or other fishing gear including lines and buoys of unknown origin (Carretta et al. 2012). One of the sightings involved an entangled female that was with a calf.

In other regions, humpback whale bycatch has involved surface longlines and gillnets (Waring et al. 1990, Félix et al. 2006, Forney & Kobayashi 2007, Carretta et al. 2012). There was one observed incidental capture (and live release) of a humpback whale in longline fisheries targeting tuna in the Atlantic Ocean (Waring et al. 1990). Similarly, three observed incidents between 1994 and 2004 in Hawaii-based deep-set tuna longline fisheries were classified as non-serious injuries, with one humpback whale entangled in “substantial" line and two floats freeing itself, while two other individuals had line wrapped around the fluke and line and a buoy attached, respectively (Forney & Kobayashi 2007). In the South Pacific, a female humpback whale (with a calf) was entangled in a longline in waters around Cook Islands in 2007, with few data available for this region in general (Carretta et al. 2012).

Incidental captures in artisanal fisheries using multifilament gillnets to target pelagic fish species pose a significant threat to humpback whale during the breeding season (between July and October) in Ecuador (Félix et al. 2006). Based on the number of humpback whale captures recorded in 74 fishing trips (of a total 349 trips), the total bycatch of this species in this fishery was estimated at 25 whales (95% c.i.: 20-32) in the 2005 breeding season. The high number of humpback whale captures appeared to be related to the species' coastal distribution during breeding, making this species particularly susceptible to bycatch in gillnet fisheries.

Humpback whale bycatch is also occasionally reported in purse-seine fisheries. In the Atlantic Ocean, two humpback whale were incidentally captured in a single incident in the European purse-seine tuna fishery, with both individuals being released alive (Amandè et al. 2010). Similarly, the observed bycatch of one humpback whale in purse-seine fisheries in United States waters in 2008 resulted in the live release of the captured animal (Waring et al. 2013). In southeastern Alaska, the coastal purse-seine fishery targeting salmon was involved in 4% of humpback whale entanglements in this region reported to the National Oceanic and Atmospheric Administration between 1997 and 2004 (Neilson 2006).

4.1.6 Southern right whale

There were no observed captures of southern right whale in New Zealand fisheries between 1992–93 and 2011–12 (Table 6). The strandings database included two records involving this species, but without any obvious signs of entanglement (Table 9).

Observations of entangled large whales in New Zealand waters include one southern right whale mortality, involving entanglement in a lobster pot (Lloyd 2003). Entanglements of southern right whale

in Western Australia have also involved fixed gear, i.e., pots and traps (Groom & Coughran 2012). Between 1982 and 2010, there were five records of entangled southern right whale in this region, including (illegal) crab fishing gear (one incident), octopus and rock lobster gear (one incident each), and ropes and float/s (two incidents). One of the entangled individuals was anchored by the fishing gear.

The Northern Hemisphere congener of southern right whale, northern right whale *Eubalaena glacialis* is critically endangered in the western North Atlantic Ocean, with the incidental capture in fishing gear identified as the second most significant human-related cause of mortality after whaling (Cassoff et al. 2011, Knowlton et al. 2012). This right whale population has experienced high levels of entanglement, with about 75% of the population (estimated at 400–450 individuals in 2012) observed with fishing gear attached or with scars that are consistent with entanglement. Some animals in this well-studied population have been entangled more than once, with a higher incident rate in juveniles than adults. Although the entanglements are often not immediately lethal, constrictions from fishing gear, acute wounds, and chronic unhealed wounds lead to mortality over time (Moore et al. 2006).

The types of fishing gear found on entangled northern right whale implicate sink-gillnet, drift-net, Danish seine, and a variety of pot and trap fisheries (Johnson et al. 2005). In the Bay of Fundy and on the Scotian Shelf/Canada, the fisheries involved in northern right whale entanglements included groundfish and pelagic hook-and-line fisheries, groundfish gillnets, and also traps and pots targeting crabs, hagfish, and lobster in inshore and offshore areas (Vanderlaan et al. 2011). Examination of seasonal differences in the gear types involved in the entanglements showed that hook-and-line gear posed the greatest threat during the summer when northern right whale were resident in fished areas, whereas entanglements in lobster fishing gear were more prevalent during spring and autumn migrations.

Recognition of the high number of incidents involving commercial fishing gear prompted the National Marine Fisheries Service in United States to introduce regulations aimed at reducing the frequency and severity of northern right whale entanglements (Knowlton et al. 2012). These management and mitigation measures include spatial and temporal restrictions in some fishing areas, the use of weak links in pot and gillnetting gear, and large whale disentanglement programmes.

Although northern right whale features frequently in entanglement reports, this species is similar to other baleen whale species in that it is rarely included in bycatch data of trawl fisheries (see for example, Fertl & Leatherwood 1997). Nevertheless, there was one observed incidental capture of northern right whale in Atlantic Ocean squid fisheries targeting *Loligo pealei* in off-bottom trawls in slope and shelf waters (Waring et al. 1990).

For southern right whale, Reilly et al. (2008h) noted in their IUCN assessment that mortalities caused by fishing gear entanglement and ship strike are not adversely affecting this species' recovery, as has been shown for North Atlantic right whale.

4.1.7 Pygmy right whale

There are no records of pygmy right whale bycatch in New Zealand fisheries observer data in the period from 1992–93 to 2011–12 (Table 6). There were 49 pygmy right whale stranding events, but none of these records indicated entanglement as a contributing factor (Table 9).

Overall, pygmy right whale is rarely included in bycatch reports, although general information regarding this species states that incidental captures in fishing nets do occur (Kemper 2009). There was one entanglement of this species on the edge of the South Australian Gulf, but the fishery involved was not specified (Kemper 2002).

4.2 Toothed whales - Odontocetes

Similar to baleen whales, incidental captures of toothed whales occur across a wide range of commercial fisheries, involving active gear, such as trawl nets, longlines and purse seines, and also stationary fishing gear, including set nets, pot and traps (Fertl & Leatherwood 1997, Starr & Langley 2000, Noke & Odell 2002, Gerrodette 2009, Hamer et al. 2012)(see summary of toothed whale interactions with commercial fisheries in Table 11). In contrast to large-sized baleen whales, interactions with commercial fisheries are often fatal for a number of toothed whale species, owing to their smaller size and their inability to free themselves once they become entrapped or entangled (Clapham et al. 1999). As a consequence, fisheries-related mortalities have been identified as the most common human-caused mortality for small cetaceans (Perrin et al. 1994, Read & Murray 2000).

As a number of toothed whale species are prevalent in coastal areas, their spatial distributions overlap with different inshore fisheries, while their propensity to form large groups and multi-species aggregations (of up to hundreds to thousands of individuals) can lead to the incidental capture of large numbers of individuals. Furthermore, the attraction to fishing vessels and feeding activities associated with fishing operations that have been documented for different odontocete species increase the risk of incidental capture and bycatch mortality (Bell et al. 2006, Dalla Rosa & Secchi 2007, Jaiteh et al. 2012).

Interactions with fishing gear in the form of depredation has been linked to marine mammal bycatch in different types of fisheries, with a recent review identifying 13 odontocete species engaging in this type of foraging behaviour with longlining operations in all major oceans (Hamer et al. 2012). Although animals do not necessarily get captured while interacting with longlines, interactions can result in entanglement and ingestion of lines and hooks, causing serious injuries and drowning. Bycatch (including mortalities) in longline fisheries has been documented for at least nine odontocete species across different target fisheries and regions (Hamer et al. 2012).

Pot and trap fisheries are also known to be depredated by marine mammals, in particular delphinids (and pinnipeds) interfere with fishing gear to access bait and trapped target species (e.g., fish and crustaceans). Similar to depredation in other fisheries, these activities do not necessarily result in mortality, although fatal interactions with pots and traps have been documented for a number of species, such as bottlenose dolphin in United States commercial crab pot fisheries (Noke & Odell 2002, McFee et al. 2006).

At the same time, a number of odontocetes are intentionally targeted by purse-seine fisheries to detect and capture fishery species such as sardines, anchovies and tuna, resulting in large-scale mortalities of different dolphin species in purse seining operations (Gerrodette 2009).

Furthermore, in addition to life history characteristics that make odontocete species susceptible to human impacts (e.g., late maturity and low reproductive output), disruptions to the social organisation and behaviours of highly social species may also hinder their recovery from these impacts (Wade et al. 2012).

Table 11: Reported interactions between toothed whales and fisheries (SLL, surface longlining; BLL, bottom longlining; n.d., no data).

Common name	Scientific name	Fishing method	Global bycatch	New Zealand bycatch
Sperm whale	*Physeter macrocephalus*	Trawl	Fertl & Leatherwood (1997)	n.d
		SLL	Ashford et al. (1996)	n.d
		Gill/set/drift net	Barlow et al. (1994), Pace et al. (2008), Carretta et al. (2012), Reeves et al. (2013)	n.d
		Purse seine	n.d	Waerebeek & Reyes (1994)
Pygmy sperm whale	*Kogia breviceps*	SLL	Keene et al. (2007)	n.d
		Gill/set/drift net	Barlow et al. (1994), Taylor et al. (2012), Reeves et al. (2013)	n.d
		Purse seine	Taylor et al. (2012)	n.d
Bottlenose dolphin	*Tursiops truncatus*	Trawl	Couperus (1997), Fertl & Leatherwood (1997), Waring et al. (2010)	NZ observer data
		SLL	Hamer et al. (2012), Forney et al. (2011)	NZ observer data
		Gill/set/drift net	Ross & Isaac (2004), Lauriano et al. (2009), Reeves et al. (2013)	n.d
		Pots/traps	Noke & Odell (2002), McFee et al. (2006)	n.d
		Purse seine	Western and Central Pacific Fisheries Commission (2012), Waring et al. (2013), Hammond et al. (2012c)	n.d
Common dolphin	*Delphinus delphis*	Trawl	Northridge (1996), Morizur et al. (1999), Mannocci et al. (2012)	NZ observer data; Cawthorn (1981, 1982, 1983, 1988, 1990, 1991)
		BLL	Hamer et al. (2012)	n.d
		SLL	Forney & Kobayashi (2007), Hamer et al. (2012)	NZ observer data
		Gill/set/drift net	Northridge (1996), Reeves et al. (2013)	Cawthorn (1981), Reeves et al. (2013)
		Pots/traps	n.d	Cawthorn (1981, 1982)
		Purse seine	Hamer et al. (2008), Gerrodette (2009), Western and Central Pacific Fisheries Commission (2012)	Cawthorn (1982)
Dusky dolphin	*Lagenorhynchus obscurus*	Trawl	Crespo et al. (1997), Dans et al. (2003)	NZ observer data; Cawthorn (1988, 1990)
		SLL	Lawson (2001)	NZ observer data
		Gill/set/drift net	Reeves et al. (2013)	NZ observer data; Cawthorn (1982, 1986, 1988, 1992), Brownell & Cipriano (1999), Reeves et al. (2013)
		Unspecified	n.d	Cawthorn (1983), Donoghue (1995)
Hector's dolphins (Hector's and Maui's subspecies	*Cephalorhynchus hectori hectori* and *C. h. maui*	Trawl	n.d	Cawthorn (1990), Starr & Langley (2000), Department of Conservation & Ministry of Fisheries (2007)

(Continued on next page)

Table 11: (*continued*)

Common name	Scientific name	Fishing method	Global bycatch	New Zealand bycatch
		Gill/set/drift net	n.d	NZ observer data; Cawthorn (1979, 1982, 1986, 1988, 1990, 1991, 1992), Starr & Langley (2000), Department of Conservation & Ministry of Fisheries (2007)
		Pots/traps	n.d	Department of Conservation (2013a)
Hourglass dolphin	*Lagenorhynchus cruciger*	Gill/set/drift net	Goodall (2009)	Goodall (2009)
False killer whale	*Pseudorca crassidens*	SLL	Bell et al. (2006), Gilman et al. (2006), Hamer et al. (2012)	n.d
		Gill/set/drift net	Reeves et al. (2013)	n.d
		Purse seine	Western and Central Pacific Fisheries Commission (2012)	n.d
Killer whale Type A	*Orcinus orca*	Trawl	Fertl & Leatherwood (1997)	Cawthorn (1981)
		BLL	Ashford et al. (1996)	n.d
		SLL	Bell et al. (2006), Keene et al. (2007)	Visser (2000a)
		Gill/set/drift net	Carretta et al. (2012), Reeves et al. (2013)	Reeves et al. (2013)
		Unspecified	Benjamins et al. (2011)	Cawthorn (1981), Donoghue (1995)
Long-finned pilot whale	*Globicephala melas*	Trawl	Couperus (1997); *Globicephala* spp. - Waring et al. (1990), Fertl & Leatherwood (1997)	NZ observer data
		BLL	n.d	NZ observer data
		SLL	Keene et al. (2007); *Globicephala* sp. - Waring et al. (2010)	NZ observer data
		Gill/set/drift net	Reeves et al. (2013)	Cawthorn (1982)
		Pots/traps	Lien (1994)	n.d
Short-finned pilot whale	*Globicephala macrorhynchus*	Trawl	Fertl & Leatherwood (1997)	n.d
		SLL	Keene et al. (2007); *Globicephala* sp. - Waring et al. (2010)	n.d
		Gill/set/drift net	Reeves et al. (2013)	n.d
		Purse seine	Carretta et al. (2012), Western and Central Pacific Fisheries Commission (2012), Waring et al. (2013)	n.d
Southern right whale dolphin	*Lissodelphis peronii*	Gill/set/drift net	Hammond et al. (2012b), Reeves et al. (2013); *Lissodelphis borealis*: Barlow et al. (1994), Reeves et al. (2013)	n.d
Beaked whales		Trawl	n.d	Cawthorn (1981)
		SLL	Forney & Kobayashi (2007), Keene et al. (2007), Hamer et al. (2012)	n.d
		Gill/set/drift net	Carretta et al. (2008), Carretta & Barlow (2011), Reeves et al. (2013)	Reeves et al. (2013)

(Continued on next page)

Table 11: (*continued*)

Common name	Scientific name	Fishing method	Global bycatch	New Zealand bycatch
		Purse seine	Western and Central Pacific Fisheries Commission (2012)	n.d
		Unspecified	n.d	Donoghue (1995)

4.2.1 Sperm whale

The New Zealand fisheries observer data from 1992–93 to 2011–12 contain no observations of incidental captures of sperm whale (Table 6).

There have been 211 sperm whale stranding events, involving 422 individuals, including one live stranding of an individual with signs of entanglement (Table 9).

Sperm whale interactions with commercial fishing gear often relate to the depredation of longlines (Hamer et al. 2012), although entanglements and mortalities have also been documented in other gear types. As one of the main species featuring in depredation reports of longline fisheries (together with killer whale *Orcinus orca*, false killer whale *Pseudorca crassidens*, and pilot whales *Globicephala* spp.), sperm whale depredation can cause substantial loss of catch. For example, in the demersal longline fishery targeting sablefish in Alaska, catches were significantly lower (23%) at stations exposed to sperm whale depredation than at stations where sperm whale were absent (Sigler et al. 2003).

In the Southern Hemisphere, sperm whale are renowned for targetting bottom longliners at higher latitudes, such as the Patagonian toothfish fishery in the Southern Ocean, where they regularly become entangled in the fishing line (Kock et al. 2006). Owing to their large size, sperm whale are seldom captured in longlines, so that there are few reported mortalities associated with this depredation behaviour (Ashford et al. 1996), but sperm whale may become injured in lines, as evident in grooved indentations around their head (possibly caused by line running through their mouth) and characteristic scars around the flukes (Donoghue et al. 2003). An individual sperm whale entanglement noted by observers in the Hawaii-based tuna longline fishery between 1994 and 2005 was considered a non-serious injury (Forney & Kobayashi 2007).

In contrast to longline fisheries, there have been a number of sperm whale mortalities in net fisheries, in particularly drift nets, and bycatch has been identified as a significant source of mortality of sperm whale in the Mediterranean Sea (Reeves et al. 2013). Between 1971 and 2004, there were 229 documented incidents of dead and entangled sperm whale off Spain, France, and Italy in illegally set drift nets, and these records are considered to be negatively biased as not all incidental captures are documented (Reeves & Sciara 2006). The social organisation of sperm whale into groups consisting of females and immatures can also result in group entanglements, such as the incidental capture of two adult females and three juveniles in a driftnet, 40 miles off the Italian coast (freed by the Italian coast guard)(Pace et al. 2008).

Offshore drift gillnet fishing is the only fishery considered to have potential bycatch of sperm whale in United States Pacific Ocean waters, with one mortality documented in each of 1996 and 1998 in drift gillnets targeting thresher sharks and swordfish off Oregon and California (Carretta et al. 2012). Based on these data, the sperm whale fishery bycatch for this region was estimated at about one or more individuals between 2004 and 2008. Earlier observer data from the California drift gillnet fishery included three incidental captures of sperm whale each in 1992 and 1993, with one individual being released alive (Barlow et al. 1994). The corresponding bycatch mortalities were estimated at 23 and 22 sperm whale for those years.

On the east coast of United States, there have been no records of sperm whale bycatch, and fisheries-related mortalities have been considered to be less than 10% of the Potential Biological Removal (Zollett 2009).

In their review of interactions of cetaceans with trawl fisheries, Fertl & Leatherwood (1997) included two reports of sperm whale bycatch, involving one and three individuals, respectively, in the Mediterranean

Sea. The same authors also refer to a stranding on the United States west coast, where a stranded sperm whale was found with tightly packed trawl net in its stomach.

In the tuna purse-seine fishery in the western and central Pacific Ocean, whale-associated net sets occasionally involve sperm whale (Western and Central Pacific Fisheries Commission 2012), although bycatch records of this species in purse-seine fisheries appear to be rare. In their account of minke whale entanglements in artisanal gillnet fisheries in South America, Waerebeek & Reyes (1994) referred to one incident of a sperm whale mortality in purse-seining operations.

4.2.2 Pygmy sperm whale

New Zealand observer data did not contain any bycatch records of pygmy sperm whale in the period between 1992–93 and 2011–12 (Table 6). The strandings database included 355 stranding events involving pygmy sperm whale, but none of these strandings included entanglements (Table 9).

Bycatch of this species (and its congener) has been reported from pelagic drift-net fisheries, but incidental captures are considered uncommon, owing to the rarity of this species (McAlpine 2009).

Reeves et al. (2013) estimated the annual bycatch pygmy sperm whale in global gillnet fisheries at one to 30 individuals between 1990 and 2009, with gillnet bycatch of this species documented in Sri Lanka, Taiwan and California/United States (Barlow et al. 1994, Taylor et al. 2012). Small numbers of this species are also occasionally bycaught in gillnet and purse-seine fisheries in the Northeast Atlantic Ocean, although this occasional bycatch is not considered to be a threat (Taylor et al. 2012).

Similarly, incidental captures of this species in longline fisheries seem to be uncommon, with few observer data including pygmy sperm whale. The observer programme of the United States large pelagic longline fisheries included one live capture of pygmy sperm whale in the northwestern Atlantic Ocean between 1992 and 2004, based on about 5% observer coverage (Keene et al. 2007).

4.2.3 Bottlenose dolphin

Observer data of bottlenose dolphin bycatch between 1992–93 and 2011–12 included 22 incidental captures in trawl fisheries and one incidental capture in surface longlining (Table 6). There was also one earlier capture of bottlenose dolphin in the period between April 1988 and May 1989, but the fishery involved in this bycatch was not reported (Table 7) (Cawthorn 1990).

Of the 157 stranding events of bottlenose dolphin in New Zealand waters, six records included entanglement, with four records in Northland, one in Auckland and one in Otago (Table 9). Two stranding events involved two individuals each, with a mother-calf pairing in one of them.

Bycatch observations and data from elsewhere document that incidental captures of this species occur in a wide range of fisheries, including multiple captures in a bycatch event (Wells & Scott 2009, Hammond et al. 2012c). In some incidents, the captured animals were released alive, but bycatch mortality is also common. A global review of cetacean interactions with trawl fisheries included bycatch information for this species from New Zealand, and bottlenose dolphin entanglements and mortalities in trawl gear have also been documented in other regions, including the Gulf of Mexico, across the Atlantic Ocean, the North and Mediterranean seas, and off India, Argentina, and Australia (Fertl & Leatherwood 1997).

The types of trawl fisheries involved in bottlenose dolphin bycatch vary in regards to target species

and operational characteristics. For example on the United States east coast, nine bottlenose dolphin were observed entangled in shrimp trawl gear between 1992 and 2008 (Waring et al. 2010), while earlier observer data from this region (1977–88) indicate that this species was bycaught in trawl fisheries targeting squids and mackerel on the continental shelf and slope (Waring et al. 1990). Bottlenose dolphin was also part of the cetacean bycatch in the Dutch pelagic mid-water trawl fishery targeting mackerel and horse mackerel off southwestern Ireland between 1989 and 1993 (Couperus 1997).

This species is also incidentally taken in longline fisheries, with incidents often linked to depredation of bait and catch (Hamer et al. 2012, Forney et al. 2011). Interactions between bottlenose dolphin and longliners can result in animals becoming entangled in lines and getting hooked, for example in the mouth and throat, as has been observed in the tuna and billfish longline fleet in Taiwan (Donoghue et al. 2003). Similarly, bottlenose dolphin have been bycaught in the United States pelagic longlining fleet targeting tuna, billfish and swordfish in the northwestern Atlantic Ocean, where fisheries observer records included six live captures of bottlenose dolphin in the period between 1992 and 2004 (Keene et al. 2007).

Gillnet bycatch of bottlenose dolphin also includes coastal and pelagic fishing operations, and interactions with gillnet fisheries include depredation behaviour (Ross & Isaac 2004, Lauriano et al. 2009, Reeves et al. 2013). In the offshore gillnet fishery in Northern Australia, bottlenose dolphin was one of the prominent species featuring in observer data of cetacean bycatch between 1981 and 1985 (Harwood & Hembree 1987). Of the 265 captured cetaceans that were identified (in a total of 319 captures), 159 records were bottlenose dolphin, 60% of the bycaught cetaceans. Based on the observer data and total fishing effort, the average cetacean catch rate was 0.801 (s.e.: 0.0956) cetaceans per gillnet set, with an estimated 13 991 cetaceans (s.e.: 1669) bycaught in this fishery between June 1981 and December 1985.

In the mid-Atlantic Ocean, the high documented number of coastal bottlenose dolphin bycatch mortalities was attributed to the gillnet fishery targeting sharks and other fish species (Waring et al. 2010). In this region, bottlenose dolphin bycatch in demersal gillnets targeting cod (*Gadus morhua*) and monkfish (*Lophius americanus*) has exceeded the sustainable level determined by United States National Marine Fisheries Service, resulting in bycatch mitigation measures to reduce captures (Mooney et al. 2007). High bycatch mortality of bottlenose dolphin in the Mediterranean Sea has also caused concerns, with both adults and immatures getting captured in coastal and offshore gillnet fisheries in the Galician fleet in Spanish waters, and in artisanal set gillnet and trammel net fisheries in Italy (Ross & Isaac 2004, Díaz López 2006, Lauriano et al. 2009).

Bottlenose dolphin are also incidentally captured in other net fisheries, including bycatch mortalities in purse seines (Waring et al. 2013) and in pound net fisheries (Schaffler et al. 2011). Documented bottlenose dolphin bycatch in the menhaden purse-seine fishery in the Gulf of Mexico includes fisher-reported bycatch mortalities and also incidental captures recorded by observers (Waring et al. 2013). Between 1992 and 1995, there were nine observed incidental captures (including three mortalities) of bottlenose dolphin in this purse-seine fishery. In the tropical purse-seine fishery in the western and central Pacific Ocean, observer bycatch data include bottlenose dolphin, with 100 individuals captured on 18 sets in 2007–2009, with 67% of captures resulting in mortality (Western and Central Pacific Fisheries Commission 2012). The corresponding encounter rate was 5.44 encounters per 1000 sets, with 3.36 observed mortalities per 1000 sets; including the total fishing effort resulted in an estimate of 148 bottlenose dolphin mortalities in 2009.

Bottlenose dolphin depredation plays an important role in bycatch mortalities and entanglements in pot fisheries. As individuals tip pots over and take bait and catch from the pots, they can become entangled, especially in the float lines. There have been high numbers of bottlenose dolphin mortalities recorded in some pot fisheries such as in southeastern United States (Noke & Odell 2002, McFee et al. 2006). On

the South Carolina coast, the highest number of fisheries-related mortalities of bottlenose dolphin in the 14-year period from 1992–2006 were in the United States Atlantic blue crab pot fishery, with 28% (14 records) of bycatch mortalities attributed to this fishery.

4.2.4 Common dolphin

In New Zealand waters, incidental captures of common dolphin reported by fisheries observers between 1992–93 and 2011–12 were in trawl and surface-longline fisheries (Table 6). In this 18-year period, there were 150 observed common dolphin captures in trawl fisheries, compared with two observed captures in surface longlines.

Common dolphin was also the most prevalent species in earlier bycatch records, with the majority of documented captures between June 1979 and April 1992 occurring in trawl fisheries (Table 7) (Cawthorn 1981, 1982, 1983, 1988, 1990, 1991). These captures included the first bycatch record of common dolphin in the Cook Strait area, where 34–35 common dolphin were captured by a deep-sea trawler targeting jack mackerel off Stephens Island at night (Cawthorn 1991). Another incident west of Cook Strait involved the incidental capture of 22 common dolphin during night trawling operations in March 1992 (Cawthorn 1993). Other trawl fishing areas identified in the early bycatch records included Poverty Bay and Bay of Plenty, with the latter area including the bycatch of an individual common dolphin in a bottom trawl targeting snapper off Whale/Moutohora Island (Cawthorn 1983, 1990, 1992).

Incidental captures of common dolphin were also reported or observed in other New Zealand commercial fisheries, including purse seining, gillnetting, and lobster pot fishing (Cawthorn 1981, 1982). Between 1980 and 1981, there were 11 reported common dolphin captures in purse-seining operations targeting skipjack tuna *Katsuwonus pelamis*, involving two and nine common dolphin in two incidents (Cawthorn 1982). The purse-seinining effort in this period was about 800 sets, and cetacean bycatch occurred on about 1% of sets. During the same period, there were also 120–150 dolphins that were incidentally captured in deep-set gillnets (to 370 m depth) off Kaikoura, with an unspecified number of common dolphin included in this bycatch (Cawthorn 1982). In the previous year, there were five reported incidental captures of common dolphin in gillnets, which all resulted in mortality (Cawthorn 1981). Furthermore, common dolphin were also captured in lobster fisheries, with two individuals entangled in pot buoys lines in 1980–81, and one reported common dolphin mortality in lobster fisheries in 1979–80 (Cawthorn 1981, 1982).

Overall, a considerable proportion of the observed common dolphin bycatch in New Zealand trawl fisheries has been on vessels targeting mackerel on the North Island west coast, such as jack mackerel (*Trachurus declivis*, *T. murphyi*, and *T. novaezelandiae*), and blue mackerel (*Scomber australasicus*) (Cawthorn 1993, Thompson et al. 2013a). There were 119 observed common dolphin captures on 4299 observed tows in this fishery between 1995–96 and 2011–12. Sufficient observer coverage of this fishery and the number of observed captures allowed estimation of total common dolphin captures per year, with estimated annual capture rates varying between 0.15 (95% c.i.: 0.00-1.74) and 6.27 common dolphin (95% c.i.: 2.49-12.27) per 100 tows over this period (Thompson et al. 2013a).

Common dolphin captures were also documented in other New Zealand trawl fisheries, including middle-depth, inshore and flatfish trawl fisheries. There was a total of 14 observed captures in middle-depth, inshore, and flatfish trawl fisheries between 1995–96 and 2011–12. Observer effort in these fisheries was low (3.4%, 0.5%, and 0.3%, respectively) over this period, compared with an average 20% observer coverage in the mackerel trawl fishery.

Strandings data include 478 stranding events of this species, including 28 events (at mostly northern

North Island locations, i.e., Auckland) indicating entanglement (Table 9). Most stranding events with entanglement involved individuals, with two and six individuals recorded in one separate stranding event each.

In the past, large numbers of common dolphin were also bycaught in the now-closed albacore tuna driftnet fishery in the Tasman Sea, with the total estimated number of individuals captured in 1989 and 1990 exceeding 4000 (Northridge 1991).

In other regions, common dolphin feature frequently in bycatch records, involving a range of different fisheries in coastal and pelagic waters (Morizur et al. 1999, Hamer et al. 2008, 2012, Reeves et al. 2013). Incidental captures of this species have been reported in trawl, drift-net, gillnet, purse-seine and longline fisheries, with bycatch records often documenting relatively high numbers of observed common dolphin bycatch, including multiple captures. For example, the estimated number of incidental captures in gillnet fisheries was over 1000 common dolphin per year in Australia before 1990, although annual gillnet bycatch estimates have since then been reduced to one to 15 common dolphin for the period between 1990 and 2009 (Reeves et al. 2013).

In United States Atlantic Ocean driftnet and pair-trawl fisheries, fisheries observers recorded 321 common dolphin captures in the 4-year period from 1989 to 1993, with the majority of captures (312) involving driftnets targeting swordfish and tuna (Northridge 1996). Based on the nine observed incidental captures and the overall fishing effort in the pair-trawl fishery, the common dolphin capture rate was estimated to be 0.06 (s.e.: 0.03) individuals per haul in this fishery. High numbers of common dolphin captures have also been estimated for pelagic pair-trawling in the eastern North Atlantic Ocean, where a recent bycatch assessment based on observer data estimated a minimum of 1000 incidental common dolphin captures per year (Mannocci et al. 2012).

In the northeast Atlantic Ocean, high numbers of common dolphin *Delphinus* get captured in pelagic trawl fisheries targeting different fish species, including mackerel, horse mackerel, and albacore tuna (Ross & Isaac 2004). Common dolphin are also captured by trawl vessels in offshore waters off Argentina, i.e., in trawl fisheries targeting Argentine hake (*Merluccius hubbsi*) and Argentine red shrimp (*Pleoticus muelleri*)(Dans et al. 2003). Monitoring of cetacean bycatch in United Kingdom waters confirmed that common dolphin feature frequently as bycatch in pair-trawl fisheries (164 observed captures), but incidental captures of this species also involved static nets (Northridge et al. 2005). Of a total of 16 captures in static nets, 13 were in tangle nets with three incidental captures in gillnets.

Gillnets, including bottom-set gillnets have also been implicated in incidental common dolphin captures in other parts of the North Atlantic Ocean and in United States waters in the Pacific Ocean (Ross & Isaac 2004, Carretta et al. 2012, Reeves et al. 2013).

Observed marine mammal captures in Pacific Ocean pelagic longline fisheries in Hawaiian waters between 1994 and 2004 included one common dolphin capture, which was considered a non-serious injury, resulting in the animal being released alive with some line still attached (Forney & Kobayashi 2007). The total number of estimated captures was two common dolphin for that year, with an estimated capture rate of 0.04 common dolphin per 1000 sets for the 10-year assessment period regarded as non-serious injuries. Incidental captures including mortalities of common dolphin have also been recorded in demersal and pelagic longline fisheries on the French Atlantic Ocean coast and the Italian coast (Hamer et al. 2012).

Large numbers of common dolphin mortalities have also been documented in some purse-seine fisheries, including yellowfin tuna target fisheries in the ETP and the South Australian sardine fishery (Hamer et al. 2008, Inter-American Tropical Tuna Commission 2013). In the ETP, yellowfin tuna frequently form

associations with common dolphin (and spotted and spinner dolphins), so that purse seiners routinely search for dolphins to detect the fish, and then encircle the entire association with purse-seine nets (Inter-American Tropical Tuna Commission 2013). This fishing method has resulted in high dolphin mortality, particularly in the period between the 1960s and 1980s (Inter-American Tropical Tuna Commission 2013). For example, over 24 000 (short- and long-beaked) common dolphins were incidentally captured in this fishery in 1986. In more recent years, the number of incidental captures has markedly decreased to less than 500 common dolphins annually; there were 188 common dolphin captures in 2009.

High numbers of common dolphin are also incidentally captured in South Australia, where purse-seine fisheries target sardine (*Sardinops sagax*) to provide food for wild-caught bluefin tuna (*Thunnus maccoyii*) in sea cages (Hamer et al. 2008). Observer data from this fishery revealed a high level of common dolphin mortality in 2004, with 0.39 individuals killed per net-set, corresponding with an estimated 377 common dolphin mortalities across the entire purse-seining fleet. Management of this South Australian purse-seine fishery included an environmental assessment in 2004, which resulted in the implementation of a code of practice that included mitigation measures to reduce the number of operational interactions with marine mammals.

Common dolphin are also incidentally captured in the tropical purse-seine fishery targeting tuna in the western and central Pacific Ocean (Western and Central Pacific Fisheries Commission 2012). In the period between 2007 and 2009, there were 61 observed captures of common dolphin on eight sets, equating to 3.02 encounters per 1000 sets. Most (95%) of the interactions were fatal, with 126 estimated common dolphin mortalities in 2009. In other purse-seine fisheries, bycatch numbers of common dolphin are markedly lower when they involve fisheries that do not use the association between dolphins and target species. For example, there was one observed common dolphin mortality in the squid purse-seine fishery off California in 2005, corresponding with an estimated annual mortality of 87 common dolphin (CV: 0.98) (Carretta et al. 2012).

4.2.5 Dusky dolphin

Between 1992–93 and 2011–12, there were 14 dusky dolphin captures recorded by fisheries observers in New Zealand waters, including trawl fisheries (eight captures), set netting (four captures), and surface longlining (two captures) (Table 6).

This species was also included in earlier bycatch reports, involving set-net, trawl, and unspecified fisheries (Table 7) (Cawthorn 1982, 1983, 1986, 1988, 1990, 1992). Dusky dolphin was considered the principal species taken in the seasonal set-net fishery around Kaikoura, and was included in the observed bycatch of a maximum 120–150 dolphins (dusky, common and Hector's dolphins) in deep-set nets off Kaikoura in 1980–81 (Cawthorn 1982). Dusky dolphin captures in this fishery were also documented in other years, involving four individuals in 1984, and one dusky dolphin in 1990 (Cawthorn 1986, 1992). As the most common delphinid species in the Kaikoura area, dusky and Hector's dolphins were also considered the main bycatch species in the regional inshore set-net fishery, with an estimated bycatch of 100–300 small cetaceans in 1986 (Cawthorn 1988).

Other estimates of incidental dusky dolphin mortalities in New Zealand fisheries include 200 individuals in gillnets off Kaikoura in 1984 (Brownell & Cipriano 1999). Annual estimates of Dusky dolphin bycatch in New Zealand gillnets were also included in a global review of marine mammal interactions with gillnet fisheries (Reeves et al. 2013). In this review, Reeves et al. (2013) estimated that 20–50 individuals were killed in New Zealand gillnets each year before 1990, while their estimate for the period between 1990 and 2009 was less than one individual per year.

Dusky dolphin bycatch in New Zealand waters was also documented for trawl and unspecified fisheries. Observers reported two incidental captures of dusky dolphin individuals in trawl fisheries in 1986–87, and another individual was bycaught in trawl operations off Greymouth in 1988–89 (Cawthorn 1988, 1990). In 1981–82, four dusky dolphin were incidentally captured in unspecified fisheries, with another record of dusky dolphin bycatch in unspecified fisheries in 1993–94 (Cawthorn 1983, Donoghue 1995).

Strandings data include 107 stranding event records of this species, with 18 records indicating entanglement, most of which were in Canterbury and Marlborough Sounds (Table 9). All of the stranding events involving entanglement included individual dusky dolphin, except for one incident that involved three individuals.

Incidental captures of dusky dolphin from other regions include a variety of fisheries such as trawling, gillnetting, purse seining, and longlining (Hammond et al. 2008a, Hamer et al. 2012, Reeves et al. 2013). A considerable number of dusky dolphin are taken as bycatch (and in directed catches) off South America, where incidental mortalities in mid-water and bottom trawls off Patagonia have been estimated at 70 to 215 dusky dolphin in 1994 based on monitoring data (Crespo et al. 1997, Dans et al. 2003). The fisheries involved ranged from relatively small, coastal trawl vessels to pair-trawlers and large factory vessels fishing offshore.

Dusky dolphin are also bycaught in coastal purse-seine fisheries in Argentina (Crespo et al. 1994), while incidental captures involving longlines have also been recorded, including fisheries targeting tuna in the western and central Pacific Ocean (Lawson 2001).

4.2.6 Hector's and Maui's dolphins

Hector's dolphin are endemic to New Zealand, and both subspecies experience bycatch in commercial fisheries in this region. Incidental captures of Hector's dolphin have been observed in trawl and set-net fisheries, with bycatch mortality in these fisheries also indicated by stranded animals entangled in gillnets and exhibiting characteristic scarring.

Fisheries observer data included four observed Hector's dolphin captures in set-net fisheries in the period between 1992–93 and 2011–12 (Table 6). Set-net fisheries were also implicated in earlier reports of Hector's dolphin bycatch and entanglements (Cawthorn 1979, 1982, 1986, 1990, 1991, 1992). In the 1979 report (for June 1977 – May 1978), Hector's dolphin mortalities were estimated at 12 to 20 individuals per year in recreational and commercial set nets in waters around Banks Peninsula and also off Taranaki, and there was one reported incidental capture of Hector's dolphin in a set net off Waiheke Island in 1980 (Cawthorn 1979, 1982). For the year from June 1977 to May 1978, Hector's dolphin captures in recreational and commercial gillnets were estimated to be 12–20 individuals per year, primarily around Banks Peninsula and off Taranaki (Cawthorn 1979). Hector's dolphin were also included (with dusky and common dolphins) in the 120–150 dolphins incidentally taken in deep-set nets around Kaikoura in 1980–81, and there were also six estimated Hector's dolphin captures in shallow, coastal set-net fisheries around Banks Peninsula in the same year (Cawthorn 1982).

Three Hector's dolphin were incidentally taken in inshore set nets in 1984–85, with one capture each off Banks Peninsula, Te Waewae Bay (Southland), and Nelson (Cawthorn 1986). Subsequent Hector's dolphin captures also involved coastal gillnet fisheries (primarily around Banks Peninsula), with two documented captures of Hector's dolphin in trawl fisheries off Greymouth, on the South Island's west coast (Cawthorn 1990, 1991, 1992).

In January 1993, two Hector's dolphin were released alive from a gillnet near Motunau Island, off

Pegasus Bay on the South Island's east coast, with three and eight Hector's dolphin captured in unspecified fisheries in 1993–1994 and 1994–95, respectively (Donoghue 1994, 1995, 1996).

The strandings database includes 249 Hector's dolphin stranding events, often involving more than one individual (Table 9). Entanglement is indicated in 45 of these records, including five incidents with 2–4 Hector's dolphin in a single stranding event; one of these multiple strandings included a mother-calf pairing. For most of these stranding records, the type of fishing gear involved in entanglements is unknown. As Hector's dolphin are bycaught in commercial and recreational gillnets, it is generally not possible to distinguish between the two types of fishery, even when gillnets are implicated in the strandings data.

In addition to entanglement records in the strandings database, bycatch of Hector's and Maui's dolphins is also recorded in the "Hector's dolphin incident database", administered by Department of Conservation (Department of Conservation 2013a). This database contains information on known, probable, and possible entanglements, and also on other human interactions when the cause of death could be identified (e.g., by necropsy). Between 1921 and 2008, fisheries-related causes of death for South Island Hector's dolphin have included known entanglements involving lobster pots (3 records), commercial set nets (45 records), trawl nets (19 records), recreational set nets (21 records), and unknown set nets (22 records). A number of these fishing gear types were also implicated in probable and possible entanglements. For Maui's dolphin, there was a total of five entanglements, with two known entanglements in unknown set nets.

Since 2008, there have been fewer incidents involving entanglement and bycatch of Hector's dolphin recorded in the database. Recent incidental captures that were confirmed as bycatch in commercial set nets included a fisher-reported incident involving a female (considered to be Maui's dolphin) in a commercial set net off Taranaki (January 2012), and two Hector's dolphin (including one live release) that were captured in commercial set nets off Timaru (October and December 2012).

Incidental mortalities in set-net and trawl fisheries have been highlighted as the most serious threat to this species (Department of Conservation & Ministry of Fisheries 2007), having caused a substantial population decline to about 27% of the 1970 population size (Slooten 2013). For the North Island subspecies Maui's dolphin, estimated human-caused mortalities greatly exceed the estimated Potential Biological Removal (by a median of 75.5 times), with fisheries mortalities (including recreational and customary set-net fisheries) considered to constitute about 95.5% of all human-caused mortality (Currey et al. 2012).

The close inshore distribution of this species in shallow waters (less than 100 m depth; Dawson et al. 2004) coinciding with low observer coverage of inshore fisheries has prevented the collection of comprehensive observer data and estimation of total captures and mortalities in commercial fisheries (Slooten 2013). On the South Island east coast, a designated observer programme was implemented by Department of Conservation for the 1997–98 fishing year to monitor bycatch of Hector's dolphin in commercial fisheries in Pegasus Bay and Canterbury Bight, where fishery interactions were known to occur (Starr & Langley 2000).

Observer effort under this scheme covered set-net and bottom trawl fisheries over 125 days and 198 set-net fishing events (Starr & Langley 2000). The inclusion of the trawl fishery was prompted by the recognition that Hector's dolphin interactions were likely to be determined by the spatial distribution of fishing effort rather than the type of fishery. Accordingly, the spatial extent of the observer coverage was within the 200-m depth contour of statistical fishery areas 018, 020, and 022. Incidental captures of Hector's dolphin were observed in both fisheries, with eight individuals captured in five set-net fishing events. Three of these capture events involved two animals, while two of the eight bycaught individuals

were released alive. In the trawl fishery, there was one observed Hector's dolphin bycatch mortality. All incidental captures occurred in inshore waters that were less than 30 m deep (Starr & Langley 2000).

A subsequent bycatch assessment used these observer data to estimate the total bycatch of Hector's dolphin in set-net fisheries in this area for the 1997–98 fishing year (Baird & Bradford 2000). Based on the observer data, the total estimated bycatch of Hector's dolphin was 18 individuals (CV: 38%). For the trawl fishery, the amount of observer data was insufficient to allow bycatch estimates (Baird & Bradford 2000).

A more recent risk assessment of Hector's dolphin bycatch considered previous analyses and also included new bycatch estimates (Slooten & Davies 2012). Based on fisheries observed data and assuming that the capture rate estimated for parts of the population's range is consistent across the entire South Island's east coast, this study derived a bycatch estimate of 23 Hector's dolphin (CV: 0.21) for this region for the period between May 2009 and April 2010. The bycatch estimate before 2008 was a total of 110–150 incidental captures per year.

For Maui's dolphin, an expert panel recently attempted to estimate mortalities from all identified threats including bycatch (Currey et al. 2012). The outcome of the technical workshop by the expert panel resulted in an estimated mortality of five Maui's dolphin per year over the next five years. This value greatly exceeds the estimated PBR of this species of one individual every 10 to 23 years (Currey et al. 2012).

In addition to commercial fisheries, Hector's dolphin are also captured during recreational gillnetting (Taylor 1992a, Dawson & Slooten 1993).

4.2.7 Hourglass dolphin

New Zealand fisheries observer did not record any incidental captures of hourglass dolphin in commercial fisheries between 1992–93 and 2011–12. There were three stranding events of this species, including one record of entanglement involving two individuals that were recently dead (Table 9).

The largely offshore distribution of this species means that hourglass dolphin are considered to be less likely to be threatened by human activities (Goodall 2009). Accordingly, there have been few incidental captures of hourglass dolphin, but these include the mortality of three females in gillnet operations in New Zealand waters (Goodall 2009). Another incidental mortality of hourglass dolphin also occurred in the South Pacific Ocean, in the Japanese experimental driftnet fishery.

Although there have been no records of hourglass dolphin bycatch in longline fisheries, individuals have been observed in the proximity of longlining vessels targeting Patagonian toothfish (Ashford et al. 1996).

4.2.8 False killer whale

There have been no incidental captures of false killer whale reported by observers in New Zealand waters in the period between 1992–93 and 2011–12. There were also no entangled individuals included in the 16 stranding events of this species listed in the strandings database (Department of Conservation 2013b).

False killer whale is one of the main species (together with pilot whales *Globicephala* spp.) involved in depredation interactions with fisheries at lower latitudes and in tropical waters, especially in pelagic longline fisheries (Hamer et al. 2012). While removing bait and hooked fish from the longlines, some

of the individuals engaged in this behaviour become hooked (i.e., in the mouth or throat) or entangled (Donoghue et al. 2003, Gilman et al. 2006). Although a proportion of animals that are incidentally captured are released alive (or free themselves)(Bell et al. 2006, Dalla Rosa & Secchi 2007), false killer whale bycatch mortalities have been documented in different longline fisheries (Forney et al. 2011, Hamer et al. 2012). In Hawaii-based pelagic longline fisheries, false killer whale is the most frequently observed species depredating catch or bait, and bycatch of this species in the deep-set component of these fisheries currently exceeds allowable levels under the United States Marine Mammal Protection Act (Forney et al. 2011). Observer data from 2003 to 2009 show that incidental captures of individual false killer whale occurred on 28 sets (0.14% of the total) in the deep-set fisheries targeting bigeye tuna and swordfish, compared with one bycaught individual on one set (0.02%) in the shallow-set pelagic longline fisheries (excluding an additional six captures across both fishery components that were identified as "blackfish").

Incidental captures of false killer whale are also known to occur in gillnets, including driftnets, but data to quantify and estimate this bycatch are generally scarce (Harwood et al. 1984, Reeves et al. 2013). In Australia, there was one incidental capture of this species in gillnet fisheries in 2001, with the number of bycaught false killer whale before 1990 estimated to exceed 11 individuals each year (Reeves et al. 2013). In comparison, over 125 incidental captures were estimated to occur annually in Sri Lankan gillnet fisheries before 1990, with bycatch numbers reduced to 33 false killer whale in the period from 1991 to 1992.

Interactions with purse-seine fisheries include reports of false killer whale preying on smaller dolphins that are escaping from purse-seine nets in the ETP, and also documented incidental captures of this species (Baird 2009, Western and Central Pacific Fisheries Commission 2012). In the period from 2007 to 2009, there were 216 observed false killer whale captures on 42 sets in the tropical purse-seine fishery in the western and central Pacific Ocean (Western and Central Pacific Fisheries Commission 2012). The corresponding encounter rate was 10.68 encounters per 1000 sets, and 51% of the observed captures resulted in mortality, equating to 5.44 mortalities per 1000 sets. The estimated number of false killer whale killed in purse-seine fishing interactions in 2009 was 239 individuals.

4.2.9 Killer whale

There were no fisheries observer records of incidental captures involving killer whale in the New Zealand region in COD for the period between 1992–93 and 2011–12. There were, however, three earlier incidents of killer whale mortality included in the New Zealand reports to the IWC (Cawthorn 1981, Donoghue 1995). For the period between June 1979–May 1980, there was one reported bycatch mortality of killer whale in trawl fisheries, with another incident of a dead killer whale found floating in the eastern Bay of Plenty linked to net and fishing gear entanglement based on marks and lacerations on the body (Cawthorn 1981). There was also one incidental capture of killer whale in an unspecified fishery documented in 1993 (Donoghue 1995).

In the strandings database, this species has been recorded in 45 stranding events, including one live-stranding of an individual in Bay of Plenty with signs of entanglement (Table 9).

A global review of cetacean interactions with trawl fisheries includes one New Zealand bycatch record of killer whale in 1979 (Fertl & Leatherwood 1997). Similarly, in their review of marine mammal bycatch in gillnet fisheries, Reeves et al. (2013) included data from New Zealand to estimate that there were six killer whale mortalities per year in gillnets globally in the period between 1993 and 2004. In addition, observations of longline depredation by killer whale in New Zealand waters include information from a fisheries observer witnessing a killer whale becoming hooked and being subsequently released (with gear

still attached) by a Japanese tuna-longlining vessel (Visser 2000a). This study was predominantly based on fisher interviews and included some direct observations, and confirmed that killer whale interact with longliners in New Zealand waters, removing school sharks (*Galeorhinus galeus*) and bluenose (*Hyperoglyphe antarctia*), although without reports of resulting entanglements.

Data from other regions indicate incidental captures of this species in gillnet, trawl and longline fisheries, with a number of live releases, although mortalities from bycatch in these fisheries have also been recorded (Fertl & Leatherwood 1997, Keene et al. 2007, Hamer et al. 2012, Carretta et al. 2012, Reeves et al. 2013).

Killer whale feature prominently in depredation studies, and this species appears to have learnt to exploit fishery operations in many different regions and across fisheries (Northridge 1984). Killer whale depredation was first recognised in the Northern Hemisphere, with an increasing number of observations of this behaviour in recent times; it has also become frequent in some Southern Hemisphere regions, including the South Pacific Ocean (Gilman et al. 2006, Taylor et al. 2008c).

The fisheries involved are primarily surface and bottom longlining, with a small proportion of killer whale becoming hooked or entangled in these fisheries (Donoghue et al. 2003, Bell et al. 2006, Kock et al. 2006, Keene et al. 2007). In the Patagonian toothfish fishery, killer whale have been shown to take considerable numbers of toothfish while the bottom longlines are hauled to the surface, resulting in considerable loss of catch in some longlining operation in southern South America, the Falklands and South Georgia (Ashford et al. 1996). Other longlining operations exposed to killer whale depredation include demersal longline fisheries targeting sablefish (*Anoplopoma fimbria*) off Alaska (Sigler et al. 2003), pelagic longline fisheries targeting tuna and swordfish in Brazil (Dalla Rosa & Secchi 2007), and the United States pelagic longliner fleet in the northwestern Atlantic Ocean (Keene et al. 2007).

Although killer whale associate with purse-seine fisheries, they seem to be able to avoid capture when they prey on other species associating with the fishing operations (such as sea lion) or depredate the fishery target species (Couperus 1994, Hückstädt & Antezana 2004).

4.2.10 Pilot whales

Pilot whales (*Globicephala* spp.) get caught in most types of fishing gear world-wide (Read et al. 2006), and are also known to associate with fishing vessels, and to engage in depredation behaviour.

New Zealand observer records for the period between 1992–93 and 2011–12 include bycatch data of long-finned pilot whale in trawl, longlining and set-net fisheries (Table 6). Of a total of 27 observed incidental captures involving this species, 21 were in trawl fisheries, followed by two and three captures in surface- and bottom-longline fisheries, and one observed capture in set nets. Earlier records of long-finned pilot whale bycatch in New Zealand include three individuals that were incidentally captured in gill nets in March 1981, with two individuals bycaught in the same net (Cawthorn 1982).

Both long-finned and short-finned pilot whales also featured in stranding events, with 280 records in the strandings database involving 7852 long-finned pilot whale, including one individual with signs of entanglement (Table 9). In comparison, there were markedly fewer strandings of short-finned pilot whale, with no entanglements recorded in the 12 stranding events involving 149 individuals this species. In addition, there were also 21 stranding events (576 individuals) that did not distinguish between the two species, with one record involving the entanglement of one individual.

In other regions, pilot whales are frequently bycaught in trawl fisheries, especially in mid-water trawls,

often involving large numbers of individuals, which has been related to their feeding at mid-water depths, and the forming of large aggregations (Fertl & Leatherwood 1997). In the EEZ of the United States, pilot whales constituted 55% of the bycatch in offshore Atlantic mackerel *Scomber scombrus* trawl fisheries, with 297 of a total 538 observed captures attributed to this genus (Waring et al. 1990). The trawl fishing involved included off-bottom high opening trawl nets and also pelagic trawls. Other examples of documented long-finned pilot whale bycatch include the Dutch pelagic trawl fishery targeting mackerel and horse mackerel on the continental slope of southwestern Ireland, where this species featured in 12% of all recorded bycatch events between 1989 and 1994 (Couperus 1997).Short-finned pilot whales have been incidentally taken in trawl fisheries in the Gulf of Mexico (see Fertl & Leatherwood (1997)).

Bycatch mortality of both pilot whale species and of unspecified pilot whales (*Globicephala* spp.) also occurs in gillnets (Reeves et al. 2013). On the east coast of United States, there were nine to 132 incidental takes of long-finned pilot whale in gillnets each per year between 1990 and 1998; there were between two and 117 incidental captures of long-finned pilot whale *Globicephala melas edwardii* reported per year in the period between 1990 and 1993 off South America (see supplementary information in Reeves et al. 2013). Data from other regions also indicate that pilot whales are commonly bycaught in gillnets, including fisheries in the Mediterranean Sea, the European and the North Atlantic Ocean, and in Taiwanese waters.

Short-finned pilot whales have also been identified as bycatch in gillnet fisheries, such as the Californian drift gillnet fishery (Barlow et al. 1994). Incidental captures recorded in this fishery included two observed short-finned pilot whale captures between 1980 and 1983, one each in 1990 and 1992, and 11 observed captures in 1993. The corresponding estimates of the fishery-related mortality of short-finned pilot whale in 1990, 1992, and 1993 ranged between eight and 81 individuals.

In longline fisheries, long-finned pilot whale was the most frequently recorded bycatch species in observer data of United States pelagic longline fisheries in the northwestern Atlantic Ocean (Keene et al. 2007). Of a total of 203 incidental marine mammal captures observed in these fisheries between 1992 and 2004, 93 were live long-finned pilot whale, with four bycatch mortalities of this species also recorded. There were also three short-finned pilot whale that were incidentally taken and released alive. Some of the bycatch mortality of pilot whales (*Globicephala* spp.) in longline fisheries has been attributed to depredation behaviour and pilot whales are one of the main species implicated in the depredation of pelagic longline fisheries at lower latitudes (Hamer et al. 2012).

Pilot whales are also incidentally taken in purse-seine fisheries, such as tuna and squid target fisheries in the Pacific Ocean (Carretta et al. 2012, Western and Central Pacific Fisheries Commission 2012, Waring et al. 2013). Incidental mortalities of short-finned pilot whale in purse seines targeting squid off southern California used to occur when the species was common in this region (Carretta et al. 2012), and interactions between pilot whales (species not distinguished) and blue tuna purse-seine fisheries have also been documented in the United States Atlantic Ocean (Waring et al. 2013). In the western and central Pacific Ocean, fisheries observers documented the bycatch of short-finned pilot whale on purse-seine vessels targeting tuna (Western and Central Pacific Fisheries Commission 2012). Between 2007 and 2009, there were 11 observed incidental captures of this species on six sets, including three mortalities. Accounting for the total fishing effort, these captures equated to 0.54 encounters per 1000 sets and 0.15 mortalities per 1000 sets. The estimated mortality in this fishery in 2009 was seven short-finned pilot whale.

Bycatch of long-finned pilot whale has been documented in trap fisheries, such as in inshore squid traps in Newfoundland and Labrador/Canada (Lien 1994). As pilot whale attempt to access the target species held within the trap, they become trapped and entangled, with most of the bycatch of 68 individuals of long-finned pilot whale between 1979 and 1990 involving squid traps, and resulting in mortality.

4.2.11 Southern right whale dolphin

There have been no southern right whale dolphin captures noted in the fisheries observer data. Furthermore, none of the recorded 16 stranding events involving this species in New Zealand waters included entanglements (Department of Conservation 2013b).

Bycatch of this species has been documented in gillnets fisheries in South America, but available data are scarce (Reeves et al. 2013), with the swordfish gillnet fishery off Chile recognised to have the most captures (Hammond et al. 2012b).

This species' congener, northern right whale dolphin has also been incidentally taken in different gillnet fisheries, including California's drift gillnet fishery for swordfish and sharks (Barlow et al. 1994, Reeves et al. 2013). In the three years from 1991 to 1993, between 7 and 15 individual northern right whale dolphin were observed bycaught each year, with estimated annual mortalities ranging between 15 and 52 individuals (Barlow et al. 1994).

4.3 Beaked whales

There were no observed incidental captures of any beaked whale species in New Zealand waters recorded by fisheries observers between 1992–93 and 2011–12. Beaked whales were included in earlier reports of incidental ceteacean captures, with one unspecified beaked whale bycaught in a pair trawl in October 1979 (Cawthorn 1981). For the year from 1 April 1993 to 31 March 1994, there were two reported incidental captures of Gray's beaked whale on "deep sea fishing vessels" in unspecified fisheries (Donoghue 1995).

There have been a number of strandings events involving different species in this group of cetaceans, including Andrews' (19 events), Cuvier's (82), dense-beaked (three), Gray's (252), Hector's (12), and Shepherd's (17) beaked whales, and strap-toothed (78), spade-toothed (one), and southern bottlenose (24) whales (Table 9). These strandings included two reports of entanglement, including one Gray's and one Cuvier's beaked whale.

Bycatch records concerning this group of cetaceans often do not identify the beaked whale species involved, so that individuals are only referred to by their genus or general grouping (Ziphiidae or "beaked whale").

Beaked whale bycatch has been documented in a number of gillnet fisheries across different regions, including in New Zealand waters (Reeves et al. 2013). Southern bottlenose whale were bycaught in the large-mesh driftnet fishery targeting albacore tuna in the Tasman Sea, which has now ceased to operate (Northridge 1991).

Beaked whales experienced significant bycatch mortality in the drift gillnet fishery off California/United States before acoustic pingers were introduced as a bycatch mitigation tool (Carretta et al. 2008, Carretta & Barlow 2011). Before the introduction of pingers, 33 beaked whales were recorded in 3303 observed sets in the 6-year period between 1990 and 1995, whereas there was no observed incidental capture of beaked whales in 4381 observed sets between 1996 and 2006. The bycatch observer data included 21 entangled Cuvier's beaked whale, two individuals in the genus *Mesoplodon*, and three unidentified individuals in the beaked whale group (Carretta et al. 2008).

Incidental takes of beaked whales were also observed in the driftnet fishery in the northeastern Atlantic Ocean between 1989 and 1993, including one Cuvier's beaked whale and 21 records of different

Mesoplodon species and also unidentified species within this genus (Northridge 1996). Cuvier's beaked whale have also been incidentally taken in the Italian surface large pelagic driftnet fishery in the Mediterranean Sea (Di Natale 1994).

In their review of global gillnet bycatch, Reeves et al. (2013) estimated that tens to hundreds of individuals of the Ziphiidae were incidentally captured in gillnets before 1990, with few individuals since then.

Beaked whales are also bycaught during longline fishing operations, as evident in the observed bycatch mortality of dense-beaked (Blainsville's beaked) whale (*Mesoplodon densirostris*) in Hawaii-based pelagic surface-longline fisheries (Forney & Kobayashi 2007), and two gingko-toothed beaked whale (*Mesoplodon ginkgodens*) that were hooked in longlines (no details on gear configuration and target species) on the Taiwanese coast (Hamer et al. 2012). In the northwestern Atlantic Ocean, there were six observed incidental takes of unspecified beaked whales in the large pelagic fisheries longlining fleet between 1992 and 2004, and the captured individuals were released alive (Keene et al. 2007).

Bycatch of beaked whales in trawl fisheries appears to be rare, although this group of toothed whale may associate with fishing vessels. The Northern Hemisphere counterpart to southern bottlenose whale, northern bottlenose whale has been reported to associate with trawlers, following them during haulback on the Scotian Shelf/Canada (Fertl & Leatherwood 1997).

Incidental captures of beaked whales in purse-seine fisheries are also reported occasionally. In the central and western Pacific Ocean, one Cuvier's beaked whale and one unspecified *Mesoplodon* sp. were included in observer data of the tuna purse-seine fishery for 2010, involving live releases in both incidents (Western and Central Pacific Fisheries Commission 2012). Based on the total purse-seining effort, the encounter rates for these interactions were 0.05 encounters per 1000 sets for either species.

4.4 Pinnipeds

Similar to cetaceans, pinnipeds are incidentally captured in a range of commercial fisheries, with the types of fisheries involved including pot and trap fisheries (see summary of pinniped interactions with commercial fisheries in Table 12) (Woodley & Lavigne 1991, Wickens 1995, 1996). Following severe over-exploitation during commercial sealing, a number of pinniped species have recovered to some extent or are currently undergoing recovery, with populations expanding in a number of regions. Owing to the increases in pinniped population sizes and the intensification of commercial fishing at the same time, interactions between pinnipeds and commercial fisheries have become more common (Arnould et al. 2003). Furthermore, most pinniped species have a coastal distribution, including land-based haul-out sites and breeding grounds, and their at-sea movement and foraging often overlap with fishing operations.

Like small-sized delphinids, fisheries interactions frequently result in pinniped mortality, as captured animals are unable to free themselves, with injuries and protracted mortalities from fishing-related causes also documented. Some incidental captures of pinnipeds have been linked to depredation behaviour, particularly involving trawl fisheries, as fur seal have been observed to routinely enter and exit trawl nets (Lyle & Wilcox 2008).

In contrast to a number of cetacean species, pinnipeds are generally considered to be more resilient to human-caused mortality, as they have a relatively high potential rate of population increase; exceptions include New Zealand sea lion *Phocarctos hookeri*, Australian sea lion *Neophoca cinerea*, and Mediterranean monk seal *Monachus monachus* (Read 2008). Although the impacts of fisheries-related mortality may not be as severe as for some cetaceans, bycatch of pinnipeds has recently been

highlighted as a serious global threat facing this group of marine mammals (Kovacs et al. 2012). Of a total of 13 pinniped taxa listed as threatened by IUCN, 11 taxa have been identified to be impacted by direct and indirect fisheries interactions.

Several reviews and studies have examined pinniped bycatch in a range of commercial fisheries (Woodley & Lavigne 1991, Wickens 1995, Reeves et al. 2013). In their recent review of gillnet bycatch, Reeves et al. (2013) identified 15 (of a total 18) species of phocid seals that were recorded in bycatch between 1990 and 2011, of which 14 species were bycaught in gillnets. Similarly, eight (of a total 14) species of otariid seals and sea lions have been incidentally taken in fisheries during the same period, including seven species that have been reported as bycatch in gillnet fisheries. The number of individuals incidentally captured in gillnets ranges between relatively low numbers to thousands of individuals for some species, such as California sea lion *Zalophus californianus* in the eastern North Pacific Ocean; bycatch of this species involved 1000–4000 individuals each year before 1990, with an estimated five to 3534 individuals per year in the subsequent period between 1990 and 2011 (Reeves et al. 2013).

The seriousness of fisheries bycatch has been highlighted for endangered Australian sea lion *Neophoca cinerea*, with incidental mortalities in demersal gillnets and trap fisheries posing a considerable threat to subpopulations of this species. On the South Australian shelf, Australian sea lion co-occurs with demersal shark gillnet fisheries, and the high level of sea lion bycatch is evident in the 283–333 individuals per breeding cycle or 193–227 individuals per year that are bycaught in this fishery (Hamer et al. 2013). As sea lion depredate sharks that are captured in the nets, they can become entangled, resulting in serious injuries and drowning (Hamer et al. 2011). Some of this mortality is possibly unnoticed as sea lion carcasses may not remain in the net when it is brought on-board, so that observed bycatch mortalities are minimum values.

This species also experiences considerable bycatch mortality throughout its range in inshore rock lobster fisheries (Campbell et al. 2008). As sea lion attempt to access bait and lobsters in the traps, a number of individuals become captured and drown, with four to five estimated incidental mortalities each fishing season on the west coast of Australia.

Australian fur seal *Arctocephalus pusillus doriferus* have also been shown to engage in depredation behaviour, including in trawl fisheries, where they feed in and around nets (Hamer & Goldsworthy 2006, Browne et al. 2005). In some fisheries, this depredation can lead to considerable bycatch mortality, such as in the Tasmania blue grenadier *Macruronus novaezelandiae* trawl fishery, where 89 fur seal were incidentally captured in 665 trawl events (Hamer & Goldsworthy 2006). This high level of bycatch mortality resulted in the introduction of a mandatory seal exclusion device to be fitted to trawl nets used by factory trawlers. Underwater video footage taken in the small pelagic fishery revealed how Australian fur seal feed in and around the net, including in groups of up to six individuals (Browne et al. 2005).

Table 12: Reported interactions between pinnipeds and fisheries (SLL, surface longlining; BLL, bottom longlining; n.d., no data).

Common name	Scientific name	Fishing method	Global bycatch	New Zealand bycatch
New Zealand sea lion	*Phocarctos hookeri*	Trawl	n.d	NZ observer data
		SLL	n.d	NZ observer data
New Zealand fur seal	*Arctophoca australis forsteri*	Trawl	n.d	NZ observer data
		BLL	n.d	NZ observer data
		SLL	Seal sp.; Bell et al. (2006)	NZ observer data
		Gill/set/drift net	n.d	NZ observer data
Southern elephant seal	*Mirounga leonina*	Trawl	n.d	NZ observer data
		SLL	Bell et al. (2006)	n.d

They also enter and exit the next via the escape opening of the seal exclusion device to feed on fish captured in the trawl net. Some of these interactions result in fur seal entanglement, including in the exclusion device, with live releases and also mortalities reported in this fishery.

Interactions between pinnipeds and purse-seine fisheries have also been documented from a number of regions, including incidental mortalities of seals and sea lions in some fisheries (Wickens 1995, Woodley & Lavigne 1991). Southern sea lion (*Otaria flavescens*) frequently associate with industrial purse seiners targeting jack mackerel (*Trachurus symmetricus*) off central Chile to depredate on the target species, with some of these interactions resulting in sea lion capture and mortality (Hückstädt & Antezana 2003). There were 18 incidental captures of this species on 30 observed sets in October 1999, with a total of 687 sea lion observed to be interacting with the commercial purse seiner. Two of the incidental captures resulted in immediate mortality, while the serious injury of a third sea lion captured and released from the purse seine was considered to cause subsequent mortality.

Similar to southern sea lion, California sea lion (*Zalophus californianus*) interact with coastal purse-seine fisheries targeting herring in Oregon/United States, and routinely escape from the nets without suffering mortality, but bycatch mortalities have been observed elsewhere (Wickens 1995). For example, there were an estimated 20 sea lion mortalities in purse-seine fisheries targeting anchovy and mackerel in California in 1979–80, and 10 estimated mortalities in squid target fisheries. More recently, between 2004 and 2008, there were two observed California sea lion mortalities in Californian purse-seine fisheries targeting anchovy, mackerel, sardine and tuna, and the annual mortality was estimated to exceed two individuals in these purse-seining operations (Carretta et al. 2012).

4.4.1 New Zealand fur seal

New Zealand fur seal are native in New Zealand and Australia, and high numbers of incidental captures of this species have been reported in both countries. In New Zealand commercial fisheries, New Zealand fur seal are the most frequently observed bycaught marine mammal species, with a total of 3465 observed captures between 1992–93 and 2011–12 (Table 6). Most of this bycatch (2815 captures) occurred in trawl fisheries, followed by a relatively high number of captures (638) in surface longlining. The remaining captures were recorded by fisheries observers in bottom-longlining (four captures) and set-net fisheries (eight captures).

There was also one recently dead fur seal with signs of entanglement included in the strandings database, with a total of 14 stranding events of this species (Table 9).

Observer data for the 9-year period between 2002–03 and 2010–11 show that incidental captures of fur seal occurred in trawl fisheries across different fishing areas and target species (Thompson et al. 2013b). Hoki fisheries consistently contributed a high proportion of the overall fur seal bycatch, with high numbers of observed captures and high estimated captures (e.g., 23 of 69 total observed captures 2010–11). In the 2010–11 fishing year, the highest observed capture rates were in southern blue whiting (8.33 fur seal captures per 100 tows) and ling trawl fisheries (1.96 observed fur seal captures per 100 tows).

The high number of observed New Zealand fur seal captures in trawl fisheries allowed the development of statistical models to estimate the total number of fur seal bycaught across different trawl fisheries in New Zealand's EEZ (Thompson et al. 2013b). Between 2002–03 and 2010–11, the total number of estimated fur seal captures ranged between 376 (95% c.i.: 221 to 668) and 1471 (95% c.i.: 914 to 2392) individuals annually. The lowest bycatch estimate was in the most recent fishing year 2010–11, with a corresponding estimated capture rate of 0.44 (95% c.i.: 0.26 to 0.78) fur seal captures per 100 tows.

For other fisheries, New Zealand fur seal bycatch in gillnets has been generally estimated at "some" individuals per year before 1990, with less than one incidental capture per year for the period between 1990 and 2010 (Reeves et al. 2013).

Data from New Zealand and Australia on the type of debris found on entangled New Zealand fur seal confirm that this species interacts with a range of fishing gears (Page et al. 2004, Boren et al. 2006a), although it is not always clear if entanglements occurred during active fishing operations. Long-term entanglement data of fur seal around Kaikoura indicate high rates of entanglement (0.6–2.8%) with trawl nets involved in 42% of the total number of entanglements (Boren et al. 2006a). Not all of these entanglements resulted in mortality, with intervention resulting in high survival, even when freed individuals suffered serious injuries from the entanglement.

In Australia, the highest proportion of commercial fishing gear observed in 91 total entanglements on Kangaroo Island between 1989 and 1991 and between 2000 and 2002 also involved trawl netting (28%), followed by lobster float rope (13%), fishing line and hook (3%, tuna longline and recreational fishing hooks), and monofilament netting (1%)(Page et al. 2004). Some of these entanglements caused serious injuries and mortalities. Furthermore, entanglement records are likely to be negatively biased, as a proportion of entangled fur seal are considered unlikely to be recorded as the nature of the entanglement may prevent them from returning to land but causes them to die at sea.

4.4.2 New Zealand sea lion

New Zealand sea lion are endemic to this region, and based on their distribution in southern South Island and subantarctic waters, interactions with commercial fisheries are restricted to those areas. Fisheries observers reported a total of 298 incidental captures of New Zealand sea lion between 1992–93 and 2011–12, with all observed captures occurring in trawl fisheries, except for one sea lion capture in surface-longlining operations (Table 6). There were no records of stranded sea lion in the strandings database.

Observer data for the period from 1995–96 to 2010–11 show that incidental captures of sea lion in New Zealand trawl fisheries occurred mostly in the squid fishery around Auckland Islands (within management area SQU6T) and the southern blue whiting fishery around Campbell Island (Thompson et al. 2013b). In the Auckland Islands squid fishery, sea lion have been reported as bycatch each year, excepting the 2010–11 and 2011–12 fishing years, and capture rates ranged between 0.3 and 6.7 sea lion per 100 tows. Based on these observer data and total fishing effort, the estimated number of captures varied between 4 (95% c.i.: 0 to 11, in 2010–11) and 142 (95% c.i.: 91 to 208) individuals per year.

The significant number of incidental sea lion captures in the Auckland Islands squid trawl fishery has led to the implementation of management strategies to reduce the impact of bycatch on the sea lion population. These management measures have included the introduction of a sea lion exclusion device (SLED) in 2001, that is fitted to trawl nets, allowing sea lion to escape from the nets (Ministry for Primary Industries 2012).

The reduction in observed sea lion captures in the Auckland Islands squid trawl fishery in recent years has been attributed to the use of SLEDs, although there have been concerns that sea lion interactions with SLEDs at depth may result in unobserved injuries and mortalities. The most likely source of this cryptic mortality is head trauma from impacts with the SLED grid, and a recent modelling study assessed the probability of this kind of head trauma (which could be fatal at depth) for sea lion interacting with SLEDs (Abraham 2011). Findings from this study revealed a 2.7–8.2% probability of mild traumatic brain injury, but uncertainties in the data informing the model mean that the higher value of 8.2% cannot

be considered an upper bound on this probability.

In contrast to the Auckland Islands squid fishery, there has been an increase in observed sea lion captures in the Campbell Island southern blue whiting fishery in recent years, with six observed sea lion captures in 2010–11 (Thompson et al. 2013b). The corresponding capture estimate for this fishery was 15 (95% c.i.: 8 to 25) sea lion in the 2010–11 fishing year, compared with 24 (95% c.i.: 15 to 36) estimated captures the previous year.

Other trawl fisheries with observed sea lion captures included scampi and also mixed target trawl fisheries around Auckland Islands, and trawl fisheries operating on the Stewart-Snares shelf (Thompson et al. 2013b).

There have been no reports of sea lion bycatch in lobster fisheries, although drowning in lobster pots has been highlighted as a significant source of mortality for Australian sea lion (Campbell et al. 2008).

4.4.3 Southern elephant seal

There was one observed incidental capture of southern elephant seal in New Zealand waters between 1992–93 and 2011–12, which occurred in trawl fisheries (Table 6).There were no recorded stranding events involving this species.

One fatal entanglement of this species has been documented in aquaculture operations in the Southern Hemisphere (salmon farm), but there have been no reported incidental captures of this species in gillnet fisheries (see Reeves et al. (2013)). Furthermore, incidental captures in fishing nets in the Southern Ocean are rare, and potential future threats of fisheries to this species are considered to be indirect, via the competition for resources (Hindell & Perrin 2009). Northern elephant seal have been captured in drift gillnet and in groundfish trawl fisheries in the Pacific Ocean on the United States west coast, with most observed mortalities of this species in the former fisheries (Carretta et al. 2012). Injuries evident in stranded individuals and caused by fishing gear have involved hook-and-line fisheries and gillnet fisheries.

5. DISCUSSION

The present study reviewed information from New Zealand and other regions to characterise interactions between different marine mammals and commercial fisheries. For baleen whales, most interactions were based on entanglements in fishing gear, often involving passive fishing operations, such as fixed nets and pots. This type of bycatch seemed to be prevalent in species or populations that reside in coastal waters or in areas that are intensively fished, such as North Atlantic northern right whale and humpback whale on the east coast of United States and Canada. For baleen species that are largely oceanic, there were few records of fisheries-interactions, and this scarcity of data has been attributed to their primarily offshore distribution. It is worth noting that any incidental captures involving this group that may occur in offshore waters are likely to be undetected.

In New Zealand, bycatch and entanglement of baleen whales have been rarely observed, with entanglement records only for Bryde's, humpback and southern right whales. As has been found elsewhere, the fishing gear involved in these entanglements included lobster pots, but also gear that could not be assigned to a particular fishery; there was one observed incidental capture of humpback whale in surface longlines. The baleen whale species involved in these interactions occur frequently in coastal regions in New Zealand waters, at least for part of the year. The New Zealand population

of Bryde's whale is resident in northern inshore waters, i.e., Hauraki Gulf, while humpback whale are found in inshore areas during their seasonal migrations; southern right whale are increasingly using coastal mainland areas during the breeding season in winter. Although the resident Bryde's population has a coastal distribution, fisheries bycatch does not appear to be the main threat to this population; instead, it is adversely affected by ship strike, particularly in Hauraki Gulf (Wiseman 2008).

In contrast to baleen whales, toothed whales frequently interact with commercial fisheries, with bycatch incidents involving a range of fisheries in New Zealand and elsewhere. Incidental captures have been reported for the majority of odontocetes, and small-sized species with a coastal distribution, such as common and Hector's dolphins, seem to be particularly affected, with interactions often resulting in bycatch mortality. Bycatch data, including from New Zealand, consistently highlight the involvement of trawl and gillnet fisheries, with declines in the endemic Hector's dolphin attributed to incidental captures in these fisheries.

A number of delphinids are attracted to fishing operations, and the depredation of bait and captured fish can cause substantial loss of catch. Longline fisheries in particular are often targeted by toothed whales, with sperm and killer whales identified as the two most prominent species engaging in this type of behaviour. Although depredation by either or both species can be extensive in some longline fisheries, such as the Southern Ocean toothfish fishery, there have been few documented incidental captures or injuries involving these fisheries. At the same time, depredation also occurs in other fisheries, involving a range of different toothed cetaceans, but this type of interaction is difficult to detect. For example, recent footage from Australia shows that dolphins (and seals) routinely swim in and out of trawl nets, but evidence of this type of fishery interaction is generally scarce.

For pinnipeds, trawl fisheries are often the most significant source of fishing-related mortality, with high numbers of New Zealand fur seal and New Zealand sea lion incidentally captured in these fisheries. This finding is consistent with information from other countries, such as Australia, where high bycatch mortality of fur seal in trawling operations has led to the introduction of mitigation measures, including the fitting of seal exclusion devices to trawl nets. In New Zealand, sea lion exclusion devices are used in the Auckland Islands squid trawl fishery, prompted by high levels of bycatch mortality of New Zealand sea lion over a period of time.

Similar to delphinids, depredation behaviour is common in some pinniped species, such as fur seal entering and exiting trawl nets while feeding on captured fish (Browne et al. 2005). This foraging behaviour has been linked to bycatch mortality of different fur seal species, but has not been identified in New Zealand fisheries to date.

In addition to trawl fisheries, a relatively high number of New Zealand fur seal was also bycaught in surface-longline fisheries, and this species has also been captured in bottom longlines and setnets in the New Zealand region.

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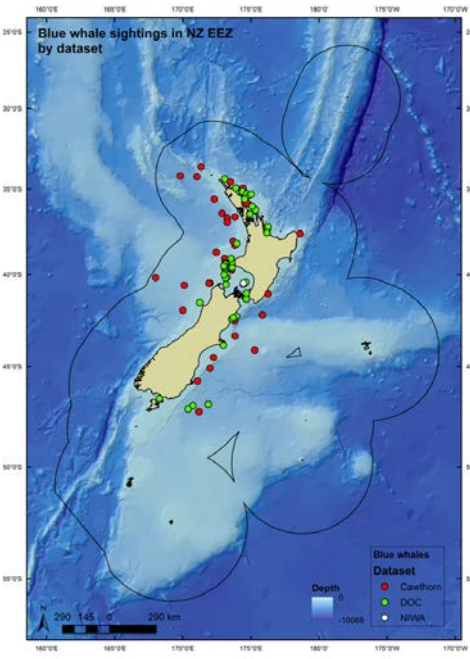
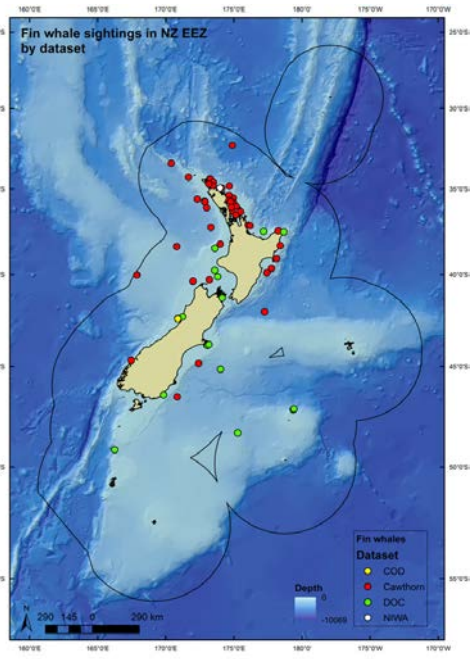
APPENDIX A: SIGHTINGS BY DATASET

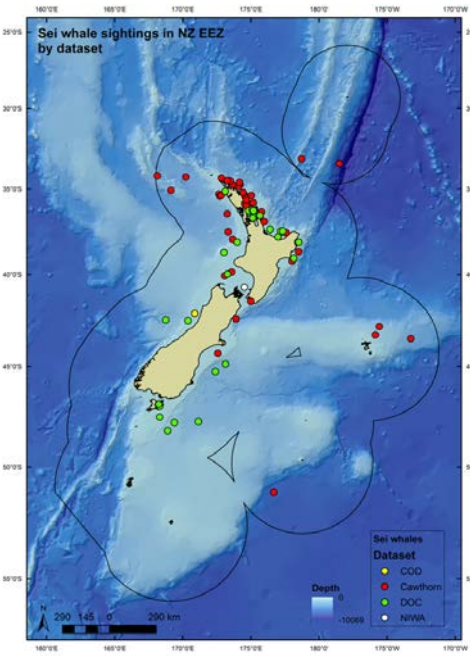
(a) Blue whales



(b) Fin whale



(c) Sei whale



(d) Humpback whale

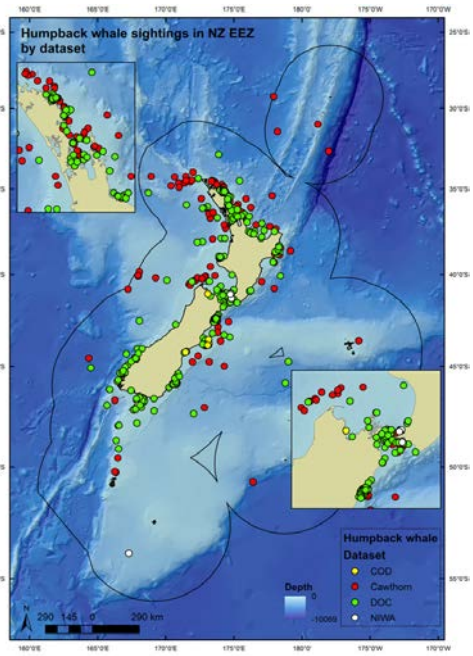
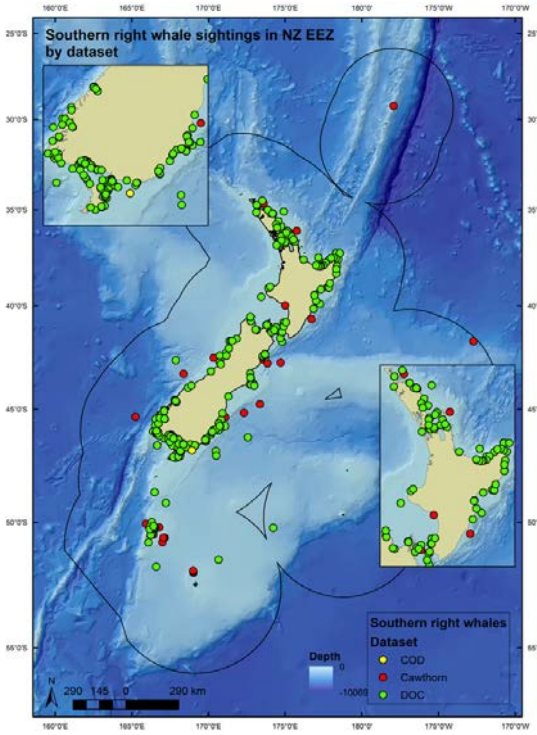
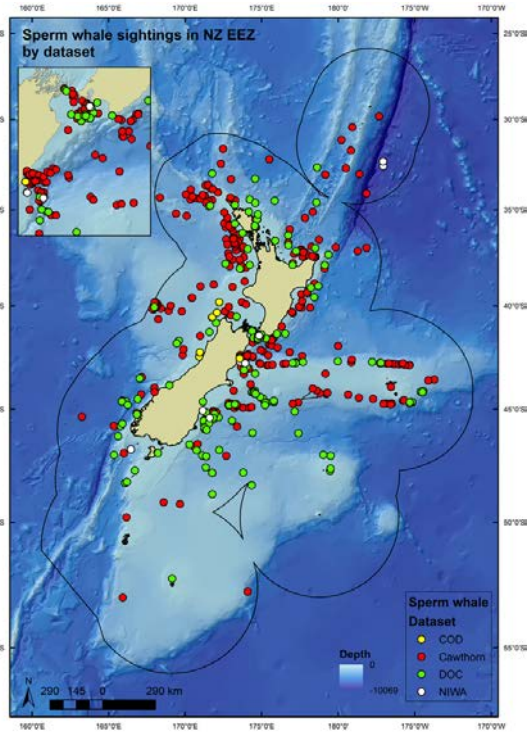


Figure A-1: Distribution of marine mammal sightings in New Zealand waters between 1970 and 2013 by data source, including Department of Conservation (DOC), Cawthorn (2009), the Ministry for Primary Industries Centralised Observer Database (COD), and opportunistic at-sea cetacean sightings (National Institute of Water and Atmospheric Research, NIWA).

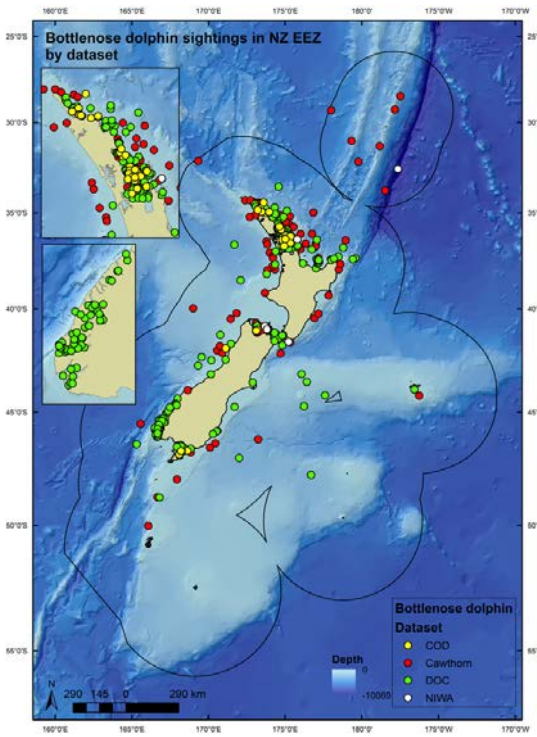
(e) Southern right whale



(f) Sperm whale



(g) Bottlenose dolphin



(h) Common dolphin

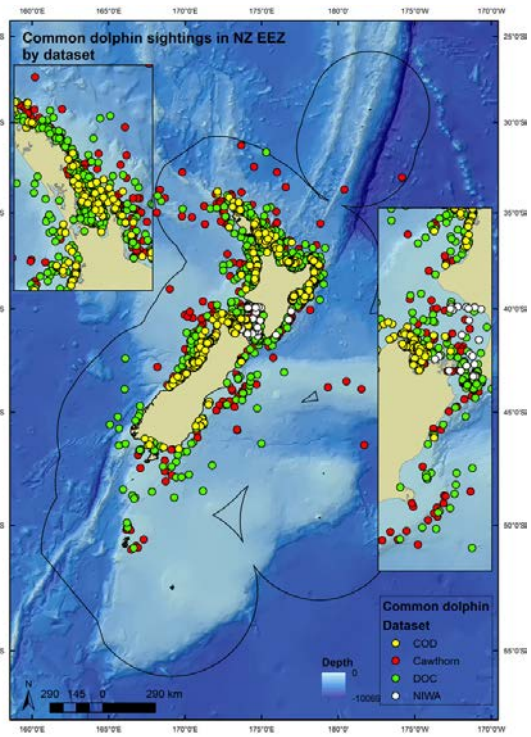
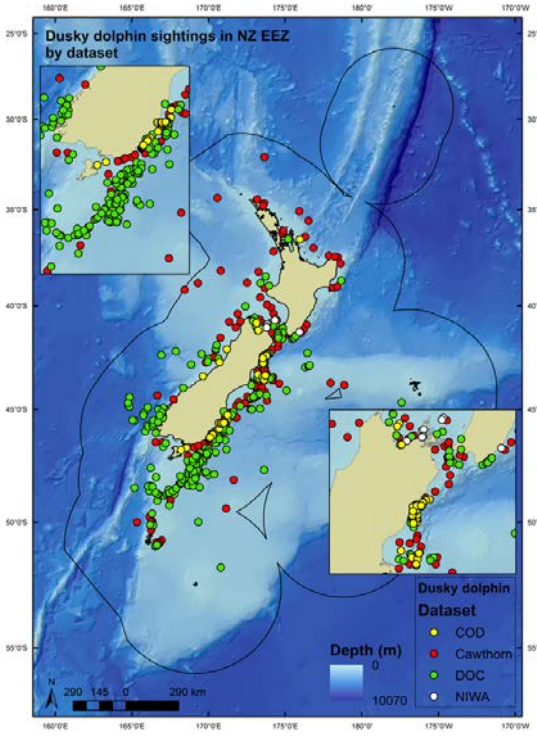
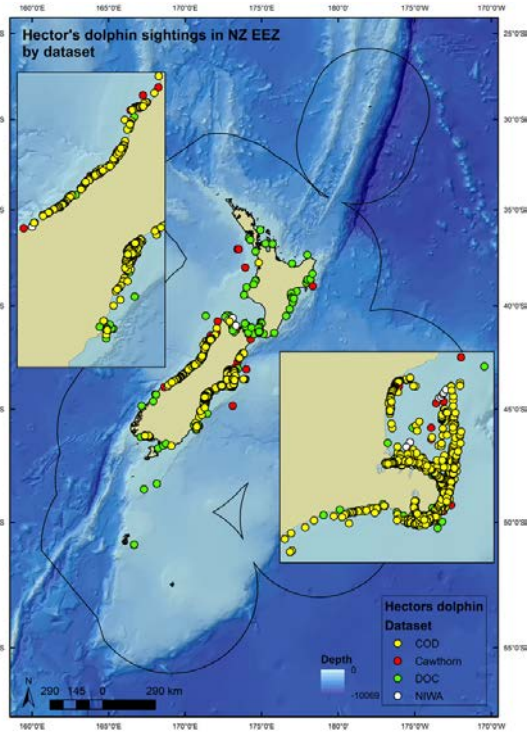


Figure A-1: (cont.) Distribution of marine mammal sightings in New Zealand waters between 1970 and 2013 by data source, including Department of Conservation (DOC), Cawthorn (2009), the Ministry for Primary Industries Centralised Observer Database (COD), and opportunistic at-sea cetacean sightings (National Institute of Water and Atmospheric Research, NIWA).

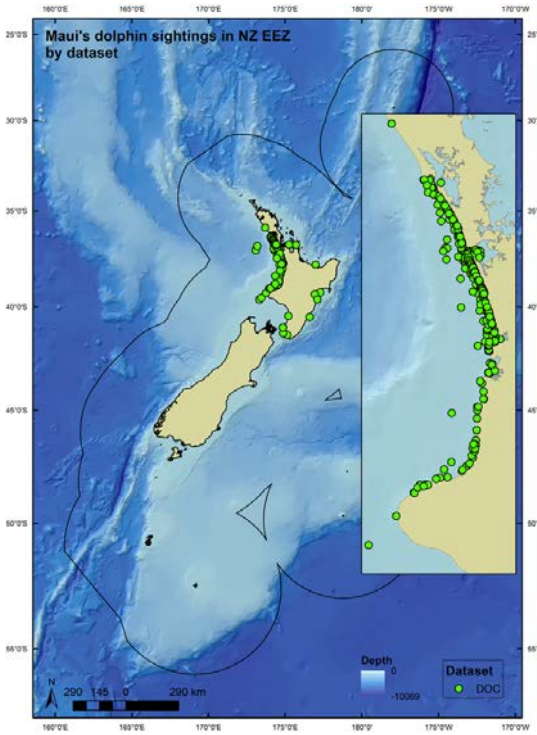
(i) Dusky dolphin



(j) Hector's dolphin



(k) Maui's dolphin



(l) False killer whale

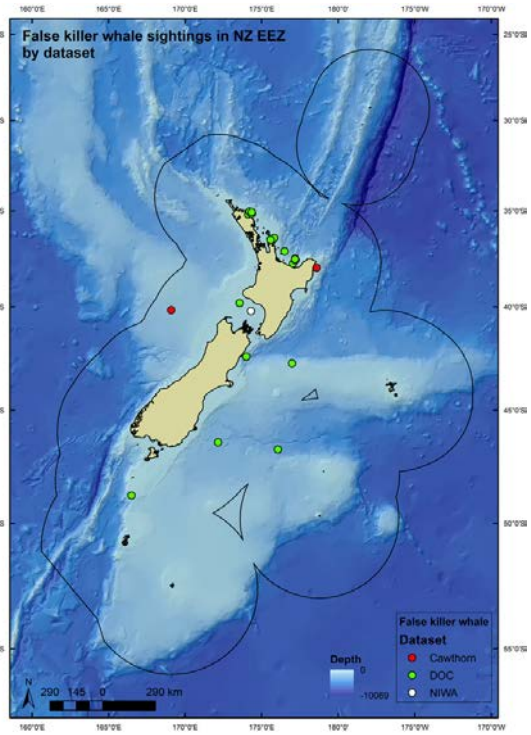
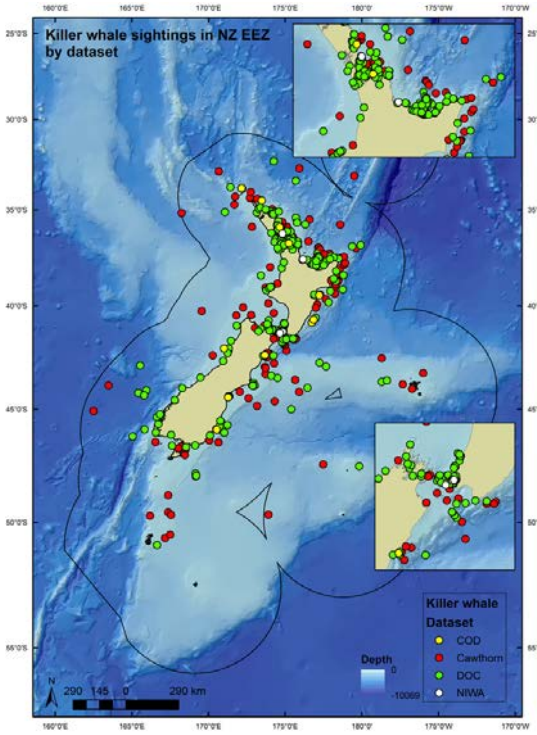
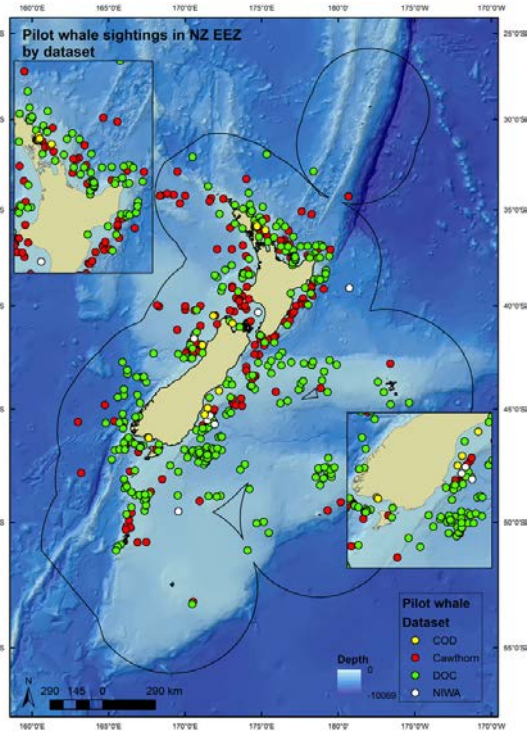


Figure A-1: (cont.) Distribution of marine mammal sightings in New Zealand waters between 1970 and 2013 by data source, including Department of Conservation (DOC), Cawthorn (2009), the Ministry for Primary Industries Centralised Observer Database (COD), and opportunistic at-sea cetacean sightings (National Institute of Water and Atmospheric Research, NIWA).

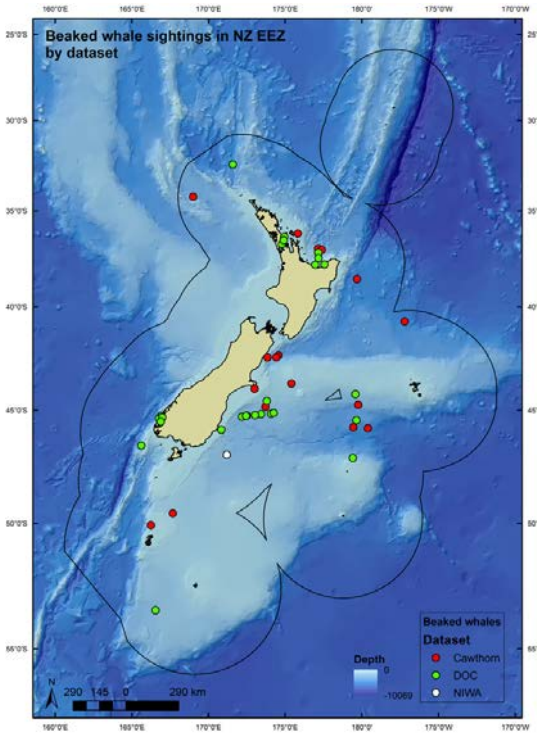
(m) Killer whale



(n) Pilot whales



(o) Beaked whales



(p) Rare cetaceans

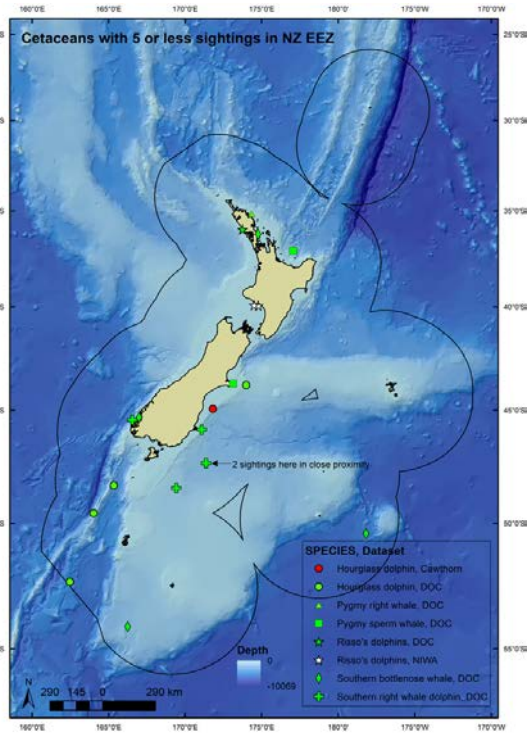


Figure A-1: (cont.) Distribution of marine mammal sightings in New Zealand waters between 1970 and 2013 by data source, including Department of Conservation (DOC), Cawthorn (2009), the Ministry for Primary Industries Centralised Observer Database (COD), and opportunistic at-sea cetacean sightings (National Institute of Water and Atmospheric Research, NIWA).

APPENDIX B: CETACEAN SIGHTINGS BY SPECIES, DATA SET, MONTH, SEASON, AND YEAR

Table B-1: Number of cetacean sightings within New Zealand's Exclusive Economic Zone for the period between January 1970 and January 2013 by species and month. U: unknown month.

Taxa	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	U	Total
Blue whales	11	12	3	5	6	17	4	8	4	14	17	9	4	114
Minke whale	6	2	3	5	4	1	2	1	8	5	10	8	5	60
Bryde's whale	80	32	19	33	19	17	23	35	57	102	95	59	6	577
Fin whale	7	11	6		4	3	1	5	2	3	7	13	2	64
Sei whale	10	7	8	6	3	2	5	4	5	4	5	14	8	81
Humpback whale	38	11	24	16	41	116	74	54	20	42	58	33	11	538
Southern right whale	4	14	16	9	10	32	89	82	73	22	7	6	2	366
Pygmy right whale									1					1
Sperm whale	70	51	44	26	36	28	41	25	22	20	35	56	41	495
Pygmy sperm whale		1	1											2
Bottlenose dolphin	69	65	32	39	38	14	39	22	9	20	41	17	37	442
Common dolphin	377	545	291	215	171	99	115	140	110	102	169	217	143	2 694
Dusky dolphin	131	105	52	33	59	17	20	31	11	25	83	104	59	730
Hector's dolphin	1 116	1 183	225	15	13	12	9	21	8	11	196	406	19	3 234
Maui's dolphin	131	149	82	15	18	27	17	22	7	37	26	42	16	589
Hourglass dolphin	1	1									1	2		5
False killer whale	5	4	8	1	2							4	3	27
Killer whale	61	49	45	33	33	45	22	17	40	49	62	63	29	548
Pilot whales	90	78	49	31	18	27	32	17	19	30	48	65	46	550
Southern right whale dolphin		3							1				1	5
Beaked whales	3	8	3	2	2		2	1	1	1	13	9	1	46
Southern bottlenose whale		1	1					1				1		4
Total	2 210	2 333	913	484	478	457	495	486	399	487	873	1 128	433	11 176

Table B-2: Number of cetacean sightings within New Zealand's Exclusive Economic Zone for the period between January 1970 and January 2013 by species and season.

Taxa	Summer	Autumn	Winter	Spring	Unknown	Total
Blue whales	32	14	29	35	4	114
Minke whale	16	12	4	23	5	60
Bryde's whale	171	71	75	254	6	577
Fin whale	31	10	9	12	2	64
Sei whale	31	17	11	14	8	81
Humpback whale	82	81	244	120	11	538
Southern right whale	24	35	203	102	2	366
Pygmy right whale				1		1
Sperm whale	177	106	94	77	41	495
Pygmy sperm whale	1	1				2
Bottlenose dolphin	151	109	75	70	37	442
Common dolphin	1 139	677	354	381	143	2 694
Dusky dolphin	340	144	68	119	59	730
Hector's dolphin	2 705	253	42	215	19	3 234
Maui's dolphin	322	115	66	70	16	589
Hourglass dolphin	4			1		5
False killer whale	13	11			3	27
Killer whale	173	111	84	151	29	548
Pilot whales	233	98	76	97	46	550
Southern right whale dolphin	3			1	1	5
Beaked whales	20	7	3	15	1	46
Southern bottlenose whale	2	1	1			4
Total	5 671	1 875	1 438	1 759	433	11 176

Table B-3: Number of cetacean sightings within New Zealand's Exclusive Economic Zone for the period between January 1970 and January 2013 by data set and year. Data sources included Department of Conservation (DOC; Department of Conservation 2012b), Cawthorn (2009), opportunistic at-sea sightings (NIWA), and the Centralised Observer Database (COD).

Year	DOC	Cawthorn	NIWA	COD	Total
Unknown	18	5			23
1970	9				9
1972	2				2
1974	2				2
1976	1				1
1977	7				7
1978	7				7
1979	8	1			9
1980	1	163			164
1981	3	188			191
1982	11	193			204
1983		184			184
1984	1	194			195
1985	9	151			160
1986	1	130			131
1987		200			200
1988	7	90			97
1989	4	66			70
1990	75	67			142
1991	60	15			75
1992	85				85
1993	156				156
1994	123				123
1995	58				58
1996	73				73
1997	41	15			56
1998	31	72			103
1999	227	3			230
2000	220				220
2001	371				371
2002	359				359
2003	249				249
2004	282				282
2005	308				308
2006	214				214
2007	360		1		361
2008	355				355
2009	573		1	2 711	3 285
2010	250		10	586	846
2011	625		58	178	861
2012	665		40		705
2013	2		1		3
Total	5 853	1 737	111	3 475	11 176