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New Zealand fur seals – summary of current knowledge

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EXECUTIVE SUMMARY

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This outline of available information about New Zealand fur seals (*Arctocephalus forsteri*) identifies the primary studies that contribute to knowledge of fur seals, in particular in relation to their incidental capture in commercial fisheries, as a resource for fishery managers. Some information is available to describe pup production and dietary and foraging characteristics, but this information is colony specific and often represents a small number of seasonal surveys. Although the life history is generally well understood, there is less information available on the basic population parameters of this fur seal. The current estimate of population numbers for the entire region is unknown; however, since the mid 1970s, there appear to be increases in numbers at some breeding colonies and expansion of areas colonised by these fur seals. Where several time series of data exist, such as the annual pup production data for three colonies on the west coast of the South Island over the last 20 years, the results are yet to be published.

The interaction between commercial fishing activity and fur seals has been described and quantified annually for major fisheries, especially trawl fisheries in which larger factory trawlers operate, but information that could describe the likelihood of fur seal interactions with the fishing activities of smaller vessels that operate in inshore fisheries is lacking. This report summarises the main body of literature relating to fur seal life history, distribution and abundance, diet and foraging, marine and terrestrial habitat, and fisheries interactions including factors affecting capture and mitigation methods. The main knowledge gaps identified include fur seal population dynamics, population numbers throughout New Zealand (or at least for those breeding colonies which are located close to fishing grounds), interactions between fur seals and fisheries for which observer coverage is moderate, low, or non-existent, proportion of the sex and life stages that are removed by fishing each year, and the provenance of the fur seals caught in fishing gear. The main recommendations are for a coordinated approach to define the best strategy for obtaining population parameters and determining comparable population estimates; the data from the west coast South Island main rookeries be published or released for analysis; and that the observer coverage of commercial fisheries, particularly those that are operated close to fur seal breeding colonies, is increased to provide improved estimates of the incidental captures.

1. INTRODUCTION

The aim of this report is to identify and summarise available information relevant to the interaction between New Zealand commercial fisheries and the New Zealand fur seal (*Arctocephalus forsteri*) to provide an overview of the current state of knowledge and identify gaps in that knowledge. This work was requested by the Ministry of Fisheries and completed as part of the project PRO2006/05 as an information source. As such, it replaces the original objective 3 — *to classify fishing areas, seasons and fishing methods into different risk categories in relation to the probability of marine mammal incidental captures for the years from 1990 through to the end of the fishing year 2005/06*. This objective was changed substantially after discussions with Ministry of Fisheries Science staff. Work on the objective was delayed to accommodate the evolving Ministry of Fisheries process of determining the most appropriate approach for risk assessment. At the stage when it was considered that the project needed to be completed, the Ministry of Fisheries agreed the objective should identify and summarise the available sources of information pertinent to New Zealand fur seals, with particular reference to interactions with commercial fisheries. The main output required was a list of useful references or information sources for input to discussions about the management of the fur seal-fisheries interaction.

A search (in February 2010) of both published and grey literature using NIWA and Department of Conservation (DOC) library and internet bibliographic databases identified relevant information from scientific papers and reports, theses from New Zealand universities, management plans from New Zealand and Australian governments, the Ministry of Fisheries website, and web-based products such the Ministry of Fisheries NABIS distribution maps (and associated data). A data extract from the Ministry of Fisheries centralised observer database (*cod*) was requested to provide data on the length and sex of fur seals killed during observed commercial fishing trips for fishing years 1990–91 to 2008–09.

The information given in this report directs the reader to the available literature sources which report on fur seal population dynamics and distribution as well as the interaction between fisheries and fur seals. Each section of the report provides a list of references that relates to that topic. Many of the papers and reports on fur seal population dynamics and ecology are based on several seasons of study at certain locations, and for some fur seal populations there are recent surveys, whereas other populations may not have been visited for many years. Although Department of Conservation staff often record counts of fur seals seen during visits to areas, these are generally ‘guesstimates’ or single counts and thus represent a snapshot in time and space of fur seal presence. Information on fisheries interactions has been produced over the last 20 years, with emphasis on fisheries with adequate observer coverage and greater levels of incidental captures. Some information is also provided from long-term studies undertaken in Australian colonies of New Zealand fur seals.

2. NEW ZEALAND FUR SEALS (*Arctocephalus forsteri*) — GENERAL INTRODUCTION

- The New Zealand fur seal is one of the two species of otariid (eared) seals that breed in New Zealand waters: the other is the New Zealand sea lion (*Phocarctos hookeri*). This fur seal species is listed as “least concern” by the IUCN and as “not threatened” by the Department of Conservation (Hitchmough et al. 2007).

- New Zealand fur seals resident in New Zealand are considered to show high genetic variation with limited gene flow between broad areas (based on mitochondrial DNA studies by Lento et al. 1994, 1997). These studies were unable to show any genetic differentiation between colonies. Robertson & Gemmell (2005) described low levels of genetic differentiation (consistent with homogenising gene flow between colonies and an expanding population) based on genetic material from fur seal pups from seven colonies. This work is ongoing (B. Robertson, University of Otago, pers. comm.) and aims to determine the provenance of animals caught during fishing activities, through the identification and isolation of any colony genetic differences.

- Crawley & Wilson (1976) provided a comprehensive account of the life history of fur seals, including distribution, movements, habitat, behaviour, and their breeding cycle. New Zealand fur seals are sexually dimorphic and polygynous (Crawley & Wilson 1976, Harcourt 2001, McKenzie et al. 2007): males may weigh up to 180–200 kg, whereas females weigh up to about 50 kg (Mattlin 1987). Adult males are much larger around the neck and shoulders than females and breeding males are on average 3.5 times the weight of breeding females (Crawley & Wilson 1976). Females are philopatric and are sexually mature at 4–6 years, whereas males mature at 5–9 years (Mattlin 1987, Dickie & Dawson 2003). The maximum age recorded for New Zealand fur seals in New Zealand waters is 22 years for females (Dickie & Dawson 2003) and 15 years for males (Mattlin 1978).

- New Zealand fur seals are distributed on rocky coastlines of New Zealand's main islands and sub-Antarctic islands, primarily in waters south of 40° S (Figure 1) (Crawley & Wilson 1976, Wilson 1981). Further populations exist on the southern and western coasts of the Australian continent and offshore islands in Australian waters, with Macquarie Island being the southernmost breeding colony (see Shaughnessy 1999). Currently, the populations in both countries are considered to be in a recolonisation phase (apparent from increases in abundance and expansion in range) following protection afforded under various pieces of legislation after numbers were decimated during sealing activities in the 1800s and further culling periods during the 1900s (Smith 1989, 2005, Lalas & Bradshaw 2001, Goldsworthy et al. 2003).

- According to Suisted & Neale (2004), the numbers of New Zealand fur seals in New Zealand waters before the sealing period were estimated at 1–2 million animals and current numbers are between 50 000 and 100 000 animals, though no references are supplied for these numbers.

- Little research was carried out on New Zealand fur seals until the mid-late 1960s, after which studies detailing distribution, abundance, population demographics, breeding biology, diet, and behaviour were initiated — some of which were in response to fishers' beliefs that fur seals were depleting fishstocks (Sorensen 1969a, 1969b, Crawley & Wilson 1976). Crawley & Wilson (1976) described the natural history, distribution, and behaviour of New Zealand fur seals based on work undertaken during 1970–74, principally at Open Bay Islands, Westland, and Snares Islands (see Figure 1 for localities). Open Bay Islands has continued to be a focus of fur seal population research (Mattlin 1978, 1987, Mattlin et al. 1998), and a 20-year pup production dataset exists for this colony and breeding colonies at Wekekura Point and Cape Foulwind (Best 2005, H. Best and Department of Conservation unpublished data). Studies at Otago Peninsula began in the 1980s and continue to be undertaken largely by the University of Otago and independent researchers (for example, Lalas & Harcourt 1995). Surveys were also carried out at colonies in Nelson-Marlborough (Taylor et al. 1995) and sub-Antarctic islands (Taylor 1982, 1992, Carey 1998). More recently, research has focused on Kaikoura and Banks Peninsula (Ryan et al. 1997, Boren 2005, Boren et al. 2006, Negro 2008).

- The most complete description of fur seal distribution that provides a New Zealand region 'count' was provided by Wilson (1981) as between 30 000 and 50 000 animals. Although counts have been made at irregular intervals at some locations (for example, Taylor et al. 1995, Boren 2005), there has been no systematic population count of New Zealand fur seals (Cawthorn et al. 1985, Anderson 1990, Baird 1994, Taylor et al. 1995).

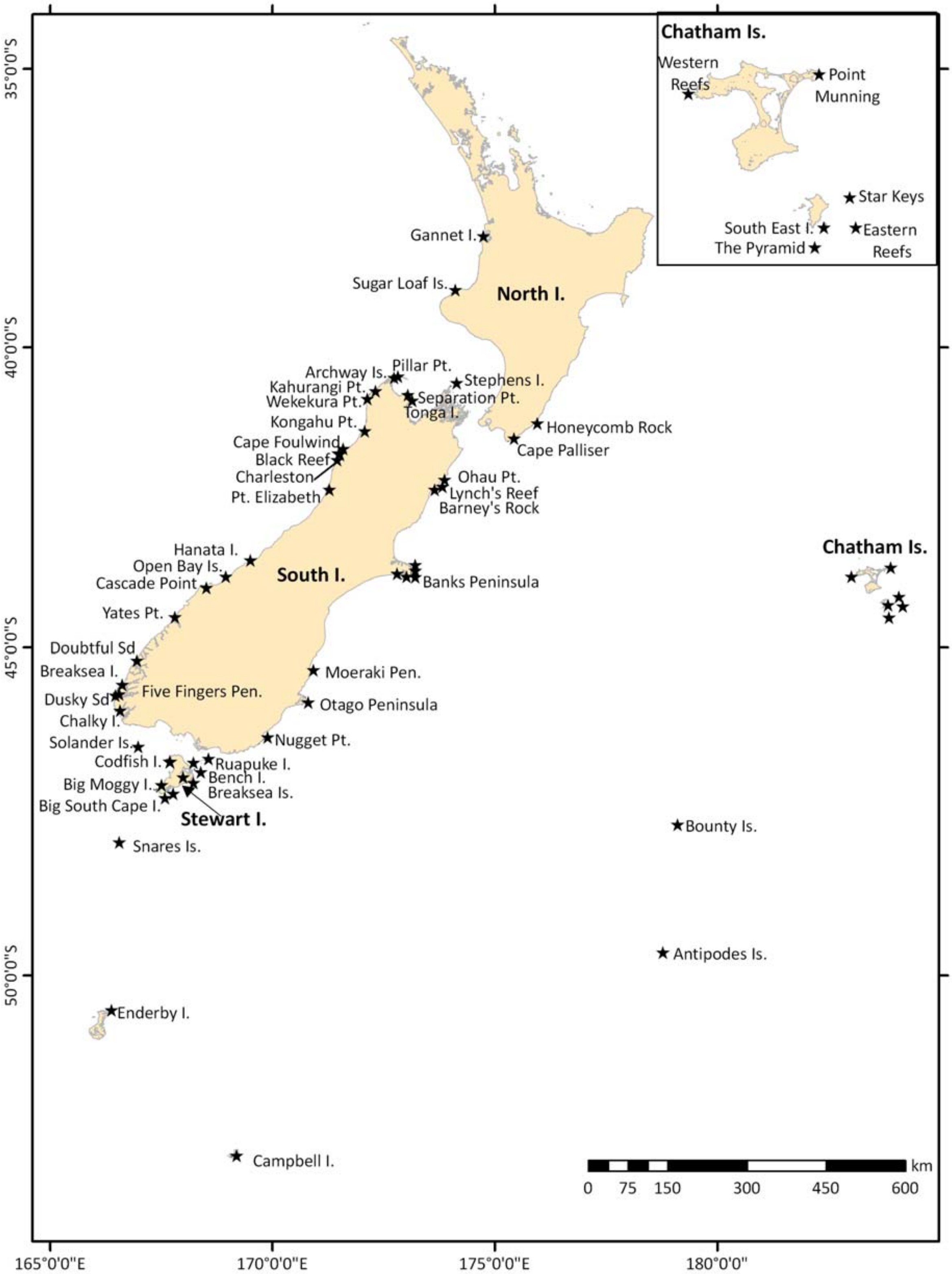

Figure 1: Locations of the main New Zealand fur seal rookeries, based on information at http://www.nabis.govt.nz. Nelson-Marlborough colonies include those at Stephens Island, Separation Point, and Tonga Island. Sub-Antarctic colonies include Antipodes Islands, Bounty Islands, Campbell Island, Enderby Island, and Snares Islands. Kaikoura colonies include those at Barney's Rock, Lynch's Reef, and Ohau Point.

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3. SOCIAL ORGANISATION, BREEDING, AND PUP SURVIVAL

- New Zealand fur seals are annual breeders and generally produce one pup after a gestation period of about 10 months (Crawley & Wilson 1976). Twinning can occur and females may foster a pup (Dowell et al. 2008).

- Breeding animals come ashore to mate after a period of sustained feeding at sea. Breeding males arrive at the breeding colonies (rookeries) to establish territories during October–November. Breeding females arrive at the colony from late November. Pregnant animals give birth shortly after. Peak pupping occurs in mid December (Crawley & Wilson 1976).

- Females remain at the colony with their newborn pups for about 10 days, by which time they have usually mated. Females then leave the colony on short foraging trips of 3–5 days before returning to suckle pups for 2–4 days (Crawley & Wilson 1976). As the pups grow, these foraging trips are progressively longer. As pups become more mobile, they congregate into groups when their mothers are at sea. Pups remain at the breeding colony from their birth date until they are weaned (at between 8 and 12 months of age).

- The breeding males generally disperse after mating to feed and occupy haulout areas, often in more northern areas (Crawley & Wilson 1976). This movement of breeding adults away from the rookery area during January allows for an influx of sub-adults from nearby areas.

- Little is described about the ratio of males to females on breeding colonies (Crawley & Wilson 1976), or the reproductive success. Boren (2005) reported a fecundity rate of 62% for a Kaikoura colony, based on two annual samples of between about 5 and 8% of the breeding female population. This rate is similar to the 67% estimated by Goldsworthy & Shaughnessy (1994) for a South Australian colony.

- Newborn pups are about 55 cm long and weigh about 3.5 kg (Crawley & Wilson 1976). Male pups are generally heavier than female pups at birth and throughout their growth (Crawley & Wilson 1976, Mattlin 1981, Chilvers et al. 1995, Bradshaw et al. 2003b, Boren 2005). Pup growth rates may vary by colony (see Harcourt 2001). The proximity of a colony to easily accessible rich food sources will vary, and pup condition at a colony can vary markedly between years (Mattlin 1981, Bradshaw et al. 2000, Boren 2005). Food availability may be affected by climate variation, and pup growth rates may represent variation in the ability of mothers to provision their pups from year to year.

- The sex ratio of pups at a colony may vary by season (Bradshaw et al. 2003a, 2003b, Boren 2005), and in years of high food resource availability, more mothers may produce males or more males may survive (Bradshaw et al. 2003a, 2003b).

- Estimates of pup mortality or pup survival vary in the manner in which they were determined and in the number of seasons they represent. It is likely that each colony will be affected by different potential sources of mortality due to its habitat, location, food availability, environment, and year, as well as the ability of observers to see and count all the dead pups. The latter may be affected by the terrain, weather, or time of day.

- Mean pup mortality for Taumaka Island, Open Bay Islands, was reported as 20% from birth to 50 days (with 70% of deaths from starvation) (Mattlin 1978). This figure was based on counts in two seasons in two subareas that comprised about 6% of the breeding animals and 6% of the rookery area (Mattlin 1978). A rate of 40% mortality from birth to 300 days for this colony was based on the decline in live pup numbers and is considered an approximation (Mattlin 1978). Other than starvation, causes of death at this colony included stillbirth, suffocation, trampling, drowning, predation, and human disturbance.

- Lalas & Harcourt (1995) reported 8% pup mortality for Otago Peninsula pups up to 30 days old and 23% for pups up to 66 days old. Boren (2005) estimated that 3% of pups died at Kaikoura colonies in 2004–05 before the age of 50 days. Bradshaw et al. (2003b) modelled mark-recapture data for three Otago colonies, incorporating data such as pup body mass, and determined pup survival for a mean 47 day interval at at least 85%. However, this estimate did not include any measure of pup mortality before the first capture effort.

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4. SOURCES OF MORTALITY

- Little is reported about the natural mortality of New Zealand fur seals. Most information describes the possible causes of pup mortality (see above).

- New Zealand fur seals are vulnerable to certain bacterial diseases and parasites and environmental contaminants, though it is not clear how threatening these are to an animal's survival. Animals returned for autopsy after capture in fishing operations have shown signs of tuberculosis infections (identical to the form found in Hawke's Bay cattle), *Salmonella*, hookworm enteritis, phocine distemper, and septicaemia (which is associated with abortion) (Duignan 2003, Duignan & Jones 2007). These reports indicated that some animals also appeared to be suffering from low food availability perhaps due to La Niña summers and that the presence of persistent organohalogen compounds (which can affect the immune and the reproductive systems) may also affect fur seal health.

- Other sources of natural mortality, apart from those listed for pups above, include known predators of fur seals, such as various sharks, leopard seals (*Hydrurga leptonyx*), killer whales (*Orca orcinus*), and New Zealand sea lions (Mattlin 1978, Bradshaw et al. 1998).

- Human-induced sources of mortality include fishing, for example, entanglement in fishing gear; vehicle-related deaths (Lalas & Bradshaw 2001, Boren 2005, Boren et al. 2006, 2008); and direct mortality through shooting, bludgeoning, and dog attacks. There is no evidence in New Zealand waters of mortality from what may be considered an indirect threat to survival due to resource competition with commercial fisheries (see Street 1964, Sorensen 1969).

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5. HABITAT

- The terrestrial habitat of New Zealand fur seals includes a variety of rocky shores. The main critical factor is ready access to their marine habitat. The preferred habitat includes tumbledown beaches (breeding animals), terrace rock ledges (non-breeding males), and small islets (immatures) (see Sorensen 1969). Various descriptors of fur seal habitat include rock platforms, rock shelves or ledges, or boulder beaches usually on points, spurs, headlands, or reefs. Island groups with rookeries and haulouts tended to have rookeries on the exposed west coasts and haulouts on the more sheltered east coast, though Campbell Island was an exception to this, perhaps due to the lack of preferred habitat (Crawley & Wilson 1976).

- Breeding colonies require shelter or some area of retreat (from heat, heavy seas, predators), large angular rocks at the base of a cliff or eroded rock structures with ridges or guts, and easy access to the sea or pools for cooling in summer (Crawley & Wilson 1976). Many such habitats are available around the New Zealand coastline. To the west of the South Island, the main rookery at Open Bay Islands is on the northern side of Taumaka Island on a “sloping platform of irregular and broken limestone rocks” (Mattlin et al. 1998). Vegetated areas may provide retreat areas for females and pups. Several females may use the same rock-filled gut to pup and thus where such areas are limited, the number of females may be restricted unless they are able to move further inland.

- Typical coastline areas, as described by Taylor et al. (1995) for the Nelson-Marlborough coastline, are “exposed coasts with cliffs, rocky shores, tumbledown piles of huge boulders, and sand or boulder beaches” often with “offshore islands and islets”. Rookeries are exposed to the open sea, with some land above highwater mark, at the foot of cliffs or on offshore islands (free from human disturbance), boulders for protection for pups or overhangs and coves (Taylor et al. 1995). In contrast, smooth granite rock is the fur seal habitat at the Bounty Islands (Taylor 1982).

- New breeding colonies are developing on Banks Peninsula (L. Allum, DOC Canterbury Conservancy, pers. comm.). The breeding habitat on this coastline is characterised by large angular boulders on steep coastlines with escape zones, crevices, and ledges; whereas haulout areas are less steep, less exposed to the sun, and have smaller, more rounded boulders (Ryan et al. 1997).

- Breeding colonies with high pup densities were distinguished from those with lower densities by Bradshaw et al. (1999) by the presence of terrain characteristics that created an optimum environment (and shelter) for pups, such as many smaller rocks, more crevices and ledges, gentler slopes, higher cliffs, and with greater exposure to the west.

- Factors that allow “recolonisation” — expansion of fur seal breeding colonies, or re-establishment, into areas of the coastline — include local availability and distribution of prey, availability of suitable habitat, a degree of isolation from human disturbance, and shelter from extreme weather (Bradshaw et al. 2002). Proximity to a marine habitat that allows benthic feeding over the continental shelf and access to rich upwelling over steep slopes are especially important during pup suckling (Bradshaw et al. 2002). Suitable habitat for breeding colonies exists near and within the colonies already present along the South Island west coast (Anderson 1990).

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6. FORAGING CHARACTERISITICS

- Most foraging research in New Zealand has focused on lactating fur seals. Various types of tracking technology have been fitted to these animals to monitor their trips away from the colony. The expense of the use of these methods has generally limited the numbers of tracked animals, and usually lactating females are fitted with devices such as Time Depth Recorders (TDRs) because these animals must return to the colony from foraging trips to suckle their pups. Each foraging track may represent the preferred foraging areas of an individual in a particular season and thus provide an indication of the waters used by fur seals.

- Several studies of female foraging have been based at west coast South Island rookeries, primarily to determine overlap with the winter hoki (*Macruronus novaezelandiae*) spawning fishery. Radio transmitters were fitted to 15 females from Cape Foulwind on the South Island west coast (Sinclair & Wilson 1994). At that time the numbers of breeding females present there and at neighbouring Charleston were described as ‘a few hundred’. Although this study suffered from some transmission problems, it showed that some females in April foraged in depths shallower than 200 m and to about 30 km offshore, with mean trip duration of 2.6 days and a minimum average of 23 h ashore. The mean minimum distance was 100.8 km (range 48.4–157.7 km), and animals travelled twice as far during daytime than at night, when fur seals are likely to be foraging. During July, seals moved further away from land, beyond the continental slope, but transmission was intermittent and data were unreliable.

- TDRs were used to determine foraging information for 19 lactating fur seals from Open Bay Islands: females dived to at least 250 m and stayed submerged for more than 8 minutes (Mattlin 1995, Mattlin et al. 1998). The maximum depth recorded was 274 m (for a 5.67 min dive in autumn) and maximum bottom time was 11.17 min at over 237 m in winter. About 37% of dives were shallower than 20 m, 73% were shallower than 100 m, and deeper dives were generally between 120 and 139 m throughout the year (Mattlin et al. 1998). Females generally dived deeper (to over 150 m) and for longer during autumn and winter compared with summer, though there were large differences between the diving patterns of individual females. About half their time at sea was spent diving to depths of 6 m or more. Most summer and autumn dives were made between 1800 and 0600 h, whereas dives in winter were made throughout the 24 hours.

- The relatively shallow dives and nocturnal feeding during summer suggested that seals fed on pelagic and vertical migrating prey species (for example, arrow squid, *Nototodarus sloanii*). The deeper dives and increased number of dives in daylight hours during autumn and winter suggested that the prey species may include benthic, demersal, and pelagic species. The deeper dives enabled seals to forage along or off the continental shelf (within 10 km) of the rookery studied (at Open Bay Islands). These deeper dives may be to the benthos or to depths in the water column where spawning hoki are concentrated. Individual females may be either shallow divers or deep divers (Mattlin et al. 1998).

- Foraging studies, in 1994 and 1995, of 24 lactating fur seals fitted with TDRs and based at an Otago Peninsula breeding colony showed similar results. In the summer months, most trips were made at night, and the deepest dives were made near dawn and dusk. Bouts of dives at night were longer than those during the day and often continued throughout the night. Longer trips were undertaken during autumn and winter and the use of distinct dive profiles (long, shallow, and deep) varied with the season (Harcourt et al. 1995, 2002). Satellite transmitted data collected in 1994 from seven Otago female fur seals showed that these animals foraged on the shelf or near the continental slope in summer, in deeper waters (67% in over 1000 m) in autumn beyond the continental shelf, and mainly in inshore waters during winter (Harcourt et al. 2002).

- Boren (2005) tracked lactating fur seals (19 in 2004 and 14 in 2005) from Ohau Point, north of Kaikoura, using very high frequency transmitters. These females generally left the colony at

1600–1800 h and returned at 0800–1000 h, and these overnight trips accounted for 29% of trips in one year and 42% in the following year (Boren 2005).

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7. DIETARY ANALYSES AND CHARACTERISTICS OF NEW ZEALAND FUR SEAL DIETS

- The different methods used to collect and analyse dietary data can influence the findings, as can the timing (relative to when the animal last fed) of the collection of material. If a sample is collected after an animal has just eaten, the diet analysis will likely reflect that meal, and it may also reflect the meal its prey ate (that is, include indirect prey items).

- Data collection methods to analyse New Zealand fur seal diets have included investigation of freshly killed animals (Sorensen 1969), scats, and regurgitates. Although prey species can be identified, sized, and quantified through analysis of stomach contents from a freshly killed animal (Pierce & Boyle 1991), there are generally few opportunities for this direct collection method. Non-invasive non-lethal methods, such as those involved in the collection and analysis of scat and regurgitation samples provide information about prey types, species, and size. Fish prey items can be recognised by the presence of otoliths, bones, scales, and lenses, and cephalopods by beaks and pens (see Bowen 2000). Fish remains predominate in scats, whereas the hard beaks of cephalopods are generally the main items in regurgitated samples. The seasonal availability of squid prey to the fur seals may influence the presence of regurgitates at the colony. Any differences between male and female diets are not necessarily obvious from these methods, and these analyses can be biased for various reasons and thus limit attempts at quantitative analysis of the species composition.

- For example, in scat analysis the retention of material is affected by different rates of erosion of hard prey parts such as otoliths and the passage through the stomach and intestine (Fea & Harcourt 1997, Tollit et al. 1997). Some parts such as squid beaks may get lodged in the stomach or be too large to move through the digestive tract and need to be regurgitated. Other hard parts may take longer to pass through the digestive tract, or be eroded or dissolved depending on their fragility. Therefore, a prey item with fragile otoliths, such as barracouta (*Thyrsites atun*), may not be reflected in the results of the analysis (see Dellinger & Trillmich 1988, Tollit et al. 1997). Corrections can be made for digestion rates of otoliths, but many factors need to be considered:

prey species and size, position in digestive tract, completeness of prey skull (Dellinger & Trillmich 1988). Thus, larger and stronger otoliths are more likely to be preserved and excreted or regurgitated. Similarly, the presence of beaks may overestimate the importance of squid in the diet (Fea et al. 1999). In a study of bias in scat analysis, many more scats were required to detect a large prey species than a smaller prey item with similar occurrence (Arim & Naya 2003).

- Some alternative approaches to dietary analysis are presented by Tollit et al. (2006): prey DNA analysis from scats, or fatty acid signatures and stable isotopes in the predator. Preliminary investigations of the DNA method of detecting fur seal prey in scats look promising (Casper et al. 2007).

- Whatever method is used, the sample sizes need to be large and samples need to be collected systematically to reflect spatial and temporal scales. Fea & Harcourt (1997) recommended the use of both scats and regurgitates. With the colony-specific feeding that appears to be a feature of New Zealand foraging at several colonies, there will be different diets represented in the scats and regurgitations of males and females as well as juveniles from one colony. The sex or age of the animal that produced a collected scat or regurgitate is generally unknown, though collections made during the months females are suckling their pups may better represent female foraging. However, Page et al. (2005a, 2005b) reported that male New Zealand fur seals in Australia can hold territories during the nonbreeding season (and thus may be present throughout the year). These males may well feed on a diet of more nutritious fish (and their favoured penguin) before the start of the breeding season.

- Dietary studies of New Zealand fur seals have been conducted at rookeries in Nelson-Marlborough, west coast South Island, Otago Peninsula, Kaikoura, Banks Peninsula, and the Snares Islands. New Zealand fur seal diet studies were summarised by Harcourt (2001) and Boren (2010).

- Early studies investigated the stomach contents of freshly killed animals from Kaikoura and Bench Island and identified prey items such as octopus (*Octopus maorum*), barracouta, and squid (*Nototodarus sloanii*, *Sepioteuthis bilineata*) (Street 1964, see Sorensen 1969). Arrow squid and octopus also predominated in regurgitate and scat analysis of Otago Peninsula fur seals (Tate 1981).

- Scat analyses from fur seals at Kaikoura on the east coast and Cape Foulwind on the west coast identified 12 fish species and suggested that there were some dietary differences between these two populations, based on identification of otoliths (Carey 1992). Lanternfish (various species of Myctophidae, *Symbolophorus* spp.) were important in the diet at Kaikoura in April–August; whereas at Cape Foulwind, aruhu (*Auchenoceros punctatus*) was important in February–April, anchovy (*Engraulis australis*) in May–August, and silverside (*Argentina elongata*) during April (Carey 1992). Hoki appeared to be more important in the diet of Kaikoura fur seals than of those at Cape Foulwind. Hoki and lanternfish featured in the diet of fur seals near Cook Strait (Dix 1993).

- Analyses of scat and regurgitate samples from an Otago Peninsula colony identified 27 fish and cephalopod taxa (Fea et al. 1999). Lanternfish were numerically dominant throughout the year in scats. Aruhu and red cod (*Pseudophycis bachus*) also featured in scats, but arrow squid was numerically dominant in the regurgitated samples. Larger prey species were considered more important in the overall biomass represented in the scats, especially jack mackerel (*Trachurus* spp.) and barracouta. These dietary analyses suggested that the Otago fur seals had foraged over the outer edge of the continental shelf in 100–200 m through winter and spring, and into deeper waters of 150–300 m during summer and autumn (Fea et al. 1999). This indicates a wider use of deeper waters than the foraging study of lactating fur seals from the same colony (see Harcourt et al. 2002). Lanternfish were present in samples throughout the year (representing offshore foraging), but aruhu, sprat, and juvenile red cod were present only during winter-spring. Medium-large arrow squid predominated in summer and autumn. Jack mackerel species, barracouta, and octopus were dominant in winter and spring. Prey such as lanternfish and arrow squid rise in the water column at night, the time when fur seals exhibit shallow foraging (Harcourt et al. 1995, Mattlin et al. 1998, Fea et al. 1999).

- Holborow (1999) identified at least 38 species in fur seal diets: 31 fish, 6 cephalopods, and at least 1 seabird (possibly diving petrel) from scats and regurgitates collected from Bench Island and Codfish Island off Stewart Island, west coast of South Island, and Snares Islands (where the greatest diversity of prey items was found). This 1999 study increased the number of identified fur seal prey species to 61. As with most studies, the number of scats sampled (574) was appreciably larger than the number of regurgitate samples (56). Fish remains were found in over 77% of scats. Holborrow (1999) found regurgitates in all seasons, unlike Fea et al. (1999) who reported that the presence of regurgitates at Otago rookeries appeared to be seasonal, representing the summer-autumn occurrence of large squid. Squid beaks, hoki otoliths from small fish (samples from west coast rookeries), and barracouta vertebrae were present. Arrow squid were prey items from samples collected from rookeries near Stewart Island and the west coast South Island; lanternfish were recorded from all sites, for at least one season; hoki from the west coast in autumn and spring; jack mackerel in all sites in winter; and barracouta near Stewart Island in spring. Octopus was a prey item in samples from near Stewart Island in autumn and winter.

- Preliminary diet analysis of scat and regurgitates from Banks Peninsula fur seals suggests that lanternfish are favoured throughout the year (Laura Allum, DOC Canterbury Conservancy, pers. comm.). Arrow squid (immatures to adults) were more commonly found in summer and autumn scats, ahuru in winter, with red cod, barracouta, red gurnard, and hoki eaten occasionally throughout the year (though hoki was not found in summer months). Molluscs supplemented the offshore diet. These findings were similar to those previously described (for example, for Otago fur seals by Fea et al. (1999)) and indicate use of different foraging habitats, with the varied diet including prey that migrate vertically during the night, and fish species occupying offshore and inshore pelagic and demersal or benthic habitats.

- The dominant species identified from fur seal scats collected during June, July, October, and November of 2007 and regurgitates found in June and July from Tonga Island in Tasman Bay were arrow squid, anchovy, pilchard, and jack mackerel species (Willis et al. 2008). Material collected in June and July was likely to be from females and pups, whereas material from October and November was probably from breeding males. Pilchards were present in all months, especially July, the only month that arrow squid were absent. Anchovy were present in scats from all months except June. Jack mackerel was found in all months except November. The inshore location of this colony was thought to be the reason for the absence of lanternfish in the samples and the presence of shallow water reef-dwelling species (Willis et al. 2008).

- Page et al. (2005a) analysed scats and regurgitates in Australian-domiciled New Zealand fur seals and found broad differences in their preferred prey: adult males ate more fish and birds (penguins); adult females ate more squid and medium sized fish; and juveniles fed on small fish in pelagic waters off the shelf break. Page et al. (2005a) suggested that the age group diets reflected their different physiological constraints and metabolic requirements.

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8. DISTRIBUTION AND ABUNDANCE IN NEW ZEALAND WATERS

8.1 Historical distribution

- Pre-European archaeological evidence suggests that New Zealand fur seals were present along much of the east coasts of the North Island (except the less rocky coastline of Bay of Plenty and Hawke Bay) and the South Island, and, to a lesser extent, on the west coasts, where in comparison fewer areas of suitable terrestrial habitat were available (Smith 1989, 2005). The rugged landscape along the Fiordland coast was a barrier to human habitation and most likely the reason for the paucity of archaeological evidence of fur seals on that southwestern coastline (Smith 2005).

- The arrival of humans significantly changed the New Zealand fur seal distribution. Between 1250 and 1500, fur seal breeding colonies were restricted to the west, south, and east coasts of the South Island, but during 1500–1700 the breeding colonies on the South Island east coast became nonbreeding areas (Smith 1989, 2005). Before European colonisation, New Zealand fur seals (particularly juveniles and subadults) were part of the subsistence Maori diet throughout coastal areas of mainland New Zealand (see McGlone 1989, Smith 1989). By the late 1700s, breeding colonies were mainly limited to remote southern areas — from Open Bay Islands south, including Fiordland (particularly Dusky Sound and Preservation Inlet), and around the southern coast of Stewart Island to Bench Island. Several colonies also existed on the South Island west coast north from Open Bay Islands to Kahurangi Point (including Cape Foulwind and Wekakura Point), and north from Bench Island to just south of Dunedin on the South Island east coast (Smith 2002). These colonies and those on offshore islands (for example, Campbell Island, Bounty Islands) were the mainstay for the sealing industry of the 1800s (Smith 2002).

- New Zealand fur seals were exploited for primarily fur (but also oil) during the major sealing industry that began in New Zealand waters in the late 18th century and continued on sporadically until 1946 (see Sorensen 1969a, 1969b, Wilson 1981, Taylor 1982, Richards 1994, Lalas & Bradshaw 2001, Smith 2002, Richards 2003). Most mainland sealing effort was between 1791 and 1839 (Smith 2002). In 1894, New Zealand fur seals in New Zealand waters were protected, though some harvest was available under licence during short open seasons when legislation was passed to outlaw sealing except during a brief limited open seasons in 1913–16, 1922–25, and 1946 (Sorensen 1969a, 1969b). This last open season was provided to alleviate concerns of fishers that the increase of fur seals in a defined area of southern New Zealand was impacting on their target fisheries, and thus their potential catch (Sorensen 1969b).

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8.2 Current distribution and abundance

- In 1978, New Zealand fur seals were given total protection under the New Zealand Marine Mammals Act. New Zealand fur seals are distributed around the New Zealand coastline, on offshore islands, and on sub-Antarctic islands (Crawley & Wilson 1976, Wilson 1981, Mattlin 1987) and in South and Western Australia (Shaughnessy et al. 1994, Shaughnessy 1999, Goldsworthy et al. 2003). Within New Zealand waters, the northernmost haulout is at Three Kings Islands, north of the North Island (Singleton 1972), and the species uses waters throughout the extent of the New Zealand EEZ (see Appendix 1 NABIS distribution, Figure 1.1). During the mid 1960s, it was recognised that fur seals were increasing in numbers and re-occupying former breeding grounds (see Crawley & Brown 1971). By the mid 1990s this was more apparent as more areas were recolonised (for example, Dix 1993a, see Harcourt 2001), and the distribution of breeding colonies and haulouts continued to expand northwards (Lalas & Bradshaw 2001).

- The seasonal distribution of the fur seals is determined by the sex and maturity of each animal. Male New Zealand fur seals begin to arrive at the breeding colonies (rookeries) from late October to establish territories (Crawley & Wilson 1976), and females arrive in November and pregnant females generally give birth in early to mid December (Mattlin 1987, see Bradshaw et al. 1999). Mating takes place shortly after and generally most males leave the colony by early February, and these animals generally move to haulout areas around the New Zealand coastline (see Bradshaw et al. 1999), with peak density of males and sub-adult males at haulouts during July–August and smallest densities in September–October (Crawley & Wilson 1976).

- Some information exists on the movement of male fur seals after breeding. For example, some male fur seals from Stewart Island rookeries moved north to haulout at Cape Saunders on Otago Peninsula, and others went south to Macquarie Island before returning to warmer waters before midwinter (Crawley & Wilson 1976).

- Animals may have preferred locations to haulout. Tagged animals from the main three west coast South Island rookeries (Wekakura Point, Cape Foulwind, and Open Bay Islands) and from Tonga Island in Golden Bay went south to haul out on Otago Peninsula, where they remained for several months. Most of the females were from Open Bay Islands and the males came from Wekakura Point (Bradshaw et al. 1999). These authors suggested that there may be some density-dependent emigration effect that causes the females to leave their pupping grounds; there appears to be no reference in this paper as to whether these transient fur seals were at the non-breeding area or the rookery. Tagged fur seals from Tonga Island and Cape Palliser were reported seen at Ohau Point near Kaikoura by L. Boren (see Robertson & Gemmell 2005).

- Lactating females remain at the rookery (apart from short foraging trips) for about 10 months until the pups are weaned, usually during August–September (Crawley & Wilson 1976). Pups are about 300 days old when weaned at Open Bay Islands, 337 days old at Kaikoura, 238–269 days at Tonga Island (see Boren 2005). Median weaning time over all measured Australian populations is 285 days (Goldsworthy 2006).

- Data used to provide colony population estimates of fur seals have been, and generally continue to be, collected in an *ad hoc* fashion. In the New Zealand region, recent fur seal population estimates are available only for a few discrete populations, with the main effort at three west coast South Island rookeries (Cape Foulwind, Wekekura Point, and Open Bay Islands) and rookeries at Otago Peninsula and Kaikoura. The west coast data consist of a 20 year time series collected and held by Hugh Best and Department of Conservation West Coast Conservancy staff (see also Best 2005). These are yet to be published. The Otago data are collected, maintained, and published primarily by Chris Lalas (assisted by Sanfords (South Island) Limited) and Otago University post-graduate students. The recent Kaikoura work by Boren (2005) covered four seasons and unpublished data are available for the subsequent seasons. Other studies of breeding colonies generally provide estimates for one or two seasons. For many areas where rookeries or haulouts exist, count data have been collected opportunistically (generally by Department of Conservation staff during their field activities) and thus data are not often comparable because counts may represent different life stages, different assessment methods, and different seasons.

- In the most comprehensive attempt to quantify the total New Zealand fur seal population, Wilson (1981) summarised population surveys of mainland New Zealand and offshore islands undertaken in the 1970s and estimated the population size within the New Zealand region at between 30 000 and 50 000 animals. This estimate is based on a thorough information search of published and unpublished counts supplemented with colony visits primarily in summer months, though some were visited in winter, during 1971 to 1974. Fur seal presence in an area was determined from questionnaires and local knowledge. Thus, the fur seal numbers contributing to the overall estimate consisted of a mixture of counts, estimates, and ranges of numbers, and each was described as such. The author noted increases in numbers in most areas when estimates from earlier studies were compared with those reported by Wilson (1981), and acknowledged differences in the methods used. More recently, several authors have suggested a number of 100 000 animals as approximating the New Zealand population (Taylor 1990, see Harcourt 2001).

- During the last 10–20 years, counts or surveys have been conducted at a few rookeries and published estimates suggest that populations have stabilised at the Snares Islands after a period of growth in the 1950s and 1960s (Carey 1998) and increased at the Bounty Islands (Taylor 1996), Nelson-Marlborough region (Taylor et al. 1995), Kaikoura (Boren 2005), Otago (Lalas & Harcourt 1995, Lalas & Murphy 1998, Lalas 2008), and near Wellington (Dix 1993a, 1993b).

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8.3 Current knowledge of population numbers at New Zealand breeding colonies

- Fur seal rookeries provide the best data for consistent estimates of population numbers, generally based on pup production in a season (see Shaughnessy et al. 1994). In the literature, the use of “rookery” or “breeding colony” is unspecific other than to describe where fur seals breed and pupping occurs, no matter how many breeding females are present or how many pups are born, or how often breeding occurs. This section attempts to summarise available information on fur seal pup numbers reported from New Zealand fur seal breeding colonies throughout the New Zealand region. The numbers given here are not directly comparable and represent many different collection methods and times (years and seasons). These numbers cannot be used to determine a New Zealand-wide total count of fur seals.

- The Ministry of Fisheries, under its NABIS projects, adopted the following definition of a fur seal breeding colony for its summary of the distribution of breeding colonies available at www.nabis.govt.nz: a New Zealand fur seal breeding colony is *any breeding location where at least 10 pups are born in at least three successive years and where offspring return each year to the same site*. Implicit in this definition is regular surveying of each possible breeding colony; however, as noted above, this rarely occurs. For many colonies, the best available information (and its derivation) is used to describe the NABIS distribution, in the absence of a time series of estimates. A fur seal colony is also considered a breeding colony when, though it doesn’t meet the criteria given above, breeding is known to occur on a regular basis. An example of this is where the available land habitat restricts the numbers of breeding females to fewer than 10 but pups are produced annually (for example, Honeycomb Rock off the Wairarapa Coast).

- Appendix 1 gives the summary of current knowledge (up to October 2010) of the numbers of pups at known breeding colonies where information is available, as part of the work completed by NIWA for the Ministry of Fisheries under NABIS project ZBD2002/26. Apart from primary literature identified through bibliographic databases, including those made available by NIWA and the Department of Conservation libraries, much of the information is from spreadsheets made available by Department of Conservation conservancies throughout the country or university researchers and is the basis of the distribution shown at www.nabis.govt.nz. The information from the DOC conservancies is variable, may represent different years or even decades, and may consist of opportunistic counts of fur seal pups as well as ‘guesstimates’, direct counts, or surveys made relatively frequently. These counts may be for haulout or rookery areas and the location may be recorded by the known geographic name, by latitude and longitude, or by map grid position. A brief summary of the information in Appendix 1 is presented below, beginning with northern colonies.

- Few rookeries exist on North Island offshore islands, with the most northern sites off Waikato, at Gannet Island (Bouma et al. 2008) and off Taranaki at Sugar Loaf Islands (Miller & Williams 2003) representing areas where pup numbers are few (but consistent pupping occurs each year) and expansion is unlikely due to the small area of available habitat. Other North Island localities with breeding fur seals are restricted to the south Wairarapa Coast (for example, Dix 1993).

- The Nelson-Marlborough area has shown recent expansion in the number of breeding colonies (Andrew Baxter, DOC, Nelson-Marlborough Conservancy Office, pers comm.). A 1994 survey showed increases in the size of established colonies compared with the mid 1970s (Taylor et al. 1995). Similar expansion has been reported for the coastline north of and around Kaikoura, in particular at Ohau Point, where over four seasons (2002–05) the population expanded by 32% per annum (Boren 2005) and by 25% during 2006–09 (L. Boren, DOC, pers. comm.), and in headland areas of Banks Peninsula (Boren 2005, Boren et al. 2006). Recent helicopter surveys have revealed new breeding sites on Banks Peninsula (L. Allum, DOC Canterbury Conservancy Office, pers. comm.).

- Breeding colonies developed on the rocky shores of the Otago Peninsula in the 1970s (Lalas & Harcourt 1995). Fur seal presence has since expanded over a 200 km length of the southeastern South Island coastline (Lalas & Bradshaw 2001). Initially these populations (including Nugget Point) grew at about 30% a year between the early 1980s and 1998, but this rate of growth was not maintained and recent data suggest the populations are beginning to plateau, to a stable population for the whole area of about 20 000–30 000 animals (Lalas 2008).

- South of Otago, on the southeastern coast of the South Island, pup counts at Nugget Point during the mid 1990s indicated an annual increase of 19% per year, and that pup numbers had increased substantially since breeding was reported from there in about 1980 (Lalas & Murphy 1998). These authors noted a large increase in the number of non-pups (about 2000 in 1994) on this stretch of coastline compared with the fewer than 10 reported by Wilson (1981). Most of these animals were at Nugget Point.

- Rookeries on the west coast of the South Island represent remnants of the original fur seal breeding colonies (that existed before the population decline caused by sealing). Few published data exist for the rookeries on the west coast of the South Island, though regular surveys to estimate the annual pup production have been carried out at Open Bay Islands, Cape Foulwind, and Wekekura Point since 1990s. The results of these surveys have not been published; however some summary findings indicated that during late January–early February 1999 and 2000 mean pup production estimates for these colonies showed an average decline of more than 50% when compared with the average estimate of pup numbers for 1992–98 (Best 2005). Some increases in pup production were seen in 2001–05, and overall, Best (pers. comm.) concluded that these rookeries are either stable, with periodic fluctuations, or declining. The 2006–09 data indicate that pup production was generally lower in the 2000s compared with the 1990s. Data for other sites where fur seals breed along the South Island west coast are generally field counts (some opportunistic) from land or boat surveys; note this information summarised for NABIS and presented in Appendix 1 was based mainly on data collated by Deborah Watson in 2003 (at the time a student at the University of Otago) because information was not available from the west coast DOC conservancy office.

- A recent aerial survey of the South Island west coast from Farewell Spit to Puysegur Point and Solander Island was undertaken in January 2009 (Baker et al. 2010). This survey excluded parts of Fiordland where aerial surveys were not considered viable and boat surveys were conducted (M. Cawthorn, pers. comm.). Pups were seen at 19 sites. Counts for the sites with corresponding ground counts (Wekakura Point, Cape Foulwind, and Taumaka Bay at Open Bay Islands) were dissimilar from those recorded by observers on the ground, primarily because of the survey design and the nature of the terrain (see Baker et al. 2010). However, this work confirmed the localities shown by Wilson (1981) of potentially large numbers of pups at sites such as Cascade Point, Yates Point, Chalky Island, and Solander Island.

- Data for fur seal populations in the Fiordland area have been collected opportunistically and provide presence information only (Southland Conservancy, Department of Conservation). A recent small boat survey of Breaksea Sound, Doubtful Sound, and Dusky Sound was completed for the Ministry of Fisheries in early 2009 to provide a point estimate to supplement the aerial survey reported by Baker et al. (2010), and pup numbers reported for two sites by Mellina & Cawthorn (2009) are included in Appendix 1.

- Fur seals are common on Stewart Island and the surrounding islands, and their numbers appear to be expanding, though few colonies have been surveyed (see Appendix 1). Carey (1998) listed 16 breeding sites on the Snares Islands, with half having at least 10 pups.

- Population numbers for the Chatham Islands are unknown, though many islands there are known to support fur seals. The most recent data were collected in the 1970s (Wilson 1981). The isolated location (and often the inaccessibility) of the sub-Antarctic islands has resulted in few consistent surveys for population counts. The most recent data available for the Bounty Islands, collected in 1993–94, indicated an increase in pup production from 1980–81, and Taylor (1996) considered that some of the islands had reached their population carrying capacity. Breeding fur seals were first observed (since 1969) in 1985, when fewer than 10 pups were reported from one site (Taylor 1982). A survey in January 1994 estimated at least 21 500 fur seals (including pups and nonbreeders) are currently found at the Bounty Islands, with over 50% of the available area occupied by the fur seals (Taylor 1996).

- New Zealand fur seals were observed breeding again on Campbell Island in 1985 (Daugherty et al. 1990). Little further information is available beyond that presented by Wilson (1981) for the numbers at Campbell Island and the Auckland Islands group where pups have been seen at one location on Enderby Island and occasionally at Disappointment Island (see Appendix 1).

- The recolonisation of the South Island colonies in particular is indicated by the increases in numbers and range: for example, Lalas & Harcourt (1995) reported an average annual rate of increase in pup production of 25% in the Otago Peninsula area from 1983 to 1994, and Taylor et al. (1995) reported an annual pup production increase of 20–23% for the Nelson-Marlborough area between 1971 and 1994, with immigration into the area, and subsequent philopatric recruitment, contributing to the increases. Bradshaw et al. (2000) showed new colonies formed close to established colonies, suggesting a "spill-over effect", though this depended on the suitability of available habitat.

- As a comparison, annual increases in pup production in Australian populations of New Zealand fur seals were estimated at 9.8% in western Australia (Gales et al. 2000) and between 3.1% and 29.2% from 1970 to early 1990s in South Australia (Shaughnessy et al. 1996).

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8.4 Reliability and comparability of population estimates derived from pup counts

- The total number of fur seals present in a rookery depends on the time of year; however, the count of pups in a season is used to estimate the rookery size, because pups are easily recognised by their distinctive coat, remain ashore until weaned, and rarely move beyond intertidal pools.

Ground counts are the most reliable because pups can be easily missed due to the nature of the preferred breeding habitat. Mark-recapture methods are generally used (for example, see Shaughnessy et al. (1994), Lalas & Harcourt (1995)) and the accepted practice is to then use a multiplier to provide an estimate of total fur seal numbers. This multiplier should be appropriate for the rookery with respect to known population parameters such as age-at-first breeding, age-related mortality, longevity, and a measure of population stability (Shaughnessy et al. 1994, Taylor et al. 1995, Lalas & Bradshaw 2001). However, since many of these parameters are unknown for New Zealand fur seals, most studies have used the multiplier of 4.9 after Taylor (1982); however, this was developed primarily from population parameters known for the Antarctic fur seal (*Arctocephauls gazella*), with some correction to account for pup mortality or miss-counts based on (sparse) New Zealand and Antarctic fur seal data. However, the multiplier may vary with different populations with different growth rates (Lalas & Bradshaw 2001).

- Various methods are used to count or estimate pup numbers: mark-recapture (generally with an assumption that the population is closed to emigration or immigration, for example, see Shaughnessy et al. 1994, Lalas & Harcourt 1995), direct counts on foot, counts from clifftops, small boats, and from photographs taken during aerial surveys. Detailed descriptions of methods used are not always provided. Various factors restrict or limit the coverage or accuracy of these methods (for example, see Eberhardt et al. 1979, Garner et al. 1999). Observer experience is one factor in the reliability of counts, as is the timing of the counts relative to the pupping period. For New Zealand fur seals, Wilson (1981) noted that accessibility, weather, sea conditions, visibility, terrain, and observer distance all affected the ability to achieve counts. Boat surveys could potentially miss more than 50% of fur seals unless the terrain was regular (with no caves or large boulders), and more than 10% on a rookery; whereas visibility from a vantage point such as a clifftop may allow 75% of the fur seals to be counted, or 33% if the ground was rough (Wilson 1981). The lack of ability to discern pups in some colonies using aerial spotting and photography was confirmed by Baker et al. (2010).

- Surveys may vary in the way (and time during the pupping period) in which pup mortality is assessed. The reported estimates of pup mortality will always be a minimum because the counts are made at certain times (of the day and the of the pupping period) and there may be unseen pup deaths as a result of pups being washed off rocks or others that may have decomposed (Lalas & Harcourt 1995, Gales et al. 2000).

- Direct counts by observers may overlook hidden pups (Lalas & Harcourt 1995); however, this method is considered a reasonably rapid way of getting counts (Gales et al. 2000). Suggestions for minimising the numbers of missed pups include using thorough and systematic methods and undertaking the count after pupping has finished when there may be better access, mainly due to the absence of adult males. This will also ensure that the full pup cohort is available for counting, but it implies knowledge of colony-specific pupping (Lalas & Harcourt 1995). Mark-recapture methods are more time consuming and require a number of assumptions to be met; for example, effort must be spread evenly throughout the colony because all pups are assumed equal with respect to their probability of capture and recapture (Eberhardt et al. 1979, Gales et al. 2000). The mark should be obvious to all observers throughout the survey time, but pup survival should not be compromised (Eberhardt et al. 1979).

- In a comparison of direct counts with mark-recapture surveys of New Zealand fur seal pups, mark-recapture estimates were greater than counts and larger counts were achieved by walking through a colony rather than from its perimeter (Shaughnessy et al. 1994). These authors noted that mark-recapture estimation was preferable for large areas with animals further away from the coast, particularly because a measure of variability is estimated at the same time. Shaughnessy et al. (1995) noted the limitations of the mark-recapture method in that it is more labour and time intensive (for example, it takes preferably 3–4 people and several days) and disturbs the rookery, though this is not generally considered to have any long-term effect. However, Mattlin (1978) reported some pup deaths from disturbance by humans at Open Bay Islands. Some preliminary work by Watson et al. (2009) explored the development of habitat-specific calibration indices from annual direct counts and mark-recapture estimates to obtain pup abundance estimates that better represent the total pup numbers than those from direct counts, without the disturbance, time, and cost involved in obtaining estimates through mark-recapture methods. These authors noted the need for further refinements of this methodology.

- Eberhardt et al. (1979) suggested that knowledge of [fur seal] activity should be used to determine the best time of day to survey [for pups]: the preferred sampling time being when the maximum number of the species (or life stage, depending on the purpose) can be seen. The importance of timing was illustrated by the survey design methods reported by Lonergan et al. (2007), though this was a survey of haulout numbers. In their study, seal activity information was used to design aerial surveys by helicopter (using thermal imaging cameras) of harbour seal haulouts, and surveys were specifically timed during the moult and restricted to low tide times on sandy shores and low tides on rocky shores in the afternoon.

- Aerial photography was a “practical” method for counting fur seals at the Bounty Islands (Taylor 1982) where the terrain is mainly smooth granite platforms, though the author did acknowledge that distinguishing pups could be difficult. Although, photographic technology is vastly different now, the differentiation of pups was recognised as a major difficulty in the 2009 west coast South Island aerial survey, particularly because of the terrain (Baker et al. 2010). For reliable results, ground counts should be undertaken as near to the same time as aerial photographs, with the same areas being sampled by both types of observers — both for groundtruthing and developing correction factors (Eberhardt et al. 1979).

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9. FISHERIES INTERACTIONS

- The overlap of commercial fishing grounds and fur seal foraging areas has resulted in fur seal captures in fishing gear (Mattlin 1987, Rowe 2009). Table 1 gives a broad summary of the temporal overlap of the operation of the main commercial fisheries with the likely distribution of fur seals at breeding colonies. Fur seals are attracted to various fishing gears, particularly those that offer the opportunity of a feed, and anecdotal evidence suggests that the sound of the winches as they haul the gear acts as a 'dinner gong'. The attraction of fish in a trawl net, on longline hooks, or caught in a setnet provide opportunities for fur seals to fatally interact with fishing gear.

Table 1: Monthly distribution of fur seal activity and the main trawl and longline fisheries with observed reports of fur seal incidental captures.

New Zealand fur seals	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Breeding males	**at breeding colony**				**dispersed at sea or at haulouts**							
Breeding females		**at breeding colony**		**at breeding colony and at-sea foraging and suckling**								**at sea**
Pups			**at breeding colony**									**at sea**
Non-breeders (including yearlings)	**dispersed at sea, at haulouts, or breeding colony periphery**											
Major fisheries	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Hoki trawl	**Puysegur**		**Chatham Rise**						**Cook Strait, west coast South Island**			
Squid trawl			**Stewart-Snares shelf, Auckland Is. Shelf, east coast South Island**									
Southern blue whiting trawl	**Campbell Rise**										**Bounty Is., Pukaki Rise**	
Southern bluefin tuna longline						**Southern bluefin tuna longline**						

- The Ministry of Fisheries Observer Programme collects data on the incidental catch of marine mammals. Observers record these captures as landed dead or released alive. Data on the interaction between trawl fishing operations and fur seals have been collected since the beginning of the observer programme in 1986, with data in the late 1980s mainly being collected from the west coast South Island hoki fishery where large numbers of fur seals were observed caught in 1989 (Mattlin 1994). This incidental capture data collection is secondary to the collection of fisheries data and thus data available for the estimation of marine mammal captures are generally based on programmes that are not specifically designed to collect incidental capture data.

- Fur seals have been observed caught during bottom and midwater trawl operations (particularly for hoki, squid (*Nototodarus* spp.), and southern blue whiting (*Micromesistius australis*) around the coastline of the South Island and the offshore islands in the southern waters of the 200 n. mile Exclusive Economic Zone (EEZ) (Baird 1994, 1996, Baird & Smith 2007, Abraham et al. 2010a). While most observed captures occur in trawl fishing, New Zealand fur seals have also been reported caught on surface longlines that target southern bluefin tuna (*Thunnus maccoyii*), and on bottom longlines (for example, bluenose (*Hyperoglyphe antarctica*)) in waters south of 40º S (Baird 2008, Abraham et al. 2010a). Animals caught on tuna longlines are more likely to be landed and released alive whereas most fur seals caught in trawl nets are dead on landing. Most research on fur seal and fisheries interactions has centred on trawl fisheries, particularly those that target middle depths and deepwater species.

- The first attempt at quantifying fur seal captures in trawl nets was by Mattlin (1994a, 1994b), after scientific observers reported fur seal deaths in trawl gear during the fishery on spawning hoki aggregations off the South Island west coast during July to September. The primary concerns were the number reported by observers, especially the 198 deaths in the 1989 winter, and the lack of knowledge relating to the extent of this mortality and any effects it may have on fur seal populations. The provenance of dead animals was unknown, as was the effect of the loss of mature females from a population. At this time, a voluntary code of practice was developed by the fishing industry in an attempt to restrict fishing practices that were thought to increase the likelihood of fur seal captures in trawl nets, for example, leaving 'stickers' in the net when it was reshot and making turns with the net at the surface (Baird 1994).

- Ministry of Fisheries observers continue to monitor these captures, and after the mid 1990s, the collection of these data was requested from other fishing methods, and fur seal captures have been reported from trawl, surface longline, bottom longline, and setnet fisheries throughout the New Zealand EEZ (Baird 2004, Rowe 2009, Abraham et al. 2010a), with most captures in waters south of 40° S. Trawl gears continue to be the main gear types from which observers report fur seal captures, and most caught in trawl nets are landed dead, particularly those captured off the west coast South Island and on the Bounty Platform (Smith & Baird 2009). Fur seals hooked or entangled in surface longline gear are generally released alive, though often still with the hook embedded in the mouth or some other body part (Baird 2008).

- Observer data and commercial effort data are used to characterise the incidental captures and estimate the total numbers caught. The main emphasis of the Ministry of Fisheries (in relation to fur seal incidental deaths) has been to estimate or predict the total annual captures during trawl fishing, and the data stratification (for example, by target species, area, gear type, vessel nationality) has varied over the last 15 years to reflect the requirements of the Ministry of Fisheries. The analytical methods used to estimate capture numbers across the commercial fisheries have depended on the quantity and quality of the data, in terms of the numbers observed captured and the representativeness of the observer coverage.

- Ratio estimates were provided for the main trawl fisheries and for all trawl fisheries (for example Baird 2005, Abraham et al. 2010a). Model-based predictions of captures are available for all trawl fisheries in waters south of 40° S, in six broad areas, for 1994–95 to 2005–06 (Smith & Baird 2009) and for specific target fishery areas for 1994–95 to 2004–05 (Baird & Smith 2007). These models use the observed and unobserved data in an hierarchical Bayesian approach that combines season and vessel-season random effects with covariates (for example, day of fishing year, time of day, tow duration, distance from shore, gear type, target) to model variation in capture rates among tows. This method compensates in part for the unrepresentativeness of the observer coverage and includes the contribution from correlation in the capture rate among tows by the same vessel. However, the method is limited by the very large differences in the observed and non-observed proportions of data for the different vessel sizes: most observer coverage is on larger vessels that generally operate in waters deeper than 200 m. Thus, fur seal capture rates are almost unknown for the smaller vessels that target inshore species and because the effort of these vessels contributes to about half of the annual tows made in the EEZ, this is a real source of error in the prediction of total numbers (Smith & Baird 2009). The operation of these vessels in terms of the location of effort, gear, and the fishing strategies used is also relatively unknown compared with the deeper water fisheries.

- Over the 12 fishing years analysed by Smith & Baird (2009), there was a small downward trend in the predicted capture rates, and the annual predictions of fur seal captures appeared to show a downward trend, though the amount of fishing effort has steadily decreased since the late 1990s. The most marked decrease of total captures was predicted for the west coast South Island area where most effort targeted hoki during winter months and on Stewart-Snares shelf where squid and hoki were main targets.

- Similar modelling methods were used to produce the most recent set of predicted fur seal captures in trawl fisheries, though tow data in this analysis were grouped (as consecutive tows targeting the same species in an area by a vessel) to reduce the computational load (Thompson & Abraham 2010). The overall downward trend in estimated annual captures for the middle depths and deepwater trawl fisheries has continued, largely as a result of the continued decrease in total tows made each year. The estimated capture rates reported by Thompson & Abraham (2010) for 2007–08 and 2008–09 (at 1.55 and 1.11 animals per 100 tows, respectively), are similar to those for 2002–03 and 2003–04 (at 1.08 and 1.43); whereas the mean estimated captures for 2002–03 and 2003–04 were 807 (95% CI 494–1238) and 971 (611–1528) compared with the 2007–08 and 2008–09 estimates of 710 (95% CI 489–996) and 550 (338–826), respectively.

- Captures were reported from trawl fisheries for species such as hoki, hake (*Merluccius australis*), ling (*Genypterus blacodes*), squid, southern blue whiting, jack mackerel, and barracouta (Baird & Smith 2007, Abraham et al. 2010a). Between 1 and 3% of observed tows targeting middle depths fish species catch fur seals compared with about 1% for squid tows, and under 1% of observed tows targeting deepwater species such as orange roughy (*Hoplostethus atlanticus*) and oreo species (for example, *Allocyttus niger, Pseudocyttus maculatus*) (Baird & Smith 2007). Observed fur seal captures are mainly from trawl effort in defined seasons in areas where fishing occurs relatively close to land (where fur seal rookeries or haulouts exist). Winter hoki fisheries attract fur seals off the west coast South Island and in Cook Strait between late June and September. In August–October, fur seals are caught in southern blue whiting effort near the Bounty Islands and Campbell Island. In September–October captures may occur in hoki and ling fisheries off Puysegur Point on the southwestern coast of the South Island. Captures are also reported from the Stewart-Snares shelf fisheries that operate during summer months, mainly for hoki and other middle depths species and squid, and from fisheries throughout the year on the Chatham Rise though captures have not been observed east of 180° on the Chatham Rise.

- The main fishery areas that contribute to the estimated annual catch of fur seals in middle depths and deepwater trawl fisheries are Cook Strait hoki, west coast South Island middle depths fisheries (mainly hoki), western Chatham Rise hoki, and the Bounty Islands southern blue whiting fishery (Baird & Smith 2007, Thompson & Abraham 2010).

- Little information is available on the interaction of fur seals with smaller vessels that target mainly inshore species in depths generally shallower than 200 m and contribute about 50% of the annual trawl effort (Smith & Baird 2009). New data collection forms for these vessels, introduced in 2007, require fishers to report the start of tow location, rather than report the broad statistical area fished. This will allow better representation of the effort by these smaller vessels. Until recently, any observer coverage on smaller trawl vessels has mainly been in northern waters away from the main haulout and rookery areas. This lack of information is being addressed by attempts to increase the observer coverage (Rowe 2009). Thompson & Abraham (2010) reported that in 2008–09, 3.5% of tows by smaller vessels were observed, an increase from under 1% in previous years. However, it was unclear what proportion of this observer coverage included inshore effort south of 40° S where many inshore vessels operate in fisheries close to fur seal rookeries and haulout areas.

- Ratio estimation is used to calculate total captures in longline fisheries by target fishery fleet and area where data are adequate (Baird 2008), and by all fishing methods (Abraham et al. 2010a). Fur seal captures in surface longline fisheries have been generally observed in waters south and west of Fiordland, but also in the Bay of Plenty-East Cape area when the animals have attempted to take bait or fish from the line as it is hauled. Estimated numbers range from 127 (95% CI 121–133) in 1998–99 to 25 (14–39) in 2007–08 during southern bluefin tuna fishing by chartered and domestic vessels (Abraham et al. 2010a).

- Captures of fur seals in other fishing gears including setnets and recreational fishing activities are not generally documented, though in a study of recreational fishers' interactions with protected species, no data were collected for fur seals (Abraham et al. 2010b). Little information is available about fur seal interactions with setnets other than that they occur with some related mortality (in setnets off the eastern and southern coast of the South Island) (Rowe 2009).

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9.1 Factors affecting fur seal capture

- During trawl fisheries, fur seals are most at risk from capture during shooting and hauling (Shaughnessy & Payne 1979), when the net mouth is within diving depths. Once in the net the animals may be confused in the low light (Shaughnessy & Davenport 1996) and have difficulty in finding their way out in the time limited by their breath-hold abilities. Most fisheries with observed captures occur in waters over or close to the continental shelf, which around much of the South Island and offshore islands slopes steeply to deeper waters relatively close to shore, and thus rookeries and haulouts.

- Ministry of Fisheries observer reports indicate that the main operational aspects that relate to fur seal captures on trawlers in New Zealand fisheries include factors that attract the fur seals, such as the presence of offal and discards, the sound of the winches, vessel lights, and the presence of 'stickers' in the net (Baird 2005). During the tow, fur seals are at risk of capture when a vessel partially hauls the net and executes a turn with the gear up close to the surface. At the haul, fur seals readily attempt to feed from the codend as it is hauled on deck and dive after fish that 'escape' from the net. Comments from observers showed that some fur seal captures were associated with a gear event, particularly during shooting and hauling the net, when gear failure, breakages, or turns executed by vessels resulted in the net being near, or at, the surface (Baird 2005). It appeared that, despite the code of practice designed to minimise the capture of fur seals, other methods of dealing with gear breakdowns need to be considered.

- Factors identified from a limited number of available variables as important influences on the potential capture of fur seals in trawl gear include the year or season, the fishery area, gear type and fishing strategies (often specific to a certain fleet nationality), time of day, and distance to shore (Baird & Bradford 2000, Mormede et al. 2008, Smith & Baird 2009). The variables available to these analyses were relevant to the fishing operation, but did not include information on what was actually happening in the water at the stern of the vessel, including the numbers of fur seals around the vessel or their behaviour.

- Studies on the behaviour of New Zealand fur seals around trawl gear off the Australian coast indicated that numbers of New Zealand fur seals at the surface in Australian trawl fisheries increased when weather conditions worsened (especially with decreased barometric pressure, increased swell height, and visibility); with increased numbers of vessels and trawl frequency; and with decreasing distance from shore (Hamer & Goldsworthy 2006). Fewer fur seals were seen as the trawl speed increased to over 4 knots. Fewer fur seals appeared to be at the surface when shooting and hauling, but video footage revealed their presence underwater at these times suggesting they were foraging on the net as it was being deployed or hauled. Typically, more deaths occurred when animals were caught during deployment, and fur seals were caught during hauling when the vessel speed was faster than the animal's swimming speed. There were similar mortality rates between those with and without Seal Exclusion Devices (SEDs). The weight of the fish catch and the presence of certain bycatch fish species may influence fur seal attendance at vessels (see Hamer & Goldsworthy 2006).

- Captures on longlines occur when the fur seals attempt to feed on the fish catch during hauling. Anecdotal evidence of the preference of fur seals for a feed of fresh livers when confronted with a trawl net is backed up by observer comments relating to captures on bottom longlines, when fur seals were reported as eating ling livers as the catch was hauled (Fairfax 2005). Most fur seals are released alive from surface and bottom longlines, typically with a hook and short length of tracer attached. As with trawl captures, most fur seal captures have been in waters south of 40° S, though in recent years a few captures have been observed in more northern waters (Abraham et al. 2010).

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9.2 Summary of observed fur seal sex and length data

- In the early Ministry of Fisheries observer data collection (during the mid 1990s) relating to fur seal interactions, more information was collected than is now in relation to the animals caught. Observers used to measure the length and girth of animals landed dead and record these along with the sex and the life status, then collect various samples such as teeth for ageing (see Dickie &

Dawson 2003), skin samples presumably for genetic analysis, and in some years animals were returned for autopsy (Robertson & Gemmell 2005). Length, sex, and life status data are currently collected and since 2006–07 information describing the capture method and the state of injuries has been collected. At the time these data were requested, the database was being transformed and only the length and sex data are briefly summarised here. These data may provide further useful information for consideration of mitigation options for fur seals.

- A preliminary summary of the observer records shows that 96% of reported male fur seal deaths (n = 1615) and 99% of female fur seal deaths (n = 878) had length measurements. Males were 46–217 cm long (median at 145 cm), whereas females were 47–200 cm long (median of 125 cm) (Ministry of Fisheries *cod* database). These data show that 70% of fur seals reported from Fishery Management Area (FMA) 5 — an area that includes the Stewart-Snares shelf and waters off Puseygur Point — were males. Males accounted for about 45% of dead fur seal records reported from FMA 7 off the west coast South Island north to waters off Taranaki and part of Cook Strait, and 88% of those from FMA 6 in sub-Antarctic waters (including around the Bounty Islands).

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9.3 Mitigation methods

- Since the early 1990s, voluntary codes of practice have been used in some trawl fisheries in an attempt to minimise the interactions, and lessen the capture likelihood, between trawl nets and fur seals and other marine mammals (for example, see Baird 1994). These have generally specified best fishing practices designed to minimise attraction to the net and subsequent interactions: removal of 'stickers', minimised deployment and haul times, and actions for when there are gear failures – headline height at least 50 m and preferably 100 m below surface or bring gear on board (headline and groundrope to keep net closed). Offal and discard management practices are now used in the major trawl fisheries (Rowe 2007) — measures introduced primarily as mechanisms to reduce incidental captures of seabirds.

- Methods that aim to mitigate against fur seal captures are primarily aimed at deterring animals from approaching the fishing gear (see Baird 2004, Stewardson & Cawthorn 2004) and have little applicability in the New Zealand trawl fisheries. The use of SEDs in the blue grenadier (hoki) fishery to exclude the larger Australian fur seal in south Australian fisheries is required on factory vessels using midwater nets in a defined fishery area (Tilzey & Wise 2005). Despite its regulated use, mortality rates for Australian fur seals were similar for tows with and without this SED. There was large variability between seasons in the numbers of fur seals around the vessel and in the numbers caught, and the results were ambiguous (Tilzey & Wise 2005, Hamer & Goldsworthy 2006). Trials of SED use are being extended for potential use in the Small Pelagic Fishery off the southeastern, southern and southwestern coasts of Australia (including Tasmania) (Anon. 2009a).

- Recently, in New Zealand waters, a modification of the Sea Lion Exclusion Device used on the southern squid trawl fishery was trialed in the hoki fishery (Anon. 2009b). This used a smaller grid bar spacing to account for the smaller size of New Zealand fur seals relative to New Zealand sea lions. These initial tests of the use of SEDs were not able to determine the ability of the SED to exclude fur seals from the net, nor whether the fish were damaged by impact with the grid. Although this was not assessed, it was assumed that damage would occur because of the levels of impact (perhaps due to the poor directional swimming exhibited by the fish). No fur seals were seen near the net other than when it was on the surface and then 2–6 animals fed from the codend. These trials met the same obstacles as were encountered in the Australian work, particularly the lack of fur seals visible in the net during towing and problems with the underwater filming gear (Tilzey & Wise 2005, Anon. 2009b).

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10 SUMMARY

10.1 Knowledge gaps and recommendations

Crawley & Wilson (1976) noted the need for knowledge of fur seal population dynamics for management, conservation, and exploitation and recognised the need for data on sex and age structure, birth and mortality rates, and growth rates and productivity. Some 20 years later, this call was repeated, in relation to fur seal captures, by Mattlin (1994a): “it will not be possible to determine what effect this incidental kill is having on the population until more is known about the population structure and dynamics of these fur seals”. Despite ongoing research into fur seal populations and interactions between fur seals and commercial fishing, this statement is still valid in 2011. Many of the primary information requirements to characterise New Zealand fur seal ecology and population dynamics are better described for New Zealand fur seal populations in South and Western Australia than in New Zealand (for example, Gales et al. 2000, Shaughnessy et al. 1996).

Within New Zealand, surveys of breeding colonies in certain locations have indicated that a time series of surveys is required to build up data to describe the dynamics of the different colonies and to understand the trends in population numbers. Many of the studies show annual variation in pup production, pup condition, foraging range, and preferred foraging depth. It is feasible to study selected rookeries (that may represent a wider geographic area) and gather the full suite of population parameters, including estimates of pup production, total numbers, age-at-first reproduction, colony fecundity rate, annual survival rates, maximum age, mortality rate and causes of natural mortality, immigration and emigration, as well as data on diet and foraging. These data would need to be collected annually at first to provide representative parameters and then at wider intervals to monitor changes, particularly any climate-related effects (which are generally not well understood). A time series of data collected from a well structured research programme at selected rookeries could be used to validate the current multiplier of 4.9 that is used to provide colony population totals.

The systematic way in which the New Zealand fur seal population numbers in Australia have been monitored provides a good example of how certain colonies can be used to measure overall population stability or otherwise (see Shaughnessy et al. 1994, Goldsworthy et al. 2003). All available knowledge should be used to design surveys so that maximum benefit can be gained. Already, data exist for certain strategically placed rookeries, in terms of fisheries interactions. There is a 20-year data set of pup production from three west coast South Island colonies, a reasonably long data series from the Otago Peninsula, and another from Kaikoura. Some of these colonies have also been used for foraging studies, and all these colonies are close to major fishing grounds.

Thus, New Zealand could well follow the example set by the Australian researchers by determining a period of seasons for a time series, conducting systematic and standardised surveys at certain colonies, and producing base data for those colonies. These colonies could then be revisited after, for example five years, to measure any changes. It is evident that some population parameters and behaviours may be specific to certain colonies, particularly where food resources vary because of proximity to foraging areas depending on underlying seafloor topography and oceanography. Similarly, the proximity of commercial fisheries, in particular trawl fisheries, may influence the likelihood of interaction of fur seals from individual colonies. Foraging tracks of individual (mainly female) fur seals indicate strong preferences for certain areas and depths. Non-breeding fur seals or mature adults during the non-breeding season have been shown to travel large distances from their breeding colony to forage and haulout. Fishing activity as well as prey distribution may influence these at-sea movements. Diet studies in conjunction with foraging studies of males and females would aid in identifying critical habitat for the main colonies at different life stages and the overlap in resources by fur seals and fishing interests.

Information about the mortality of fur seals from incidental capture in commercial fisheries also requires more data because of the low to moderate levels of observer coverage in most fishery-area strata. When the likelihood of observing a fur seal capture in most middle depths and deepwater trawl fisheries is 1–3% of observed tows, for example, higher levels of observer coverage will provide a more accurate assessment and allow assessment of fisheries about which little or nothing is currently known. Substantial and representative observer coverage would provide accurate and informative data of the fishing operations as well as on the observed incidental catch (for example, life stage, sex, size, and a sample collection to allow determination of the provenance, or at least provide a data source for testing when the genetic techniques have been refined). This information in concert with (preferably) colony-specific, fur seal population demographics and at-sea distribution would greatly increase our understanding of the consequences of the incidental capture (mortality) of fur seals.

There has long been interest in attempting to get an overall total number of fur seals for the New Zealand region. Some fur seal populations appear to be increasing in size and the species appears to be recolonising areas it used to occupy before it was afforded protection; however, it may be that other colonies are facing declines, for whatever reason. Although standard (and accepted) methods of estimating total population sizes are available and readily used, a population estimate for the entire New Zealand range would require a systematic survey of pup production at breeding colonies based on standardised, repeatable techniques over many consecutive seasons.

One obvious piece of research that would provide useful information is the long time series of pup production for three west coast South Island fur seal colonies. The locations of these rookeries span the latitudinal limits of the commercial trawling off the west coast, with a large proportion of the fishing by larger vessels occurring in winter when mothers are feeding their pups, foraging day and/or night on longer trips, and targeting a variety of prey. Thus, these breeding colony data should be made available for analysis or published by the owners/custodians.

The ongoing monitoring of fisheries by observers should be used to collect fishery-specific data, incidental catch data and observations (notes), and morphometric measurements of captured animals, as well as sample material that can be used to age (teeth), indicate prey preferences and perhaps indicate foraging distribution (through fatty acid/stable isotope analysis), determine reproductive status, or determine the provenance (for example, ear tissue). These extra sets of information will aid in characterisation of fur seal captures, for example, observers could be trained to collect samples for genetic analysis and comparison with colony information. The DNA analysis of fur seal samples is ongoing (B. Robertson, University of Otago, pers. comm.) and potentially this work could aid in determining the origin of incidentally caught fur seals.

The extent of observer coverage in the inshore fleet, especially around the South Island, needs to be markedly increased, at least if only to establish the level of interaction fur seals have with these vessels. Any increases in observer coverage would provide more certainty in the estimated captures and perhaps allow analyses that better define the spatial and temporal take of fur seals. Given the apparent differences in foraging behaviour between sexes and life stages and within colonies and varying pup production estimates between years in some colonies, a finer breakdown may better describe the distribution of predicted captures.

Research into methods to minimise or mitigate fur seal captures in commercial fisheries have focused on fisheries in which fur seals are more likely to be killed, that is, trawl fisheries. Finding ways to mitigate captures when the animals are free swimming, can easily dive to the depths of the net when it is being deployed or hauled or brought to the surface during a turn, is proving a difficult task worldwide. Any measures also need to ensure that the catch is not compromised, neither the amount of fish nor the condition of the fish. Seal exclusion devices do not appear to be useful in preventing captures. More understanding is required on the behaviour of fur seals underwater when the net is close to the surface. Further research on ways to stop fur seals diving into nets may be one research direction. If vessels adhered strictly to vessel management plans or codes of practice, fewer fur seals may be caught, but when gear events occur, logistic, safety, and financial considerations may take priority over preventing fur seal captures.

Most of the points above were identified as research requirements at the “Seals and sea birds-fisheries interactions workshop” in Wellington in 1992 (Mattlin 1994b) and many were referred to by Taylor et al. (1995) and Lalas & Bradshaw (2001). Output from these types of research would enable understanding of the wider ecosystem-fisheries interaction picture through trophic and distribution models such as those used by Goldsworthy et al. (2003). It appears that isolated areas of research on fur seals are underway throughout the country; research that is currently undertaken by government, university, and other research entities. These research threads need to be coordinated under a national management plan to define a systematic programme of research based on standardised approaches and expert knowledge. The biggest challenge will be to decide what is important and thus formulate the management objectives.

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11. ACKNOWLEDGMENTS

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Appendix 1: NABIS distribution of New Zealand fur seals in the New Zealand region

[updated October 2010]

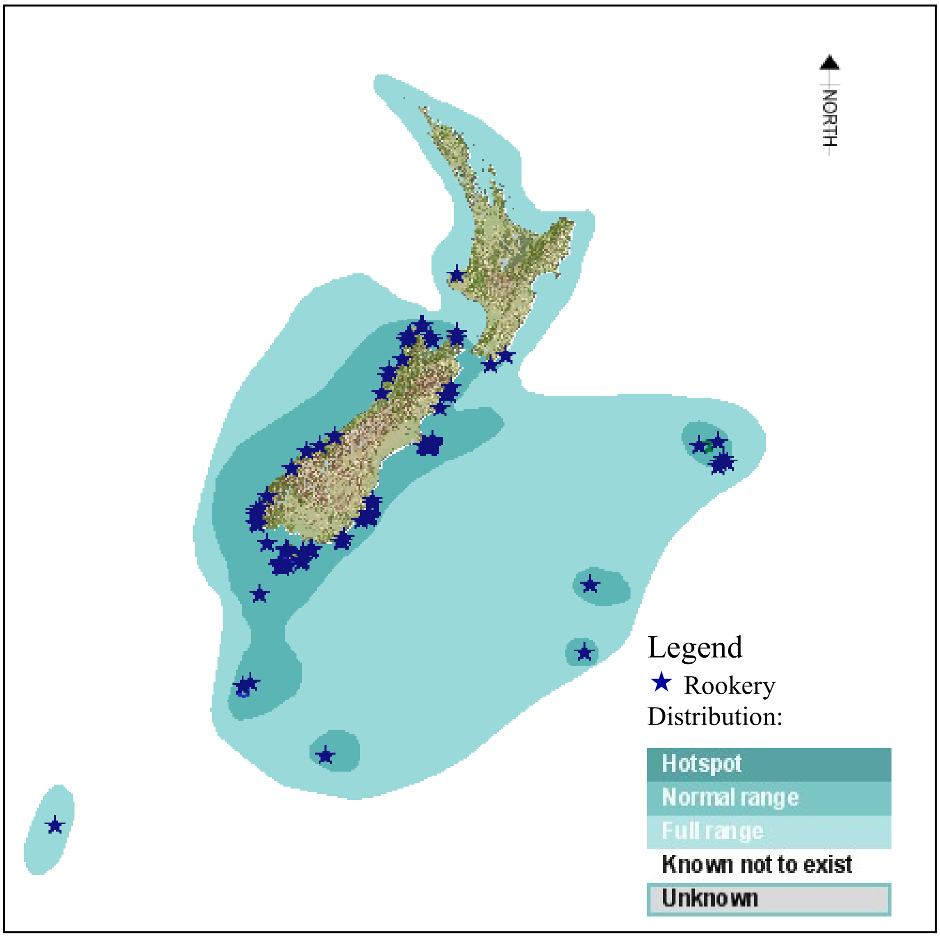

Figure 1.1: At-sea distribution and location of New Zealand fur seal rookeries, as defined by NABIS (from www.nabis.govt.nz.) The main rookeries are named on Figure 1.2.

Appendix 1: — *continued*

Lineage file for the Annual Distribution of New Zealand fur seal breeding colonies [as at October 2010]

The following information was gathered from the sources listed below. For a fuller description, see www.nabis.govt.nz. Literature sources were searched for information on the distribution of breeding colonies or occasional breeding locations.

a. Aquatic Sciences and Fisheries Abstracts (1960–2010)
b. Fish and Fisheries Worldwide (1971–2010)
c. BIOSIS Previews (1993–2010)
d. NZ Science (1800–2010)
e. Te Puna
f. Department of Conservation library databases
g. NIWA library databases
h. Ministry of Fisheries website
i. Scientific papers, unpublished reports, and university theses
j. Internet search engines.

Other sources. The marine mammal staff and students of Otago University and staff at the Department of Conservation Gisborne, Wanganui, Wellington, Nelson-Marlborough, Canterbury, Southland, Southern Islands, and West Coast conservancies provided further information in the form of maps, spreadsheets, and verbal and email comments.

Definitions. For this NABIS distribution, a "breeding colony" for New Zealand fur seals (*Arctocephalus forsteri* Lesson, 1828) is defined as "any breeding location where at least 10 pups are born in at least three successive years and where offspring return each year to the same site". NOTE: in some locations established colonies are known, but actual counts or estimates may not have been conducted for three successive years, mainly because of accessibility problems. Further, detailed mark-recapture studies are necessary to determine the return of pups and these occur at very few sites. Comments relating to these points are detailed in the paragraphs below. There is one exception to the definition of a breeding colony that is included as a "known breeding" colony, the small colony at Honeycomb Rock (see below). This colony is constrained by the availability of suitable habitat and 10 or fewer pups are seen there in a season.

"Occasional breeding" refers to the boundary of any known location where New Zealand fur seals breed, (though not at a colony level (as defined above)), but not necessarily at that location every year. This category includes locations where occasional births have been recorded. Some locations listed as "occasional" are known amongst the marine mammal community of researchers as rookeries or breeding colonies, though they do not fit the definition given here. This is because the available area restricts the numbers that could possible breed in some locations, e.g. Lynch's Reef or Barney's Rock. These locations operate as breeding colonies, not as haul-outs. Further, the "pups returning" caveat required in the definition above requires long-term tagging data with frequent monitoring. This is not possible for many sites and is assumed to be valid for those localities described here as "known breeding colonies".

The following pages summarise the information available for each described breeding colony, including the numbers of pups, where known. The locations of most of these colonies are given in Figure 1 of the main text body. All named colonies in the following table are shown at www.nabis.govt.nz. The derivation of the given pup numbers is described where possible. All references cited in this appendix are included in the body of the report.

Appendix 1: — *continued*

Location	No. pups	Explanation
Around the North Island		
Gannet Island and Albatross Point	~ 4	The northernmost locality where New Zealand fur seal pupping occurs is Gannet Island off the Waikato coast. An aerial photographic survey on 22 January 2007 indicated at least 4 pups on the rock platform on the southern part of Gannet Island (Bouma et al. 2008). Three pups were counted from a similar survey on 26 January 2010 (Waikato Conservancy data). The available area for breeding is small, and this island is considered an occasional breeding colony until evidence shows that pups are regularly born here. Occasional breeding also occurs at Albatross Point where at least one pup was counted on 26 January 2010 and several during the January 2007 survey.
Sugar Loaf Islands Marine Protected Area	12	Between December 1989 and December 2001, fewer than 10 pups were produced annually at Sugar Loaf Islands (Ngā Motu) Marine Protected Area (Miller & Williams 2003). Numbers have increased, though the colony size is limited by the available habitat. The number given here represents the number of pups (about 12) seen in the 2006–07 season (December–January) at Lion Rock (Whareumu) which is the main pupping area (B. Williams, Department of Conservation, pers comm.). Females and pups then disperse to Moturoa Island, Saddleback Island (Motumahanga), and Seal Rock (Waikaranga) (B. Williams, Department of Conservation, pers comm.). There have been no formal surveys since that season, but 8–12 pups are probably born there each year.
Honeycomb Rock	10	Pupping occurs regularly at Honeycomb Rock (H. Best, pers. comm.), and the available habitat area restricts colony growth. Up to 10 pups are produced here each season.
Cape Palliser	40–50	Data from Cape Palliser are direct counts made on the rock stack off Cape Palliser as well as on the mainland in February 1999 (H. Best, pers. comm.).

Appendix 1: — *continued*

Location	No. pups	Explanation
Around the South Island: Nelson-Marlborough		
Adele Island	30	In 2010, Department of Conservation staff provided a "guesstimate" for the recently established breeding colony on Adele Island in the Abel Tasman National Park – about 30 pups.
Pinnacle Island	10	Pupping occurs in small numbers at Pinnacle Island, where the physical area limits the carrying capacity and about 10 pups is probably the maximum number in a season.
Separation Point	50	The pup numbers for the breeding colony at Separation Point are rough estimates provided by Department of Conservation field staff in 2010.
Stephens Island	300	The number for Stephens Island is an approximate estimate of mean annual pup production from the Department of Conservation Nelson-Marlborough Conservancy Office. Published records, with summer survey counts based on binocular counts from vantage points or from a boat close inshore (multiplied by 2.4 after subsampling by foot to ascertain the level of "missed" pups), were given by Taylor et al (1995). Breeding grounds are at the eastern end of Razorback Point and the midsection of the southern shore. Mean annual estimates of pup production given by Taylor et al. (1995) are 264 pups (1991–92), 314 (1992–93), and 276 (1993–94). These represent a large increase on the 1970–71 annual estimate of 4 pups.
Tonga Island	86.4 (s.e. = 7.6)	Tonga Island annual pup estimates increased from 92 in 1992–93 to 130 in 1993–94 (Taylor et al. 1995). Boat and walk-through counts and mark-recapture counts were used in the 1993 season, and mark-recapture counts were used in February 1994. In subsequent seasons, mark-recapture estimates reached a maximum of about 179 fur seals in 1998. The given estimate (86.4 fur seals, s.e. = 7.5) was for a survey in 2001 (L. Boren, pers. comm.).
Trio Islands	50	A breeding colony has recently been established at Trio Islands (Kuru Pongi), and the count given is for January 2007 (about 50 pups were counted from a boat as part of a wider survey of Marlborough Sounds).

Appendix 1: — *continued*

Location	No. pups	Explanation
Around the South Island: South Island east coast		
Ohau Point	1508 (s.e. = 28)	Data for Ohau Point (12 km south of Clarence River) are based on mark-recapture work (Petersen estimates) and indicate the population is expanding (Boren 2005). The population expanded by 32% per annum over the years 1990–2005 (Boren et al. 2006) and at a rate of 25% from 2005–09 (L. Boren, Department of Conservation, unpublished data). An estimate of 600 pups was reported for 2005 (Boren 2005).
Kaikoura Peninsula (Point Kean to Sugar Loaf Point)	100	Fur seals are extending their breeding location around the Kaikoura Peninsula and in 2009, direct counts made by Department of Conservation staff suggest that about 100 pups were born in 2009 in the reef area from Point Kean or Lynch's Reef south to Sugar Loaf Point.
Barney's Rock and adjacent mainland shoreline	50	Data for Barney's Rock (10 km south of Kaikoura Peninsula and also known as Riley's Lookout and Panau Island) include an area on the mainland near Rosy Morn Stream and directly opposite Barney's Rock (M. Morrissey, Department of Conservation, 2010)
Motunau Beach to Waiau River	300	Fur seals are known to breed along the North Canterbury coast from Motunau Beach to Waiau River where there is suitable habitat, but as of October 2010 there have been no surveys of pup numbers (L. Allum, Department of Conservation, 2010).
Tonga Island	86.4 (s.e. = 7.6)	Tonga Island annual pup estimates increased from 92 in 1992–93 to 130 in 1993–94 (Taylor et al. 1995). Boat and walk-through counts and mark-recapture counts were used in the 1993 season, and mark-recapture counts were used in February 1994. In subsequent seasons, mark-recapture estimates reached a maximum of about 179 fur seals in 1998. The given estimate (86.4 fur seals, s.e. = 7.5) was for a survey in 2001 (L. Boren, Department of Conservation, 2010).
Trio Islands	50	A breeding colony has recently been established at Trio Islands (Kuru Pongi), and the count given is for January 2007 (about 50 pups that were counted from a boat as part of a wider survey of Marlborough Sounds).

Appendix 1: — *continued*

Location	No. pups	Explanation
Banks Peninsula		
South Head	20–50	Mark-recapture techniques during February 2002, 2003, and 2005 were used to estimate pup production at Horseshoe Bay on Banks Peninsula (Boren 2005). This population may have reached its carrying capacity. Two smaller colonies have been established at Island Bay and Whakamoa Bay and it is suggested that these may include animals from Horseshoe Bay (Boren 2005, Boren et al. 2006).
Boaz	< 20	
Damons Bay	20–50	
Hell's Gate	< 20	
Hickory Bay	20–50	
Horseshoe Bay	200–300	
Long Bay-Island Bay	> 100	
Murray's Mistake	< 20	
North Head	< 20	
Otanerito Bay	20–50	
Peraki Bay	> 50	Mark-recapture techniques during January-February 2003–05 were used to estimate pup production at Te Oka Bay on Banks Peninsula (Boren 2005, Boren et al. 2006). Since 2002 pup production has increased from <100 to almost 300 pups per annum.
Pukakolo Head	20–50	
Redcliffe Point	20–50	
Robin Hood Bay	20–50	
Rocky Nook	< 20	
Short Reef Point	20–50	
Steep Head-East Head	> 50	Ryan et al. (1997) noted that breeding occurred at headland areas of Banks Peninsula where previous haulouts were recorded: Flea Bay, Pompey's Pillar, Goat Point South, and Ducksfoot Bay. Many other sites on Banks Peninsula are now known to have colonies: Long Lookout Point, Murray's Mistake, Boaz, Robin Hood Bay, Hell's Gate, Peraki Bay, Long Bay–Island Bay, Rocky Nook, Waihuakina Bay, Damons Bay, Redcliffe Point, Short Reef point, Otanerito Bay, Goat Point, South Head, North Head, Hickory Bay, Pukakolo Head, Steep Head–East Head (L. Allum, Canterbury conservancy, Department of Conservation). The pup numbers given are "guesstimates" based on work completed in 2007.
Te Oka Bay	300	
Waihuakina Bay	< 20	
Whakamoa Bay	> 50	
Flea Bay	20–50	
Pompey's Pillar	> 50	
Goat Point South	20–50	
Long Lookout Point	20–50	
Ducksfoot Bay	Unknown	

Appendix 1: — *continued*

Location	No. pups	Explanation
Otago-Southland, and southern offshore islands		
Green Island Nature Reserve	155	Data given for the following locations (with the most recent surveyed year) are counts of live pups from surveys undertaken by Chris Lalas at Otago colonies: Moeraki Peninsula (2008–09), Shag Point (2008–09), Heyward Point (2009–10), Green Island Nature Reserve (2009–10), and Sandy Bay to Tuck's Bay (2008–09). The live pup counts for the whole of the Otago Peninsula in 2008–09 are given for: Otago Peninsula – north (Taiaroa Head to north end of Victory beach); Otago Peninsula – centre (south end of Victory Beach to north end of Allen's Beach); and Otago Peninsula – south (south end of Allen's Beach to Seal Point (Chris Lalas, pers. comm.). Data for Penguin Bay are from a January-March survey in 2003 (Chris Lalas, pers. comm.).
Moeraki Peninsula (Tikoraki Point to Katiki Point)	199	
Nugget Point	474	
Otago Peninsula centre	538	
Otago Peninsula - north	836	
Otago Peninsula - south	191	
Penguin Bay	32	
Sandy Bay to Tuck's Bay	179	
Shag Point	unknown	
Heyward Point	82	
Bench Island	707 (657–786)	Data for many of the islands around Stewart Island are based on work collated by Deborah Watson of Otago University in the early 2000s. Historical information is available in Wilson (1981). James Holborow of Otago University also provided comments on the presence or absence of pups around Stewart Island and offshore islands. Few comprehensive surveys have been carried out other than at Codfish Island and Bench Island. The pup numbers given for Edwards Island are from a single land-based count of over 300 pups in the mid-2000s (P. McClelland, Department of Conservation), and the pup number for Kundy Island is a "guesstimate" made in 2009 (L. Boren, Department of Conservation). The pup number given for Bench Island is the mark-recapture estimate and confidence intervals for a survey completed in 2009 (G. Funnell, Department of Conservation). Data for Codfish Island were provided by James Holborrow (former student, University of Otago). The count for Northwest Bay on Codfish Island (Whenuahau) was made in January 1997.The estimate range for Big Bight Bay on Codfish Island is based on mark-recapture work done by Corey Bradshaw during the 1996–98 breeding seasons. South of Big Bight Bay on Codfish Island, pups were observed during the 1996–98 breeding seasons, and some pups were observed at South Bay on Codfish Island during the 1996–98 breeding seasons.
Big Bight Bay, Codfish Island	230–380	
Northwest Bay, Codfish Island	30	
Edwards Island (Motunui)	> 300	
Kundy Island	~ 100	
Big Moggy Island	Unknown or unavailable	
Big South Cape Island		
Breaksea Island		
Bunker Islets		
Ernest Island		
Herekopare Island (Te Marama)		
Jacky Lee Island (Pukeokaoka)		
Little Moggy Island		
Owen (Horomamae) Island		
Pohowaitai		
Ruapuke Island		
Tia Island		
Solomon Island		
South Islets		
Tamaitemioka Island		
The Rocks, Riverton	Unknown	Unknown numbers of pups are born at rocky beaches off Southland including at The Rocks near Riverton and Pahia Point (R. Cole, Department of Conservation).
Pahia Point		

Appendix 1: — *continued*

Location	No. pups	Explanation
West coast South Island, from Farewell Spit to Chalky Island		
Pillar Point	80	The number given for Pillar Point represents the annual pup production for the 1993–94 breeding season; the previous season was assessed at 70 pups (Taylor et al. 1995). Direct counts were easily made from vantage points. No signs of breeding were present in 1984. [Note that Pillar Point is the most northern rocky headland in the broad area described below (Archway Islands to Cape Farewell).]
Archway Islands-Cape Farewell	150	The published estimated annual pup production for Archway Islands from Taylor et al. (1995) was 6 pups. The rookery is at the southeastern end of the inner island and counts were made using binoculars from a vantage point. Pup production was assessed at three pups in the previous season. These data have been updated by Department of Conservation field staff (Andrew Baxter, Nelson-Marlborough Conservancy Office), and the area has been extended north as far as Cape Farewell because animals are thought to use a wider area for breeding in recent years. The number given is a coarse estimate; many rookeries are not surveyed on a regular basis. However, Department of Conservation field staff recognise this area as a breeding colony and provided a "guesstimate" for 2010 of about 150 pups.
Otukoroiti Point	200	Data for Otukoroiti are field counts from Department of Conservation West Coast Conservancy staff (as supplied by Deborah Watson, University of Otago, in 2003).
Kahurangi Point	300	The number given for Kahurangi Point is a "guesstimate" made in 2007 by Department of Conservation field staff. The population is increasing, but no formal counts have been made.
Wekakura Point	434	Data for Wekakura Point represent the mean annual estimated number of pups (based on mark-recapture estimates) for the 2006–2010 seasons (Department of Conservation West Coast Tai Poutini Conservancy & Hugh Best, unpublished data.). This estimate does not take into account pup mortality between birth and the time when the counts were made. For the 2006–08 seasons at Wekakura Point, the annual pup estimates were between about 450 and 550 pups (and these estimates are within the range of annual estimates since 1999). However, the estimate for 2009 was 305 pups and this represented the lowest annual count in the 1992–2009 series. For this colony, pup numbers estimated in the 2000s were generally lower than those estimated for the 1990s. An aerial photographic survey of this colony in 2009 was unable to provide similar counts to mark-recapture estimates produced from ground counts provided above (Baker et al. 2010).
Kongahu Point	Unknown	Data for Kongahu Point are field counts from Department of Conservation West Coast Conservancy staff (as supplied by Deborah Watson, University of Otago, in 2003).

Appendix 1: — *continued*

Location	No. pups	Explanation
Cape Foulwind	250	Data for Cape Foulwind represent the mean annual estimated number of pups (based on mark-recapture estimates) for the 2006–2010 seasons (Department of Conservation West Coast Tai Poutini Conservancy & H. Best, unpublished data.). This estimate does not take into account pup mortality between birth and the time when the counts were made. For Cape Foulwind, the annual pup estimates for the 2006–08 seasons were similar to those for the previous five years, between about 250 and 310 pups. The 2009 estimate was slightly lower at 203 pups. For this colony, pup numbers estimated in the 2000s were generally lower than those estimated for the 1990s. An aerial photographic survey of this colony in 2009 was unable to provide similar counts to mark-recapture estimates produced from ground counts provided above (Baker et al. 2010).
Black Reef (Three Steeples)	200	Data for Black Reef represent the mean annual estimated number of pups for the 2006–2010 seasons (Department of Conservation West Coast Tai Poutini Conservancy & Hugh Best, unpublished data.). This estimate does not take into account pup mortality between birth and the time when the counts were made. For Black Reef, the same conversion factor was applied to pup count data from a boat survey in January 1989 by Anderson (1990) (H. Best, independent researcher, 2010).
Charleston	476	Data for Charleston represent the mean annual estimated number of pups for the 2006–2010 seasons (Department of Conservation West Coast Tai Poutini Conservancy & Hugh Best, unpublished data.). This estimate does not take into account pup mortality between birth and the time when the counts were made. For Charleston, a mark-recapture estimate (mean of five estimates) the Cape Foulwind data series was used with an appropriate conversion factor to derive a mean estimate (H. Best, independent researcher, 2010).
Point Elizabeth	10	Data for Point Elizabeth are field counts from Department of Conservation West Coast Conservancy staff (as supplied by Deborah Watson, former University of Otago student, 2003).
Hanata Island	10	Data for Hanata Island are field counts from Department of Conservation West Coast Conservancy staff (as supplied by Deborah Watson, former University of Otago student, 2003).
Open Bay Islands	1063	Data for Open Bay Islands represent the mean annual estimated number of pups for the 2006–2010 seasons (Department of Conservation West Coast Conservancy & Hugh Best, unpublished data.). This estimate does not include pup mortality between birth and the time when the counts were made. The Open Bay Islands data are based on mark-recapture data from the main rookery at Taumaka Island. [A smaller colony exists on nearby Popotai Island but these numbers are not included in the Taumaka Island estimate.] The 2009 estimate was slightly lower (203 pups). For Taumaka Island, annual pup estimates for 2006–08 increased each year, from about 1000 to 1300. The 2009 estimate was 941 pups. Pup numbers estimated in the 2000s were generally lower than those estimated for the 1990s. An aerial photographic survey of this colony in 2009 was unable to provide similar counts to mark-recapture estimates produced from ground counts provided above (Baker et al. 2010).

Appendix 1: — *continued*

Location	No. pups	Explanation
Cascade Point	Unknown	
Yates Point	848	Data for Yates Point south to Chalky Island are from the Department of Conservation Southland Conservancy Excel spreadsheet that summarises all Department of Conservation fur seal counts and a map of known breeding colonies and haulouts in the Fiordland area (provided in 2002). These data vary in the type of data collected and time of year of the visit. Data represent direct counts from boats or land visits. Department of Conservation field staff confirm that breeding colonies exist at the nominated locations. Pup production numbers are given where data exist. The Yates Point count was made in September 1986 (outside the breeding season of November to March). Data from one bay and one peninsula on Breaksea Island are summarised from direct counts made by boat and by foot at two sites (about 140 pups at North West Bay and about 8 at North East Peninsula) in February 1992. A survey undertaken in mid January 2009 provided land-based counts from two colonies. At Wairaki Island just south of Breaksea Island, direct counts by three observers were made during a walk-through of the colony and a mark-recapture estimate was derived for a colony at one of the Seal Islands in Dusky Sound, based on counts by four observers (Mellina & Cawthorn, 2009). Fur seals breed on the western coastline of Five Fingers Peninsula and at Seal Islands (Rocks) at the entrance of Dusky Sound (H. Best, independent researcher, 2010). comm.). Counts were made in July 1983 from Newton River-Cape Providence and 13 immature fur seals and 1 juvenile were found. Note that this count was made outside the breeding season of November to March. Data for Chalky Island date from 1947, when about 1000 seals were counted in December. Data from 1972 suggest breeding colony several sites, with a minimum of 1000 fur seals.
Breaksea Island	150	
Wairaki Island	179 (154–204)	
Dusky Sound - Seal Islands	186 (177–195)	
Five Fingers Peninsula	Unknown	
Doubtful Sound (Shelter Island)		
Newton River-Cape Providence		
Chalky Island		

Appendix 1: — *continued*

Location	No. pups	Explanation
Sub-Antarctic islands and Chatham Islands		
Bounty Islands	4 380	The numbers for Bounty Islands are from Taylor (1996) and are based on large-scale oblique aerial photographs taken in January 1994. This gave a rough estimate of the annual pup production at 4 380 pups based on a 37:63 ratio of pups to other seals of one year or more in age and includes an additional 20% pups missed or already dead. This value was based on a sample of only 10% of all seals and is an increase from the 3280 pup count made in 1980–81 (Taylor 1982). Taylor (1996) gives a total estimate of 1225 pups for the 1993–94 breeding season at Penguin Island, an increase from 863 in 1980–81. The main known breeding colonies are at Spider Island, Depot Island, Penguin Island, Ruatara Island, and Funnel Island. Haulouts are present on most islands and rocks. Penguin Island and Depot Island are thought to have reached carrying capacity. The area used for haulouts and breeding increased by about 30% between 1980 and 1985. The islands are monitored infrequently due to their inaccessibility and no recent updates are available.
Reef Point, Antipodes Islands	7	Reef Point on Antipodes Island is the only location for which there is a published direct count of fur seal pups, from March 1985 (Taylor 1992). No breeding was seen in earlier trips in February-March 1969 or November-December 1978. No recent updates are available.
Snares Islands	171	The pup number for the Snares Islands is from a count from North East and Broughton Islands in March 1997 and includes all pups seen; an earlier census of fur seals throughout the islands and islets of the Snares Islands group was conducted in February 1984 and resulted in a pup count of 164 pups (Carey 1998). Counts were made by use of binoculars from high vantage points. Sixteen breeding sites are listed by Carey (1998), seven of which meet the numerical criterion of the breeding colony definition. Aerial photographs showed that fur seals were present in all areas of suitable habitat and that the breeding areas were physically defined from the haulout areas. Fur seals were present around most of the coastlines of the islands, with the main breeding areas on the southern and western coasts of North East Island and the haulout area on the eastern coast. Carey (1998) noted three new breeding areas have been established on the east coast since a census in 1970–71 (reported by Crawley 1972). No recent updates are available.
Solander Islands	370	Data for the Solander Islands group are from Wilson (1981) and include all data where the pup counts are separately defined from the overall fur seal count. Thus, the data probably represent the minimum total pup presence. Counts were made from the beach for Solander Island bays and rock stacks during January 1973. No recent updates are available.

Appendix 1: — ***continued***

Location	No. pups	Explanation
Derry Castle Reef, Enderby Island	11	Fur seals breed at Derry Castle Reef on Enderby Island, Auckland Islands. No breeding colonies are known to exist on Auckland Island, but colonies were present along the western cliffs of Auckland Island and the southern coast of Adam Island during the 1800s.
Disappointment Island	Unknown	There is occasional breeding on the western coast of Disappointment Island, Auckland Islands (P. McCelland, Department of Conservation Southern Islands, pers. comm.).
Rocky Beach, Campbell Island	Unknown	Marine mammal work on Campbell Island is concentrated on New Zealand sea lions, thus few data exist on the presence of fur seal breeding colonies. A breeding colony exists at Rocky Beach, with at least 10 pups seen in some seasons, but surveys here are not regular. Fur seal breeding sites on Campbell Island are restricted by the habitat available and the presence of New Zealand sea lions (P. McCelland, Department of Conservation Southern Islands, pers. comm.). Further information is available in Wilson (1981). No recent updates are available.
Chatham Islands: Eastern Reefs Point Munning South East Island Star Keys The Pyramid Western Reef	Unknown	There are no recent data available for the fur seal populations on islands in the Chatham Islands group. Wilson (1981) named some rookeries, and the existence of these breeding colonies given for these islands, as well as for The Pyramid, has been confirmed by Department of Conservation staff based at the Chatham Islands area office: South East Island, Eastern Reefs, Western Reef, Point Munning, and Star Keys, The Pyramid.