4.2.2. Distribution

Pre-European archaeological evidence suggests that NZ 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 fewer areas of suitable habitat were available (Smith 1989, 2005, 2011). A combination of subsistence hunting and commercial harvest resulted contraction of the species' range and in population decline almost to the point of extinction (Smith 1989, 2005, 2011, Ling 2002, Lalas 2008). NZ fur seals became fully protected in the 1890's and, with the exception of one year of licenced harvest in the 1950's, have remained protected since.

Currently, NZ fur seals are dispersed throughout New Zealand waters, especially in waters south of about 40º S to Macquarie Island. On land, NZ fur seals are distributed around the New Zealand coastline, on offshore islands, and on sub-Antarctic islands (Crawley and Wilson 1976, Wilson 1981, Mattlin 1987). The recolonisation of the coastline by NZ fur seals has resulted in the northward expansion of the distribution of breeding colonies and haulouts (Lalas and Bradshaw 2001), and breeding colonies present on many exposed rocky areas (Baird 2011). The extent of breeding colony distribution in New Zealand waters is bounded to the north by a very small (space-limited) colony at Gannet Island off the North Island west coast (latitude 38° S), to the east by colonies of unknown sizes at the Chatham Islands group, to the west by colonies of unknown size on Fiordland offshore islands, and to the south by unknown numbers on Campbell Island. Outside New Zealand waters, breeding populations exist in South and Western Australia (Shaughnessy *et al.* 1994, Shaughnessy 1999, Goldsworthy *et al.* 2003).

The seasonal distribution of the NZ fur seals is determined by the sex and maturity of each animal. Males are generally at the breeding colonies from late October to late January then 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 lowest densities in September–October (Crawley and Wilson 1976). Females arrive at the breeding colony from November and lactating females remain at the colony (apart from short foraging trips) for about 10 months until the pups are weaned, usually during August–September (Crawley and Wilson 1976).

4.2.3. Foraging ecology

Most foraging research in New Zealand has focused on lactating NZ fur seals at Open Bay Islands off the South Island west coast (Mattlin *et al.* 1998), Otago Peninsula (Harcourt *et al.* 2002), and Ohau Point, Kaikoura (Boren 2005), using time-depth-recorders, satellite-tracking, or very-high-frequency transmitters. Individual females show distinct dive pattern behaviour and may be relatively shallow or deep divers, but most forage at night and in depths shallower than 200 m. At Open Bay Islands, dives were generally deeper and longer in duration during autumn and winter. Females can dive to at least 274 m (for a 5.67 min dive in autumn) and remain near the bottom at over 237 m for up to 11.17 min in winter (Mattlin *et al.* 1998). Females in some locations undertook longer dive trips, with some to deeper waters, in autumn (in over 1000 m beyond the continental shelf; Harcourt *et al.* 2002).

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*). Conversely, the deeper dives and increased number of dives in daylight during autumn and winter suggested that the prey species may include benthic, demersal, and pelagic species (Mattlin *et al.* 1998, Harcourt *et al.* 2002). The deeper dives enabled seals to forage along or off the continental shelf (within 10 km) of the colony 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.

Methods to analyse NZ fur seal diets have included investigation of freshly killed animals (Sorensen 1969), scats, and regurgitates (e.g. Allum and Maddigan 2012). Fish prey items can be recognised by the presence of otoliths, bones, scales, and lenses, while cephalopods are indicated by beaks and pens. Foraging appears to be specific to individuals and different diets may be represented in the scats and regurgitations of males and females as well as juveniles from one colony. These analyses can be biased, however, particularly if only one collection method is used, and this limits fully quantitative assessment of prey species composition.

Dietary studies of NZ fur seals have been conducted at colonies in Nelson-Marlborough, west coast South Island, Otago Peninsula, Kaikoura, Banks Peninsula, Snares Islands, and off Stewart Island, and summaries are provided by Carey (1992), Harcourt (2001), Boren (2010), and Baird (2011).

NZ fur seals are opportunistic foragers and, depending on the time of year, method of analysis, and location, their diet includes at least 61 taxa (Holborow 1999) of mainly fish (particularly lanternfish (myctophids) in all studied colonies except Tonga Island (in Golden Bay, Willis *et al.* 2008), as well as anchovy (*Engraulis australis*), aruhu (*Auchenoceros punctatus*), barracouta (*Thrysites atun*), hoki (*Macruronus novaezelandiae*), jack mackerel (*Trachurus* spp.), pilchard (*Sardinops sagax*), red cod (*Pseudophycis bachus*), red gurnard (Chelidonichthys kumu), silverside (*Argentina elongate*), sprat (*Sprattus* spp.) and cephalopods (octopus (*Macroctopus maorum*), squid (*Nototodarus sloanii*, *Sepioteuthis bilineata*)). For example, myctophids were present in Otago scats throughout the year (representing offshore foraging), but aruhu, sprat, and juvenile red cod were present only during winter-spring (Fea *et al.* 1999). 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 NZ fur seals exhibit shallow foraging (Harcourt *et al.* 1995, Mattlin *et al.* 1998, Fea *et al.* 1999).

4.2.4. Reproductive biology

NZ fur seals are sexually dimorphic and polygynous (Crawley and Wilson 1976); males may weigh up to 160 kg, whereas females weigh up to about 50 kg (Miller 1975; Mattlin 1978a, 1987; Troy *et al.* 1999). 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 and Wilson 1976). Females are philopatric and are sexually mature at 4–6 years, whereas males mature at 5–9 years (Mattlin 1987, Dickie and Dawson 2003). The maximum age recorded for NZ fur seals in New Zealand waters is 22 years for females (Dickie and Dawson 2003) and 15 years for males (Mattlin 1978).

NZ fur seals are annual breeders and generally produce one pup after a gestation period of about 10 months (Crawley and Wilson 1976). Twinning can occur and females may foster a pup (Dowell *et al.* 2008), although both are rare. Breeding animals come ashore to mate after a period of sustained feeding at sea. Breeding males arrive at the colonies to establish territories during October–November. Breeding females arrive at the colony from late November and give birth shortly after. Peak pupping occurs in mid December (Crawley and 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 and Wilson 1976). As the pups grow, these foraging trips are progressively longer in duration. Pups remain at the breeding colony from birth until weaning (at 8–12 months of age).

Breeding males generally disperse after mating to feed and occupy haulout areas, often in more northern areas (Crawley and Wilson 1976). This movement of breeding adults away from the colony 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 and 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 and Shaughnessy (1994) for a South Australian colony.

Newborn pups are about 55 cm long and weigh about 3.5 kg (Crawley and Wilson 1976). Male pups are generally heavier than female pups at birth and throughout their growth (Crawley and 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 probably 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).

4.2.5. Population biology

Historically, the population of NZ fur seals in New Zealand was thought to number above 1.25 million animals (possibly as high as 1.5 to 2 million) before the extensive sealing of the early 19th century (Richards 1994). Present day population estimates for NZ fur seals in New Zealand are few and highly localised. In the most comprehensive attempt to quantify the total NZ 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. Since then, several authors have suggested a population size of ~100,000 animals (Taylor 1990, see Harcourt 2001), but this estimate is very much an approximation and its accuracy is difficult to assess in the absence of comprehensive surveys.

Fur seal colonies provide the best data for consistent estimates of population numbers, generally based on pup production in a season (see Shaughnessy *et al.* 1994). Data used to provide colony population estimates of NZ fur seals have been, and generally continue to be, collected in an *ad hoc* fashion. Regular pup counts are made at some discrete populations. A 20-year time series of Otago Peninsula colony data is updated, maintained, and published primarily by Chris Lalas (assisted by Sanford (South Island) Limited), and the most recent estimate is 20,000–30,000 animals (Lalas 2008). A 20-year plus time series of pup counts exists for three west coast South Island colonies (Cape Foulwind, Wekekura Point, and Open Bay Islands; Best 2011). 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, but many of these are more than 10 years old. 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 and Harcourt 1995, Lalas and Murphy 1998, Lalas 2008), and near Wellington (Dix 1993).

For many areas where colonies 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 (see Baird 2011).

Baker *et al.* (2010a) conducted an aerial survey of the South Island west coast from Farewell Spit to Puysegur Point and Solander Island in 2009 but were their counts were quite different from ground counts collected at a similar time at the main colonies (Melina and Cawthorn 2009). This discrepancy was thought to be a result mainly of the survey design and the nature of the terrain. However, the aerial survey 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.

Population numbers for some areas, especially more isolated ones, are not well known. The most recent counts for the Chatham Islands were collected in the 1970s (Wilson 1981), and the most recent for the Bounty Islands in 1993–94. Taylor (1996) reported an increase in pup production at the Bounty Islands since 1980, and estimated that the total population was at least 21 500, occupying over 50% of the available area. Information is sparse for populations at Campbell Island, the Auckland Islands group and the Antipodes Islands

Little is reported about the natural mortality of NZ fur seals, other than reports of sources and estimates of pup mortality for some breeding colonies. Estimates of pup mortality or pup survival vary in the manner in which they were determined and in the number of seasons they represent, and are not directly comparable. Each colony will be affected by different sources of mortality related to habitat, location, food availability, environment, and year, as well as the ability of observers to count all the dead pups (may be limited by terrain, weather, or time of day).

Reported pup mortality rates vary: 8% for Otago Peninsula pups up to 30 days old and 23% for pups up to 66 days old (Lalas and Harcourt 1995); 20% from birth to 50 days and about 40% from birth to 300 days for Taumaka Island, Open Bay Islands pups (Mattlin 1978b); and in one year, 3% of Kaikoura pups before the age of 50 days (Boren 2005). Starvation was the major cause of death, although stillbirth, suffocation, trampling, drowning, predation, and human disturbance also occur. Pup survival of at least 85% was estimated for a mean 47 day interval for three Otago colonies, incorporating data such as pup body mass (Bradshaw *et al.* 2003b), though pup mortality before the first capture effort was unknown. Other sources of natural mortality for NZ fur seals include predators such as sharks and NZ sea lions (Mattlin 1978b, Bradshaw *et al.* 1998).

Human-induced sources of mortality include: fishing, for example, entanglement or capture in fishing gear; vehicle-related deaths (Lalas and Bradshaw 2001, Boren 2005, Boren *et al.* 2006, 2008); and mortality through shooting, bludgeoning, and dog attacks. NZ fur seals are vulnerable to certain bacterial diseases and parasites and environmental contaminants, though it is not clear how life-threatening these are. The more obvious problems include tuberculosis infections, *Salmonella*, hookworm enteritis, phocine distemper, and septicaemia (associated with abortion) (Duignan 2003, Duignan and Jones 2007). Low food availability and persistent organohalogen compounds (which can affect the immune and the reproductive systems) may also affect NZ fur seal health.

Various authors have investigated fur seals genetic differentiation among colonies and regions in New Zealand (Lento *et al.* 1994; Robertson and Gemmell (2005). Lento *et al.* (1994) described the geographic distribution of mitochondrial cytochrome *b* DNA haplotypes, whereas Robertson and Gemmell (2005) described low levels of genetic differentiation (consistent with homogenising gene flow between colonies and an expanding population) based on genetic material from NZ fur seal pups from seven colonies. One aim of the work is to determine the provenance of animals captured during fishing activities, through the identification and isolation of any colony genetic differences.

4.2.6. Conservation biology and threat classification

Threat classification is an established approach for identifying species at risk of extinction (IUCN 2010). The risk of extinction for NZ fur seals has been assessed under two threat classification systems: the New Zealand Threat Classification System (Townsend *et al.* 2008) and the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species (IUCN 2010).

In 2008, the IUCN updated the Red List status of NZ fur seals, listing them as Least Concern on the basis of their large and apparently increasing population size (Goldsworthy and Gales 2008). In 2010, DOC updated the New Zealand Threat Classification status of all NZ marine mammals (Baker *et al.* 2010b). In the revised list, NZ fur seals were classified as Not Threatened with the qualifiers increasing (Inc) and secure overseas (SO) (Baker *et al.* 2010b).

4.3. *Global understanding of fisheries interactions*

NZ fur seals are found in both Australian and New Zealand waters. Overall abundance has been suggested to be as high as 200 000, with about half of the population in Australian waters (Goldsworthy and Gales 2008). However, this figure is very much an approximation, and its accuracy is difficult to assess in the absence of comprehensive surveys.

Pinnipeds are caught incidentally in a variety of fisheries worldwide (Read *et al.* 2006), including: NZ fur seals, Australian fur seals, and Australian sea lions in Australian trawl and inshore fisheries (e.g., Shaughnessy 1999, Norman 2000); Cape fur seals in South African fisheries (Shaughessy and Payne 1979); South Amercian sea lions in trawl fisheries off Patagonia (Dans *et al.* 2003); and seals and sea lions in United States waters (Moore *et al.* 2009).

4.4. *State of knowledge in New Zealand*

NZ fur seals are attracted to feeding opportunities in various fishing gears and anecdotal evidence suggests that the sound of winches as trawlers haul their 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 NZ fur seals to interact with fishing gear, which can result in capture and, potentially, death via drowning or injury.

Most captures occur in trawl fisheries and NZ fur seals are most at risk from capture during shooting and hauling (Shaughnessy and Payne 1979), when the net mouth is within diving depths. Once in the net some animals may have difficulty in finding their way out within their maximum breath-hold time (Shaughnessy and Davenport 1996). The operational aspects that are associated with NZ fur seal captures on trawlers include factors that attract the NZ 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). NZ fur seals are at particular risk of capture when a vessel partially hauls the net during a tow and executes a turn with the gear close to the surface. At the haul, NZ fur seals pften attempt to feed from the codend as it is hauled and dive after fish that come loose and escape from the net (Baird 2005).

Factors identified as important influences on the potential capture of NZ fur seals in trawl gear include the year or season, the fishery area, gear type and fishing strategies (often specific to certain nationalities within the fleet), time of day, and distance to shore (Baird and Bradford 2000, Mormede *et al.* 2008, Smith and Baird 2009). These analyses did not include any information on NZ fur seal numbers or activity in the water at the stern of the vessel. Other influences on NZ fur seal capture rate (of Australian and NZ fur seals) may include inclement weather and sea state, vessel speed, increased numbers of vessels and trawl frequency, and potentially the weight of the fish catch and the presence of certain bycatch fish species (Hamer and Goldsworthy 2006). This Australian study found similar mortality rates for tows with and without Seal Exclusion Devices (see also Hooper *et al.* 2005).

The spatial and temporal overlap of commercial fishing grounds and NZ fur seal foraging areas has resulted in NZ fur seal captures in fishing gear (Mattlin 1987, Rowe 2009). Most fisheries with observed captures occur in waters over or close to the continental shelf. Because the topography around much of the South Island and offshore islands slopes steeply to deeper waters, most captures occur close to colonies and haulouts (Figures 4.1 and 4.2).

Observed NZ fur seal captures are mainly from trawls in defined seasons in areas where fishing occurs relatively close to NZ fur seal colonies or haulouts. Winter hoki fisheries attract NZ fur seals off the west coast South Island and in Cook Strait between late June and September (Table 4.1). In August–October, NZ 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 longitude 180° on the Chatham Rise.

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 and Smith 2007, Abraham *et al.* 2010a). Between 1 and 3% of observed tows targeting middle depths fish species catch NZ 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 and Smith 2007). The main fishery areas that contribute to the estimated annual catch of NZ fur seals (modelled from observed captures) 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 and Smith 2007, Thompson and Abraham 2010). Captures on longlines occur when the NZ fur seals attempt to feed on the fish catch during hauling. Most NZ fur seals are released alive from surface and bottom longlines, typically with a hook and short snood or trace still attached.

Table 4.1: Monthly distribution of NZ fur seal activity and the main trawl and longline fisheries with observed reports of NZ fur seal incidental captures.

NZ 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 sea	At breeding colony		At breeding colony and at-sea foraging and suckling								At sea
Pups	At sea		At breeding colony									At sea
Non-breeders	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						Fiordland						

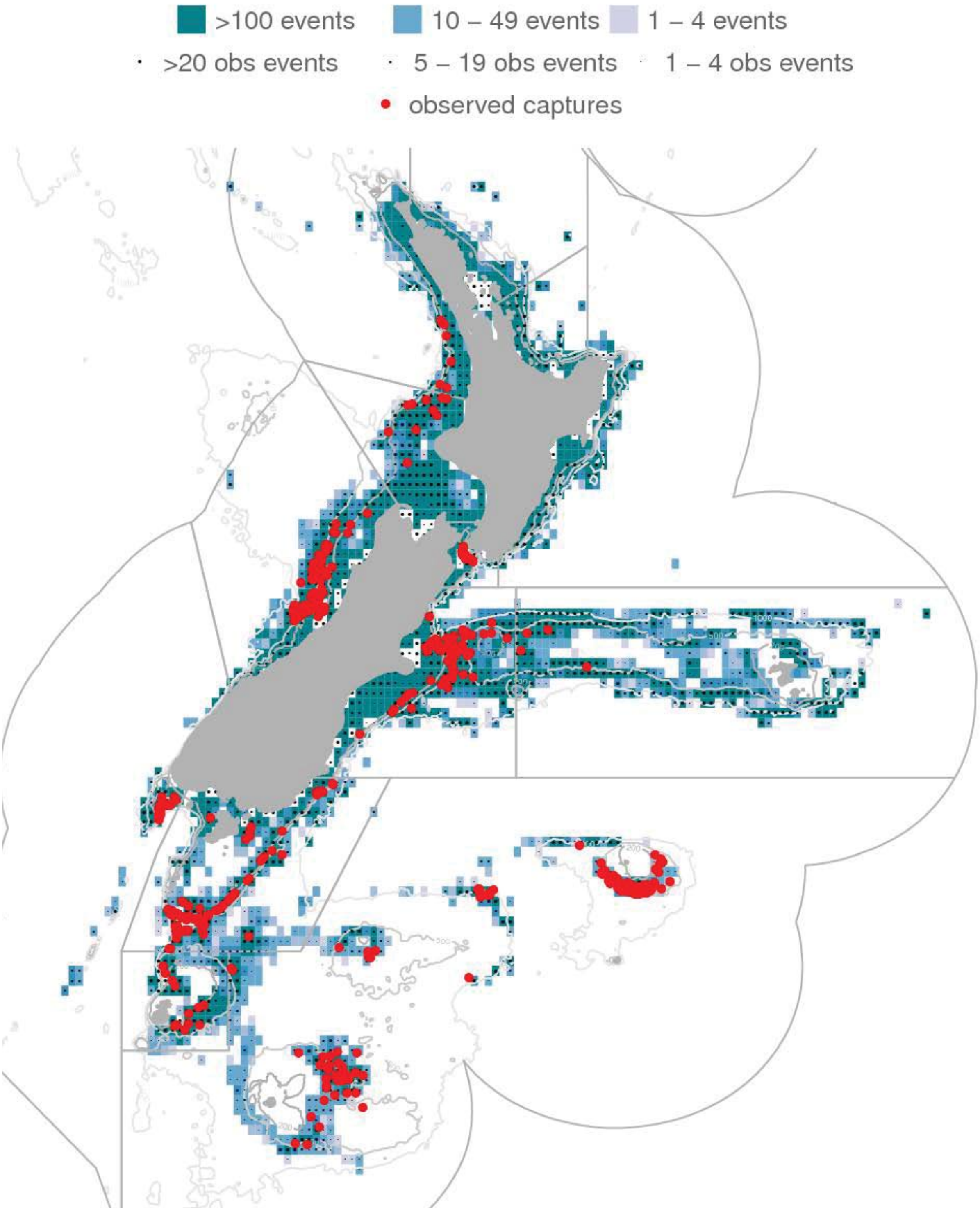


Figure 4.1: Distribution of trawl fishing effort and observed NZ fur seal captures, 2002-03 to 2010-11 (for more information see http://data.dragonfly.co.nz/psc/). Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 96.0% of the effort is shown.

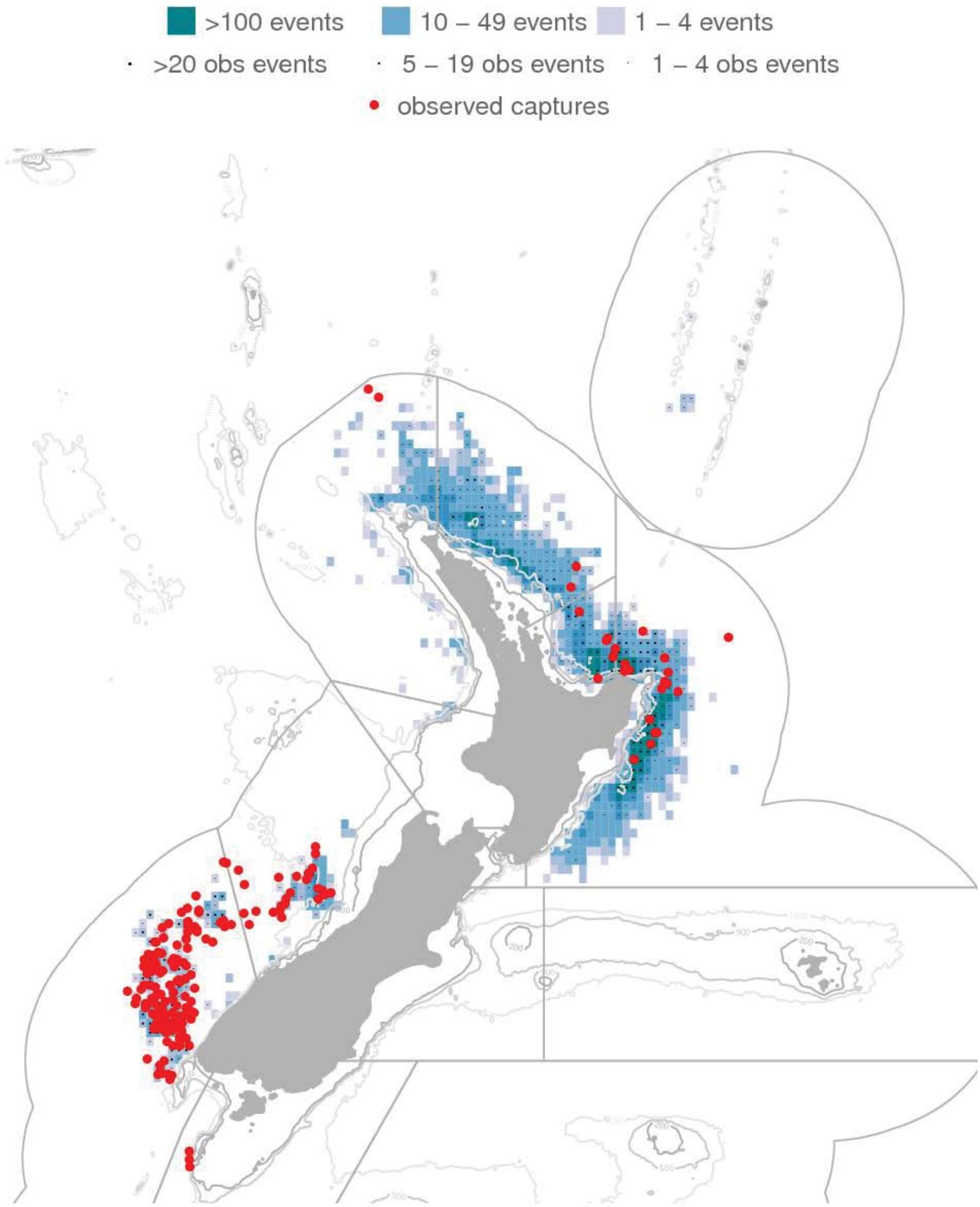


Figure 4.2: Distribution of surface longline fishing effort and observed NZ fur seal captures, 2002-03 to 2010-11 (for more information see http://data.dragonfly.co.nz/psc/). Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 75.3% of the effort is shown.

4.4.1. Quantifying fisheries interactions

Observer data and commercial effort data have been used historically to characterise the incidental captures and estimate the total numbers caught (Baird and Smith 2007, Smith and Baird 2009, Thompson and Abraham 2010, Abraham and Thompson 2011). This approach is currently applied using information collected under DOC project INT2012-01 and analysed under MPI project PRO2010-01 (Thompson *et al.* 2011, Thompson *et al.* 2012). 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. Initially, stratified ratio estimates were provided for the main trawl fisheries, starting in the late 1980s, after scientific observers reported 198 NZ fur seal deaths during the July to September west coast South Island spawning hoki fishery (Mattlin 1994a, 1994b). In the following years, ratio estimation was used to estimate NZ fur seal captures in the Taranaki Bight jack mackerel fisheries and Bounty Platform, Pukaki Rise, and Campbell Rise southern blue whiting fisheries, based on observed catches and stratified by area, season, and gear type (Baird 1994).

In the last 10 years, model-based estimates of captures have been developed for all trawl fisheries in waters south of 40° S (Baird and Smith 2007, Smith and Baird 2009, Thompson and Abraham 2010, Abraham and Thompson 2011, Thompson *et al.* 2011, Thompson *et al.* 2012). 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 lack of representativeness of the observer coverage and includes the contribution from correlation in the capture rate among tows by the same vessel. 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. The operation of inshore vessels in terms of the location of effort, gear, and the fishing strategies used is also relatively unknown compared with the deeper water fisheries although changes to reporting requirements means that data is now improving and inshore trawl effort (not including flatfish trawl effort) is now able to be included in the modelling (Thompson *et al.* 2012, see also description of the Trawl Catch Effort Return, TCER, in use since 2007/08, in Chapter 7 on benthic effects).

Since 2005, there has been a small downward trend in estimated capture rates, and annual estimated NZ fur seal captures (Smith and Baird 2009, Thompson and Abraham 2010, Abraham and Thompson 2011, Thompson *et al.* 2011, Thompson *et al.* 2012, Figure 4.3). This probably reflects efforts to reduce bycatch combined with a reduction in fishing effort since the late 1990s. Similar modelling methods were used to produce the most recent set of estimated NZ fur seal captures in trawl fisheries (Thompson and Abraham 2010, Abraham and Thompson 2011, Thompson *et al.* 2011, Thompson *et al.* 2012). The overall downward trend in estimated annual captures for trawl fisheries has continued (see Table 4.2), as a result of the continued decrease in total tows made each year and a concurrent decrease in capture rate. Note these capture rates include animals that are released alive (7% of observed trawl capture in 2008-09, Thompson and Abraham 2010).

Ratio estimation was used to calculate total captures in longline fisheries by target fishery fleet and area (Baird 2008) and by all fishing methods (Abraham *et al.* 2010a). NZ 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 and off East Cape. Estimated numbers range from 127 (95% c.i. 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). These capture rates include animals that are released alive (100% of observed surface longline capture in 2008-09, Thompson and Abraham 2010). Captures of NZ fur seals have also been recorded in other fisheries; 8 in setnets and 2 in bottom longline fisheries since 2002-03

(Thompson *et al.* 2012). Captures associated with recreational fishing activities are poorly known (Abraham *et al.* 2010b).

Table 4.2: Effort, observed and estimated NZ fur seal captures in trawl and surface longline fisheries by fishing year in the New Zealand EEZ (Abraham and Thompson 2011 and http://data.dragonfly.co.nz/psc/). For each fishing year, the table gives the the total number of tows or hooks; the observer coverage (the percentage of tows or hooks that were observed); the number of observed captures (both dead and alive); the capture rate (captures per hundred tows or per thousand hooks); the estimation method used (model or ratio); and the mean number of estimated total captures (with 95% confidence interval). For more information on the methods used to prepare the data, see Abraham and Thompson (2011).

Fishing year	Fishing effort		Observed captures		Estimated captures		
	All effort	% observed	Number	Rate	Type	Mean	95% c.i.
Trawl fisheries							
1998–1999	153 412	4.7	190	2.62	Ratio	1 591	1454–1744
1999–2000	139 057	5.5	203	2.65	Ratio	1 539	1400–1693
2000–2001	134 243	6.8	170	1.87	Ratio	1 490	1348–1649
2001–2002	127 883	6.0	157	2.03	Ratio	1 273	1164–1394
2002–2003	130 344	5.2	68	1.00	Model	841	503 – 1380
2003–2004	121 494	5.4	84	1.28	Model	1 052	635 – 1728
2004–2005	120 590	6.4	200	2.59	Model	1 471	914 – 2392
2005–2006	110 230	5.9	143	2.18	Model	917	577 – 1479
2006–2007	103 529	7.7	73	0.92	Model	533	324 – 871
2007–2008	89 537	10.1	141	1.56	Model	765	476 – 1348
2008–2009	87 587	11.2	72	0.73	Model	546	308 – 961
2009–2010	92 886	9.7	72	0.80	Model	472	269 – 914
2010–2011	86 073	8.6	69	0.93	Model	376	221 – 668
Surface longline fisheries							
1998–1999	6 855 124	18.9	102	0.08	Ratio	138	120–160
1999–2000	8 258 537	10.4	42	0.05	Ratio	67	54–83
2000–2001	9 698 805	10.8	43	0.04	Ratio	64	51–83
2001–2002	10 833 533	9.1	44	0.04	Ratio	75	61–93
2002–2003	10 764 588	20.4	56	0.03	Ratio	73	63–87
2003–2004	7 380 779	21.8	40	0.02	Ratio	107	61–189
2004–2005	3 676 365	21.3	20	0.03	Ratio	46	26–71
2005–2006	3 687 339	19.1	12	0.02	Ratio	59	28–100
2006–2007	3 738 362	27.8	10	0.01	Ratio	31	18–49
2007–2008	2 244 339	19.0	10	0.02	Ratio	29	17–46
2008–2009	3 115 633	30.1	22	0.02	Ratio	48	29–75
2009–2010	2 992 285	22.3	19	0.03	Ratio	65	35–103
2010–2011	3 164 159	21.3	17	0.03	Ratio	57	26–99

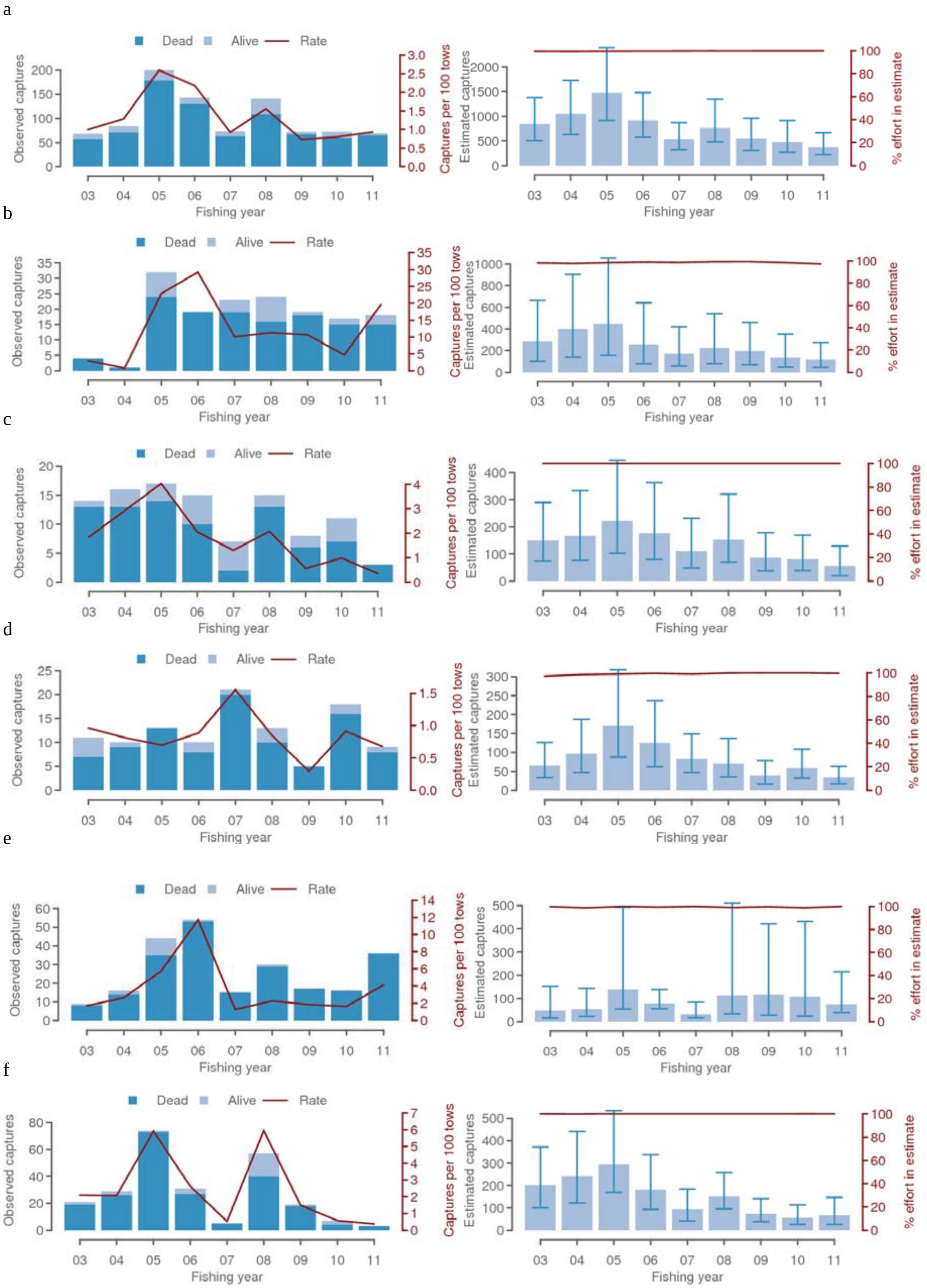


Figure 4.3: Observed captures of NZ fur seals in trawl fisheries (both dead and alive), the capture rate (captures per hundred tows) and the mean number of estimated total captures (with 95% confidence interval) by fishing year for regions with more than 50 observed captures since 2002-03: (a) the New Zealand EEZ; (b) the Cook Strait area; (c) the East Coast South Island area; (d) the Stewart Snares Shelf area; (e) the Subantarctic area; and (f) the West Coast South Island area (Abraham and Thompson 2011 and http://data.dragonfly.co.nz/psc/). For more information on the methods used to prepare the data, see Abraham and Thompson (2011).

4.4.2. Managing fisheries interactions

The impact of fishing related captures on the NZ fur seal population is presently unknown. However, fishing interactions are considered unlikely to have adverse population-level consequences for NZ fur seals given: the scale of bycatch relative to overall NZ fur seal abundance; the apparently increasing population and range; and the NZ and IUCN threat status of the species. The consequences of fishing related mortality for some individual colonies may be more or less severe.

Management has focused on encouraging vessel operators to alter fishing practices to reduce captures, and monitoring captures via the observer programme. A marine mammal operating procedure (MMOP) has been developed by the deepwater sector to reduce the risk of marine mammal captures and is currently applied to trawlers greater than 28 m LOA and is supported by annual training. It includes a number of mitigation measures, such as managing offal discharge and refraining from shooting and hauling the gear when NZ fur seals are congregating around the vessel. Its major focus is reducing the time gear is at or near the surface when it poses the greatest risk. MPI monitors and audits vessel performance against this procedure (see the MPI National Deepwater Plan for further details).

Research into methods to minimise or mitigate NZ fur seal captures in commercial fisheries has focused on fisheries in which NZ fur seals are more likely to be captured (trawl fisheries, see Clement and Associates 2009). Finding ways to mitigate captures has proven difficult because the animals are free swimming, can easily dive to the depths of the net when it is being deployed, hauled, or brought to the surface during a turn, and are known to deliberately enter nets to feed. Further, any measures also need to ensure that the catch is not greatly compromised, either in terms of the amount of fish or their condition. This is one potential drawback of using seal exclusion devices (see Rowe 2007). Adhering to current risk mitigation methods (e.g. MMOP) will help to minimise the level of impacts, however rates may fluctuate depending on fleet deployment, NZ fur seal abundance and local feeding conditions.

4.4.3. Modelling population-level impacts of fisheries interactions

The uncertainty about the size of the NZ fur seal population has restricted the potential to investigate any effects that NZ fur seal deaths through fishing may have on the population as a whole or on the viability of colonies or groups of colonies. The provenance of NZ fur seals caught during fishing is presently unknown, although proposed genetic research potentially could identify which animals belonged to a specific colony (Robertson and Gemmell 2005).

In response to the requirements for the Marine Stewardship Council certification of the hoki fishery (one target fishery contributing to NZ fur seal mortality), expert knowledge about NZ fur seals and their interactions with trawl gear (including some comparisons of annual capture estimates) have been used for an expert-based qualitative ecological risk assessment (ERAs). The results of this study have not been reviewed by the AEWG or DOC’s CSP-TWG.

The impact of fisheries interactions on NZ fur seal populations (and other marine mammal populations) will be assessed in the marine mammal risk assessment project (PRO2012-02) due to be commissioned in 2013. The goal of this project is to assess the risk posed to marine mammal populations by New Zealand fisheries by applying a similar approach to the recent seabird risk assessment (Richard *et al.* 2011). In this approach, risk is defined as the ratio of total estimated annual fatalities due to bycatch in fisheries, to the level of Potential Biological Removal (PBR, Wade 1998). The results should be available in 2014.

4.4.4. Sources of uncertainty

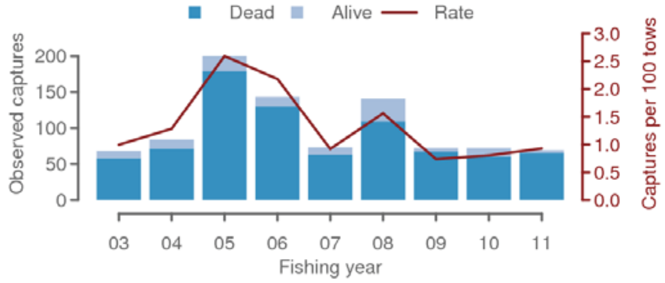
Any measure of the effect of NZ fur seal mortality from commercial fisheries on NZ fur seal populations requires adequate information on the size of the populations at different colonies. Although there is reasonable information about where the main NZ fur seal breeding colonies exist, the size and dynamics of the overall populations are poorly understood. At present, the main sources of uncertainty are the lack of consistent data on: abundance by colony and in total; population demographic parameters; and at-sea distribution (which would ideally be available at the level of a colony or wider geographic area where several colonies are close together) (Baird 2011). Collation and analysis of existing data, such as that for the west coast South Island, would fill some of these gaps; there is a 20-year time series of pup production from three west coast South Island colonies, a reasonably long data series from the Otago Peninsula, and another from Kaikoura. Maximum benefit could be gained through the use of all available data, as shown by the monitoring of certain colonies of NZ fur seals in Australia to provide a measure of overall population stability (see Shaughnessy *et al.* 1994, Goldsworthy *et al.* 2003).

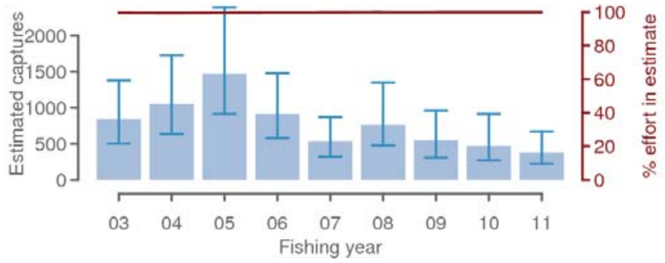
Fur seals may forage in waters near a colony or haulout, or may range widely, depending on the sex, age, and individual preferences of the animal (Baird 2011). It is not known whether the NZ fur seals around a fishing vessel are from colonies nearby. Some genetic work is proposed to test the potential to differentiate between colonies so that in the future NZ fur seals drowned by fishing gear may be identified as being from a certain colony (Robertson and Gemmell 2005).

The low to moderate levels of observer coverage in some fishery-area strata adds uncertainty to the total estimated captures. However, the main source of uncertainty in the level of bycatch is the paucity of information from the inshore fishing fleets using a variety of methods. Recent increases in observer coverage enabled fur seal capture estimates to include inshore fishing effort. Further increases in coverage, particularly for inshore fisheries, would provide better data on the life stage, sex, and size of captured animals, as well as samples for fatty acid or stable isotope analysis to assess diet and to determine provenance. Information on the aspects of fishing operations that lead to capture in inshore fisheries would also be useful to design mitigation.

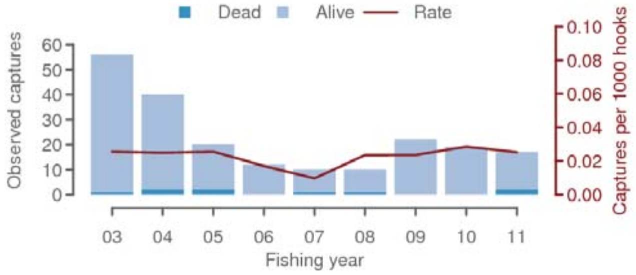
4.5. Indicators and trends

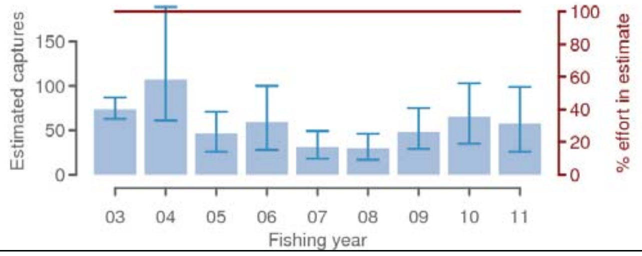
<table>
<tr><td>Population size</td><td>Unknown, but potentially ~100 000 in the New Zealand EEZ[21].</td></tr>
<tr><td>Population trend</td><td>Increasing at some mainland colonies but unknown for offshore island colonies. Range is thought to be increasing.</td></tr>
<tr><td>Threat status</td><td>NZ: Not Threatened, Increasing, Secure Overseas, in 2010[22].
IUCN: Least Concern, in 2008[23].</td></tr>
<tr><td>Number of interactions[24]</td><td>376 estimated captures (95%CI: 221-668) in trawl fisheries in 2010-11
57 estimated captures (95%CI: 26-99) in surface longline fisheries in 2010-11
69 observed captures in trawl fisheries in 2010-11
17 observed captures in surface longline fisheries in 2010-11</td></tr>
<tr><td>Trends in interactions</td><td>
Trawl fisheries:





Surface longline fisheries:





</td></tr>
</table>

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[21] Taylor (1990), Harcourt (2001).

[22] Baker *et al.* (2010b).

[23] Goldsworthy and Gales (2008).

[24] For more information, see: http://data.dragonfly.co.nz/psc/.

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5. New Zealand seabirds

Scope of chapter	This chapter focuses on estimates of captures and risk assessments conducted for seabirds that breed in New Zealand waters. Also included are descriptions of the nature of fishing interactions, the management context and approach, trends in key indicators and major sources of uncertainty. It does not include detail on the biology or response of individual seabird species other than those four taxa for which quantitative population modelling has been conducted.
Area	New Zealand EEZ and Territorial Sea (noting that many seabirds are highly migratory and spend prolonged periods outside the NZ EEZ; on the high seas these effects are considered by CCSBT, WCPFC, CCAMLR, SPRFMO, etc. and New Zealand capture estimates are reported to those organisations).
Focal localities	Interactions with fisheries occur in many parts of the EEZ and TS.
Key issues	Quantitative and semi-quantitative risk assessments can be improved through better estimates of: incidental captures in fisheries that are poorly or un-observed; species identity, especially of birds released alive; cryptic mortality rates; survival of birds released alive; and the ability of seabird populations to sustain given levels of bycatch, especially given fisheries interactions and captures outside the New Zealand EEZ and in non-commercial fisheries. Consolidating qualitative and (semi) quantitative risk assessments is a key challenge.
Emerging issues	Assessing fisheries impacts in the context of other factors influencing seabird survival and reproduction, including other anthropogenic effects. Magnitude of “deck strike” mortality.
MFish Research (current)	PRO2006-01 *Demographic, distributional and trophic information on selected seabird species*; PRO2006-02 *Modelling the effects of fishing on selected seabird species*; PRO2010-01 *Estimating incidental captures of protected species*; PRO2010-02 *Addressing key areas of uncertainty (including in risk assessments) for a revised NPOA-seabirds*.
Other Govt Research (current)	DOC Conservation Services Programme (CSP) projects: INT2012-01, *Observing commercial fisheries*; INT2010-02, *Identification of seabirds captured in New Zealand fisheries*; POP2011-02, *Flesh-footed shearwater population study trial and at-sea distribution*; POP2012-03, *Black petrel at-sea distribution and population estimate*; POP2012-04, *Campbell Island and grey-headed albatrosses population estimates*; POP2012-05, *White-capped albatross population estimate*; POP2012-06, *Salvin’s albatross population estimate and at-sea distribution*; POP2012-07, *Gibson’s albatross population estimate*; POP2012-08, *Pitt Island shags foraging ecology*; MIT2012-01, *Inshore bottom longline seabird mitigation design and analysis*; MIT2012-02, *Inshore trawl warp-strike mitigation analysis of effectiveness*; MIT2012-03, *Review of mitigation techniques in setnet fisheries*; MIT2012-04, *Surface longline seabird mitigation*; MIT2012-05, *Protected species bycatch newsletter*
Links to 2030 objectives	Objective 6: Manage impacts of fishing and aquaculture. Strategic Action 6.2: Set and monitor environmental standards, including for threatened and protected species and seabed impacts.
Related chapters/issues	National Plan of Action to reduce the incidental catch of seabirds in New Zealand fisheries

5.1. *Context*

Seabird names and taxonomy in this document generally follow that adopted by the Ornithological Society of New Zealand (OSNZ 2010) except where a different classification has been agreed by the parties to the Agreement for the Conservation of Albatrosses and Petrels, ACAP, or the New Zealand Threat Classification Scheme (NZTCS) classifies multiple taxa within a single OSNZ species (Table 5.1). The key exceptions to the OSNZ (2010) classification are for: white-capped albatross (OSNZ cites a subspecies *Thalassarche cauta steadi* whereas full species status is used here following ACAP); blue penguins (OSNZ cites a single species, little penguin *Eudyptula minor*, whereas multiple sub-species are used here to reflect NZTCS); and OSNZ (2010) and white-fronted tern (OSNZ cite a single species *Sterna striata*, whereas multiple sub-species are use here to reflect NZTCS). Southern and northern Buller’s albatrosses are treated as separate taxa here, although ACAP lists a single species “Buller’s albatross”. The taxonomy and common names adopted here will, therefore, differ in some instances from those used in legislation or other documents.

There are about 140 000 bird species worldwide, but fewer than 400 are classified as seabirds (being specialised marine foragers). All but seven seabird taxa in New Zealand are absolutely protected under s.3 of the Wildlife Act 1953, meaning that it is an offence to hunt or kill them. Southern black-backed gull, *Larus dominicanus*, is the only species that is not protected. Black shag, *Phalacrocorax carbo,* and sea hawk, *Catharacta lonnbergi,* are partially protected, and sooty shearwater, *Puffinus griseus*, grey-faced petrel, *Pterodroma macroptera*, little shag, *Phalacrocorax melanoleucos brevirostris*, and pied shag, *Phalacrocorax varius*, may be hunted or killed subject to Minister’s notification. Of the 85 seabird taxa that breed in New Zealand waters, 47 are considered threatened (by far the largest number on the world). For albatrosses and petrels, a key threat is injury or death in fishing operations, although the Wildlife Act provides defences if the death or injury took place as part of a fishing operation or if all reasonable steps to avoid the death or injury were taken, as long as the interaction is reported. Commercial fishers are required to complete a Non-Fish and Protected Species Catch Return (NFPSR, s11E of the Fisheries (Reporting) Regulations 2001).

Relevant, high level guidance from the 2005 statement of General Policy under the Conservation Act 1987 and Wildlife Act 1953 includes the following stated policies:

- 4.4 (f) Marine protected species should be managed for their long-term viability and recovery throughout their natural range.
- 4.4 (g) Where unprotected marine species are identified as threatened, consideration will be given to amending the Wildlife Act 1953 schedules to declare such species absolutely protected.
- 4.4 (j) Human interactions with marine mammals and other marine protected species should be managed to avoid or minimise adverse effects on populations and individuals.
- 4.4 (l) The Department should work with other agencies and interests to protect marine species.

The Minister of Conservation may approve a Population Management Plan (PMP) for one or more species under s.14F of the Wildlife Act and a PMP can include a maximum allowable level of fishing-related mortality for a species (MALFiRM). Such a limit would apply to New Zealand fisheries waters and would be for the purpose of enabling a threatened species to achieve a non-threatened status as soon as reasonably practicable or, in the case of non-threatened species, neither cause a net reduction in the size of the population nor seriously threaten the reproductive capacity of the species (s.14G). No PMPs are in place for seabirds but, in the absence of a PMP, the Minister of Fisheries (Primary Industries) may, after consultation with the Minister of Conservation, take such measures as they consider necessary to avoid, remedy, or mitigate the effect of fishing-related mortality on any protected species (s.15(2) of the Fisheries Act).

New Zealand is a signatory to a number of international conventions and agreements to provide for the management of threats to seabirds, including:

- the United Nations Convention on the Law of the Sea (UNCLOS);
- the United Nations Fish Stocks Agreement (insofar as it relates to the conservation of non-target, associated and dependent species);
- the Convention on Biological Diversity (CBD);
- the Convention on Migratory Species (CMS);
- the Food and Agriculture Organisation's (FAO) International Plan of Action for Reducing the Incidental Catch of Seabirds in Longline Fisheries (IPOA);
- the FAO Code of Conduct for Responsible Fisheries and the interpretive Best Practice Technical Guidelines;
- the Agreement on the Conservation of Albatrosses and Petrels (ACAP)

The ACAP agreement requires that parties achieve and maintain a favourable conservation status for a number of albatross and petrel taxa. Under the IPOA-seabirds, New Zealand developed a National Plan of Action (NPOA) to reduce the incidental catch of seabirds in New Zealand fisheries in 2004 (MFish and DOC 2004) and recently (2012) consulted on a revised NPOA-seabirds (http://www.fish.govt.nz/en-nz/Consultations/npoa+seabirds/default.htm). The scopes of the 2004 NPOA (and the 2012 draft) are broader than the original IPOA to facilitate a co-ordinated and long-term approach to reducing the impact of fishing activity on seabirds.

Management of fishing-related mortality of seabirds is consistent with Fisheries 2030 Objective 6: *Manage impacts of fishing and aquaculture*. Further, the management actions follow Strategic Action 6.2: *Set and monitor environmental standards, including for threatened and protected species and seabed impacts.*

All National Fisheries Plans except that for freshwater fisheries are relevant to the management of fishing-related mortality of seabirds.

Under the National Deepwater Plan, the objective most relevant for management of seabirds is Management Objective 2.5: *Manage deepwater and middle-depth fisheries to avoid or minimise adverse effects on the long-term viability of endangered, threatened and protected species.*

Management objective 7 of the National Fisheries Plan for Highly Migratory Species (HMS) is to "*Implement an ecosystem approach to fisheries management, taking into account associated and dependent species*". This comprises four components: *Avoid, remedy, or mitigate the adverse effects of fishing on associated and dependent species, including through maintaining food-chain relationships; Minimise unwanted bycatch and maximise survival of incidental catches of protected species in HMS fisheries, using a risk management approach; Increase the level and quality of information available on the capture of protected species; and Recognise the intrinsic values of HMS and their ecosystems, comprising predators, prey, and protected species*.

The Environment Objective is the same for all groups of fisheries in the draft National Fisheries Plan for Inshore Finfish and the draft National Fisheries Plan for Inshore Shellfish, to "*Minimise adverse effects of fishing on the aquatic environment, including on biological diversity*". The draft National Fisheries Plan for Freshwater has the same objective but is unlikely to be relevant to management of fishing-related mortality of seabirds.

Table 5.1: List of New Zealand seabird taxa, excluding occasional visitors and vagrants, according to the Ornithological Society of New Zealand (OSNZ 2010) unless otherwise indicated (all taxa under the New Zealand Threat Classification System are listed and ACAP taxonomy generally takes precedence). Broad categories of threat status are listed, but comprehensive threat classifications are given by IUCN (http://www.iucnredlist.org/) and DOC (http://www.doc.govt.nz/publications/conservation/nz-threat-classification-system/nz-threat-classification-system-lists-2008-2011/, see also Miskelly *et al.* 2008, to be updated shortly).

Common name	Scientific name	DOC category
Wandering albatross	*Diomedea exulans*	–
Antipodean albatross	*Diomedea antipodensis antipodensis*	Threatened
Gibson's albatross	*Diomedea antipodensis gibsonii*	Threatened
Southern royal albatross	*Diomedea epomophora*	At Risk
Northern royal albatross	*Diomedea sanfordi*	At Risk
Black-browed albatross	*Thalassarche melanophrys*	–
Campbell black-browed albatross	*Thalassarche impavida*	At Risk
Southern Buller's albatross	*Thalassarche bulleri*	At Risk
Northern Buller's albatross	*Thalassarche bulleri platei.*	At Risk
White-capped albatross	*Thalassarche steadi**	Threatened
Salvin's albatross	*Thalassarche salvini*	Threatened
Chatham Island albatross	*Thalassarche eremita*	At Risk
Indian yellow-nosed albatross	*Thalassarche carteri*	–
Grey-headed albatross	*Thalassarche chrysostoma*	Threatened
Light mantled sooty albatross	*Phoebetria palpebrata*	At Risk
Flesh-footed shearwater	*Puffinus carneipes*	Threatened
Wedge-tailed shearwater	*Puffinus pacificus*	At Risk
Buller's shearwater	*Puffinus bulleri*	At Risk
Sooty shearwater	*Puffinus griseus*	At Risk
Short-tailed shearwater	*Puffinus tenuirostris*	–
Fluttering shearwater	*Puffinus gavia*	At Risk
Hutton's shearwater	*Puffinus huttoni*	At Risk
Kermadec little shearwater	*Puffinus assimilis kermadecensis*	At Risk
North Island little shearwater	*Puffinus assimilis haurakiensis*	At Risk
Subantarctic little shearwater	*Puffinus elegans*	At Risk
Northern diving petrel	*Pelecanoides urinatrix urinatrix*	At Risk
Southern diving petrel	*Pelecanoides urinatrix chathamensis*	At Risk
Subantarctic diving petrel	*Pelecanoides urinatrix exsul*	–
South Georgian diving petrel	*Pelecanoides georgicus*	Threatened
Grey petrel	*Procellaria cinerea*	At Risk
Black (Parkinson's) petrel	*Procellaria parkinsoni*	Threatened
Westland petrel	*Procellaria westlandica*	At Risk
White-chinned petrel	*Procellaria aequinoctialis*	At Risk
Kerguelen petrel	*Lugensa brevirostris*	–
Southern Cape petrel	*Daption capense capense*	–
Snares Cape petrel	*Daption capense australe*	At Risk
Antarctic fulmar	*Fulmarus glacialoides*	–
Southern giant petrel	*Macronectes giganteus*	–
Northern giant petrel	*Macronectes halli*	At Risk
Fairy prion	*Pachyptila turtur*	At Risk
Chatham fulmar prion	*Pachyptila crassirostris crassirostris*	At Risk
Lesser fulmar prion	*Pachyptila crassirostris flemingi*	At Risk
Thin-billed prion	*Pachyptila belcheri*	–
Antarctic prion	*Pachyptila desolata*	At Risk
Salvin's prion	*Pachyptila salvini*	–
Broad-billed prion	*Pachyptila vittata*	At Risk
Blue petrel	*Halobaena caerulea*	–
Pycroft's petrel	*Pterodroma pycrofti*	At Risk
Cook's petrel	*Pterodroma cookii*	At Risk
Black-winged petrel	*Pterodroma nigripennis*	–
Chatham petrel	*Pterodroma axillaris*	Threatened
Mottled petrel	*Pterodroma inexpectata*	At Risk
White-naped petrel	*Pterodroma cervicalis*	At Risk
Kermadec petrel	*Pterodroma neglecta*	At Risk
Grey-faced petrel	*Pterodroma macroptera gouldi*	–
Chatham Island taiko	*Pterodroma magentae*	Threatened

White-headed petrel	*Pterodroma lessonii*	–
Soft-plumaged petrel	*Pterodroma mollis*	–
Wilson's storm petrel	*Oceanites oceanicus*	–
Kermadec storm petrel	*Pelagodroma albiclunis*	Threatened
New Zealand storm petrel	*Pealeornis maoriana*	Threatened
Grey-backed storm petrel	*Garrodia nereis*	At Risk
New Zealand white-faced storm petrel	*Pelagodroma marina maoriana*	At Risk
Black-bellied storm petrel	*Fregetta tropica*	–
White-bellied storm petrel	*Fregetta grallaria grallaria*	Threatened
Yellow-eyed penguin	*Megadyptes antipodes*	Threatened
Northern blue penguin**	*Eudyptula minor iredalei***	At Risk
Southern blue penguin**	*Eudyptula minor minor***	At Risk
Chatham Island blue penguin**	*Eudyptula minor chathamensis***	At Risk
White-flippered blue penguin**	*Eudyptula minor albosignata***	Threatened
Eastern rockhopper penguin	*Eudyptes filholi*	Threatened
Fiordland crested penguin	*Eudyptes pachyrhynchus*	Threatened
Snares crested penguin	*Eudyptes robustus*	At Risk
Erect-crested penguin	*Eudyptes sclateri*	At Risk
Red-tailed tropicbird	*Phaethon rubricauda*	Threatened
Australasian gannet	*Morus serrator*	–
Masked booby	*Sula dactylatra fullageri*	Threatened
Black shag	*Phalacrocorax carbo novaehollandiae*	At Risk
Pied shag	*Phalacrocorax varius varius*	Threatened
Little black shag	*Phalacrocorax sulcirostris*	At Risk
Little shag	*Phalacrocorax melanoleucos brevirostris*	–
Stewart Island shag	*Leucocarbo chalconotus*	Threatened
King shag	*Leucocarbo carunculatus*	Threatened
Chatham Island shag	*Leucocarbo onslowi*	Threatened
Bounty Island shag	*Leucocarbo ranfurlyi*	Threatened
Auckland Island shag	*Leucocarbo colensoi*	Threatened
Campbell Island shag	*Leucocarbo campbelli*	At Risk
Spotted shag	*Stictocarbo punctatus punctatus*	–
Blue shag	*Stictocarbo punctatus oliveri*	At Risk
Pitt Island shag	*Stictocarbo featherstoni*	Threatened
Subantarctic skua	*Catharacta antarctica lonnbergi*	At Risk
South Polar skua	*Catharacta maccormicki*	–
Pomarine skua	*Stercorarius pomarinus*	–
Arctic skua	*Stercorarius parasiticus*	–
Long-tailed skua	*Stercorarius longicaudus*	–
Southern black-backed gull	*Larus dominicanus dominicanus*	–
Red-billed gull	*Larus novaehollandiae scopulinus*	Threatened
Black-billed gull	*Larus bulleri*	Threatened
Caspian tern	*Hydroprogne caspia*	Threatened
White-fronted tern***	*Sterna striata striata****	At Risk
Southern white-fronted tern***	*Sterna striata aucklandorna****	Threatened
Arctic tern	*Sterna paradisaea*	–
New Zealand Antarctic tern	*Sterna vittata bethunei*	At Risk
Eastern little tern	*Sternula albifrons sinensis*	–
New Zealand fairy tern	*Sternula nereis davisae*	Threatened
Sooty tern	*Onychoprion fuscata serratus*	At Risk
Black-fronted tern	*Chlidonias albostriatus*	Threatened
White-winged black tern	*Chlidonias leucopterus*	–
Brown noddy	*Anous stolidus pileatus*	–
Black noddy	*Anous tenuirostris minutus*	At Risk
Grey noddy	*Procelsterna cerulea albivittata*	At Risk
White tern	*Gygis alba candida*	Threatened

Notes:

* OSNZ (2010) classify New Zealand white-capped albatross as a subspecies *Thalassarche cauta steadi*. Full species status is used here following ACAP.

** OSNZ (2010) classify a single species, little penguin *Eudyptula minor*. Multiple taxa are included here to reflect classification in the New Zealand Threat Classification Scheme.

*** OSNZ (2010) classify a single species, white-fronted tern *Sterna striata*. Multiple taxa are included here to reflect classification in the New Zealand Threat Classification Scheme.

5.2. *Biology*

Taylor (2000) provided an excellent summary of the characteristics, ecology, and life history traits of seabirds (defined for the purpose of this document by the list in Table 5.1) which is further summarised here.

All seabirds spend part of their life cycle feeding over the open sea. They have webbed feet, water-resistant feathering to enable them to fully immerse in salt water, and powerful wings or flippers. All have bills with sharp hooks, points, or filters which enable them to catch fish, cephalopods, crustaceans, and plankton. Seabirds can drink saltwater and have physiological adaptations to remove excess salt.

Most seabird taxa are relatively long-lived; most live to 20 years and 30–40 years is typical for the oldest individuals. A few groups, notably albatrosses, can live for 50–60 years. Most taxa have relatively late sexual maturity. Red-billed gull and blue penguin have been recorded nesting as yearlings and diving petrels and yellow-eyed penguins can begin as 2-year-olds, but most seabirds start nesting only at age 3–6 years, and some albatross and petrel taxa delay nesting until 8–15 years old. In these late developers, individuals first return to colonies at 2–6 years old. Richard *et al.* (2011) list values for several demographic parameters that they used for a comprehensive seabird risk assessment. Most seabirds, and especially albatrosses and some petrels, usually return to the breeding colony where they were reared, or nest close-by. Seabirds also have a tendency to mate for long periods with the same partner, and albatross pairs almost always remain together unless one partner fails to return to the colony.

The number of eggs laid varies among families. Albatrosses and petrels lay only one egg per year (sometimes nesting every other year) and do not replace it if it is damaged or lost. Other taxa such as gannets lay one egg but can replace it if the egg is lost. Most penguins lay two eggs but some raise only one chick and eject the second egg; replacement laying is uncommon. Blue penguins, gulls, and terns lay 1–3 eggs and can lay up to three clutches in a year if eggs are damaged or lost. Shags lay 2–5 eggs, can replace clutches, and have several breeding seasons in a year. Incubation in albatrosses and petrels lasts 40–75 days and chick rearing 50–280 days. In gulls and terns, incubation is completed in 20–25 days and chicks fledge in 20–40 days. In general, the lower the potential reproductive output of a taxon, the higher the adult survival rates and longevity.

Some seabirds such as shags, blue penguins, and yellow-eyed penguins live their lives and forage relatively close to where they breed, but many, including most albatrosses and petrels, spend large parts of their lives in international waters or in the waters of other nations far away from their breeding locations. They can travel great distances across oceans during foraging flights and migratory journeys.

5.3. *Global understanding of fisheries interactions*

Fishing related mortality of seabirds has been recognised as a serious, worldwide issue for only about 20 years (Bartle 1991, Brothers 1991, Brothers *et al.* 1999, Croxall 2008) and the Food & Agriculture Organization of the United Nations (FAO) released its International Plan of Action for reducing incidental catch of seabirds in longline fisheries (IPOA-seabirds) in 1999 (FAO 1999). The IPOA-Seabirds called on countries with (longline) fisheries that interact with seabirds to assess their fisheries to determine if a problem exists and, if so, to develop national plans (NPOA–seabirds) to reduce the incidental seabird catch in their fisheries. Lewison *et al.* (2004) noted that, in spite of the recognition of the problem, few comprehensive assessments of the effects of fishing-related mortality had been conducted in the decade or so after the problem was recognised. They reasoned that: many vulnerable species live in pelagic habitats, making surveys logistically complex and expensive; capture data are sparse; and understanding of the potential for affected populations to sustain additional mortality is poor. Soykan *et al.* (2008) identified similar questions in a Theme Section published in Endangered Species Research, including: Where is bycatch most prevalent? Which species are taken as bycatch? Which fisheries and gear types result in the highest bycatch of marine megafauna? What are the population-level effects on bycatch species? How can bycatch be reduced?

There has been substantial progress on these questions since 2004. Croxall et al (2012) reviewed the threats to 346 seabird taxa and concluded that: seabirds are more threatened than other comparable groups of birds; that their status has deteriorated faster over recent decades; and that fishing-related mortality is the most pervasive and immediate threat to many albatross and petrels. They listed the principal threats while at sea were posed by commercial fisheries (through competition and mortality on fishing gear) and pollution, and those on land were alien predators, habitat degradation and human disturbance. Direct exploitation, impacts of aquaculture, energy generation operations, and climate change were listed as threats for some taxa or areas where understanding was particularly poor.

Croxall et al (2012) categorise responses to the issue of fishing-related mortality as

- using long-term demographic studies of relevant seabird species, linked to observational and recovery data to identify the cause of population declines (e.g. Croxall *et al.* 1998, Tuck *et al.* 2004, Poncet *et al.* 2006);
- risk assessments, based on spatiotemporal overlap between seabird species susceptible to bycatch and effort data for fisheries likely to catch them (e.g. Waugh *et al.* 2008; Filippi *et al.* 2010; Tuck *et al.* 2011);
- working with multinational and international bodies (e.g. FAO and RFMOs) to develop and implement appropriate regulations for the use of best-practice techniques to reduce or eliminate seabird bycatch and;
- working with fishers (and national fishery organisations) to assist cost-effective implementation of these mitigation techniques.

Seabirds are ranked by the International Union for the Conservation of Nature (IUCN) as the world’s most threatened bird grouping (Croxall *et al.* 2012). Globally they face a number of threats to their long term viability, both at their breeding sites and while foraging at sea. Work at the global level on reducing threats at breeding sites is a major focus of the Agreement on the Conservation of Albatrosses and Petrels (ACAP) and, in New Zealand, is a DOC responsibility, but the key threat to seabirds at sea, especially albatrosses and petrels, is incidental capture and death through fishing operations.

Some seabirds do not range far from their breeding or roosting sites and incidental captures of these taxa can be managed by a single jurisdiction. Conversely, conservation of highly migratory taxa such as albatrosses and petrels cannot be achieved by one country acting independently of other nations which share the same populations (e.g., ACAP). Because of this, in recent years countries which share populations of threatened seabirds have sought to take actions on an international level to complement policy and actions taken within their own jurisdictions.

The ICES Working Group on Seabird Ecology agreed (WGSE 2011) that the three most important indirect effects of fisheries on seabird populations were: the harvesting of seabird food; discards as food subsidies; and modification of marine habitats by dredges and trawls. Many seabird prey species are fished commercially (e.g., Furness 2003) or can be impacted indirectly by fishing of larger predators. These relationships are complex and poorly understood but WGSE (2011) agreed that impacts on populations of seabirds were inevitable. Fishery discards and offal have the potential to benefit seabird species, especially those that ordinarily scavenge (Furness *et al.* 1992, Wagner and Boersma 2011). However, discarding can also modify the way in which birds forage for food (e.g., Bartumeus *et al.* 2010; Louzao *et al.* 2011), sometimes with farther-reaching behavioural consequences with negative as well as positive effects. Louzao *et al.* (2011) stated that discards can affect movement patterns (Arcos and Oro 1996), improve reproductive performance (Oro *et al.*, 1997;

1999) and increase survival (Oro and Furness, 2002; Oro *et al.* 2004). Benefits for scavengers and kleptoparasitic taxa (those that obtain food by stealing from other animals) feeding on discards can also have consequent negative impacts on other species, especially diving species, that share breeding sites or are subject to displacement (Wagner and Boersma 2011). Dredging and bottom trawling both affect benthic habitat and fauna (see Rice 2006 and the benthic effects chapter in this document) and WGSE (2011) agreed that this probably affects some seabird populations, although little work has been done in this area.

5.4. *State of knowledge in New Zealand*

Before the arrival of humans, the absence of mammalian predators in New Zealand made it a relatively safe breeding place for seabirds and large numbers of a wide variety of taxa bred here, including substantial numbers on the main North and South Islands. Today, New Zealand's extensive coastline, numerous inshore and offshore islands (many of them predator free) and surrounding seas and oceans continue to make it an important foraging and breeding ground for about 145 seabird taxa, second only to the USA (GA Taylor, Department of Conservation, personal communication). Roughly 95 of these taxa breed in New Zealand (Figures 5.1 and 5.2; Table 5.2), including the greatest number of albatrosses (14), petrels (32), shags (13) and penguins (9) of any area in the world (Miskelly *et al.* 2008). More than a third are endemic (i.e. breed nowhere else in the world), giving New Zealand by far the largest number of endemic seabird taxa in the world.

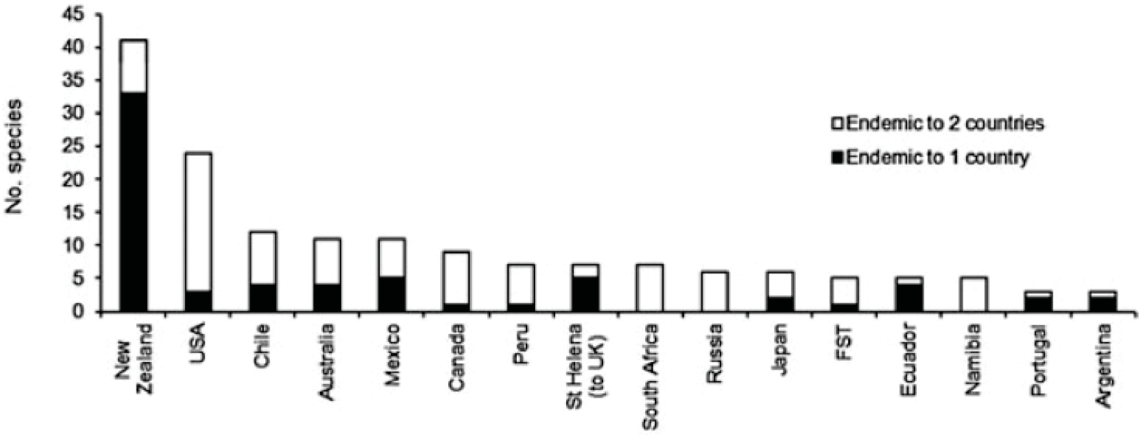

Figure 5.1 (after Croxall et al 2012). Number of endemic breeding seabird taxa by country.

Some seabirds use New Zealand waters but do not breed here. Some visit here occasionally to feed (e.g. Indian Ocean yellow-nosed albatross and snowy wandering albatross), whereas others are frequent visitors (e.g. short-tailed shearwater and Wilson's storm petrel), sometimes for extended durations (e.g. juvenile giant petrels).

Taylor (2000) lists a wide range of threats to New Zealand seabird taxa including introduced mammals, avian predators (weka), disease, fire, weeds, loss of nesting habitat, competition for nest sites, coastal development, human disturbance, commercial and cultural harvesting, volcanic eruptions, pollution, plastics and marine debris, oil spills and exploration, heavy metals or chemical contaminants, global sea temperature changes, marine biotoxins, and fisheries interactions. Seabirds are caught in trawl, longline, set-net, and, occasionally, other fisheries (e.g, annual assessments by SJ Baird from 1994 to 2005, Baird & Smith 2008, Waugh *et al.* 2008, Abraham *et al.* 2010) and New Zealand released its National Plan of Action to reduce the incidental catch of seabirds (NPOA-seabirds) in 2004. This stated there was, at that time, limited information about the level of incidental catch and population characteristics of different seabird taxa, and that this made quantifying the overall impact of fishing difficult. A key objective of New Zealand's NPOA-seabirds was to improve this information and gain a better understanding of the impact of incidental catch on seabird taxa. Seabird taxa caught in New Zealand fisheries range in IUCN threat ranking from critically endangered (e.g. Chatham Island shag), to least concern (e.g. flesh-footed shearwater) (e.g., Vie *et al.* 2009).

Table 5.2 (after Taylor 2000): Number of species (spp.) and taxa of seabirds of different families in New Zealand and worldwide in 2000. Additional taxa may have been recorded since.

		World breeding		**NZ breeding**		**NZ visitors, vagrants**	
Family	**Common name**	**N spp.**	**N taxa**	**N spp.**	**N taxa**	**N spp.**	**N taxa**
Spheniscidae	Penguins	17	26	6	10	8	10
Gaviidae	Divers, loons	4	6	–	–	–	–
Podicipedidae	Grebes	10	20	2	2	–	–
Diomedeidae	Albatrosses	24	24	13	13	7	7
Procellariidae	Petrels, shearwaters	70	109	28	31	20	23
Hydrobatidae	Storm-petrels	20	36	4	5	2	3
Pelecanoididae	Diving petrels	4	9	2	4	–	–
Phaethontidae	Tropicbirds	3	12	1	1	1	1
Pelecanidae	Pelicans	7	12	–	–	1	1
Sulidae	Gannets	9	19	2	2	1	1
Phalacrocoracidae	Shags	39	57	12	13	–	–
Fregatidae	Frigatebirds	5	11	–	–	2	2
Anatidae	Marine ducks	18	27	–	–	–	–
Scolopacidae	Phalaropes	2	2	–	–	2	2
Chionididae	Sheathbills	2	5	–	–	–	–
Stercorariidae	Skuas	7	10	1	1	4	4
Laridae	Gulls	51	78	3	3	–	–
Sternidae	Terns, noddies	43	121	10	11	8	8
Rynchopidae	Skimmers	2	4	–	–	–	–
Alcidae	Auks, puffins	22	45	–	–	–	–
	Total	359	633	84	96	56	62

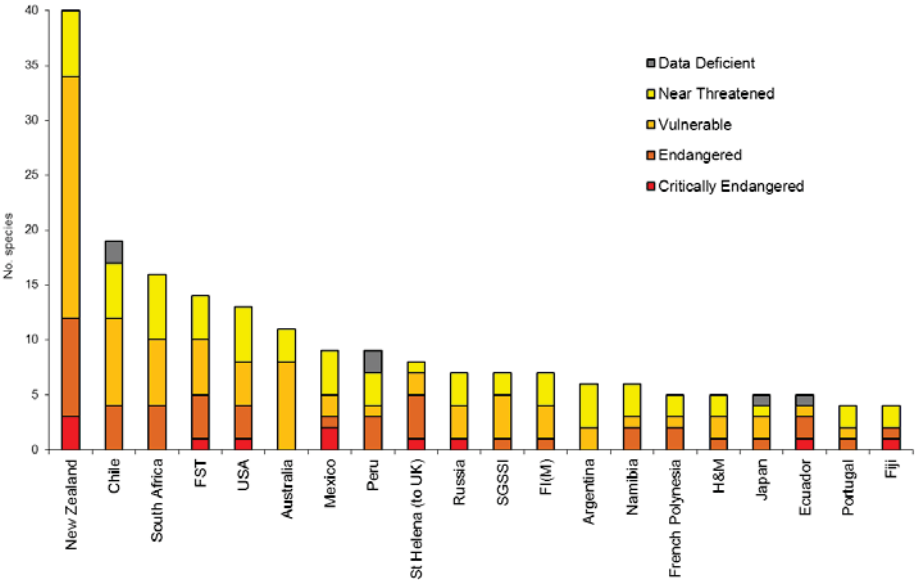

Figure 5.2 (from Croxall *et al.* 2012, supplementary material): The number of breeding and resident seabird species by country in each IUCN category (excluding Least Concern). FST, French Southern Territories; SGSSI, South Georgia & South Sandwich Islands; FI(M), Falkland Islands (Malvinas); H&M, Heard Island & McDonald Islands.

Different taxa and populations face different threats from fishing operations depending on their biological characteristics and foraging behaviours. Biological traits such as diving ability, agility, size, sense of smell, eyesight and diet, foraging factors such as the season and areas they forage, their aggressiveness, the boldness (or shyness) they display in their attraction to fishing activity can all determine their susceptibility to capture, injury, or death from fishing operations. Some fishing methods pose particular threats to some guilds or types of seabirds. For example, penguins are particularly vulnerable to set net operations and large albatrosses appear to be vulnerable to all forms of longlining. The nature and extent of interactions differs spatially, temporally, seasonally and diurnally between sectors, fisheries and between fleets and vessels within fisheries. In 2010/11 the taxa most frequently observed caught in New Zealand commercial fisheries in descending order were white-chinned petrel, sooty shearwater, southern Buller's albatross, white-capped albatross, Salvin's albatross, and flesh footed shearwater, grey petrel, cape petrel, storm petrels, and black petrel.

The management of fisheries to ensure the long-term viability of seabird populations requires an understanding of the risks posed by fishing and other anthropogenic drivers. Several studies have already estimated the number of seabirds caught annually within the New Zealand Exclusive Economic Zone (EEZ) in a range of fisheries (e.g., Baird & Smith 2008, Waugh *et al.* 2008, Abraham *et al.* 2010). In order to evaluate whether the viability of seabird populations is jeopardised by incidental mortality from commercial fishing, the number of annual fatalities needs to be compared with the capacity of the populations to replace those losses; this depends on the size and productivity of each population. Seabirds that breed in New Zealand die as a result of interactions with commercial or recreational fishing operations in waters under New Zealand jurisdiction, through interactions with New Zealand vessels or other nations' vessels on the High Seas and through interactions with commercial, recreational or artisanal fishing operations in waters under the jurisdiction of other states.

Unfortunately, sufficient data to build fully quantitative population models to assess risks and explore the likely results of different management approaches are available for only very few taxa (e.g., Fletcher *et al.* 2008, Francis and Bell 2010, Francis *et al.* 2008, Dillingham and Fletcher 2011). For this reason, broad seabird risk assessments need to rely on expert knowledge (level-1) or to be semi-quantitative (level-2) (Hobday *et al.* 2007). Rowe 2010b described a level-1 seabird risk assessment and Baird and Gilbert (2010) described a semi-quantitative assessment for seabird taxa for which reasonable numbers of observed captures were available. These assessments were based on expert knowledge or not comprehensive and could not be used directly to assess risk for all seabird taxa and fisheries.

5.4.1. Quantifying fisheries interactions

Information with which to characterise seabird interactions with fisheries comes from a variety of sources. Some is opportunistically collected, whilst other information collection is targeted at specifically describing the nature and extent of seabird captures in fisheries. This section is focussed on the targeted information collection.

Many New Zealand commercial fisheries have MPI observer coverage, much of which is funded by DOC's CSP programme (e.g., Rowe 2009, 2010, Ramm 2011, 2012). Observers generate independent data on the number of captures of seabirds, the number of fishing events observed, and at-sea identification of the seabirds for these fisheries. Commercial fishers are required to provide effort data allowing estimation of the total number of fishing events in a fishery. In combination these data have been used for many years to assess the nature and extent of seabird captures in fisheries (e.g., Abraham *et al.* 2010, Abraham and Thompson 2009a, 2010, 2011 a&b, Ayers *et al.* 2004, Baird 1994, 1995, 1996, 1997, 1999, 2000 a&b, 2001 a&b, 2003, 2004 a–c, 2005, Baird *et al.* 1998, 1999, Baird & Griggs 2004, Thompson and Abraham 2009). Fisher-reported captures (on NFPSR forms available since 1 October 2008) have not been used to estimate total captures because the reported capture rates are much lower than those reported by independent observers (Abraham and Thompson 2011) and the species identification is less certain. Specimens and photographs (especially for birds released alive) are also collected allowing verification of at-sea identifications (from carcasses or photographs) and description of biological characters (sex, age, condition, etc., available only from carcasses).

In some fisheries observer data are temporally and spatially well stratified, whilst in others data are only available from a spatially select part of the fishery, or a limited part of the year. Where sufficient observer data are available, estimates of total seabird captures in the fishery are calculated. The methods currently used in estimating seabird captures in New Zealand fisheries are described in Abraham and Thompson (2011a). In this context, captures include all seabirds recovered on a fishing vessel except birds that simply land on the deck or collide with a vessel's superstructure, decomposing animals, records of tissue fragments, and birds caught during trips carried out under special permit (e.g., for trials of mitigation methods). Observer coverage has been highly heterogeneous in that some fisheries and areas have had much higher coverage than others. This complicates estimation of the total number of seabirds captured, especially when estimates include more than one fishery, because the distribution of birds and captures is heterogeneous (Figure 5.3).

Abraham and Thompson (2011, available at: http://fs.fish.govt.nz/Doc/22872/AEBR_79.pdf.ashx) made model-based estimates of captures in New Zealand trawl and longline fisheries for the following taxa or groups: sooty shearwater (*Puffinus griseus*); white-chinned petrel (*Procellaria aequinoctialis*); white-capped albatross (*Thalassarche steadi*); other albatrosses; and all other birds. The three individual species were chosen because they are the most frequently caught in trawl and longline fisheries. Captures of other albatrosses are mostly Salvin's, southern Buller's, Gibson's or Antipodean wandering albatrosses, or Campbell albatrosses. The other birds category includes many taxa but grey, black, great-winged, and Cape petrels, flesh-footed shearwater, and spotted shag are relatively common observed captures (the latter based on few observations that included 31 captures in one event). Estimated captures up to and including the 2010/11 year are shown in Tables 5.3 and 5.4.

Observed captures of seabirds in trawl fisheries were most common off both coasts of the South Island, along the Chatham Rise, on the fringes of the Stewart-Snares shelf, and around the Auckland Islands (Figure 5.4). This largely reflects the distribution of the major commercial fisheries for squid, hoki, and middle-depth species which have tended to have relatively high observer coverage. White-capped, Salvin's, and southern Buller's have been the most frequently observed captured albatrosses, and sooty shearwater and white chinned petrel have been the other species most frequently observed (Table 5.5). About 42% of observed captures were albatrosses.

Observed captures of seabirds in surface longline fisheries were most common off the southwest coast of the South Island and the northeast coast of the North Island (Figure 5.5), again largely reflecting the distribution of the major commercial fisheries (for southern bluefin and other tunas). The charter fleet targeting tuna has historically had much higher observer coverage than the domestic fleet. Southern Buller's and white-capped have been the most frequently observed captured albatrosses, and grey, white-chinned, and black petrels have been the other species most frequently observed (Table 5.6). About 77% of observed captures were albatrosses.

Observed captures of seabirds in bottom longline fisheries were most common off the south coast of the South Island, along the Chatham Rise, scattered throughout the SubAntarctic, and off the northeast coast of the North Island, especially around the Hauraki Gulf (Figure 5.6). This distribution largely reflects the distribution of the ling and snapper longline fisheries that have received most observer coverage; other bottom longline fisheries have had much less coverage. Salvin's and Chatham have been the most frequently observed captured albatrosses, and white chinned petrel, grey petrel, sooty shearwater, and black petrels have been the other species most frequently observed (Table 5.7). Only about 14% of observed captures were albatrosses.

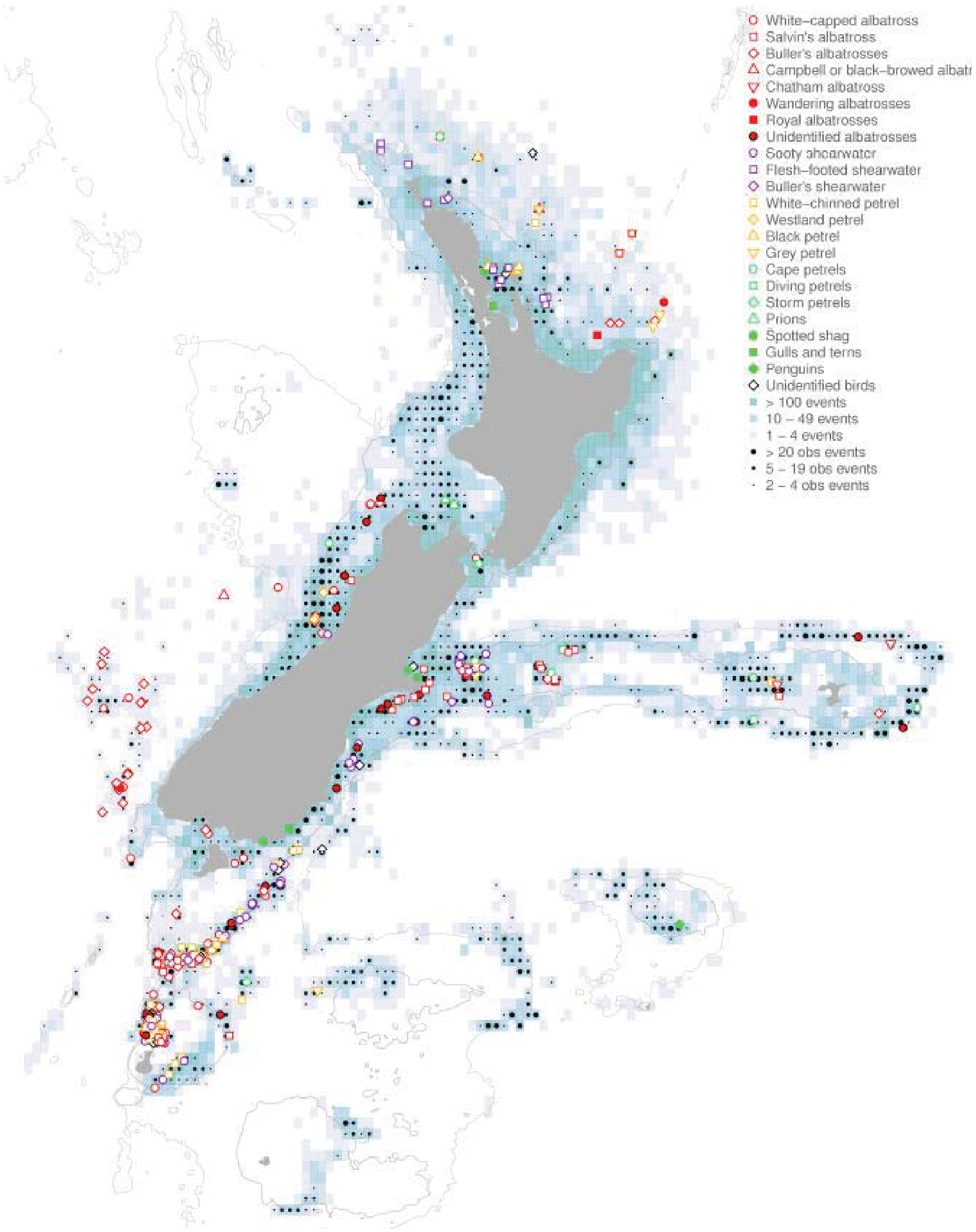

Figure 5.3 (reproduced from Abraham and Thompson 2011): All observed seabird captures in trawl, surface longline, and bottom longline fishing within the New Zealand region, between October 2008 and September 2009. The colour within each 0.2 degree cell indicates the number of fishing events (tows and sets, darker colours indicate more fishing) and the black dots indicate the number of observed events (larger dots indicate more observations). The coloured symbols indicate the location of observed seabird captures, randomly jittered by 0.2 degrees. The 500 m and 1000 m depth contours are shown.

Table 5.3: Summary of observed and model-estimated total captures of all seabirds (top half) and white-capped albatross (bottom half) by October fishing year in trawl (BT, effort in tows)), surface longline (SLL, effort in hooks) and bottom longline (BLL, effort in hooks) fisheries between 2002–30 and 2010–11. Observed and modelled rates are per 100 trawl tows or 1000 longline hooks. Caps, observed captures; % obs, percentage of effort observed; % incl, percentage of total effort included in the model. Data version v20121101.

Models for all seabirds	Fishing effort			Seabirds		Model estimates			
Year	All effort	Observed	% obs	Caps	Rate	Mean	95% c.i.	% incl	Rate
BT 2002–03	130 344	6 834	5.2	269	3.94	3126	2451–4045	100.0	2.40
BT 2003–04	121 498	6 546	5.4	262	4.00	2624	2034–3456	100.0	2.16
BT 2004–05	120 585	7 709	6.4	483	6.27	4337	3358–5861	100.0	3.60
BT 2005–06	110 234	6 553	5.9	356	5.43	3424	2696–4363	100.0	3.11
BT 2006–07	103 529	7 928	7.7	211	2.66	2027	1559–2678	100.0	1.96
BT 2007–08	89 537	9 046	10.1	234	2.59	1976	1515–2574	100.0	2.21
BT 2008–09	87 589	9 804	11.2	469	4.78	2505	2059–3140	100.0	2.86
BT 2009–10	92 886	9 006	9.7	256	2.85	2176	1672–2882	100.0	2.34
BT 2010–11	86 074	7 445	8.6	370	4.97	2788	2172–3611	100.0	3.24
SLL 2002–03	10764 588	2 195 152	20.4	115	0.05	2349	1735–3271	100.0	0.022
SLL 2003–04	7 380 779	1 607 304	21.8	71	0.04	1582	1212–2064	100.0	0.021
SLL 2004–05	3 676 365	783 812	21.3	41	0.05	660	499–885	100.0	0.018
SLL 2005–06	3 687 339	705 945	19.1	37	0.05	785	589–1062	100.0	0.021
SLL 2006–07	3 738 362	1 040 948	27.8	187	0.18	923	720–1239	100.0	0.025
SLL 2007–08	2 244 339	426 310	19.0	41	0.10	509	397–650	100.0	0.023
SLL 2008–09	3 115 633	937 233	30.1	57	0.06	642	502–814	100.0	0.021
SLL 2009–10	2 992 285	665 883	22.3	135	0.20	903	702–1191	100.0	0.030
SLL 2010–11	3 164 159	674 522	21.3	47	0.07	740	547–1019	100.0	0.023
BLL 2002–03	37 671 038	10 772 020	28.6	296	0.03	1718	1250–2268	89.2	0.005
BLL 2003–04	43 397 540	5 162 608	11.9	54	0.01	1151	761–1604	90.2	0.003
BLL 2004–05	41 818 638	2 883 725	6.9	30	0.01	1191	802–1661	88.0	0.003
BLL 2005–06	37 126 833	3 802 951	10.2	41	0.01	1037	701–1431	87.3	0.003
BLL 2006–07	38 124 470	2 315 772	6.1	58	0.03	1236	833–1716	86.2	0.003
BLL 2007–08	41 464 276	3 589 511	8.7	40	0.01	1193	824–1621	86.0	0.003
BLL 2008–09	37 389 512	4 024 816	10.8	33	0.01	1037	699–1458	86.5	0.003
BLL 2009–10	40 413 281	2 271 623	5.6	68	0.03	1062	716–1474	86.1	0.003
BLL 2010–11	40 826 726	1 730 585	4.2	29	0.02	1403	955–1967	85.8	0.003

White-capped albatross models									
Year	All effort	Observed	% obs	Caps	Rate	Mean	95% c.i.	% incl	Rate
BT 2002–03	130 344	6 834	5.2	85	1.24	861	648–1119	100.0	0.66
BT 2003–04	121 498	6 546	5.4	148	2.26	905	701–1144	100.0	0.74
BT 2004–05	120 585	7 709	6.4	243	3.15	1200	976–1502	100.0	1.00
BT 2005–06	110 234	6 553	5.9	69	1.05	609	439–826	100.0	0.55
BT 2006–07	103 529	7 928	7.7	57	0.72	437	315–591	100.0	0.42
BT 2007–08	89 537	9 046	10.1	42	0.46	312	205–443	100.0	0.35
BT 2008–09	87 589	9 804	11.2	97	0.99	471	352–625	100.0	0.54
BT 2009–10	92 886	9 006	9.7	48	0.53	381	266–527	100.0	0.41
BT 2010–11	86 074	7 445	8.6	39	0.52	356	236–496	100.0	0.41
SLL 2002–03	10764 588	2 195 152	20.4	2	0.00	101	63–149	100.0	0.001
SLL 2003–04	7 380 779	1 607 304	21.8	17	0.01	228	148–325	100.0	0.003
SLL 2004–05	3 676 365	783 812	21.3	3	0.00	58	35–86	100.0	0.002
SLL 2005–06	3 687 339	705 945	19.1	2	0.00	54	32–81	100.0	0.001
SLL 2006–07	3 738 362	1 040 948	27.8	28	0.03	42	32–55	100.0	0.001
SLL 2007–08	2 244 339	426 310	19.0	4	0.01	55	33–81	100.0	0.002
SLL 2008–09	3 115 633	937 233	30.1	3	0.00	78	48–114	100.0	0.003
SLL 2009–10	2 992 285	665 883	22.3	31	0.05	135	94–185	100.0	0.005
SLL 2010–11	3 164 159	674 522	21.3	3	0.00	84	52–123	100.0	0.003
BLL 2002–03	37 671 038	10 772 020	28.6	0	0.00	1	0–4	44.8	0.000
BLL 2003–04	43 397 540	5 162 608	11.9	1	0.00	3	0–7	50.3	0.000
BLL 2004–05	41 818 638	2 883 725	6.9	0	0.00	2	0–6	39.6	0.000
BLL 2005–06	37 126 833	3 802 951	10.2	1	0.00	3	1–6	36.4	0.000
BLL 2006–07	38 124 470	2 315 772	6.1	0	0.00	2	0–5	30.6	0.000
BLL 2007–08	41 464 276	3 589 511	8.7	0	0.00	2	0–6	29.9	0.000
BLL 2008–09	37 389 512	4 024 816	10.8	0	0.00	2	0–5	32.1	0.000
BLL 2009–10	40 413 281	2 271 623	5.6	0	0.00	2	0–6	30.1	0.000
BLL 2010–11	40 826 726	1 730 585	4.2	0	0.00	2	0–5	28.6	0.000

Table 5.4: Summary of observed and model-estimated total captures of sooty shearwater (top half) and white-chinned petrel (bottom half) by October fishing year in trawl (BT, effort in tows), surface longline (SLL, effort in hooks) and bottom longline (BLL, effort in hooks) fisheries between 2002–30 and 2010–11. Observed and modelled rates are per 100 trawl tows or 1000 longline hooks. Caps, observed captures; % obs, percentage of effort observed; % incl, percentage of total effort included in the model. Data version v20121101.

Sooty shearwater models		**Fishing effort**		**Seabirds**		**Model estimates**			
Year	**All effort**	**Observed**	**% obs**	**Caps**	**Rate**	**Mean**	**95% c.i.**	**% incl**	**Rate**
BT 2002–03	130 344	6 834	5.2	120	1.76	999	642–1523	100.0	0.77
BT 2003–04	121 498	6 546	5.4	54	0.82	370	224–590	100.0	0.30
BT 2004–05	120 585	7 709	6.4	74	0.96	494	319–758	100.0	0.41
BT 2005–06	110 234	6 553	5.9	169	2.58	976	657–1456	100.0	0.89
BT 2006–07	103 529	7 928	7.7	84	1.06	497	328–748	100.0	0.48
BT 2007–08	89 537	9 046	10.1	82	0.91	416	276–627	100.0	0.46
BT 2008–09	87 589	9 804	11.2	152	1.55	521	371–744	100.0	0.59
BT 2009–10	92 886	9 006	9.7	43	0.48	260	159–409	100.0	0.28
BT 2010–11	86 074	7 445	8.6	110	1.48	488	331–722	100.0	0.57
SLL 2002–03	10 771 388	2 195 152	20.4	8	0.00	14	8–31	100.0	0.000
SLL 2003–04	7 386 864	1 607 304	21.8	3	0.00	7	3–19	100.0	0.000
SLL 2004–05	3 679 865	783 812	21.3	0	0.00	2	0–9	100.0	0.000
SLL 2005–06	3 689 879	705 945	19.1	0	0.00	2	0–9	100.0	0.000
SLL 2006–07	3 739 962	1 040 948	27.8	2	0.00	4	2–10	100.0	0.000
SLL 2007–08	2 245 939	426 310	19.0	0	0.00	2	0–6	100.0	0.000
SLL 2008–09	3 115 633	937 233	30.1	0	0.00	2	0–8	100.0	0.000
SLL 2009–10	2 992 285	665 883	22.3	0	0.00	2	0–7	100.0	0.000
SLL 2010–11	3 166 559	674 522	21.3	0	0.00	2	0–9	100.0	0.000
BLL 2002–03	37 789 058	10 772 020	28.6	32	0.00	97	45–216	100.0	0.000
BLL 2003–04	43 493 500	5 162 608	11.9	17	0.00	82	30–202	100.0	0.000
BLL 2004–05	41 868 788	2 883 725	6.9	3	0.00	81	20–213	100.0	0.000
BLL 2005–06	37 138 783	3 802 951	10.2	3	0.00	46	6–151	100.0	0.000
BLL 2006–07	38 150 820	2 315 772	6.1	1	0.00	53	7–169	100.0	0.000
BLL 2007–08	41 502 096	3 589 511	8.7	6	0.00	61	17–157	100.0	0.000
BLL 2008–09	37 424 356	4 023 916	10.8	0	0.00	54	6–169	100.0	0.000
BLL 2009–10	40 445 221	2 279 233	5.6	7	0.00	53	10–165	100.0	0.000
BLL 2010–11	40 878 991	1 728 765	4.2	0	0.00	69	6–235	100.0	0.000
White-chinned petrel models									
Year	**All effort**	**Observed**	**% obs**	**Caps**	**Rate**	**Mean**	**95% c.i.**	**% incl**	**Rate**
BT 2002–03	130 344	6 834	5.2	13	0.19	148	67–280	100.0	0.11
BT 2003–04	121 498	6 546	5.4	18	0.27	117	61–207	100.0	0.10
BT 2004–05	120 585	7 709	6.4	55	0.71	266	169–403	100.0	0.22
BT 2005–06	110 234	6 553	5.9	70	1.07	436	270–688	100.0	0.40
BT 2006–07	103 529	7 928	7.7	29	0.37	135	82–216	100.0	0.13
BT 2007–08	89 537	9 046	10.1	59	0.65	271	168–430	100.0	0.30
BT 2008–09	87 589	9 804	11.2	104	1.06	316	222–453	100.0	0.36
BT 2009–10	92 886	9 006	9.7	74	0.82	295	189–461	100.0	0.32
BT 2010–11	86 074	7 445	8.6	130	1.75	540	359–817	100.0	0.63
SLL 2002–03	10764 588	2 195 152	20.4	4	0.00	79	43–128	100.0	0.001
SLL 2003–04	7 380 779	1 607 304	21.8	2	0.00	53	27–87	100.0	0.001
SLL 2004–05	3 676 365	783 812	21.3	3	0.00	30	14–49	100.0	0.001
SLL 2005–06	3 687 339	705 945	19.1	1	0.00	30	14–50	100.0	0.001
SLL 2006–07	3 738 362	1 040 948	27.8	5	0.00	30	16–48	100.0	0.001
SLL 2007–08	2 244 339	426 310	19.0	4	0.01	22	11–35	100.0	0.001
SLL 2008–09	3 115 633	937 233	30.1	3	0.00	26	13–43	100.0	0.001
SLL 2009–10	2 992 285	665 883	22.3	3	0.00	25	12–41	100.0	0.001
SLL 2010–11	3 164 159	674 522	21.3	8	0.01	34	19–52	100.0	0.001
BLL 2002–03	37 671 038	10 772 020	28.6	132	0.01	350	246–540	100.0	0.001
BLL 2003–04	43 397 540	5 162 608	11.9	15	0.00	139	81–215	100.0	0.000
BLL 2004–05	41 818 638	2 883 725	6.9	11	0.00	188	105–290	100.0	0.000
BLL 2005–06	37 126 833	3 802 951	10.2	13	0.00	189	108–303	100.0	0.001
BLL 2006–07	38 124 470	2 315 772	6.1	12	0.01	225	123–364	100.0	0.001
BLL 2007–08	41 464 276	3 589 511	8.7	10	0.00	261	143–423	100.0	0.001
BLL 2008–09	37 389 512	4 024 816	10.8	1	0.00	204	97–380	100.0	0.001
BLL 2009–10	40 413 281	2 271 623	5.6	1	0.00	172	86–282	100.0	0.000
BLL 2010–11	40 826 726	1 730 585	4.2	24	0.01	422	225–769	100.0	0.001

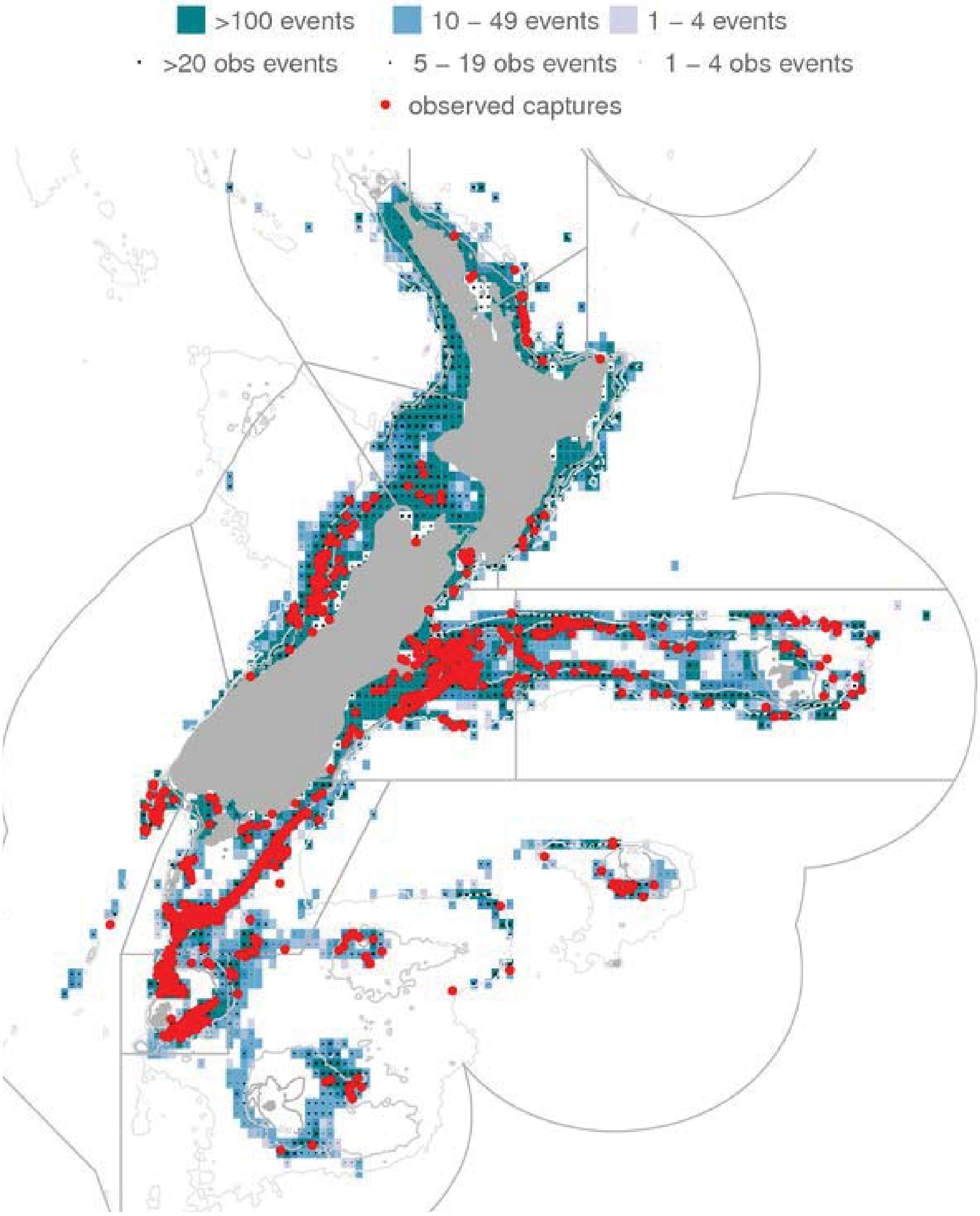

Figure 5.4: Map of trawl fishing effort and all observed seabird captures in trawls, October 2003 to September 2011. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort (events). Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is shown only if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell (here, 96% of effort is displayed).

Table 5.5: Summary of seabirds observed captured in trawl fisheries 2002–03 to 2010–11. Declared target species are: SQU, arrow squid; HOK+, hoki, hake, ling; Mid., other middle depth species silver, white, and common warehou, barracouta, alfonsinos, stargazer; SCI, scampi; ORH+, orange roughy and oreos; SBW, southern blue whiting; JMA, Jack mackerels; Ins., other inshore species for which one or more captures have been observed; tarakihi, red cod, spiny dogfish, John dory, snapper; FLA, flatfishes. Data version v20121101.

									Declared target species	
Species or group	**SQU**	**HOK+**	**Mid.**	**SCI**	**ORH+**	**SBW**	**JMA**	**Ins.**	**FLA**	**Total**
White capped albatross	679	54	52	15	6	0	1	22	0	829
Salvin's albatross	18	87	25	29	16	2	0	20	0	197
Southern Buller's	49	41	19	4	3	0	1	1	0	118
Campbell albatross	2	5	0	1	0	1	0	0	0	9
Chatham Island albatross	0	0	0	1	8	0	0	0	0	9
Southern royal albatross	5	0	0	0	0	1	0	0	0	6
Southern black-browed	1	2	0	0	0	0	0	2	0	5
Gibson's albatross	0	0	0	0	1	0	0	0	0	1
Northern royal albatross	0	0	0	0	1	0	0	0	0	1
Albatross indet.	10	10	1	5	0	4	1	1	0	32
All albatrosses	764	199	97	55	35	8	3	46	0	1207
Sooty shearwater	540	181	119	37	5	0	5	1	0	888
White chinned petrel	387	43	42	48	1	0	9	0	0	530
Cape petrels	1	34	1	3	19	1	2	0	0	61
Flesh footed shearwater	0	1	0	35	0	0	0	2	0	38
Spotted shag	0	0	0	0	0	0	0	0	32	32
Grey petrel	1	2	0	0	3	22	0	0	0	28
Common diving petrel	5	5	0	1	2	0	1	0	0	14
Westland petrel	0	11	1	0	0	0	1	0	0	13
Fairy prion	0	4	0	0	0	0	5	0	0	9
Antarctic prion	7	0	0	0	0	0	0	0	0	7
Northern giant petrel	0	3	1	1	1	0	0	0	0	6
Giant petrel	3	1	0	0	0	0	0	0	0	4
Grey-backed storm petrel	3	1	0	0	0	0	0	0	0	4
Fulmar prion	0	0	0	0	0	0	3	0	0	3
Black petrel	0	0	0	1	0	0	0	1	0	2
Black-bellied storm petrel	1	1	0	0	0	0	0	0	0	2
White-faced storm petrel	0	0	0	0	2	0	0	0	0	2
Black backed gull	0	0	0	0	0	0	0	0	1	1
Short tailed shearwater	0	0	1	0	0	0	0	0	0	1
White headed petrel	1	0	0	0	0	0	0	0	0	1
Other bird indet.	11	5	3	2	1	5	0	2	2	31
All other birds	960	292	168	128	34	28	26	6	35	1677
All observed birds	1724	491	265	183	69	36	29	52	35	2884
Approx. proportion obs	0.23	0.14	0.06	0.09	0.26	0.35	0.25	0.01	0.01	0.08

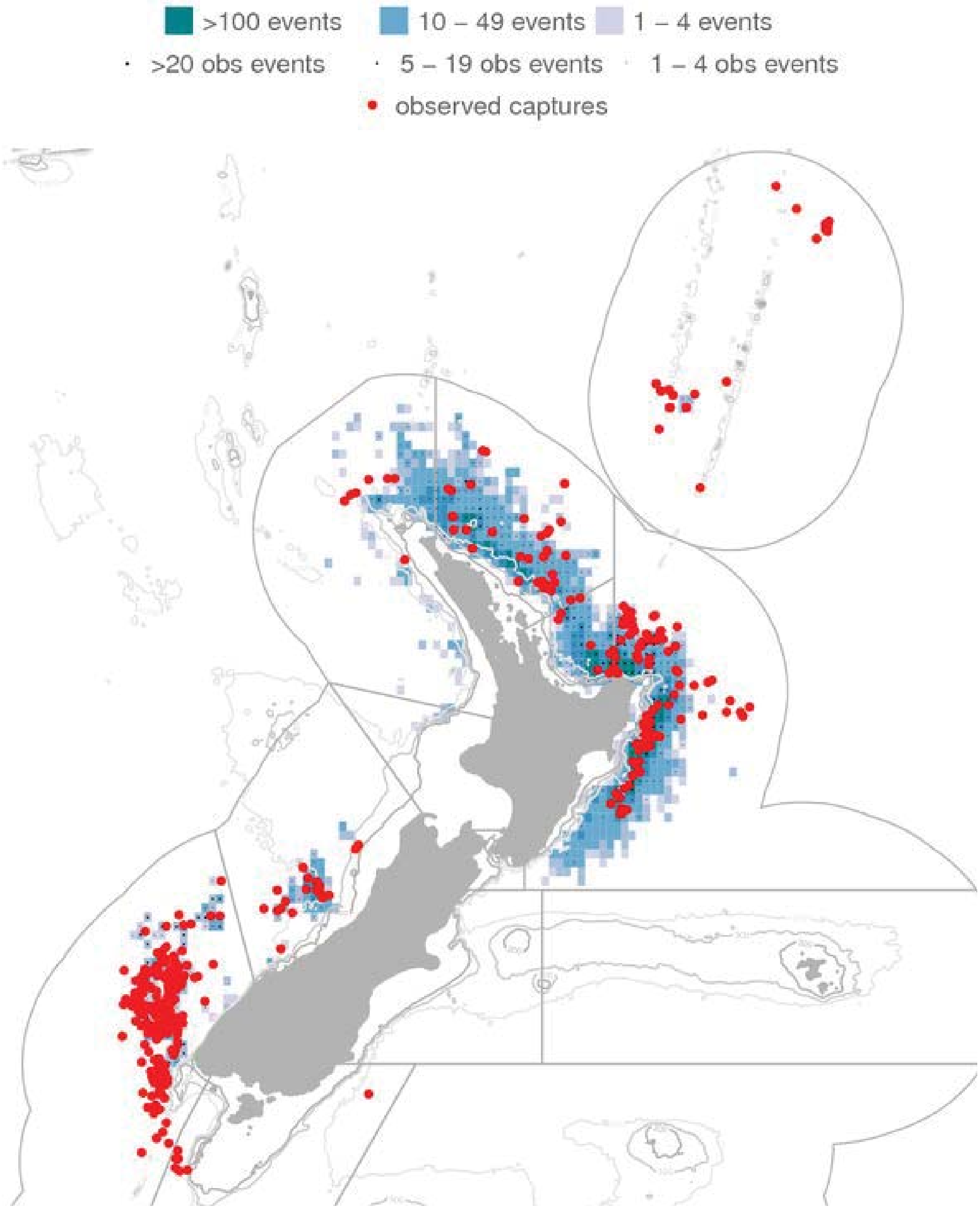

Figure 5.5: Map of surface longline fishing effort and all observed seabird captures by surface longlines, October 2003 to September 2011. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort (events). Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is shown only if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell (here, 75.3% of effort is displayed).

Table 5.6: Summary of seabirds observed captured in surface longline fisheries 2002–03 to 2010–11. Declared target species are: SBT, southern bluefin tuna; BIG, bigeye tuna; SWO, broadbill swordfish; ALB, albacore tuna. Data version v20121101.

					Declared target species
Species or group	**SBT**	**BIG**	**SWO**	**ALB**	**Total**
Southern Buller's albatross	296	7	1	8	312
White capped albatross	91	1	1	0	93
Campbell albatross	18	3	2	17	40
Antipodean albatross	4	8	15	3	30
Gibson's albatross	8	6	9	7	30
Wandering albatrosses	8	3	0	0	11
Salvin's albatross	3	4	0	1	8
Antipodean / Gibson's	0	2	5	0	7
Black browed albatrosses	0	2	2	0	4
Southern royal albatross	4	0	0	0	4
Southern black-browed	2	0	0	0	2
Light-mantled sooty	1	0	0	0	1
Northern royal albatross	0	1	0	0	1
Pacific albatross	1	0	0	0	1
Albatrosses indet.	2	1	33	0	36
Total albatrosses	438	38	68	36	580
Grey petrel	38	0	3	5	46
White chinned petrel	21	8	2	2	33
Black petrel	0	23	2	1	26
Great winged petrel	0	1	2	17	20
Sooty shearwater	4	0	1	8	13
Flesh footed shearwater	0	11	1	0	12
Westland petrel	6	0	0	2	8
Cape petrels	2	0	0	0	2
Southern giant petrel	2	0	0	0	2
White headed petrel	0	0	0	2	2
Petrels indet.	0	1	0	0	1
Total other birds	73	44	11	37	165
All observed birds	511	82	79	73	745
Approx. proportion obs	0.42	0.03	0.10	0.38	0.22

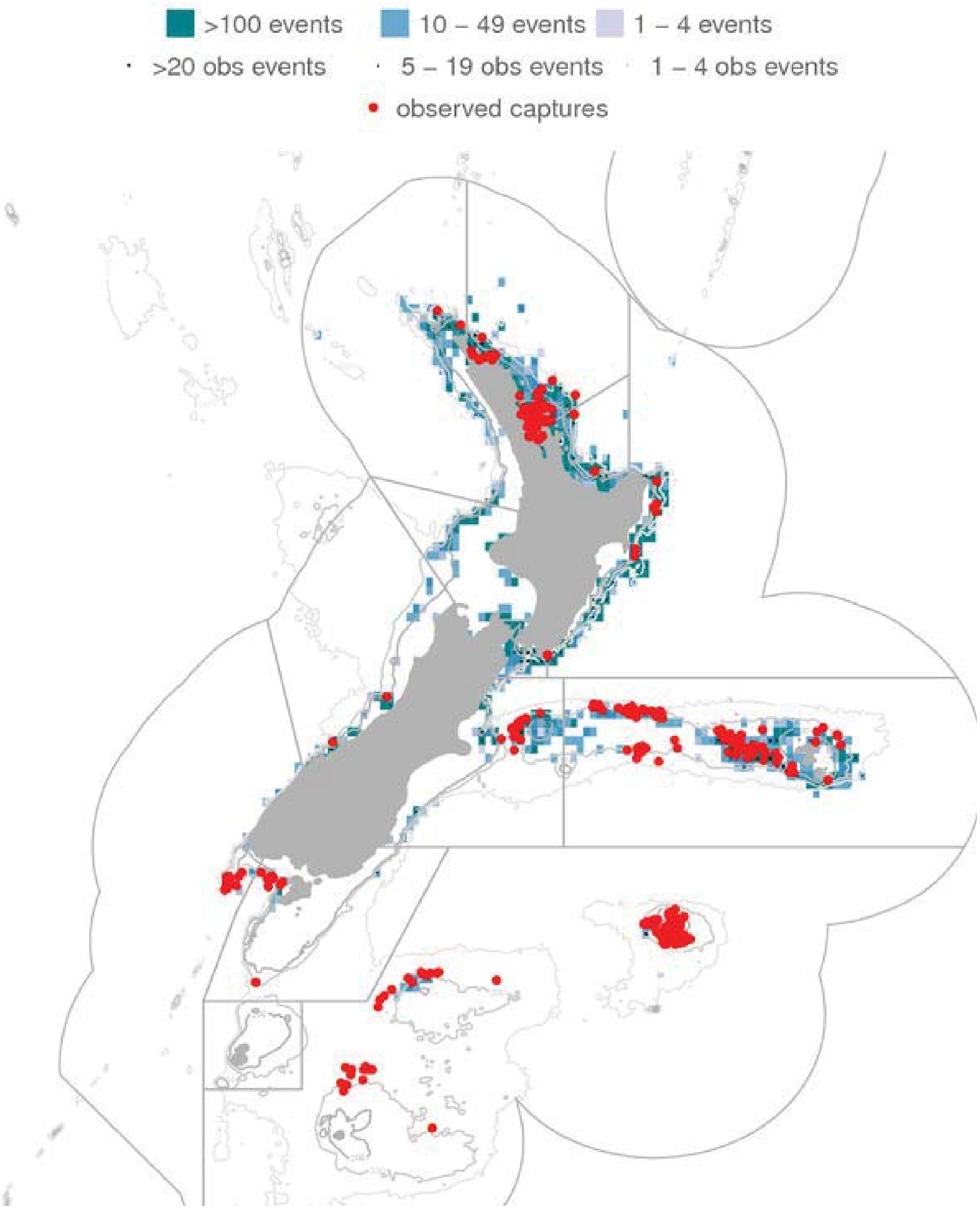

Figure 5.6: Map of bottom longline fishing effort and all observed seabird captures by bottom longlines, October 2003 to September 2011. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort (events). Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is shown only if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell (here, 79.3% of effort is displayed).

Table 5.7: Summary of seabirds observed captured in bottom longline fisheries 2002–03 to 2010–11. Declared target species are: LIN, ling; SNA, snapper; BNS, bluenose; HPB, hapuku or bass. Data version v20121101.

	Declared target species				
Species or group	**LIN**	**SNA**	**BNS**	**HPB**	**Total**
Salvin's albatross	51	0	0	0	51
Chatham Island albatross	18	0	0	0	18
Southern Buller's albatross	4	0	3	0	7
Campbell albatross	0	0	2	1	3
Wandering albatrosses	2	0	1	0	3
White capped albatross	2	0	0	0	2
Black browed albatrosses	1	0	0	0	1
Indian yellow-nosed albatross	1	0	0	0	1
Southern royal albatross	1	0	0	0	1
Albatross indet.	2	0	0	0	2
All albatrosses	82	0	6	1	89
White chinned petrel	217	0	2	0	219
Grey petrel	79	0	0	0	79
Sooty shearwater	68	0	0	1	69
Black petrel	0	28	14	7	51
Flesh footed shearwater	0	36	0	3	39
Cape petrels	24	0	0	0	24
Common diving petrel	23	0	0	0	23
Great winged petrel	0	0	0	6	6
Fluttering shearwater	0	4	0	0	4
Northern giant petrel	4	0	0	0	4
Prions	4	0	0	0	4
Storm petrels	3	0	0	0	3
Gannets	0	2	0	0	2
Pied shag	0	2	0	0	2
Black backed gull	0	1	0	0	1
Buller's shearwater	0	1	0	0	1
Crested penguins	1	0	0	0	1
Giant petrel	1	0	0	0	1
Red billed gull	0	1	0	0	1
Other birds indet	1	10	0	0	11
All other birds	425	85	16	17	545
All birds observed	507	85	22	18	634
Approx. proportion obs	0.20	0.01	0.01	0.01	0.10

Model-based estimates of captures can be combined across trawl and longline fisheries (Figure 5.7). Summed across all bird taxa, trawl, surface longline, and bottom longline fisheries account for 55%, 21%, and 24% of captures, respectively, but there are substantial differences in these proportions among seabird taxa. A high proportion (87% between 2003 and 2011) of white-capped albatross captures are taken in trawl fisheries with almost all of the remainder taken in surface longline fisheries. The trawl fishery also accounts for 89% of sooty shearwaters captured, with most of the remainder taken by bottom longliners. The proportion captured by trawl fisheries reduces to 53% for all other albatrosses combined, with 30% and 17% taken in surface and bottom longline fisheries, respectively. Bottom longline and trawl take similar proportions of the white-chinned petrels captured (43% and 50%, respectively).

Over the 2003 to 2011 period, there appear to have been downward trends (across all fisheries) in the estimated captures of all birds combined, white-capped albatross, and non-albatross taxa other than sooty shearwaters and white-chinned petrel (Figure 5.7). Estimated captures of other albatrosses, sooty shearwaters, and white-chinned petrel appear to have fluctuated without much trend, although there is some evidence for an increasing trend for white-chinned petrel, especially in trawl fisheries.

Because fishing effort often changes with time, estimates of total captures may not be the only index required for comprehensive monitoring. The number of captures (with certain caveats, see later) is clearly more biologically relevant for the birds, but capture rates by fishery may be more useful measures to assess fishery performance and the effectiveness of mitigation approaches. Dividing modelled catch estimates by the number of tows or hooks set in a particular fishery in each year provides catch rate indices by fishery. These are typically reported as the number of birds captured per 100 trawl tows or per 1000 longline hooks (Figures 5.8 to 5.10).

Figure 5.7: Model-based estimates of captures of the most numerous seabird taxa observed captured in trawl, surface longline, and bottom longline fisheries between 2002/03 and 2010/11. For confidence limits see Tables 3 and 4. Note this level of aggregation conceals any different trends within a fishing method (e.g., deepwater vs. inshore and flatfish trawl or large vs. small longliners).

For white-capped albatross, captures rates declined between 2002/03 and 2010/11, and especially up to 2006/07, in the major offshore trawl fisheries for squid and hoki (Figure 5.8) but showed no trend for inshore trawlers and increased for surface longliners targeting southern bluefin tuna. Together, these fisheries account for 82% of all estimated captures of white-capped albatross in these years.

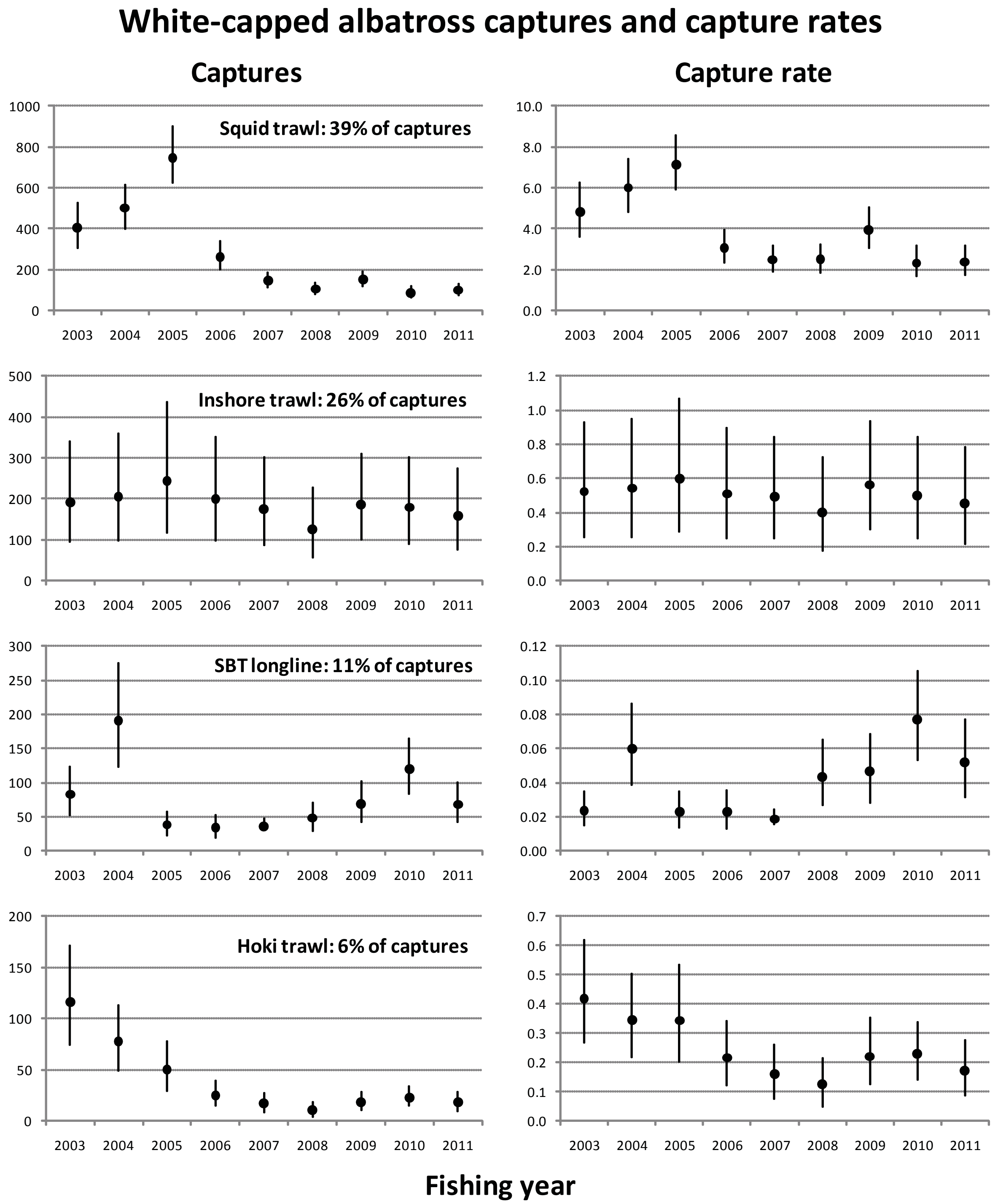

Figure 5.8: Model-based estimates of captures (left panels) and capture rates (right panels, captures per 100 trawl tows or 1000 longline hooks) of white capped albatross in the four fisheries estimated to have taken the most captures between 2002/03 and 2010/11 (cumulatively, 82% of all white-capped albatross captures). Data version v20121101.

For white-chinned petrel, captures rates increased between 2002/03 and 2010/11 in squid and scampi trawlers (Figure 5.9) but showed no trend for bottom longliners targeting ling and bluenose. Together, these fisheries account for 81% of all estimated captures of white-chinned petrel in these years.

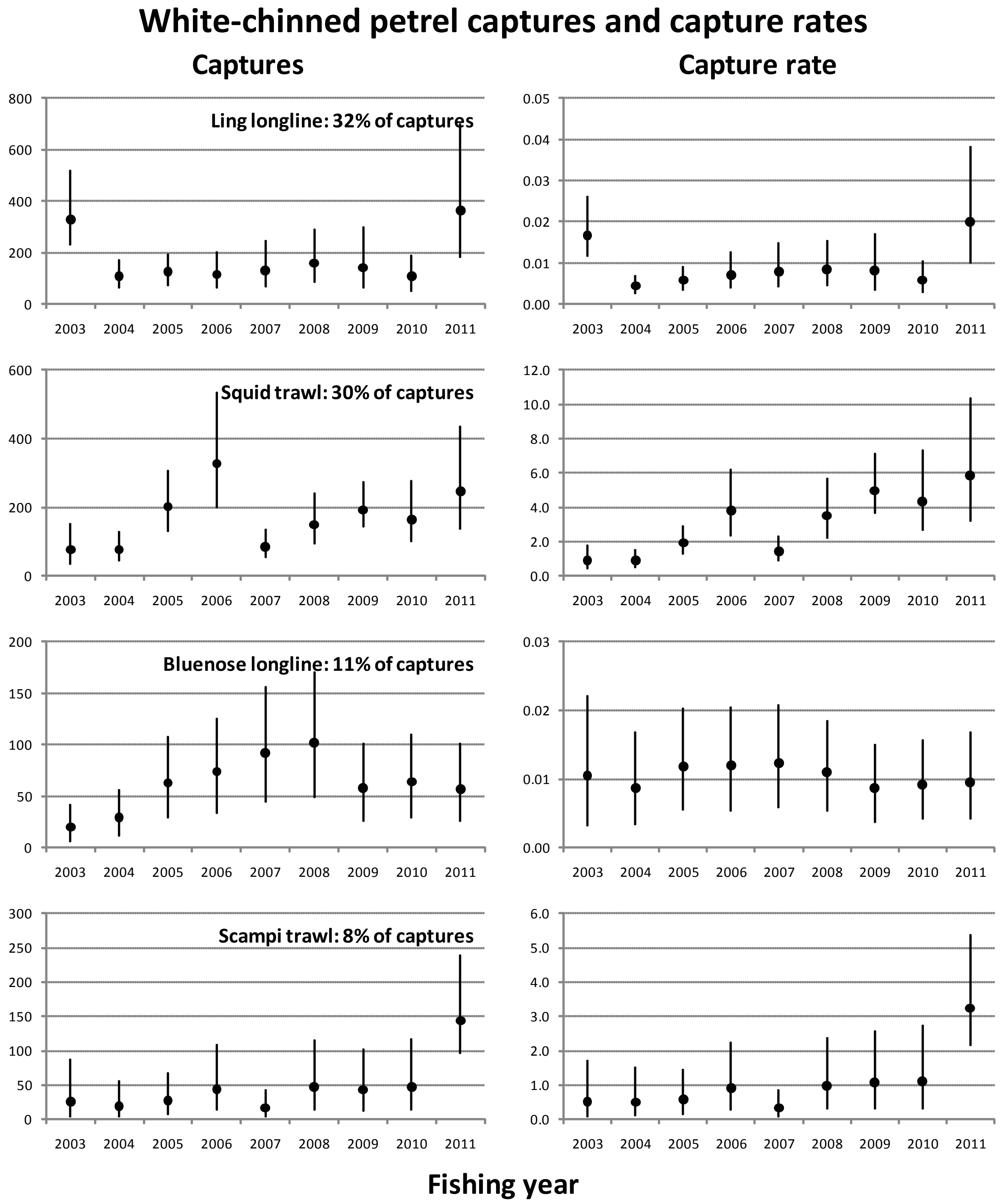

Figure 5.9: Model-based estimates of captures (left panels) and capture rates (right panels, captures per 100 trawl tows or 1000 longline hooks) of white chinned petrels in the four fisheries estimated to have taken the most captures between 2002/03 and 2010/11 (cumulatively, 81% of all white-chinned petrel captures). Data version v20121101.

For sooty shearwaters, captures rates decreased between 2002/03 and 2010/11 for bottom longliners targeting ling, but showed no trend in squid, middle-depth, and hoki trawlers (Figure 5.10). Together, these fisheries account for 80% of all estimated captures of sooty shearwaters in these years.

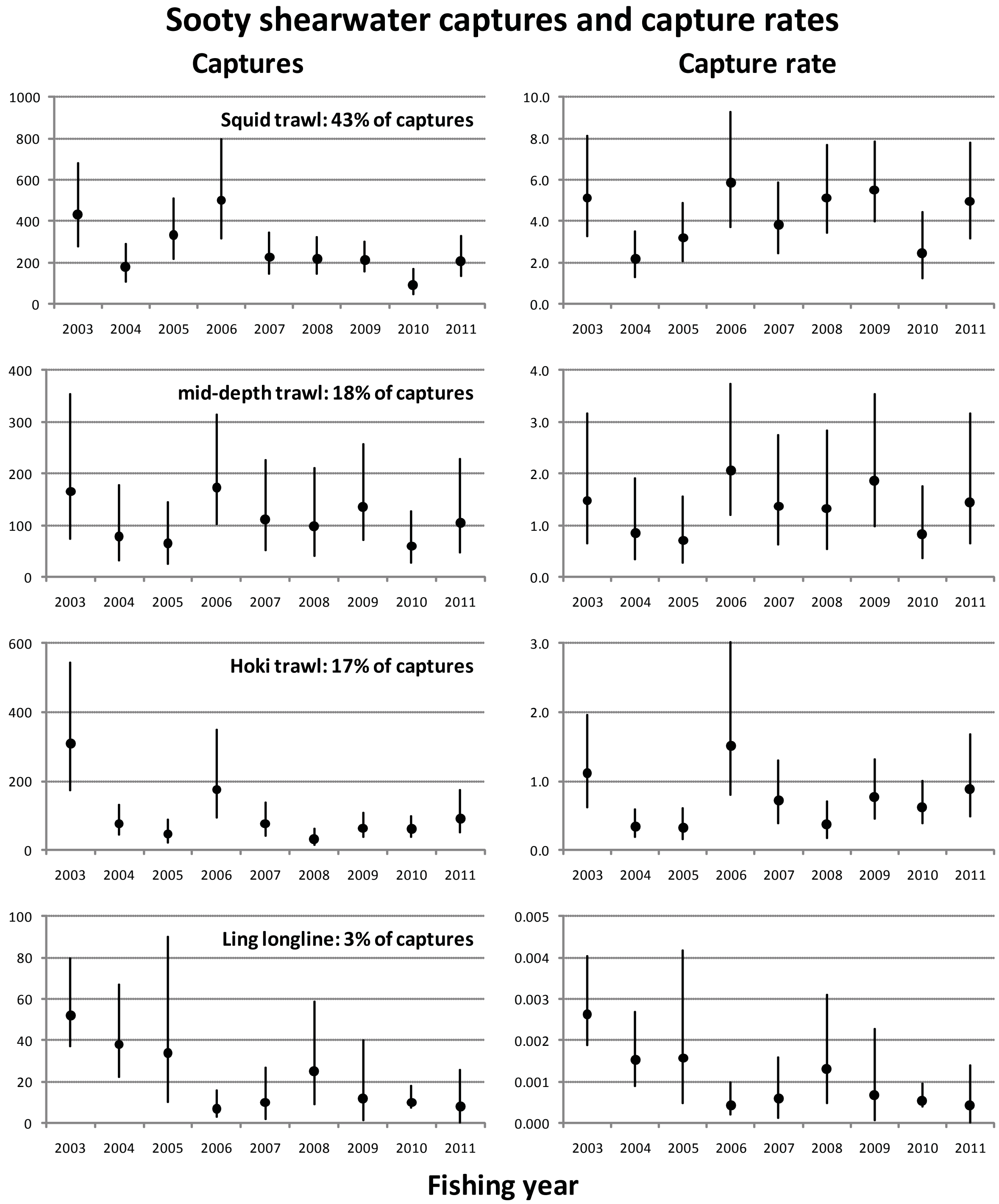

Figure 5.10: Model-based estimates of captures (left panels) and capture rates (right panels, captures per 100 trawl tows or 1000 longline hooks) of sooty shearwaters in the four fisheries estimated to have taken the most captures between 2002/03 and 2010/11 (cumulatively, 80% of all sooty shearwater captures). Data version v20121101.

On-board captures recorded by observers represent the most reliable source of information for monitoring trends in total captures and capture rates, but these data have three main deficiencies with respect to estimating total fatalities, especially to species level. First, some captured seabirds are released alive (23% in trawl fisheries between 2002–03 and 2010–11, 29% in surface longline fisheries, and 25% in bottom longline fisheries), meaning that, all else being equal, estimates of captures may overestimate total fatalities, depending on the survival rate of those released. Second, identifications by observers are not completely reliable and sometimes use generic codes rather than species codes. A high proportion of dead captures are returned for necropsy and formal identification (87% in trawl fisheries between 2002–03 and 2010–11, 83% in surface longline fisheries, and 89% in bottom longline fisheries), but there remains uncertainty in the identity of 11–17% of dead captures and 100% of those released alive. Third, not all birds killed or mortally wounded by fishing gear are recovered on a fishing vessel. Some birds caught on longline hooks fall off before being recovered, and birds that collide with trawl warps may be dragged under the water and drowned or injured to the extent that they are unable to fly or feed. Excluding this “cryptic” mortality means that, all else being equal, estimates of captures will underestimate total fatalities. These deficiencies do not greatly affect the suitability of estimates of captures and capture rates for monitoring purposes, but they have necessitated the development of alternative measures for assessing risk and population consequences.

5.4.2. Managing fisheries interactions

New Zealand had taken steps to reduce incidental captures of seabirds before the advent of the IPOA in 1999 and the NPOA in 2004. For example, regulations were put in place under the Fisheries Act to prohibit drift net fishing in 1991 and prohibit the use of netsonde monitoring cables (“third wires”) in trawl fisheries in 1992. The use of tori lines (streamer lines designed to scare seabirds away from baited hooks) was made mandatory in all tuna longline fisheries in 1992.

The fishing industry also undertook several initiatives to reduce captures include funding research into new or improved mitigation measures, and adopting voluntary codes of practice and best practice fishing methods. Codes of practice have been in place in the joint venture tuna longline fishery since 1997–98, requiring, *inter alia*, longlines to be set at night and voluntary upper limits on the incidental catch of seabirds. That limit was steadily reduced from 160 “at risk” seabirds in 1997–98, to 75 in 2003–04. Most vessels in the domestic longline tuna fishery had also voluntarily adopted night setting, by 2004. A code of practice was in place for the ling auto-line fishery by 2002–03. Other early initiatives included reduced deck lighting, the use of thawed rather than frozen baits, sound deterrents, discharging of offal away from setting and hauling, weighted branch lines, different gear hauling techniques and line shooters. Current regulated and voluntary initiatives are summarised by fishery in Table 5.8.

In 2002, MFish, DOC, and stakeholders began working with other countries to reduce the incidental catch of seabirds. As a result, a group called Southern Seabird Solutions was formed and formally established as a Trust in 2003 (http://www.southernseabirds.org/) and received royal patronage in 2012. Southern Seabird Solutions exists to promote responsible fishing practices that avoid the incidental capture of seabirds in New Zealand and the southern ocean. Membership includes representatives from the commercial fishing industry, environmental and conservation groups, and government departments. The Trust’s vision is that: *All fishers in the Southern Hemisphere avoid the capture of seabirds*, and this is underpinned by the strategic goals on: Culture Change; Supporting Collaboration; Mitigation Development and Knowledge Transfer; Recognising Success; and Strengthening the Trust.

Building on these initiatives, New Zealand’s 2004 NPOA established a more comprehensive framework to reducing incidental captures approach across all fisheries (because focussing on longline fisheries like the IPOA was considered neither equitable nor sufficient).

It included two goals that set the overall direction:

1. To ensure that the long-term viability of protected seabird species is not threatened by their incidental catch in New Zealand fisheries waters or by New Zealand flagged vessels in high seas fisheries; and
2. To further reduce incidental catch of protected seabird species as far as possible, taking into account advances in technology, knowledge and financial implications.

Together the two goals established the NPOA as a long-term strategy. The second goal was designed to build on the first goal by promoting and encouraging the reduction of incidental catch beyond the level that is necessary to ensure long term viability. The goals recognised that, although seabird deaths may be accidentally caused by fishing, most seabirds are absolutely protected under the Wildlife Act. The second goal balances the need to continue reducing incidental catch against the factors that influence how this can be achieved in practice (e.g., advances in technology and the costs of mitigation). The scope of the NPOA included:

- all seabird species absolutely or partially protected under the Wildlife Act;
- commercial and non-commercial fisheries;
- all New Zealand fisheries waters; and
- high seas fisheries in which New Zealand flagged vessels participate, or where foreign flagged vessels catch protected seabird species.

Specific objectives were established in the NPOA as follows:

1. Implement efficient and effective management measures to achieve the goals of the NPOA, using best practice measures where possible;
2. Ensure that appropriate incentives and penalties are in place so that fishers comply with management measures;
3. Establish mandatory bycatch limits for seabird species where they are assessed to be an efficient and effective management measure and there is sufficient information to enable an appropriate limit to be set;
4. Ensure that there is sufficient, reliable information available for the effective implementation and monitoring of management measures;
5. Establish a transparent process for monitoring progress against management measures;
6. Ensure that management measures are regularly reviewed and updated to reflect new information and developments, and to ensure the achievement of the goals of the NPOA;
7. Encourage and facilitate research into affected seabird species and their interactions with fisheries;
8. Encourage and facilitate research into new and innovative ways to reduce incidental catch;
9. Provide mechanisms to enable all interested parties to be involved in the reduction of incidental catch;
10. Promote education and awareness programmes to ensure that all fishers are aware of the need to reduce incidental catch and the measures available to achieve a reduction.

The NPOA-seabirds sets out the mix of voluntary and mandatory measures that would be used to help reduce incidental captures of seabirds, noted research into the extent of the problem and the techniques for mitigating it, and outlined mechanisms to oversee, monitor and review the effectiveness of these measures. It was not within the scope of the NPOA to address threats to seabirds other than fishing. Such threats are identified in DOC’s Action Plan for Seabird Conservation in New Zealand (Taylor 2000) and their management is undertaken by DOC.

Since publication of the NPOA in 2004, more progress has been made in the commercial fishing sector, including:

- in the deepwater fishing sector;
    - industry has implemented vessel specific risk management plans (VMPs) comprising non-mandatory seabird scaring devices offal management and other measures to reduce risks to seabirds,
    - Government has implemented mandatory measures to reduce risk to seabirds (e.g., use and deployment of seabird scaring devices), and
    - industry has taken a proactive stance in resourcing a 24/7 liaison officer to undertake incident response actions, mentoring, VMP and regime development and reviewing, and fleet wide training;

- in the bottom and surface long-line sectors, Government has implemented mandatory measures including tori lines, night setting, line weighting and offal management;
- a number of research projects have been or are currently being undertaken by government and industry into offal discharge, efficacy of seabird scaring devices, line weighting and longline setting devices; and
- workshops organised by both industry bodies and Southern Seabird Solutions are being held for the inshore trawl and longline sectors.

Areas still requiring progress identified in MPI’s 2012 consultation documents for a revision to the NPOA-seabirds included:

- development and implementation of mitigation measures, and education, training and outreach in commercial set net fisheries and inshore trawl fisheries;
- implementation of spatially and temporally representative at-sea data collection in inshore and some HMS fisheries;
- development and implementation of mitigation measures for net captures in trawl fisheries;
- development and implementation of mitigation measures, education, training and outreach in, and risk assessment of non-commercial fisheries (especially setnet and line fisheries).

Mitigation has developed substantially since FAO’s IPOA was published and a number of recent reviews consider the effectiveness of different methods (Bull 2007, 2009) and summarise currently accepted best practice (ACAP 2011). In December 2010, FAO held a Technical Consultation where International Guidelines on bycatch management and reduction of discards were adopted (FAO2010). The text included an agreement that the guidelines should complement appropriate bycatch measures addressed in the IPOA-Seabirds and its Best Practice Technical Guidelines (FAO 2009). The Guidelines were subsequently adopted by FAO in January 2011.

The most important factor influencing contacts between seabirds and trawl warp cables is the discharge of offal (Wienecke and Robertson 2002; Sullivan *et al.* 2006, ACAP 2011). Offal management methods used to reduce the attraction of seabirds to vessels include mealing, mincing, and batching. ACAP recommends (ACAP 2011) full retention of all waste material where practicable because this significantly reduced the number of seabirds feeding behind vessels compared with the discharge of unprocessed fish waste (Abraham 2009; Wienecke and Robertson 2002; Favero *et al.* 2010) or minced waste (Melvin *et al.* 2010). Offal management has been found to be a key driver of seabird bycatch in New Zealand trawl fisheries (Abraham 2007; Abraham and Thompson 2009b; Abraham *et al.* 2009; Abraham 2010; Pierre et al 2010, 2012 a&b). Other best practice recommendations (ACAP 2011) are the use of bird-scaring lines to deter birds from foraging near the trawl warps, use of snatch blocks to reduce the aerial extent of trawl warps, cleaning fish and benthic material from nets before shooting, minimising the time the trawl net is on the surface during hauling, and binding of large meshes in pelagic trawl before shooting.

Table 5.8 (after MPI 2012, consultation documents for a revised NPOA-seabirds): summary of current mitigation measures applied to New Zealand vessels fishing in New Zealand waters to avoid incidental seabird captures. R, regulated; SM, required via a self-managed regime (non-regulatory, but required by industry organisation and audited independently by Government); V, voluntary with at least some use known; N/A, measure not relevant to the fishery; years in parentheses indicate year of implementation; *, part of a vessel management plan (VMP). Note, this table may not capture all voluntary measures adopted by fishers.

Mitigation Measure	**Surface longline**	**Bottom longline**	**Trawl >=28 m**	**Trawl <28 m**	**Set net**	**Notes**
Netsonde cable prohibition	N/A	N/A	R (1992)	R (1992)	N/A	Netsonde cables also called third wires
Streamer (tori) lines	R	R	N/A	N/A	N/A	
Additional streamer line	–	–	N/A	N/A	N/A	
Night setting	R (or line weighting)	R (or line weighting)	–	–	–	Longlines must use night setting if not line weighting, or *vice-versa*
Line weighting	R (or night setting)	R (or night setting)	N/A	N/A	N/A	
Seabird scaring device	N/A	N/A	R (2006)	R?	N/A	To prevent warp captures and collisions
Additional bird scaring device	N/A	N/A	SM (2008)*	–	N/A	
Dyed bait	V	–	N/A	N/A	N/A	
Offal management	V	R	SM (2008)*	–	–	
VMPs			SM (2008)	V	–	Some VMPs developed for vessels < 28m
Code of Practice	V	–	VMP	–	–	

Note: A vessel management plan (VMP) is a vessel-specific seabird risk management plan which specifies seabird mitigation devices to be used, operational management requirements to minimise the attraction of seabirds to vessels, and incident response requirements and other techniques or processes in place to minimise risk to seabirds from fishing operations.

In New Zealand, the three legally permitted devices used for mitigation by trawlers are tori lines (e.g., Sullivan *et al.* 2006), bird bafflers (Crysel 2002), and warp scarers (Carey 2005). Middleton and Abraham (2007) reported experimental trials of mitigation devices designed to reduce the frequency of collisions between seabirds and trawl warps on 18 observed vessels in squid trawl fishery in 2006. The frequencies of birds striking either warps or one of three mitigation devices (tori lines, 4-boom bird bafflers, and warp scarers) were assessed using standardised protocols during commercial fishing. Different warp strike mitigation treatments were used on different tows according to a randomised experimental design. Middleton and Abraham (2007) confirmed that the discharge of offal was the main factor influencing seabird strikes; almost no strikes were recorded when there was no discharge, and strike rates were low when only sump water was discharged (see also Abraham *et al.* 2009). In addition to this effect, tori lines were shown to be most effective mitigation approach and reduced warp strikes by 80–95% of their frequency without mitigation. Other mitigation approaches were only 10–65% effective. Seabirds struck tori lines about as frequently as they did the trawl warps in the absence of mitigation but the consequences are unknown.

Recommended best practice for surface (pelagic) longline fisheries and bottom (demersal) longlines (ACAP 2011) includes weighting of lines to ensure rapid sinking of baits (including integrated weighted line for bottom longlines), setting lines at night when most vulnerable birds are less active, and the proper deployment of bird scaring lines (tori lines) over baits being set, and offal management (especially for bottom longlines). A range of other measures are offered for consideration.

5.4.3. Modelling fisheries interactions and estimating risk

5.4.3.1. Hierarchical structure of risk assessments

Hobday et al (2007) described a hierarchical framework for ecological risk assessment in fisheries (see Figure 5.11). The hierarchy included three levels: Level 1 qualitative, expert-based assessments (often based on a Scale, Intensity, Consequence Analysis, SICA); Level 2 semi-quantitative analysis (often using some variant of Productivity Susceptibility Analysis, PSA); and Level 3 fully quantitative modelling including uncertainty analysis. The hierarchical structure is designed to “screen out” potential effects that pose little or low risk for the least investment in data collection and analysis, escalating to risk treatment or higher levels in the hierarchy only for those potential effects that pose non-negligible risk. This structure relies for its effectiveness on a low potential for false negatives at each stage, thereby identifying and screening out activities that are ‘low risk’ with high certainty. This focuses effort on remaining higher risk activities. In statistical terms, risk assessment tolerates Type I errors (false positives, i.e. not screening out activities that may actually present a low risk) in order to avoid Type II errors (false negatives, i.e. incorrectly screening out activities that actually constitute high risk), and it is important to distinguish this approach from normal estimation methods. Whereas normal estimation strives for a lack of bias and a balance of Type I and Type II errors, risk assessment is designed to answer the question “how bad could it be?” The divergence between the risk assessment approach and normal, unbiased estimation approaches should diminish at higher levels in the risk assessment hierarchy, where the assessment process should be informed by good data that support robust estimation.

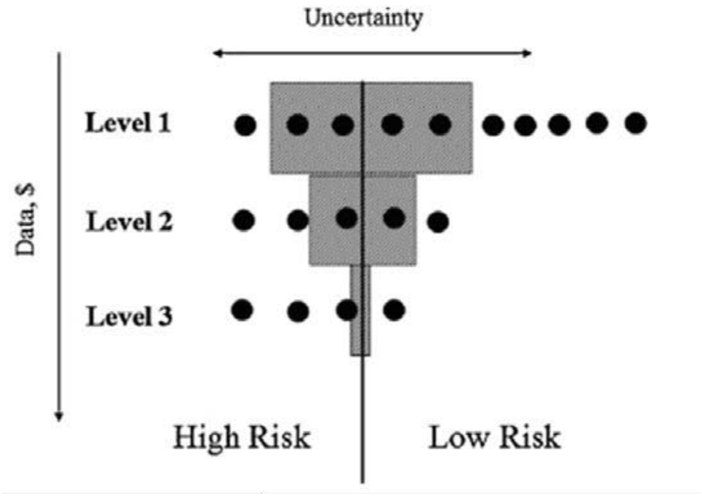

Figure 5.11 (from Hobday *et al.*): Diagrammatic representation of the hierarchical risk assessment process where activities that present low risk are progressively screened out by assessments of increasingly high data content, sophistication, and cost.

5.4.3.2. Qualitative (Level 1) risk assessment

Rowe (2010) summarised an expert-based, qualitative (Level 1) risk assessment, commissioned by DOC, for the incidental mortality of seabirds caused by New Zealand fisheries. The main focus was on fisheries operating within the NZ EEZ and on all seabirds absolutely or partially protected under the Wildlife Act 1953. New Zealand flagged vessels fishing outside the EEZ were included, but risk from non-NZ fisheries and other human causes were not included.

The panel of experts who conducted the Level 1 risk assessment assessed the threat to each of 101 taxa posed by 26 fishery groups, scoring exposure and consequence independently according to the schemas in Tables 5.9 and 5.10 (details in Rowe 2010b). The risk for a given taxon posed by a given fishery was calculated as the product of exposure and consequence scores. Potential risk was estimated as the risk posed by a fishery assuming no mitigation was in place, and residual risk (called “optimum risk” by Rowe 2010b) was estimated assuming that mitigation was in place throughout a given fishery and deployed correctly. The panel also agreed a confidence score for each taxon-fishery interaction using the schema in Table 5.11.

Table 5.9: Exposure scores used by Rowe (2010) (modified from Fletcher 2005, Hobday et al 2007)

Score	**Descriptor**	**Description**
0	Remote	The species will not interact directly with the fishery
1	Rare	Interactions may occur in exceptional circumstances
2	Unlikely	Evidence to suggest interactions possible
3	Possible	Evidence to suggest interactions occur, but are uncommon
4	Occasional	Interactions likely to occur on occasion
5	Likely	Interactions are expected to occur

Table 5.10: Consequence scores used by Rowe (2010) (modified from Fletcher 2005, Campbell & Gallagher 2007, Hobday *et al.* 2007)

Score	**Descriptor**	**Description**
1	Negligible	Some or one individual/s impacted, no population impact.
2	Minor	Some individuals are impacted, but minimal impact on population structure or dynamics. In the absence of further impact, rapid recovery would occur
3	Moderate	The level of interaction / impact is at the maximum acceptable level that still meets an objective. In the absence of further impact, recovery is expected in years
4	Major	Wider and longer term impacts; loss of individuals; potential loss of genetic diversity. Level of impact is above the maximum acceptable level. In the absence of further impact, recovery is expected in multiple years
5	Severe	Very serious impacts occurring, loss of seabird populations causing local extinction; decline in species with single breeding population, measurable loss of genetic diversity. In the absence of further impact, recovery is expected in years to decades
6	Intolerable	Widespread and permanent / irreversible damage or loss occurring; local extinction of multiple seabird populations; serious decline of a species with a single breeding population, significant loss of genetic diversity. Even in the absence of further impact, long-term recovery period to acceptable levels will be greater than decades or may never occur

Table 5.11: Confidence scores used by Rowe (2010) (after Hobday 2007)

Score	**Descriptor**	**Rationale for confidence score**
1a	Low	Data exists, but is considered poor or conflicting.
1b		No data exists.
1c		Agreement between experts, but with low confidence
1d		Disagreement between experts
2a	High	Data exists and is considered sound.
2b		Consensus between experts
2c		High confidence exposure to impact can not occur (e.g. no spatial overlap of fishing activity and at-sea seabird distribution)

Total potential and residual risk for a seabird taxon was estimated by summing the scores across all fisheries (Table 5.12 shows taxa with an aggregate score of 30 or higher), and total potential and residual risk posed by a fishery group was estimated by summing the scores across all seabird taxa (Table 5.13 shows the results for all 26 fishery groups).

White-chinned petrel, Sooty shearwater, Black (Parkinson's) petrel, Salvin's albatross, White-capped albatross, and Flesh-footed shearwater were all estimated by this procedure to have an aggregate risk score of 90 or higher (range 92 to 123) even if mitigation was in place and deployed properly across all fisheries. Of the 101 seabird taxa considered, the aggregate risk score was less than 30 for 70 taxa with respect to potential risk and for 72 taxa with respect to residual risk.

Table 5.12: Potential and residual risk scores for each seabird taxon with a potential risk score of >=30 in Rowe (2010). Residual risk ("optimal risk" in Rowe 2010b, not tabulated therein for grey-faced petrel or light-mantled albatross) is estimated assuming mitigation is deployed and correctly used throughout all interacting fisheries.

Taxon	Potential score	Residual score	Percent reduction
White-chinned petrel	159	123	23
Sooty shearwater	126	108	14
Black (Parkinson's) petrel	139	106	24
Salvin's albatross	161	106	34
White-capped albatross	141	94	33
Flesh-footed shearwater	117	92	21
Southern Buller's albatross	123	85	31
Grey petrel	123	84	32
Black-browed albatross	114	80	30
Northern Buller's albatross	107	72	33
Chatham albatross	114	71	38
Campbell albatross	97	66	32
Westland petrel	89	59	34
Antipodean albatross	89	55	38
Gibson's albatross	89	55	38
Wandering albatross	89	55	38
Southern royal albatross	79	49	38
King shag	48	48	0
Pitt Island shag	46	46	0
Chatham Island shag	45	45	0
Hutton's shearwater	37	35	5
Northern giant petrel	62	35	44
Pied shag	35	35	0
Indian yellow-nosed albatross	58	34	41
Southern giant petrel	61	34	44
Fluttering shearwater	34	32	6
Spotted shag	31	31	0
Stewart Island shag	31	31	0
Yellow-eyed penguin	30	30	0
Grey-faced petrel	31	–	–
Light-mantled albatross	30	–	–

Setnet and inshore trawl fisheries groups posed the greatest residual risk to seabirds (summed across all taxa); both had aggregate scores of over 200 and had no substantive mitigation. Surface and bottom longline fisheries and middle-depth trawl fisheries for finfish and squid also had aggregate risk scores of 100 or more. These risk scores were substantially reduced if mitigation was assumed to be deployed throughout these fisheries (reductions of 24 to 56%), but all remained above 100. Trawling for southern blue whiting and deep-water species, inshore drift net, various seine methods, ring net, diving, dredging, and hand gathering all had aggregate risk scores of 40 or less if mitigation was assumed to be deployed throughout these fisheries. Diving, dredging, and hand gathering were all judged by the panel to pose essentially no risk to seabirds.

Table 5.13: Cumulative potential risk and residual risk scores across all seabird taxa for each fishery from Rowe (2010). Residual risk ("optimal risk" in Rowe 2010b) is estimated assuming mitigation is deployed and correctly used throughout a given fishery.

Fishery group	No. taxa	Potential risk	Residual risk	Percent reduction
Setnet	42	374	374	0
Inshore trawl	44	225	225	0
Surface longline: charter	25	313	191	39
Surface longline: domestic	25	302	184	39
Bottom longline: small	33	354	154	56
Bottom longline: large	32	311	139	55
Mid-depth trawl: finfish	22	160	122	24
Mid-depth trawl: squid	21	156	118	24
Mid-depth trawl: scampi	23	94	94	0
Hand line	27	68	68	0
Squid jig	44	62	62	0
Dahn line	29	61	61	0
Pots, traps	17	61	61	0
Trot line	29	61	61	0
Pelagic trawl	27	63	51	19
Troll	23	50	50	0
Mid-depth trawl: southern blue whiting	21	53	40	25
Deep water trawl	21	46	35	24
Inshore drift net	12	33	33	0
Danish seine	15	32	32	0
Beach seine	16	29	29	0
Purse seine	11	22	22	0
Ring net	12	13	13	0
Diving	0	0	0	–
Dredge	0	0	0	–
Hand gather	0	0	0	–

5.4.3.3. Semi-quantitative (Level 2) risk assessment

The level 2 method developed by MPI arose initially from an expert workshop hosted by the Ministry of Fisheries in 2008 and attended by experts with specialist knowledge of New Zealand fisheries, seabird-fishery interactions, seabird biology, population modelling, and ecological risk assessment. The overall framework is described in Sharp *et al.* (2011) and has been variously applied and improved in multiple iterations (Waugh *et al.* 2008, developed further by Sharp 2009, Waugh and Filippi 2009, Filippi *et al.* 2010, Richard *et al.* 2011). The method applies the "exposure-effects" approach where exposure refers to the number of fatalities arising from an activity and effect refers to the consequence of that exposure for the population. The relative encounter rate of each seabird taxon with each fishery group is estimated as a function of the spatial overlap between seabird distributions (e.g., Figure 5.12) and fishing effort distributions (e.g., see Figures 5.4–5.6), and compares these estimates with observed captures from fisheries observer data to estimate vulnerability by taxon (capture rates per encounter) to each fishery group, yielding estimates of total observable captures and population-level potential fatalities from all New Zealand commercial fisheries. Impact estimates are subsequently compared with population estimates and biological characteristics to yield estimates of population-level risk.

The current level 2 risk assessment (i.e., as described by Richard *et al.* 2011) estimated the risk posed to each of 64 seabird taxa by trawl and longline fisheries within New Zealand's TS and EEZ. Insufficient information was available to include some other fisheries thought to pose substantial risk to seabirds, especially setnet. For each taxon, the risk was assessed by dividing the estimated number of potential fatalities by an estimate of Potential Biological Removals (PBR, after Wade 1998). This index represents the amount of human-induced mortality a population can sustain without compromising its ability to achieve and maintain a population size above its maximum net productivity (MNPL) or to achieve rapid recovery from a depleted state. In the risk assessment, PBR was estimated from the best available information on the demography of each taxon (Figure 5.13). Because estimates of seabirds' demographic parameters and of fisheries related mortality are imprecise, the uncertainty around the demographic and mortality estimates was propagated through the analysis. This allowed uncertainty in the resulting risk to be calculated, and also allowed the identification of parameters where improved precision would reduce overly large uncertainties. However, not all sources of uncertainty could be included, and the results are best used as a guide in the setting of research and management priorities. In general, seabird demographics, the distribution of seabirds within New Zealand waters, and sources of cryptic mortality were poorly known.

Amongst the 64 studied taxa, black (Parkinson's) petrel (*Procellaria parkinsoni*) clearly stood out as at most risk from commercial fishing activities within the New Zealand Exclusive Economic Zone (estimated annual potential fishing-related fatalities almost 10 times higher than the PBR, Figures 5.14 and 5.15). Seven other taxa had estimated annual potential fatalities with 95% confidence intervals of their risk ratios completely above one. These were grey-headed albatross, Chatham albatross, Westland petrel, light-mantled albatross, Salvin's albatross, fleshfooted shearwater, and Stewart Island shag. For a further 12 taxa, the confidence interval of the risk ratio included one.

Small inshore fisheries, especially trawl fisheries targeting flatfish, and small bottom and surface fisheries, were associated with the highest estimated risk to seabirds. This was due to a combination of low observer coverage, high effort, and overlap with the distributions of many seabirds. In fisheries where there were few observations, the number of potential fatalities was estimated in a precautionary way, with the estimates being biased toward the high end of the range of values that were consistent with the observer data. In these poorly observed fisheries, the risk estimates are often primarily associated with the lack of information. Of the taxa that had a risk ratio greater than one, the risk for four of them (grey-headed albatross, Westland petrel, Chatham albatross, and light-mantled albatross) was associated with low observer coverage in inshore fisheries that overlap with the distribution of these birds. Increasing the number of observations in inshore trawl and small vessel longline fisheries, especially in FMAs 1, 2, 3, and 7, would increase the precision of the estimated fatalities. The risk was estimated independently for each fishery, and it was assumed that the vulnerabilities of seabirds to capture in different fisheries were independent. This has the consequence that birds (such as light-mantled sooty albatross) may be caught infrequently in well observed fisheries, but still have high risk associated with poorly observed fisheries.