Distribution and abundance of deepwater sharks in New Zealand waters, 2000–01 to 2005–06

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EXECUTIVE SUMMARY

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Seven species of squaloid deepwater sharks, shovelnose dogfish (*Deania calcea*), Baxter's dogfish (*Etmopterus baxteri*), lucifer dogfish (*Etmopterus lucifer*), Owston's dogfish (*Centroscymnus owstoni*), longnose velvet dogfish (*Centroselachus crepidater)*, leafscale gulper shark (*Centrophorus squamosus*), and seal shark (*Dalatias licha*) commonly occur over the middle and lower New Zealand continental slope, in depths greater than 600 m. Shovelnose dogfish has a wider distribution, as it also occurs on the upper and middle slope (400–600 m in depth). Baxter's dogfish is restricted to New Zealand and Australia, while the others have a worldwide distribution in temperate waters. These seven shark species are commonly taken as bycatch in the New Zealand middle depths and deepwater fisheries for hoki, orange roughy, and oreos. This report examines trends in relative biomass, size structure, and spatial distribution of these species using data from fishery observers, commercial catches, and the research vessels.

The seven shark species are either discarded at sea, or processed for their fins and livers. Catches have been consistently reported for only two of the species (seal shark and shovelnose dogfish). Catches increase through the early 1990s, peak in the early 2000s, and then decline, but these trends may be affected by improved identification and reporting of deepwater shark catches. More accurate data are available from the Observer Programme (OP), but coverage of the distribution of deepwater sharks has been poor. Analysis was confined to the Chatham Rise where observer coverage has remained relatively constant. Little change occurred in bycatch in the main target fisheries (hoki, orange roughy, and oreo) between 2001—02 and 2006.

Available abundance indices for six of the deepwater shark species showed little change, or an increase in relative abundance on the northeast Chatham Rise between 1986 and 2002. The relative abundance indices for Baxter's dogfish were more variable, where indices declined on the northeast Chatham Rise between 1986 and 2002. Only the Chatham Rise middle depths (600–800 m) trawl survey series has continued through to recent years, though a summer survey series has resumed on the Sub-Antarctic shelf. These survey series cover only a small part of the known distribution of these species, and it is not known how representative the results are.

Few length and weight data have been collected from trawl surveys in the period examined. Scaled length frequencies are too variable to monitor trends in recruitment for shovelnose dogfish, Baxter's dogfish, and longnose velvet dogfish, although these data are generally consistent with known patterns of sex-related and size-related migration. Insufficient data are available for other species and areas to determine trends.

These deepwater sharks represent a widely distributed, but poorly known, fishery resource and are potentially vulnerable to over-fishing due to their low productivity, slow growth rates, and low fecundity. Continued monitoring of deepwater shark stocks is recommended. While these species are difficult for commercial fishers to identify, increased use of an identification guide for deepwater shark species should improve data accuracy. The usefulness of the OP database could be significantly improved by a reduction in the amount of landings reported to generic species codes.

1. BACKGROUND

Deepwater squaloid sharks occur widely over the New Zealand continental slope. They represent a potentially important, but poorly known, fisheries resource (Francis 1998) that appears to be relatively lightly exploited (Blackwell & Stevenson 2003). Wetherbee (2000) listed 16 shark species from the Chatham Rise (Figure 1), but the most common species in commercial catch and trawl survey data are shovelnose dogfish (*Deania calcea,* SND); Baxter's dogfish (*Etmopterus baxteri,* ETB); lucifer dogfish (*Etmopterus lucifer*, ETL); Owston's dogfish (*Centroscymnus owstoni,* CYO); longnose velvet dogfish (*Centroselachus crepidater,* CYP); leafscale gulper shark (*Centrophorus squamosus*, CSQ); and seal shark (*Dalatias licha,* BSH).

Figure 1: Map of New Zealand fisheries waters showing main locations mentioned in the text. Base map and bathymetry from NABIS (MFish).

Six of these species have a worldwide distribution, but Baxter's dogfish is restricted to Australia and New Zealand. All, other than shovelnose dogfish, occur over the continental shelf and slope of the New Zealand Exclusive Economic Zone, in depths of 600–1300 m, while shovelnose dogfish also occurs in shallower waters of the upper slope in depths of 400–600 m (Anderson et al. 1998). Detailed distribution maps are available for shovelnose dogfish and for seal shark on the NABIS website administered by MFish (http://ww2.nabis.govt.nz), but insufficient information is currently available to provide maps for the remaining deepwater shark species.

Relatively little is known about their life history, abundance, and productivity, and concerns have been raised about the ability of deepwater sharks to sustain anything other than low levels of fishing mortality (Daley et al. 2002, Kyne & Simpfendorfer 2007). Recent deepwater shark catches in the Australian South East Shark Fishery are considered unlikely to be sustainable, due to low productivity, slow growth rates, and low fecundity (Graham et al. 2001).

Deepwater sharks are target fished in South Australian waters by line fishing and trawling (Daley et al. 2002). In New Zealand waters, little, if any, target fishing occurs for these species (Blackwell & Stevenson 2003), and they are mainly taken as trawl bycatch in the orange roughy (*Hoplostethus atlanticus*), hoki (*Macruronus novaezelandiae*), and oreo (*Allocyttus niger*, *Neocyttus rhomboidalis*, *Pseudocyttus maculatus*) fisheries (Clark et al. 2000a, 2000b). They are a minor bycatch in the ling (*Genypterus blacodes*) line fishery (Hurst et al. 2000, Anderson et al. 2001a, Blackwell & Stevenson 2003).

Reported Licensed Fish Receiver Return (LFRR) landings gradually increased from about 500 t per year during the early 1980s (Francis 1998), to peak around 1200 t in the late 1990s (Blackwell & Stevenson 2003). Annual catches, to 2005–06, have declined slightly, to vary around 800 t. As little demand exists for fillet products (Francis 1998), most catch is either dumped or part-processed at sea for fins (King & Clark 1987), oil (Summers & Wong 1992), and other industrial by-products such as squalene (Summers 1987). Catch and landings data from the commercial fishery appear to be inaccurate, largely due to species misidentification, and the continued use of available generic codes such as deepwater dogfish (DWD). More accurate species identification is available from the Observer Programme (OP) database. This is limited in coverage to the major target fisheries, and available data may not be representative of the wider distribution of these species.

The Ministry of Fisheries (MFish) is responsible for managing the impact of target fisheries on interdependent species such as deepwater sharks. Previous research includes reviews of distribution and relative abundance for these species (Francis et al. 2002, Blackwell & Stevenson 2003), a review of the effect of fishing on seamounts (Tracey et al. 2004), and the sea bottom (Jones 1992, Tracey et al. 2004), and analysis of trends in discards from deepwater trawl fisheries (Anderson et al. 2001b). The effect of reduction in biomass of major deepwater target fisheries on associated species has been reviewed for the Challenger Plateau orange roughy fisheries (Clark & Tracey 1994), and for the orange roughy, hoki, and oreo trawl fisheries on the Chatham Rise (Wetherbee 2000, Clark et al. 2000a, Livingston et al. 2003).

This report updates the previous report (Blackwell & Stevenson 2003) to the 2005–06 fishing year. It summarises data from the OP database, the commercial fishery, and research databases to review trends in relative abundance of seven deepwater sharks throughout the EEZ and across all depth ranges. It reviews distribution and catch composition data to provide information on possible stock range, and segregation by size and sex (Yano & Tanaka 1987, Clark & King 1989, Wetherbee 1996). It also updates previous estimates of commercial landings (Francis 1998, Blackwell & Stevenson 2003), and updates and extends the reviews of trends in relative abundance for these species from the Chatham Rise (Clark et al. 2000a, Blackwell & Stevenson 2003, Livingston et al. 2003).

1.1 Objectives

This report was prepared under MFish project DEE2006/03 “To assess the productivity and relative abundance of deepwater sharks” and addresses Objective 1:

1. To monitor the abundance of deepwater sharks taken by commercial trawl fisheries.

This objective has one key activity.

1. To monitor trends and characterise the catch of deepwater sharks in the deepwater and middle depth trawl fisheries.

2. METHODS

2.1 Review of previous research

The previous report (Blackwell & Stevenson 2003) examined published information on the six main deepwater sharks in New Zealand, shovelnose dogfish, Baxter's dogfish, Owston's dogfish, longnose velvet dogfish, leafscale gulper shark, and seal shark. In this report, a seventh common deepwater shark, lucifer dogfish (*Etmopterus lucifer*, ETL), has been included.

2.2 Review of data from the commercial fishery

Deepwater sharks are mainly taken as bycatch of deepwater trawl fishing (Francis 1998). The very small bycatch from line fisheries (Anderson et al. 2001a) is not included in this report. Reported trawl fishery data were extracted from the MFish LFRR database, and the previous data series for deepwater shark catches (1986–87 to 2000–01) reported by Blackwell & Stevenson (2003) were updated to 2005–06.

In this report, total reported greenweight catch refers to catches, including estimated discards, and part-processed totals of fins and shark livers, determined using conversion factors. Reported landings refers to the calculated greenweight of landed products, excluding sharks discarded at sea. LFRR data refers to greenweight landings of deepwater sharks, reported on the LFRR database. This is mostly scaled to greenweight equivalents from landed processed shark totals using conversion factors.

Total catches (including discards) and landings were also extracted from the CELR (Catch Effort Landing Return), CLR (Catch Landing Returns), and TCEPR (Trawl, Catch, Effort and Processing Return) databases. The daily processing data record estimated catches (scaled to greenweight), including discards, but do not provide target species information. To review catches by target species, estimated catch data were also extracted from the MFish TCEPR and CELR databases. Deepwater sharks were not generally among the top five species recorded from each tow, and estimated catches were recorded only on a trip basis. These data may not include discarded catch, and are likely to seriously underestimate actual catches and landings.

Additional data are also reported by the OP on deepwater shark bycatch. These data are more likely to accurately identify and report sharks by species than data from the commercial fishery (Blackwell & Stevenson 2003). Data were extracted to identify the target fisheries, geographical areas, and depth ranges from which deepwater sharks are commonly caught.

2.3 Review of trawl survey data

Deepwater sharks are commonly recorded in low numbers from middle depth and deepwater trawl surveys in the New Zealand EEZ. As numbers are low, they are rarely included in the top 20 species for which abundance data are published. The distribution of these shark species was described by Anderson et al. (1998), Hurst et al. (2000), O'Driscoll et al. (2003c), and summarised and updated to 2010 on the NABIS database administered by MFish. However, trawl survey series are biased towards areas that have been surveyed frequently, and as such, are unlikely to fully describe the entire range of distribution of minor bycatch species such as these deepwater sharks.

Data for relative biomass estimation were restricted to time series of random trawl surveys where at least three years of data were available, and where the series was consistent in survey design, stratification, vessel, and sampling gear (D. Gilbert, NIWA, pers. comm. 2002). Biomass data recorded from earlier transect based surveys, such as the 1985–86 FV *Wanaka* survey series of Clark & King (1989), were considered unsuitable for biomass estimation (M. Francis, NIWA, pers. comm., 2003). Since the early 1980s, most deepwater trawl surveys have used acoustic survey techniques, which are targeted on fish marks rather than from random trawl stations. These data continue to provide length frequency and distribution data, but the non-random nature of their associated trawls generally precluded their use in relative biomass estimation.

Because trawl survey series have been designed to optimally sample their target species, they may not necessarily provide a reasonable sample design for other species. Trawl survey series were not included in this review where a significant proportion of the shark biomass estimates was less than 100 t, or where the coefficient of variation (c.v.) of the estimates was greater than 40%. Such surveys were also considered to poorly sample deepwater sharks (M. Francis, pers. comm., 2002).

The trawl survey series considered suitable for estimation of relative biomass and changes in length frequency distribution are given in Table 1. Where appropriate, relative biomass estimates were derived using the *TrawlSurvey Analysis* program (Vignaux 1994) where data had not previously been analysed, and linear regression was used to identify any temporal trends in relative abundance. Statistical significance was assessed using a standard t-test of the regression slope. These methods were used by Clark et al. (2000a) for the northeast Chatham Rise orange roughy surveys and by Livingston et al (2003) for the south Chatham Rise oreo surveys. A number of other surveys provided distribution data only during the review period (see Appendix 2). These data are summarised in the distribution plots provided by species on the NABIS website (see above).

Previous research on shovelnose dogfish (Clark & King 1989), Baxter's dogfish (Wetherbee 1996), and Owston's dogfish (Yano & Tanaka 1987) indicates these species may be segregated by size and sex. To investigate trends in size and sex composition with depth and region, scaled length-frequency distributions were derived for surveys in which at least 100 fish were measured. Individual fish weight data, or a known length-weight relationship, are necessary to scale the raw length frequencies to the catch. Where weight data were not available, but at least 100 fish were measured, raw (unscaled) length frequency data were plotted. Unscaled length frequency data may represent a biased estimate of the population length frequency distribution, and should be interpreted with caution.

Table 1: Trawl surveys (to 2006) that provided relative abundance and length frequency data, by species. SND, shovelnose dogfish; ETB, Baxter's dogfish; CYP, longnose velvet dogfish; CSQ, leafscale gulper shark.

Survey	Depth	Species	Date	Suitability
Chatham Rise	600–800	SND	1991–2006	Abundance
		SND	1998–2006	Length frequency
		ETB	1996–2006	Abundance
		ETB	2002–2006	Length frequency
		CYP	2004–2006	Abundance
		CYP	2002–2006	Length frequency
Southland, Sub-Antarctic	750–1000	SND	2000–2005	Abundance/length frequency
		ETB	2000–2005	Abundance
		ETB	2000–2005	Length frequency
		CYP	2002–2005	Abundance
		CYP	2002–2005	Length frequency
		CSQ	2002–2005	Abundance
Northwest Chatham Rise	750–1500	SND	2004–2005	Length frequency
		ETB	2004–2005	Length frequency
		CYP	2004–2005	Length frequency

3. RESULTS

3.1 Previous research

A major target deepwater shark fishery occurs in southern Australian waters, and two main major groupings of deepwater sharks have been identified: upper slope (200–650 m) and mid-slope (650–1200 m) (Daley et al. 1998). Between the 1970s and 1990s, large declines in catch rates of many upper slope deepwater shark species were observed off the New South Wales shelf (Graham et al. 2001) and in South Australia (Stevens et al. 2000, Daley et al. 2002). Large declines in relative biomass have not been observed for deepwater shark species in New Zealand waters, with the exception of Baxter's dogfish in depths of 750–1500 m on the northeast Chatham Rise (Wetherbee 2000, Clark et al. 2000a, Livingston et al. 2003, Blackwell & Stevenson 2003). Insufficient or inaccurate data precluded biomass estimation for other species and other areas where trawl surveys have been carried out.

Wetherbee (2000) reviewed deepwater shark distribution and species composition on the northwest and northeast Chatham Rise (Figure 1), and found overall densities declined with depth between 700 and 1200 m. Species composition varied with depth. Shovelnose dogfish and leafscale gulper shark dominated catches between 700 and 800 m, while shovelnose dogfish and longnose velvet dogfish were dominant between 800 and 1000 m. Baxter's dogfish mainly occurred in depths greater than 1000 m. Densities of all deepwater sharks were low in depths greater than 1000 m (Anderson et al. 1998).

3.1.1 Shovelnose dogfish (SND)

This medium (to 122 cm T.L (total length)) sized dogfish varies from light grey to brown, the snout is elongate, the first dorsal fin is long and low, and both dorsal fins have prominent spines (Last & Stevens 1994, Tracey & Shearer 2002). It is widely distributed in temperate waters between 70° N and 45° S, in the Eastern Atlantic (from Iceland to South Africa); the Eastern Pacific (Chile), and the Western Pacific (Japan, Australia, and New Zealand). It occurs over the continental slope in depths of 70–1450 m (Last & Stevens 1994, Anderson et al. 1998, Blackwell & Stevenson 2003). Shovelnose dogfish is believed to form a single stock off the North Island, but is strongly segregated by size, sex, and reproductive state among depth strata and areas (Clark & King 1989), possibly as a result of sex-related and maturity-related migratory behaviour. Similar behaviour has been reported for *Deania* and *Centrophorus* spp. from Japanese waters (Yano & Tanaka 1984). The biology and distribution were summarised by Blackwell & Stevenson (2003).

3.1.2 Baxter's dogfish (ETB)

This small (to 80 cm T.L.) deepwater dogfish is also known as the southern, or New Zealand, lantern shark (Last & Stevens 1994). Coloration is uniformly brown-black, with a short caudal peduncle and prominent dorsal spines. The skin contains photophores (Last & Stevens 1994, Tracey & Shearer 2002). Although initially synonymised with *Etmopterus granulosus,* it is now considered valid (Tachikawa et al. 1989, L. Compagno, South African Museum, pers. comm., 2002). It occurs in New Zealand, and probably also in Australia. In New Zealand, it is common off the east coast North Island, the west coast South Island, the Chatham Rise, and the Southland, Sub-Antarctic, and Campbell Plateaus, over the shelf and lower slope between 600 and 1400 m. It is relatively uncommon in northern New Zealand (Clark & King 1989, Anderson et al. 1998, Wetherbee 2000). Francis et al. (2002) found Baxter's dogfish to be most common in deep water (median 1500 m, 90% range 600–1400 m), and mid-latitudes (median 45.9° S, 90% range 37°–53° S), although this species may also undergo size-related and sex-related migratory behaviour (Wetherbee 2000). The biology and distribution were summarised by Blackwell & Stevenson (2003).

3.1.3 Owston's dogfish (CYO)

This medium (70–120 cm T.L.) sized deepwater dogfish is dark-brown to black, with a short snout. The small denticles give the skin a smooth sheen. The second dorsal fin is larger than the first, with small fin spines. It has a prominent belly ridge on the lower side of the body (Last & Stevens 1994, Tracey & Shearer 2002). It is widely distributed in temperate waters between 40° N and 45° S, including the western North Atlantic and the western Pacific, including Japan, Australia, and New Zealand, on the upper continental slope in depths from 500–1400 m (Last & Stevens 1994, Anderson et al. 1998). In New Zealand, it commonly occurs north of the Subtropical Convergence in depths from 600 to 1500 m off the northern and east coasts of the North Island, the north and southeast Chatham Rise, the west coast of the South Island, the Challenger Plateau, and Puysegur Bank (Anderson et al. 1998, O'Driscoll et al. 2003a, 2003b). Francis et al. (2002) found Owston's dogfish occurred in deep water (median 980 m, 90% range 700–1300 m), and mid-latitudes (median 40.0° S, 90% range 35°–48° S). The biology and distribution of Owston's dogfish were summarised by Blackwell & Stevenson (2003).

3.1.4 Longnose velvet dogfish (CYP)

This medium (to 110 cm T.L.) sized slender shark is dark brown to black, superficially similar to Owston's dogfish, but with a longer nose, a much longer first dorsal fin, and short dorsal fin spines with only the tips protruding through the skin. The small skin denticles produce a velvet sheen (Last & Stevens 1994). It is widely distributed on the continental slope in the eastern Atlantic Ocean, from Iceland to South Africa; the Indian Ocean; the western Pacific Ocean, from Australia and New Zealand; and Chile in the eastern Pacific Ocean (Last & Stevens 1994). In New Zealand waters it commonly occurs around the northern and eastern North Island, the Chatham Rise, Puysegur Bank, the west coast South Island including the Hokitika Trench, and the Challenger Plateau, but is rare on the Campbell Plateau (Anderson et al. 1998, O'Driscoll et al. 2003a, 2003b). Longnose velvet dogfish has a similar latitude range to shovelnose dogfish (median 42.7^{o} S, 90% range 36^{o} – 54^{o} S), but inhabits deeper water (median 930 m, 90% range 650–1300 m) (Francis et al. 2002). The biology and distribution were summarised by Blackwell & Stevenson (2003).

3.1.5 Leafscale gulper shark (CSQ)

This large (to 150 cm T.L.) deepwater shark is light grey-brown to dark grey, with a short, blunt snout. Dorsal spines are prominent, and the caudal peduncle has a pronounced ventral lobe (Last & Stevens 1994, Tracey & Shearer 2002). It occurs widely in temperate waters from Iceland to South Africa in the eastern Atlantic Ocean; from South Africa to Aldabra in the Indian Ocean; and from Japan, the Philippines, Australia, and New Zealand in the western Pacific Ocean (Last & Stevens 1994, Anderson et al. 1998). It is found on the continental slope in 230–2400 m, but also occurs in the upper 1250 m of deep oceanic waters (Last & Stevens 1994). In New Zealand, it ranges from the Three Kings Islands to the Campbell Plateau (Anderson et al, 1998). Francis et al. (2002) found leafscale gulper shark occupies medium depths (median 820 m, 90% range 550 –1390 m), and latitudes (median 46.2^{o} S., 90% range 35^{o}–53^{o}S). Diet consists of fish (76%) and squid (24%) (King & Clark 1987). Leafscale gulper shark may undergo depth segregation in relation to sex and maturity stage in northern hemisphere waters (Clarke et al. 2001), although insufficient data are available to determine trends in New Zealand. The biology and distribution were summarised by Blackwell & Stevenson (2003).

3.1.6 Seal shark (BSH)

This large (to 182 cm T.L.) deepwater dogfish is dark chocolate brown to black, with an abrasive skin (Last & Stevens 1994, Tracey & Shearer 2002). It occurs widely on the continental shelf and slope from Iceland to South Africa in the eastern Atlantic, off Japan in the western Pacific, and from south Australia and New Zealand to Chile in the South Pacific. It occurs in a wide depth range, from 400 to 1450 m (Last & Stevens 1994, Anderson et al. 1998). Seal shark occurs throughout most of the New Zealand EEZ, most commonly on the east coast North Island, Challenger Plateau, Puysegur Bank, west coast South Island, and the Chatham Rise (King & Clark 1987, Anderson et al. 1998). Francis et al. (2002) found seal shark occurred over a wide depth range (median 720 m, 90% range 400–1050 m). It also occurred over a wide range of latitudes (median 43.1^{o} S., 90% range 35^{o} – 50^{o} S). Seal shark feeds mainly on bony fish, and also on elasmobranches and cephalopods (Last & Stevens 1994). The biology and distribution were summarised by Blackwell & Stevenson (2003).

3.1.7 Lucifer dogfish (ETL)

This small (to 47 cm T.L.) slender deepwater shark is brown to black, with a prominent black streak above and behind the pelvic fins, and has a luminescent belly which may serve to attract prey, or assist in schooling behaviour in deep waters (Compagno 1984, Last & Stevens 1994). It occurs widely in temperate waters from 40° N to 48° S, including the southwest Atlantic, the western Indian Ocean, and the southeastern and western Pacific Ocean. It occurs on the outer continental shelf, and upper continental slope, in depths ranging from 150 to 1250 m. Lucifer dogfish occurs at relatively low densities over most of the New Zealand EEZ, with a similar, but shallower, distribution to that of the related Baxter's dogfish (Anderson et al. 1998). It feeds on squid, small bony fish, and shrimps. Lucifer dogfish is ovoviviparous (Compagno 1984).

3.2 Commercial fishery data

3.2.1 LFRR data

Total landings data for deepwater sharks recorded on the LFRR database (Table 2) initially declined from 637 t (1986–87) to a minimum of 364 t (1991–92), increased to peak at 1257 t (1998–99), then varied about 1000 t until 2000–01. Recent catches have averaged about 800 t. These data update previous estimates provided by Francis (1998), and include few or no landings data for leafscale gulper shark, longnose velvet dogfish, Owston's dogfish, or Baxter's dogfish, although landings of these species are reported on the CELR and TCEPR databases (Blackwell & Stevenson 2003). An unknown amount of deepwater dogfish landings is reported against the generic code "other sharks and dogfish" (OSD), but this could also include inshore and pelagic shark species. The catch attributed to generic codes represents almost 30% of recorded deepwater shark landings annually between 2000–01 and 2005–06. These shortcomings preclude further analysis of the data.

3.2.2 CLR and CELR-landed data

Total reported catches appeared to increase from 293 t in 1989–90 (previous data are unavailable), peaked at 2711 t in 1999–2000, then slowly declined to reach 1899 t in 2005–06 (Figure 2). These data should be viewed with caution, as earlier catches (before 1997–98) may grossly underestimate actual catch. Much of the apparent trend relates to catches of "other sharks and dogfish", which included catches of "deepwater dogfish (unspecified)" as well as "other sharks and dogfish (unspecified)". The latter is likely to include other shark species, as well as pelagic shark species such as blue shark (*Prionace glauca*) and bronze whaler (*Carcharhinus brachyurus*).

Reported catches of the main species do not generally follow these trends. Seal shark and shovelnose dogfish catches slowly increased until 2001–02, and then have remained relatively stable, while reported catches of leafscale gulper shark and Baxter's dogfish remained low between 1989–90 and 2005–06. The seal shark data probably include other black sharks (such as lucifer dogfish), and may overestimate actual catch. The reported catches and landings differ between data sources (CELR/CLR and LFRR databases), and from the estimated TCEPR and CELR catch data (Appendix 1), although the latter may not include discards.

Reported discards increased for all species to 2000–01, but have since remained stable at around 1000 t per year. Discards represented 56% of all reported shark catch, 32% of the seal shark catch, 56% of the shovelnose dogfish catch, and almost 100% of the "deepwater dogfish (unspecified)" catch respectively in 2005–06, consistent with continuing under-estimation of actual catches. Because deepwater sharks are often part-processed at-sea to trunks, fins, and livers, greenweight is determined from the processed catch weight by applying an appropriate conversion factor, the value of which may vary among years.

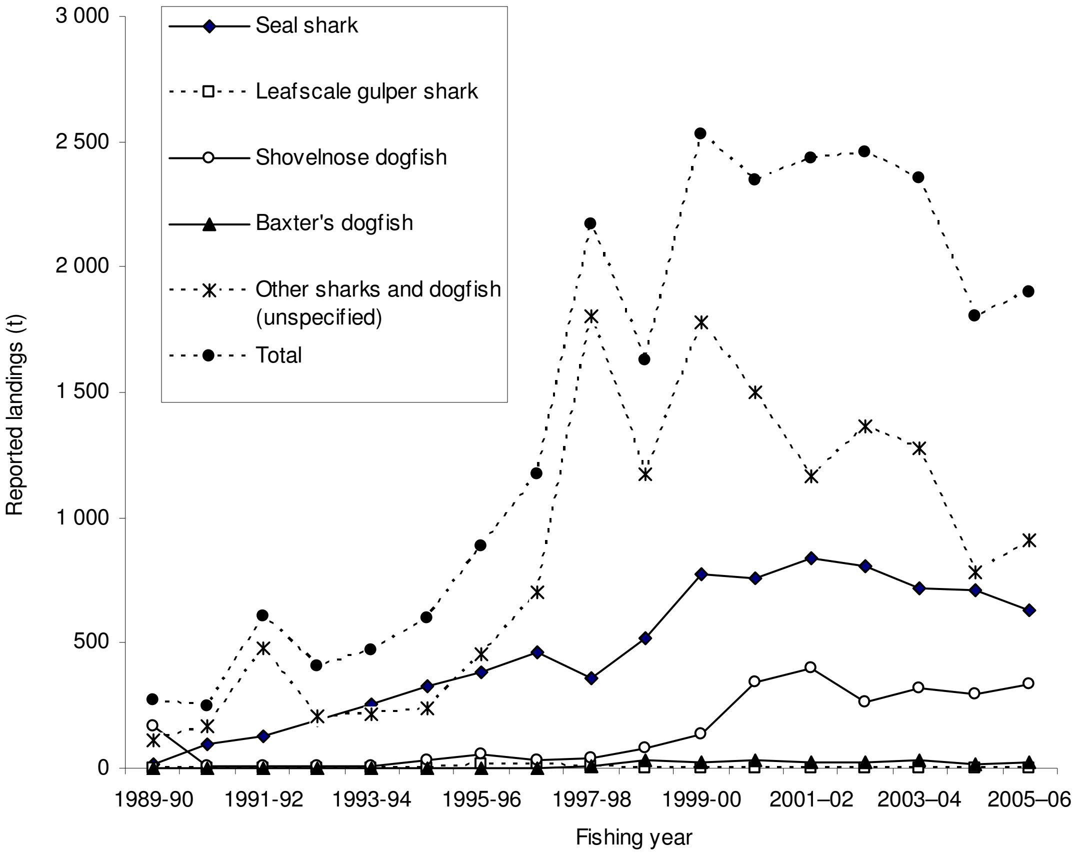


Figure 2: Total catch, including discards of seal shark, leafscale gulper shark, Baxter's dogfish, and shovelnose dogfish reported from the CELR and TCEPR databases, 1989–90 to 2005–06. Landings of other sharks and dogfish (unspecified) include landings coded to deepwater dogfish (DWD), and other sharks and dogfish (OSD). The latter may also include other shallow water and pelagic sharks. No data are reported for longnose velvet dogfish, lucifer dogfish, or Owston's dogfish. Data from MFish extract, January 2007.

Table 2: Landings and discards (t) of seal shark, leafscale gulper shark, shovelnose dogfish, Baxter's dogfish, other sharks and dogfish (unspecified), and deepwater dogfish (unspecified), from the combined CLR and CELR-landed databases, and the LFRR database. L, landed; D, discarded; T, total (excluding minor destination codes). Other sharks and dogfish (unspecified) may also include shallow water and pelagic sharks, and Baxter's dogfish may also include landings of lucifer dogfish. The table also summarises total landings (t) of deepwater sharks from the Observer database during this period, where landings before 2000–01 may not include deepwater dogfish. The table also provides an estimate of the percentage of deepwater sharks landed by vessels carrying observers.

Fishing	Seal shark				Leafscale gulper shark				Shovelnose dogfish				Baxter's dogfish				Other sharks and dogfish				Deepwater dogfish				Total			Total LFRR landings	Observed landings	Estimated observer coverage
year	L	D	T	LFRR	L	D	T	LFRR	L	D	T	LFRR	L	D	T	LFRR	L	D	T	LFRR	L	D	T	LFRR	L	D	T			
1986–87	0	0	0	190	0	0	0	0	0	0	0	164	0	0	0	0	0	0	0	283	0	0	0	0	0	0	0	637	0	0
1987–88	0	0	0	379	0	0	0	0	0	0	0	167	0	0	0	0	0	0	0	69	0	0	0	0	0	0	0	615	152	25
1988–89	0	0	0	203	0	0	0	0	0	0	0	101	0	0	0	0	0	0	0	69	0	0	0	0	0	0	0	373	183	49
1989-90	15	1	16	104	0	0	0	0	164	5	169	199	0	0	0	0	73	17	90	97	0	18	18	0	252	41	293	400	54	14
1990-91	96	1	97	141	0	0	0	0	2	2	4	0	0	0	0	0	64	79	143	234	13	8	21	0	175	90	265	375	125	33
1991-92	123	2	125	183	0	0	0	0	3	5	8	1	0	0	0	0	431	44	475	180	0	0	0	0	557	51	608	364	81	22
1992-93	185	3	188	231	0	0	0	0	3	2	5	6	0	0	0	0	191	19	210	274	0	0	0	0	379	24	403	511	69	14
1993-94	254	2	256	304	0	0	0	0	4	2	6	5	0	0	0	0	183	27	210	256	0	2	2	0	441	33	474	565	85	15
1994-95	323	8	331	372	0	0	0	0	25	7	32	21	0	0	0	0	191	45	236	467	0	1	1	0	539	61	600	860	58	7
1995-96	332	47	379	282	13	0	13	12	50	3	53	44	0	0	0	0	263	178	441	506	0	11	11	0	658	239	897	844	17	2
1996-97	275	184	459	327	13	0	13	11	28	0	28	21	0	0	0	0	390	280	670	629	11	19	30	0	717	483	1 200	988	50	5
1997-98	333	23	356	419	6	0	6	5	34	2	36	36	0	5	5	0	1 388	376	1 764	540	17	21	38	0	1 778	427	2 205	1 000	87	9
1998-99	377	144	521	356	1	0	1	1	16	65	81	16	29	0	29	0	349	649	998	884	1	177	178	0	773	1 035	1 808	1 257	127	10
1999-00	301	470	771	319	0	0	0	0	27	111	138	28	26	0	26	0	691	903	1 594	573	22	160	182	0	1 067	1 644	2 711	920	162	18
2000-01	372	411	783	406	1	0	1	0	37	305	342	57	21	8	31	2	206	1 016	1 222	672	8	271	279	0	645	2 011	2 658	1 137	240	21
2001–02	406	432	838	444	1	0	1	1	96	303	399	88	23	4	27	22	133	771	904	121	41	223	264	25	700	1 733	2 433	701	404	58
2002–03	493	311	804	533	2	0	2	1	55	205	260	54	17	9	26	22	225	890	1 115	245	31	221	252	27	823	1 636	2 459	882	200	23
2003–04	383	335	718	401	3	0	3	3	87	233	320	89	14	21	35	14	281	731	1 012	295	6	261	267	2	774	1 581	2 355	804	199	25
2004–05	506	206	712	497	0	0	0	0	118	175	293	112	6	10	16	6	181	360	541	212	0	244	244	1	811	995	1 806	828	170	21
2005–06	431	201	632	429	0	3	3	0	148	185	333	143	13	12	25	16	237	465	702	233	1	203	204	1	830	1 069	1 899	822	277	34

A review of the rig SPO 8 commercial fishery (Blackwell et al. 2005) highlighted inconsistencies in the reporting and application of conversion factors on the MFish databases, and similar issues may affect the deepwater shark data. Other issues include poor species identification and the accuracy of subsequent reporting, while an unknown amount of catch is reported to generic codes such as "deepwater dogfish", or "other sharks and dogfish (unspecified)". These data should be interpreted with caution, and were not considered sufficiently accurate for more detailed analysis.

3.2.3 Estimated catch data

Estimated deepwater shark catches summarised by target species for fishing years 2000–01 to 2005–06 (Appendix 1) varied widely among fishing years. While longnose velvet dogfish and Owston's dogfish were not separately reported, they are likely to make up most of the reported deepwater dogfish (DWD) catch (Livingston et al. 2003). Seal shark and shovelnose dogfish were generally associated with hoki, ling, and orange roughy target fishing, and deepwater dogfish were mainly associated with the orange roughy and oreo fisheries. Few data were reported for leafscale gulper shark or Baxter's dogfish.

Fishing effort (number of tows where deepwater sharks were reported) (Table 3) has remained relatively constant between 2000–01 and 2005–06. On average, 35% of tows were located on the central and eastern Chatham Rise (FMA 4), 22% in Southland and Sub-Antarctic waters (FMA 6), and 17% on the western Chatham Rise and the Mernoo Bank in FMA 3 (Table 4). These data were considered likely to underestimate actual catch, due to poor species identification and subsequent misreporting, the use of generic codes, and the inconsistent reporting of dumped fish. No further analysis has been completed on these data.

Table 3: Fishing effort (number of tows where deepwater sharks were reported), by Fishery Management Area (FMA), 2000–01 to 2005–06. Source: MFish data extract February 2007.

	Fishing year						
FMA	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	Total
1	111	117	210	143	100	75	756
2	170	278	307	430	619	540	2 344
3	865	894	807	953	929	1 081	5 529
4	1 685	1 602	2 177	1 950	1 903	2 020	11 337
5	615	412	306	226	285	372	2 216
6	1 343	1 361	1 171	1 057	1 044	1 019	6 995
7	381	337	395	521	283	342	2 259
8	2	-	-	-	4	1	7
9	31	50	129	212	104	161	687
Total	5 203	5 051	5 502	5 492	5 271	5 611	32 130

Table 4: Percentage distribution of fishing effort (percentage of tows where deepwater sharks were reported), by Fishery Management Area (FMA), 2000–01 to 2005–06. Source: MFish data extract February 2007.

	Fishing year						
FMA	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	Mean
1	2	2	4	3	2	1	2
2	3	6	6	8	12	10	7
3	17	18	15	17	18	19	17
4	32	32	40	36	36	36	35
5	12	8	6	4	5	7	7
6	26	27	21	19	20	18	22
7	7	7	7	9	5	6	7
8	0	-	-	-	-	-	0
9	1	1	2	4	2	3	2

3.3 Observer Programme data

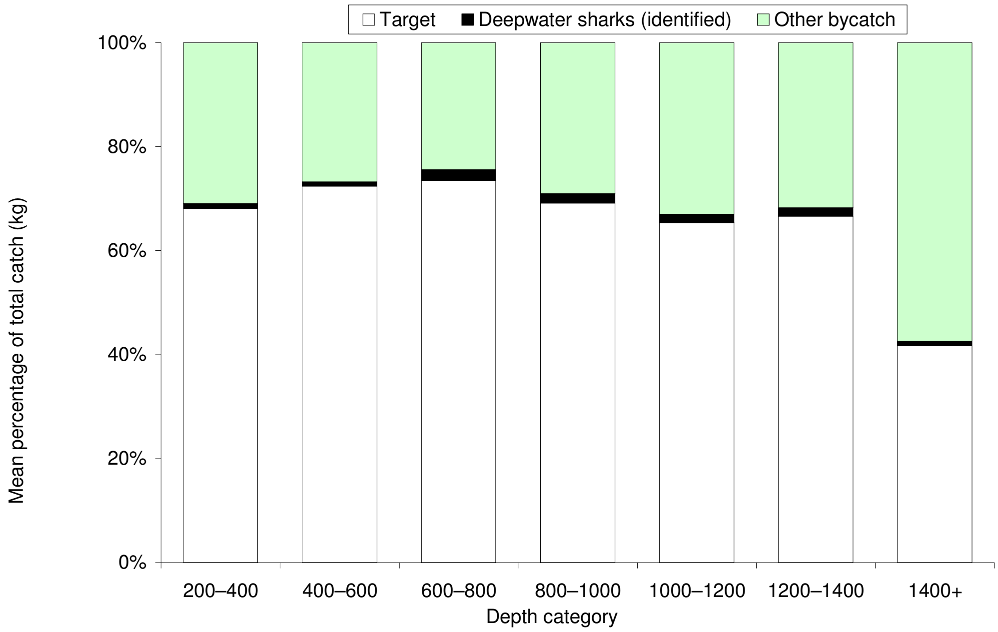
The OP database has the most accurate data available from the commercial fishery (Blackwell & Stevenson 2003), but trends were difficult to infer as the focus of the OP has varied among fishing years, grounds, and target fisheries, and the estimated observer coverage of deepwater shark catches has also varied (see Table 2).

Analysis of the OP data was also limited by the widespread use of generic reporting codes, which represent 35–50% of all observed data. Relative species composition of the deepwater shark catch is presented below by depth stratum, and by major deepwater target fishery (hoki, orange roughy, and oreo (all)). Few length/sex data were reported for deepwater sharks and available data are unlikely to be representative of the commercial catch.

3.3.1 Species composition by depth

If it is assumed that the observed data represent a random sample of the target species catch, then changes in the species composition of deepwater sharks with depth between 2001–02 and 2005–06 can be estimated. Most observed tows occurred within the depth range 400–1200 m, with only 97 tows occurring in depths greater than 1200 m (Table 5).

Deepwater sharks represented 1% of reported catch in depths less than 600 m between 2001–02 and 2005–06, 6% in 600–799 m, 2–4% between 800 and 1200 m, and 1% in depths greater than 1400 m (Figure 3). Species composition varied among depth strata. The proportion of unidentified sharks declined with increasing depth, from about 60% in depths less than 400 m, to about 30% in depths from 400 to 1000 m. Few unidentified sharks were reported from depths greater than 1400 m, where catches were dominated by seal shark. While shovelnose dogfish, Baxter's dogfish, and seal shark were common in all depth strata, shovelnose dogfish mainly occurred in 400–600 m, and seal shark was most abundant in depths greater than 1000 m. Baxter's dogfish was more common in depths greater than 600 m, while longnose velvet dogfish, Owston's dogfish, and leafscale gulper shark were rarely recorded in depths less than 600 m.



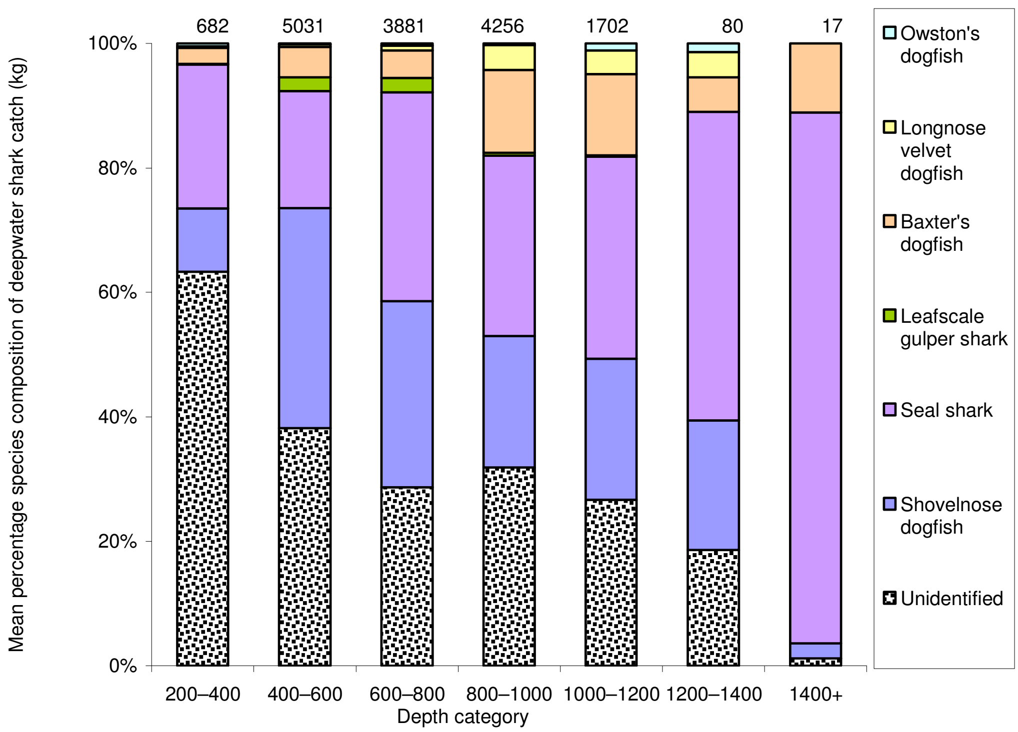


Figure 3: Mean catch composition of deepwater sharks reported from the Scientific Observer database, all years 2001–02 to 2005–06, by major target fishery, giving number of observations. Source: MFish data extract, February 2007.

Table 5: Depth distribution of observed tows where deepwater sharks were reported on the Scientific Observer database, 2001–02 to 2005–06, by 200 m depth zone and target species (Source: MFish data extract, February 2007).

Target species	Depth range (m)							Total observed tows
	200-400	400-600	600-800	800-1000	1000-1200	1200-1400	1400+	
Hoki	256	4 267	2 350	243	19	4		7 139
Orange roughy	2	42	943	2 738	1 228	63	11	5 027
Oreo		3	121	1 194	451	13	6	1 788
Hake	3	215	298	15				531
Scampi	252	250	1					503
Ling		91	71					162
Cardinalfish		7	73	58	4			142
Arrow squid	99	8						107
Alfonsino	19	40	20	1				80
Silver warehou	30	36						66
White warehou	14	38	3					55
Southern blue whiting		28						28
Other	7	6	1	7				21
Total	682	5 031	3 881	4 256	1 702	80	17	15 649
Grand Total	682	5031	3881	4256	1702	80	17	15 649

3.3.2 Species composition by target fishery

The target fisheries for hoki, orange roughy, and oreos represent over 85% of the total observed tows from which deepwater sharks were reported, although the actual catch of deepwater sharks is almost inconsequential compared to the catch of the target species. Deepwater sharks represented 2% of total catch in the target hoki fishery (Figure 4). The shark component was dominated by shovelnose dogfish (26%) and seal shark (25%), with 36% reported as unidentified. Deepwater sharks represented 3% of the total catch in the oreo fishery: this comprised mainly seal shark (27%) and Baxter's dogfish (21%), while 47% of the deepwater sharks were unidentified. For the orange roughy fishery, deepwater sharks represented 9% of the total catch, which was dominated by seal shark (30%) and shovelnose dogfish (18%), while 31% of the shark catch was unidentified.

3.3.3 Trends in the Chatham Rise hoki fishery

Most observer data for deepwater sharks were reported from the target hoki fishery, particularly on the Chatham Rise (QMAs 3 & 4), in depths of 600–800 m (Table 3, Figure 4). Trends in both total deepwater shark catch and the percentage shark species composition were examined separately for these two QMAs for fishing between 1989–90 and 2005–06. Fishing patterns in the target fishery changed after 2003–04, when less fishing occurred on the northwestern Chatham Rise hoki spawning aggregations, and more target fishing occurred on the widely dispersed feeding aggregations on the main Chatham Rise (Livingston et al. 2003, Sullivan et al. 2005).

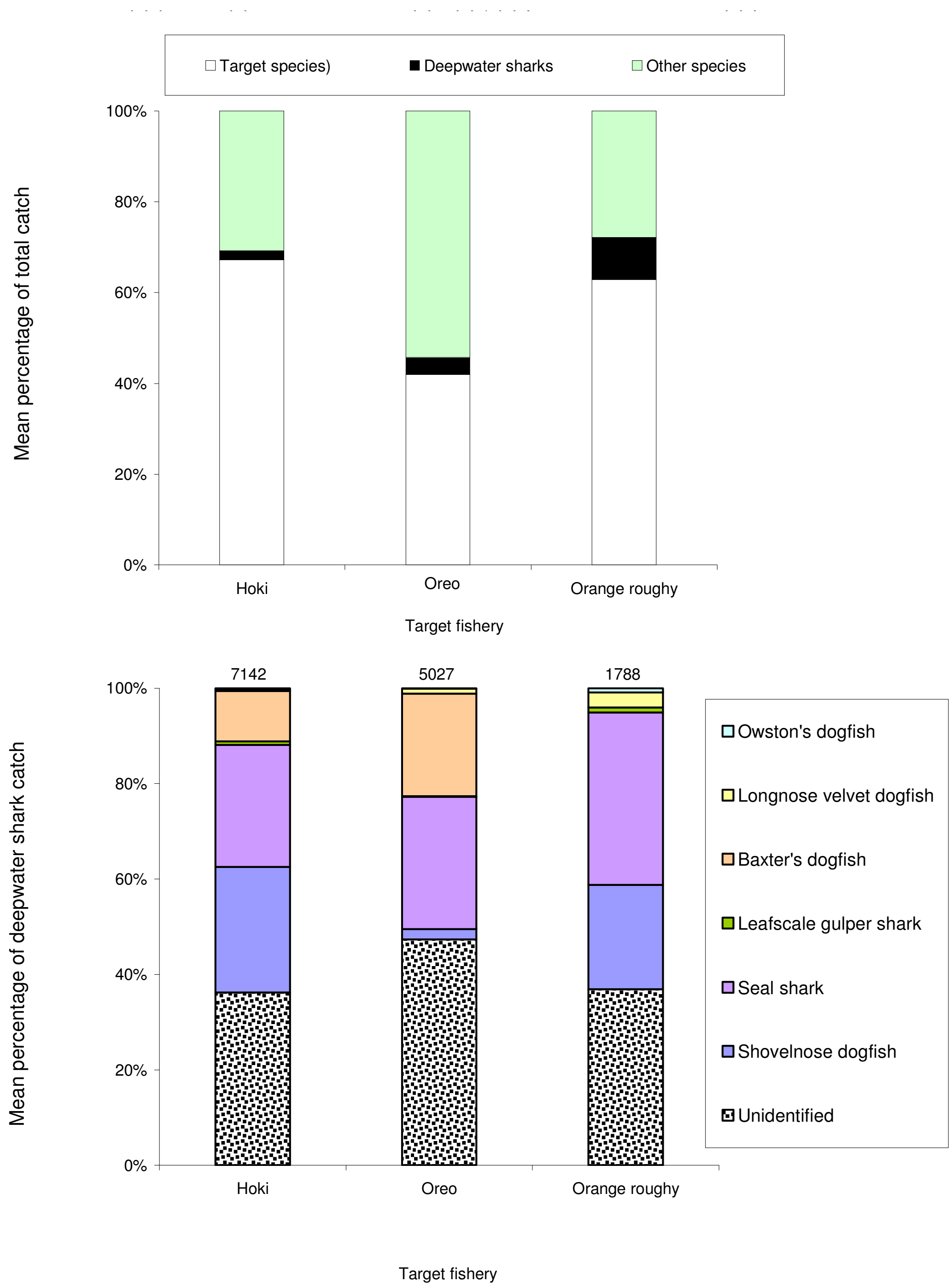


Figure 4: Mean catch composition of deepwater sharks reported from the Scientific Observer Programme database, 2001–02 to 2005–06, by major target fishery, giving number of observations. Source: MFISH data extract, February 2007.

The number of observed tows reported from the northwestern Chatham Rise in QMA 3 varied widely (from 52 in 1992–93 to 984 in 1997–98). Identification of trends in shark bycatch was limited by the high amount of shark bycatch reported to generic species codes before 2000–01 (from 50% of shark bycatch in 1989–90 to 73% of shark bycatch in 1994–95). Identified bycatch was dominated by shovelnose dogfish before 1994–95. Seal shark increased in importance, particularly after 2000–01. Little trend was apparent for the other bycatch species (Figure 5).

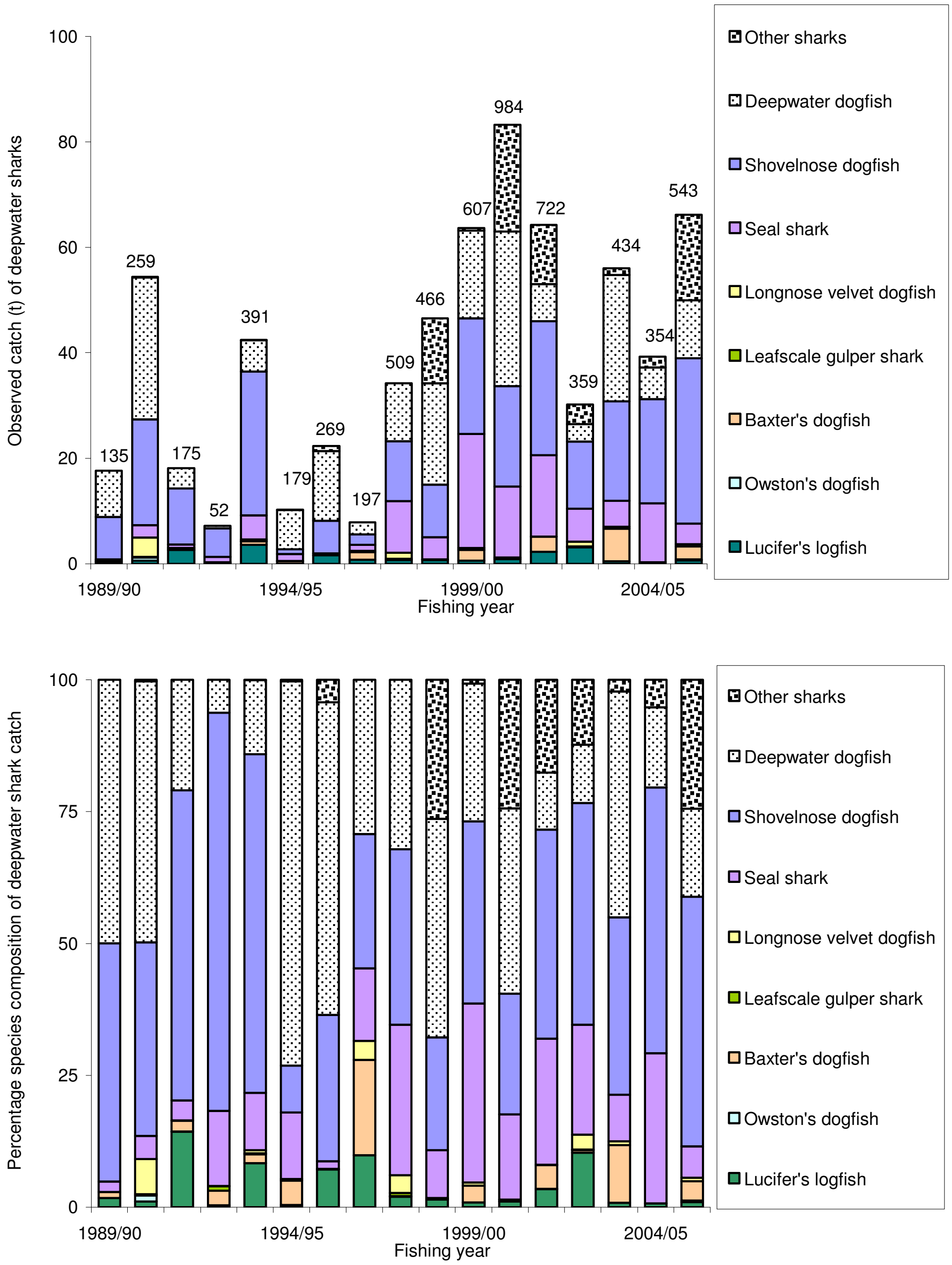
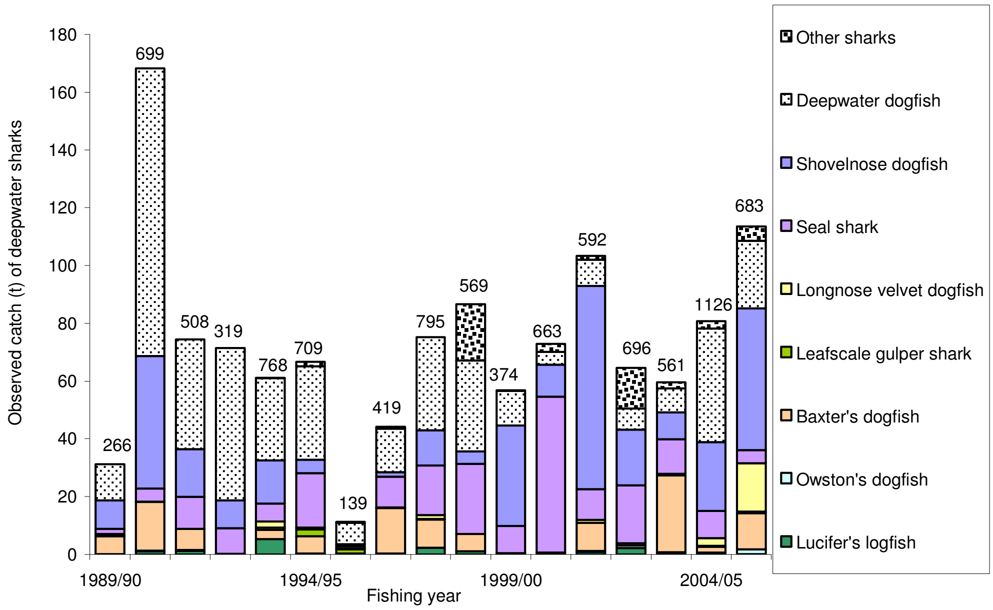


Figure 5: Deepwater shark bycatch (t) from the northwestern Chatham Rise (QMA 3) target hoki trawl fishery, reported on the Scientific Observer database, 1989–90 to 2005–06, giving number of observations, and the relative percentage species composition of shark bycatch. Source: MFish data extract, February 2007.

The hoki target fishery on the Chatham Rise in QMA 4 had higher observer coverage than in QMA 3, ranging from 139 tows in 1995–96 to 1126 tows in 2004–05. The amount of deepwater shark bycatch reported against generic codes generally declined after 1998–99, except for 2004–05 when it exceeded 50% of landings. Catches were dominated by shovelnose dogfish and seal shark, while Baxter's dogfish was particularly important in 1989–90, 1996–97, and 2003–04 (Figure 6).



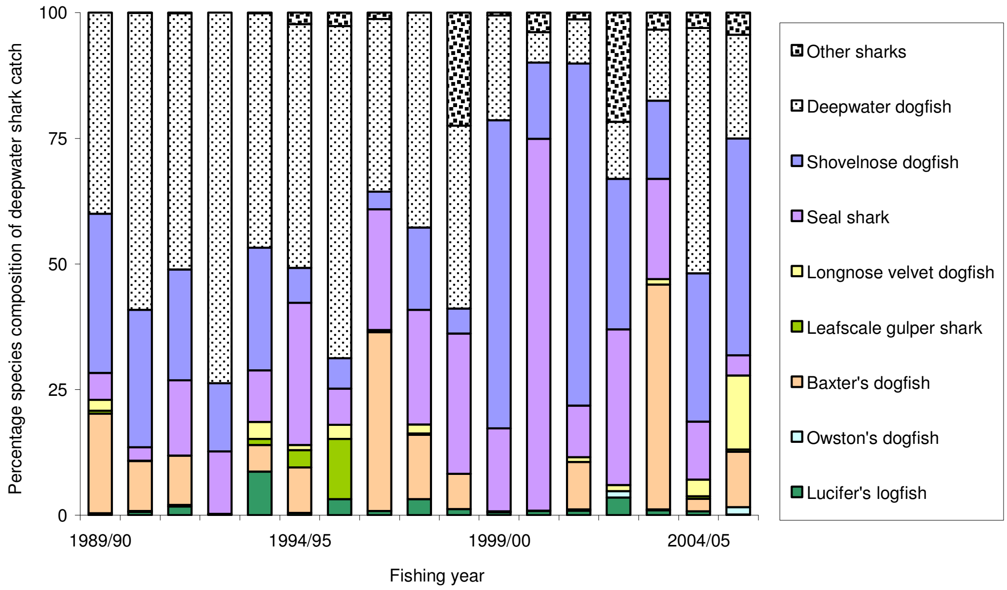


Figure 6: Deepwater shark bycatch (t) from the Chatham Rise (SOE) target hoki trawl fishery, reported on the Scientific Observer database, 1989–90 to 2005–06, giving number of observations, and the relative percentage species composition of shark bycatch. Source: MFish data extract, February 2007.

Tow position data from the Observer database provide information on the occurrence of deepwater sharks (Figure 7). Deepwater sharks are common bycatch in the hoki and oreo fisheries, in depths between 600 and 1200 around the Chatham Rise, and the Mernoo Bank. Most reported catch was of shovelnose dogfish or unidentified deepwater sharks. Seal shark was mainly reported from the deeper waters off the northwest Chatham Rise. Baxter's dogfish was less commonly reported, in deeper waters between 800–1200 m.

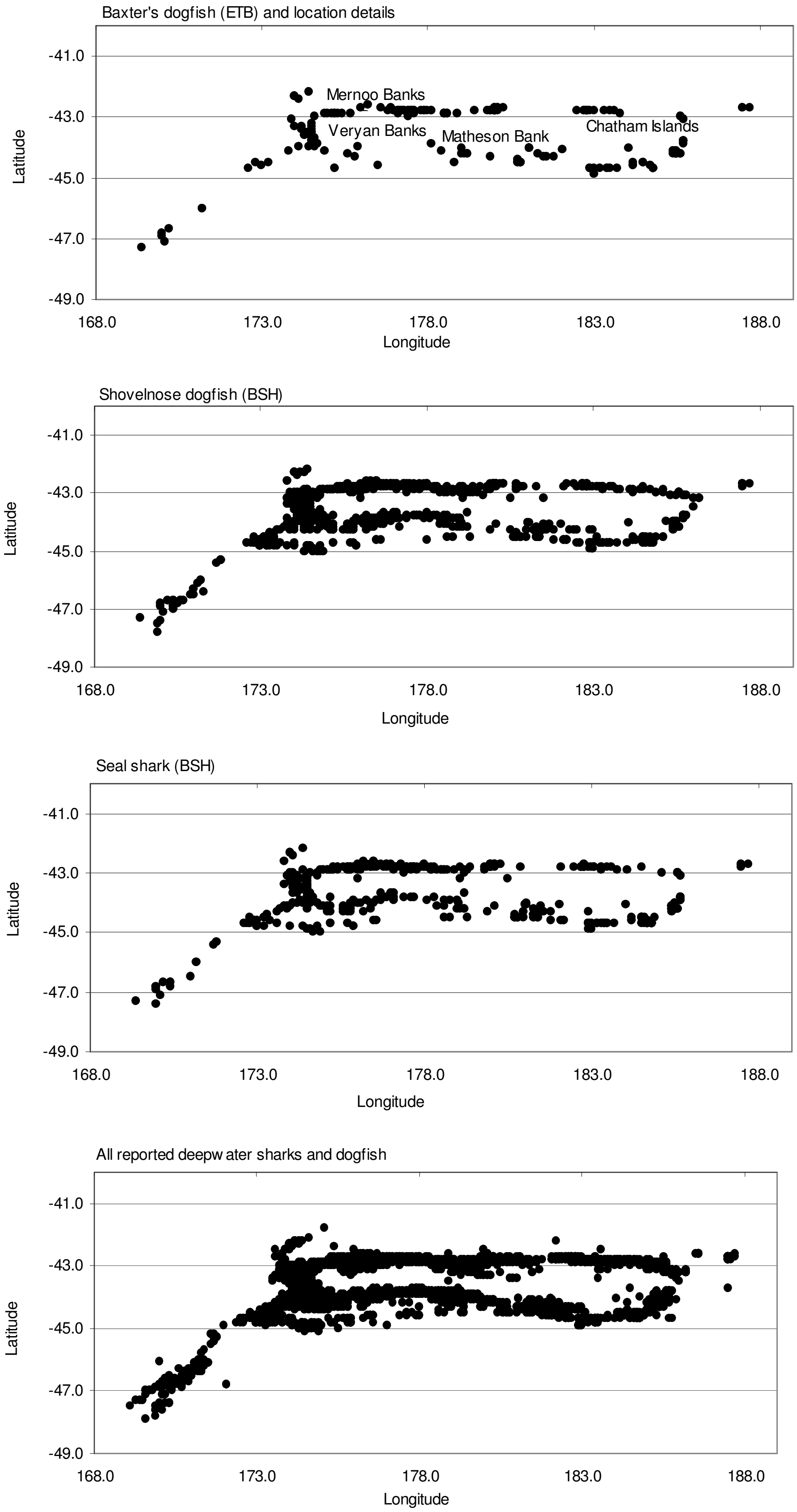


Figure 7: Distribution of the main deepwater shark bycatch species (shovelnose dogfish, seal shark, Baxter's dogfish, and all deepwater sharks) reported from the Chatham Rise hoki fishery, 1989–90 to 2005–06. Source: M.Fish data extract, February 2007.

4. REVIEW OF RESEARCH SURVEY DATA

4.1 Survey data

Deepwater sharks are commonly reported from middle-depth (600–800 m) and deepwater (750–1500 m) bottom trawl surveys (see Appendix 2). Few surveys provide sufficient data from which to derive scaled length frequency distributions and determine accurate or precise estimates of relative biomass. Deepwater trawl surveys were often replaced by acoustic sampling programmes after the mid 1990s, and recent (2002 to 2006) trawl survey data are available for the Chatham Rise and Sub-Antarctic only. Because trawl tows completed as part of acoustic survey programmes are used for detailed examination of a particular echo trace, these data are inappropriate for use in relative biomass estimation (S. Hanchet, NIWA, pers. comm., 2002).

Blackwell & Stevenson (2003) previously identified four random trawl survey series that provided valid time series of relative biomass estimates for deepwater sharks, and focused mainly on surveys completed by RV *Tangaroa*. These were the 1992–1994 deepwater (750–1500 m) east coast North Island survey series (Blackwell & Stevenson 2003); the 1984–1994 deepwater (750–1500 m) northeast Chatham Rise series (which used FV *Otago Buccaneer*, FV *Cordella*, and RV *Tangaroa*) (Clark et al. 2000a); the 1992–2000 middle depths (600–800 m) Chatham Rise *Tangaroa* hoki survey series (Livingston et al. 2003); and the 1991–1995 south Chatham Rise deepwater (750–1500 m) RV *Tangaroa* survey series (Livingston et al. 2003) (Table 6, Appendix 2).

Survey series were excluded where derived biomass estimates were less than 100 t, or where sampling variability was high (c.v. greater than 40%), as these surveys were assumed to have poorly sampled the deepwater shark population (M. Francis, pers. comm., 2003). Other survey series were excluded due to inconsistent stratification. Deepwater sharks generally occur in the deeper strata (800–1500 m), where the catch rates of the target species may not be high. These deeper strata were not consistently sampled in many survey series. Surveys that focused on particular target species aggregations, or on specific undersea structures, were also excluded because they were unlikely to have adequately sampled widely distributed species such as deepwater sharks (M. Clark, NIWA, pers. comm., 2002).

4.2 Relative biomass estimates

Two trawl survey series using RV *Tangaroa* provide biomass estimates for deepwater sharks on the Chatham Rise. The 2003–2006 hoki and middle depths (600–800 m) surveys continue the previous data series (Livingston et al. 2003, Livingston & Stevens 2004, 2005, Stevens & O'Driscoll 2002, 2006, 2007). Biomass estimates and c.v.s for deepwater sharks derived from these surveys (Table 6) update the previous estimates by Blackwell & Stevenson (2003). Length-weight relationships used to derive biomass estimates are given in Appendix 3. This will be referred to as the Chatham Rise survey series.

The second data series was the 2004–2005 deepwater (750–1500 m) random trawl survey series using RV *Tangaroa* to target orange roughy on the northwest Chatham Rise (Smith et al. 2008). This series includes only two surveys, which is insufficient for relative biomass estimation. This will be referred to as the northwest Chatham Rise survey series.

Outside the Chatham Rise, the only other recent survey series suitable for relative biomass estimation is the 2000–2005 Sub-Antarctic deepwater (750–1000 m) RV *Tangaroa* summer survey series (O'Driscoll et al. 2000, O'Driscoll & Bagley 2001, 2003a, 2003b, 2004, 2006a, 2006b). This series will be referred to as the Sub-Antarctic survey series. Data from the earlier surveys in this series (prior to TAN0012) were not included as the c.v.s of the biomass estimates exceeded the constraints for analysis (Blackwell & Stevenson 2003).

Blackwell & Stevenson (2003) also provided relative biomass estimates for deepwater shark species from three other survey series that have subsequently been discontinued. These were: the 1991–1995 northeast Chatham Rise deepwater (750–1500 m) survey series which used FVs *Cordella* and *Otago Buccaneer*, and RV *Tangaroa* (Clark et al 2000a); the south Chatham Rise deepwater (750–1500 m) RV *Tangaroa* survey series (Livingston et al. 2003); and the 1992–1994 east coast North Island deepwater (750–1500 m) RV *Tangaroa* survey series (Grimes 1994, 1996a, 1996b). The biomass estimates for deepwater sharks previously derived for these surveys have also been included in Table 6 for completeness. The trends from these surveys are summarised in Table 7.

4.2.1 Shovelnose dogfish

No trend in relative biomass was determined for the Chatham Rise surveys between 1991 and 2006, or from the Sub-Antarctic survey series between 2000 and 2005 (Table 6, Figure 8).

4.2.2 Baxter's dogfish

No trend in relative biomass was determined from the Chatham Rise surveys between 1991 and 2006, or from the Sub-Antarctic survey series between 2000 and 2005 (Table 6, Figure 9).

4.2.3 Longnose velvet dogfish

No trend in relative biomass could be determined for the northeast Chatham Rise surveys between 1984 and 1994. While data from the Sub-Antarctic series was suggestive of an increase in relative abundance ($F_{(1,5)} = 70.56$, $p<0.05$) between 2000 and 2005, the lack of any subsequent pattern in the data (after 2002) has been interpreted as representing no consistent trend in relative biomass (Table 6, Figure 10).

4.2.4 Leafscale gulper shark

No trend in relative biomass was apparent for the Sub-Antarctic series between 2000 and 2005 (Table 6, Figure 11).

Table 6: Biomass estimates for Owston's dogfish, longnose velvet dogfish, Baxter's dogfish, shovelnose dogfish, leafscale gulper shark, and seal shark from trawl survey data where - indicates data are generally unreliable (either less than 100 t, or where c.v.s exceed 40%). Estimates where c.v.s slightly exceed 40% are included for completeness. The c.v.s for the biomass estimates from the northeast and south Chatham Rise survey series did not exceed 40%. Biomass estimates from surveys before 2002 after Blackwell & Stevenson (2003).

1. Chatham Rise

Trip	Owston's dogfish		Longnose velvet dogfish		Baxter's dogfish		Shovelnose dogfish		Leafscale gulper shark		Seal shark	
	Biomass (t)	c.v. (%)	Biomass (t)	c.v. (%)	Biomass (t)	c.v. (%)	Biomass (t)	c.v. (%)	Biomass (t)	c.v. (%)	Biomass (t)	c.v. (%)
Chatham Rise (600–800 m): RV *Tangaroa*. Data after Livingston et al. (2003), Livingston & Stevens (2005), Stevens et al. (2002), Stevens & O'Driscoll (2005), NIWA (unpublished data)												
TAN9106	-	-	-	-	-	-	5 090	14	-	-	-	-
TAN9219	-	-	-	-	-	-	3 810	23	-	-	-	-
TAN9401	-	-	-	-	-	-	1 884	20	-	-	-	-
TAN9501	-	-	-	-	-	-	4 189	17	-	-	-	-
TAN9601	-	-	-	-	3 528	60	3 803	43	-	-	-	-
TAN9701	-	-	-	-	1 575	66	3 724	38	-	-	-	-
TAN9801	-	-	-	-	-	-	2 776	27	-	-	-	-
TAN9901	-	-	-	-	2 078	32	4 121	26	-	-	-	-
TAN0001	-	-	-	-	857	29	4 420	19	-	-	-	-
TAN0101	-	-	-	-	854	27	4 190	18	-	-	-	-
TAN0201	-	-	-	-	2 302	33	5 943	21	-	-	-	-
TAN0301	-	-	-	-	1 398	37	3 781	18	305	25	-	-
TAN0401	-	-	237	41	836	24	2 363	11	-	-	163	26
TAN0501	-	-	777	40	809	27	2 576	16	808	43	177	33
TAN0601	-	-	650	44	1 608	49	2 815	14	334	45	-	-
Northeast Chatham Rise (750–1500 m): FV *Cordella, Otago Buccaneer*, RV *Tangaroa*. Data after Clark et al. (2000a)												
BUC8401	250		370		770		1 520		-	-	-	-
BUC8501	277		281		347		912		-	-	-	-
BUC8601	593		551		493		2 341		-	-	-	-
BUC8701	730		588		547		2 782		-	-	-	-
COR8801	420		1 976		393		2 949		-	-	-	-
COR8901	263		1 121		123		1 383		-	-	-	-
COR9002	248		1 739		377		3 146		-	-	-	-
TAN9206	705		1 602		331		2 706		-	-	-	-
TAN9406	488		1 351		200		1 733		-	-	-	-
Northwest Chatham Rise (750–1500 m): RV *Tangaroa*. Data after Smith et al. (2008), NIWA (unpublished data).												
TAN0408	-	-	640	29	715	28	2 915	9	-	-	-	-
TAN0509	-	-	-	-	186	12	184	13	-	-	-	-
South Chatham Rise (750–1500 m): RV *Tangaroa*. Data after Livingston et al. (2003)												
TAN9104	-	-	883		5 626		4 382		-	-	-	-
TAN9210	-	-	1 020		4 752		4 689		-	-	-	-
TAN9309	-	-	950		7 454		6 179		-	-	-	-
TAN9511	-	-	867		10 770		4 820		-	-	-	-

Table 6: – continued

2. **Other areas**

Trip	Owston's dogfish		Longnose velvet dogfish		Baxter's dogfish		Shovelnose dogfish		Leafscale gulper shark		Seal shark	
	Biomass (t)	c.v. (%)	Biomass (t)	c.v. (%)	Biomass (t)	c.v. (%)	Biomass (t)	c.v. (%)	Biomass (t)	c.v. (%)	Biomass (t)	c.v. (%)
East Coast North Island (750–1500 m): RV *Tangaroa*. Data after Clark et al. (2000).												
TAN9203	116	17	387	13	138	17	2 336	15	-	-	-	-
TAN9303	165	24	654	63	593	52	3 259	17	-	-	-	-
TAN9403	197	23	230	40	238	15	3 501	21	-	-	-	-
Sub-Antarctic (750–1000 m): RV Tangaroa summer series. Data after O'Driscoll et al. (2000), O'Driscoll & Bagley (2001, 2003a, 2003b, 2004,2006a, 2006b)												
TAN0012	184	32	1 482	19	2 540	16	131	22	832	37	-	-
TAN0118	38	44	-	-	1 781	16	612	21	627	33	-	-
TAN0219	-	-	2 293	13	2 334	16	524	29	214	33	-	-
TAN0317	-	-	2 112	28	1 665	25	263	22	375	48	-	-
TAN0414	-	-	2 241	38	1 628	21	738	17	404	46	-	-
TAN0515	-	-	2 260	21	2 144	22	583	21	594	27	-	-

Table 7: Summary of trends in relative biomass for deepwater sharks from recent trawl survey series, updating descriptions provided in Livingston et al (2003), and Blackwell & Stevenson (2003). (↑rising trend; ↓declining trend; nil, no trend; - no data)

(a) Chatham Rise

Area	Chatham Rise	Northwest	Northeast	South
Depth range (m)	600–800	> 800	750–1500	750–1500
Series	1991–2006	2004–2005	1984–94	1991–95
Vessel	*Tangaroa*	*Tangaroa*	Various, *Tangaroa*	*Tangaroa*
Species				
Shovelnose dogfish	nil	–	↑	nil
Baxter's dogfish	nil	–	↓	↑
Owston's dogfish	–	–	nil	–
Longnose velvet dogfish	nil	–	↑	nil
Leafscale gulper shark	–	–	nil	–
Lucifer dogfish	–	–	–	–
Seal shark	–	–	nil	–

(b) Other areas

Area	East coast North Island	Sub-Antarctic
Depth range (m)	750–1500	750–1000
Series	1992–1994	2001–2005
Vessel	*Tangaroa*	*Tangaroa*
Species		
Shovelnose dogfish	nil	nil
Baxter's dogfish	nil	nil
Owston's dogfish	–	–
Longnose velvet dogfish	–	nil
Leafscale gulper shark	–	nil
Lucifer dogfish	–	–
Seal shark	–	–

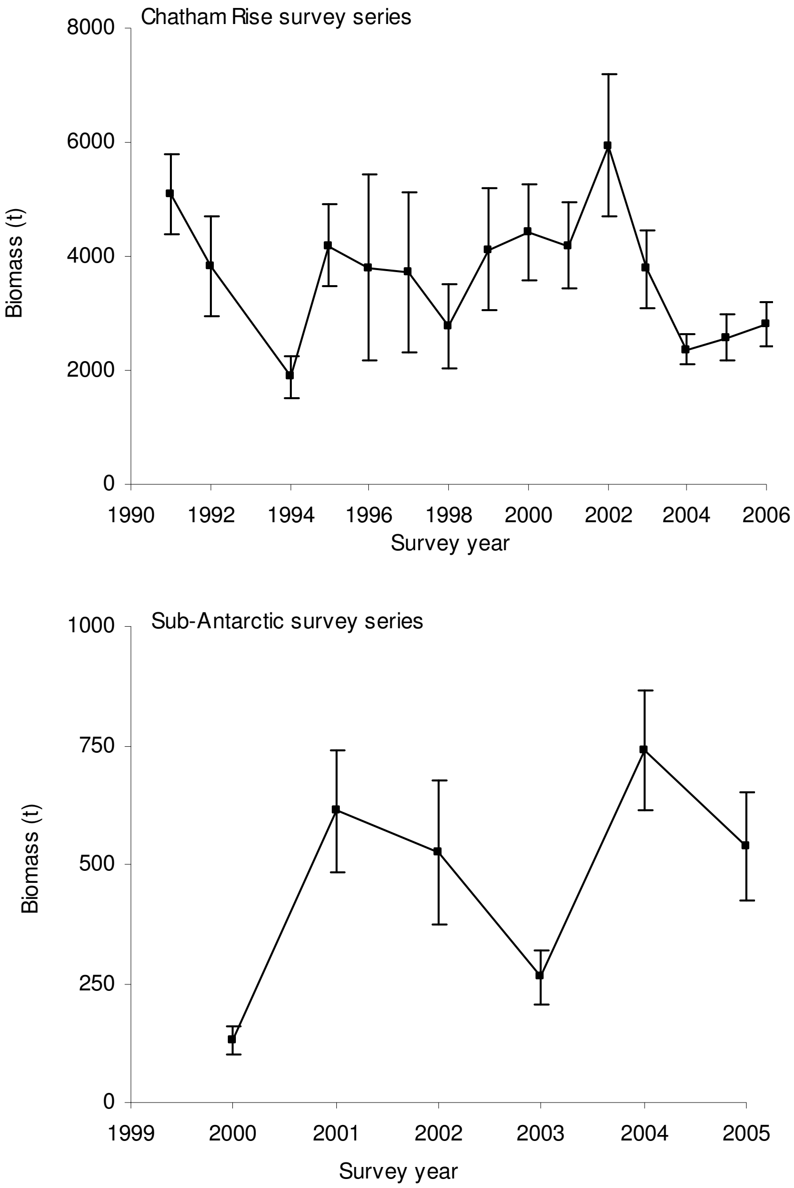


Figure 8: Trends in relative biomass estimates of shovelnose dogfish from trawl surveys, 1990 to 2005, where error bars represent 1 St.dev. Vessels used and estimates of sampling error are given in Table 6.

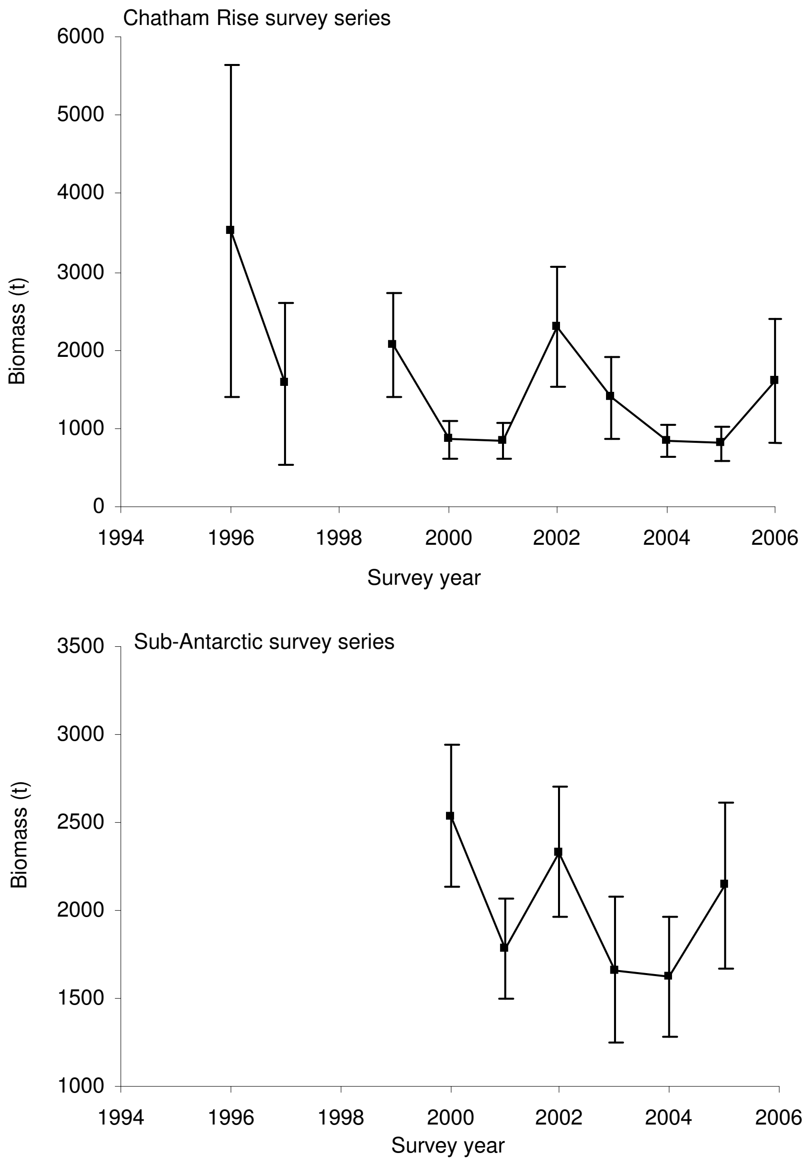
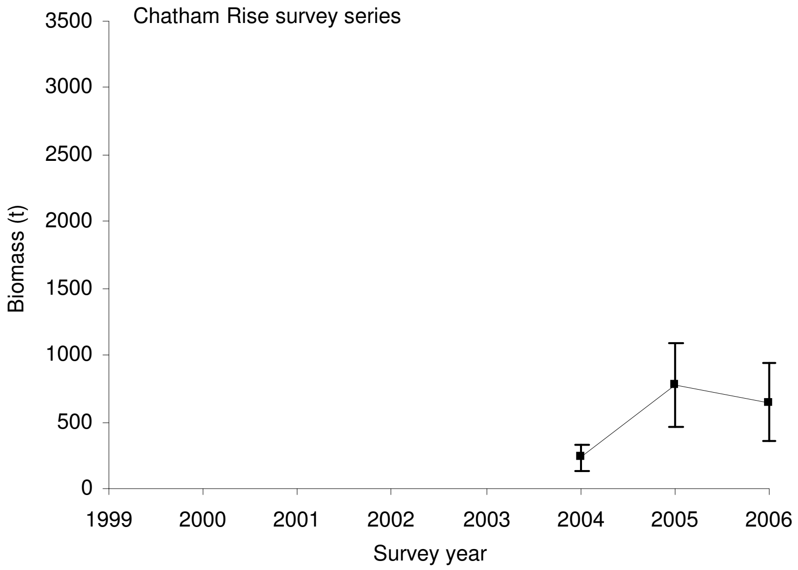


Figure 9: Trends in relative biomass estimates of Baxter's dogfish from trawl surveys, 1990 to 2005, where error bars represent 1 St.dev. Vessels used and estimates of sampling error are given in Table 6.



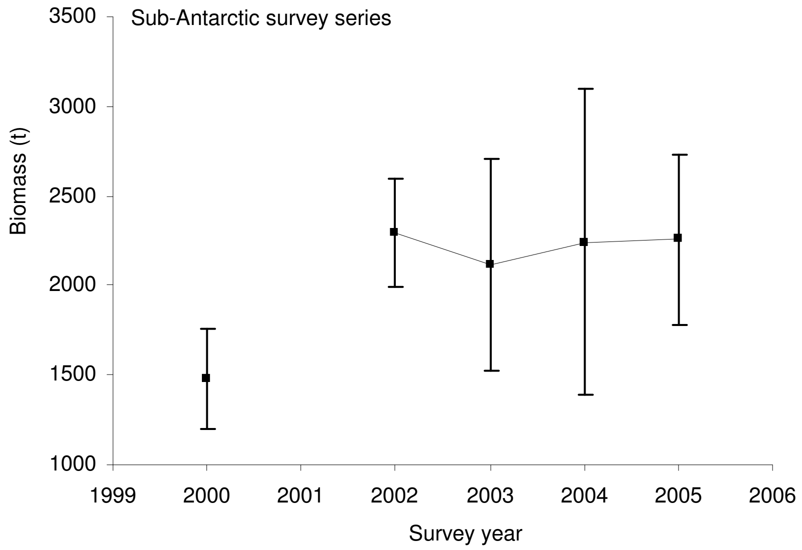


Figure 10: Trends in relative biomass estimates of longnose velvet dogfish from trawl surveys, 1992 to 2006, where error bars represent 1 Std.dev. Vessels used and estimates of sampling error are given in Table 6.

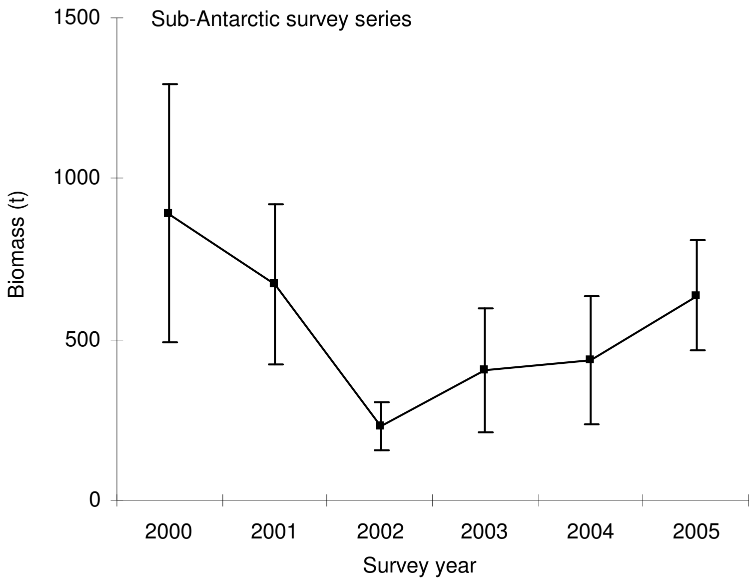


Figure 11: Trends in relative biomass estimates of leafscale gulper shark from trawl surveys, 1992 to 2006, where error bars represent 1 Std.dev. Vessels used and estimates of sampling error are given in Table 6.

4.3 Length frequency data from trawl surveys

Scaled length frequencies were derived where more than 100 fish were measured, and where weight data are available. Unscaled (raw) length frequencies are given where no weight data are available, but more than 100 sharks of each species were measured.

4.3.1 Shovelnose dogfish

Scaled length frequencies from trawl survey series on the Chatham Rise were generally similar between 1998 and 2006, between 2000 and 2005 for the Sub-Antarctic, and between 2004 and 2005 on the northwest Chatham Rise (Figure 12). Numbers of juveniles were variable, with little signal indicating possible modal progression of size classes through the population.

4.3.2 Baxter's dogfish

Scaled length frequencies were generally similar on the Chatham Rise (600–800 m) between 1991 and 2006, and for the Sub-Antarctic survey series from 1992 to 2005 (Figure 13). Many juvenile females (under 30 cm in length) were present in 2005.

Chatham Rise survey series

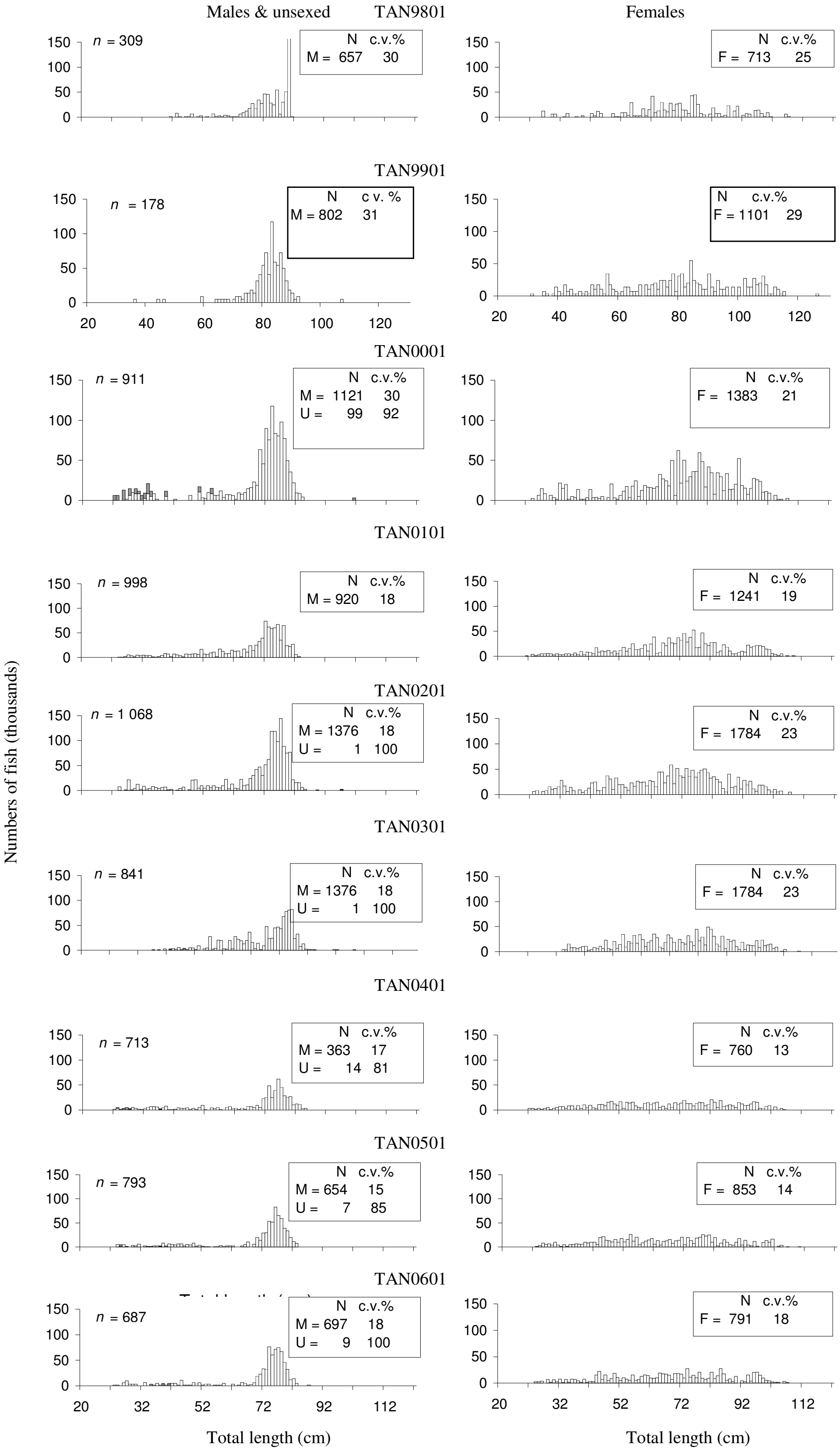


Figure 12: Scaled length frequencies for shovelnose spiny dogfish from trawl surveys where more than 100 fish were measured. N, scaled number of fish (thousands); M, males; F, females; U, (shaded) unsexed; n, number of fish measured. Areas and survey series are given in Appendix 2.

Sub-Antarctic survey series

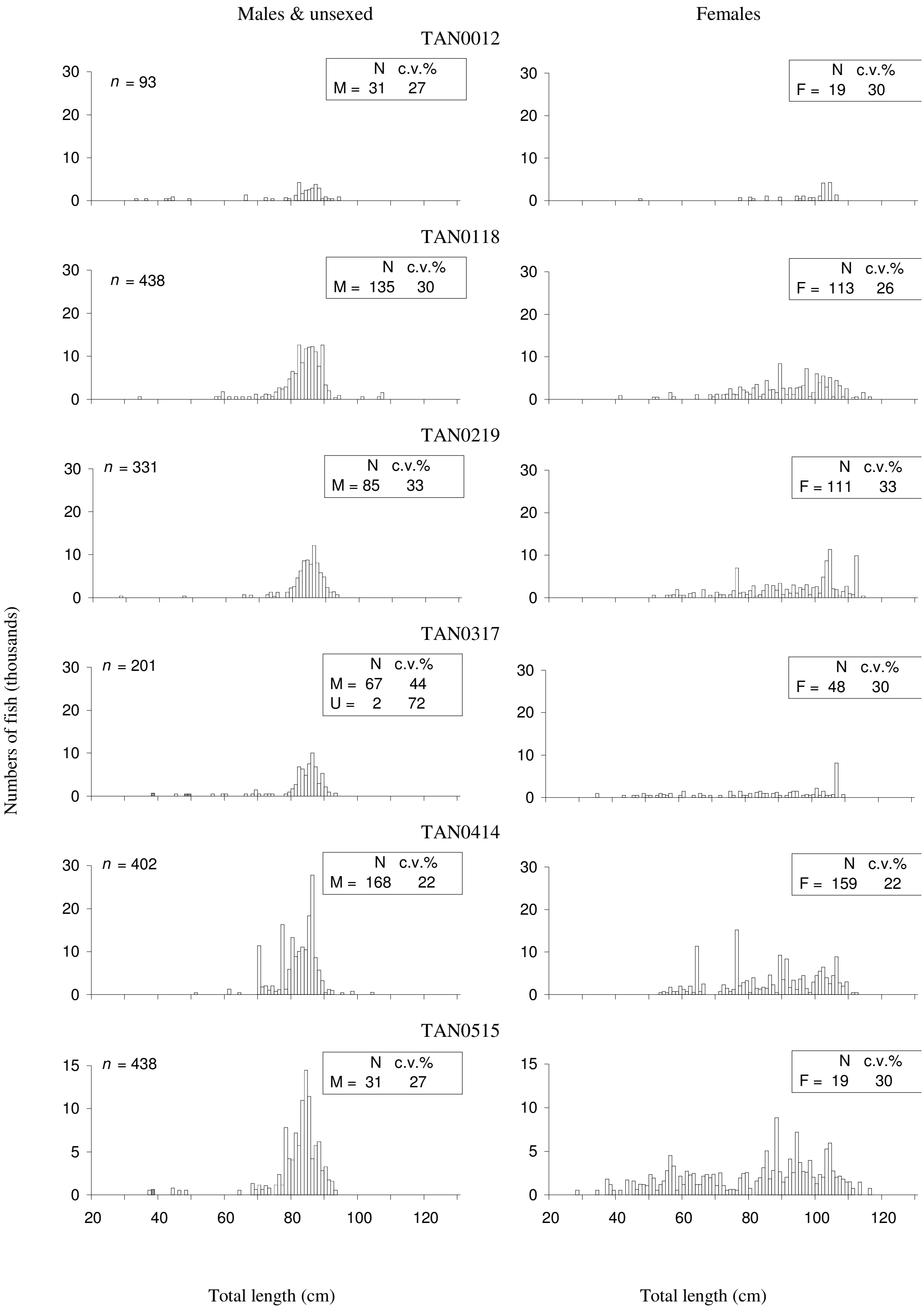


Figure 12: – continued

Northwest Chatham Rise survey series

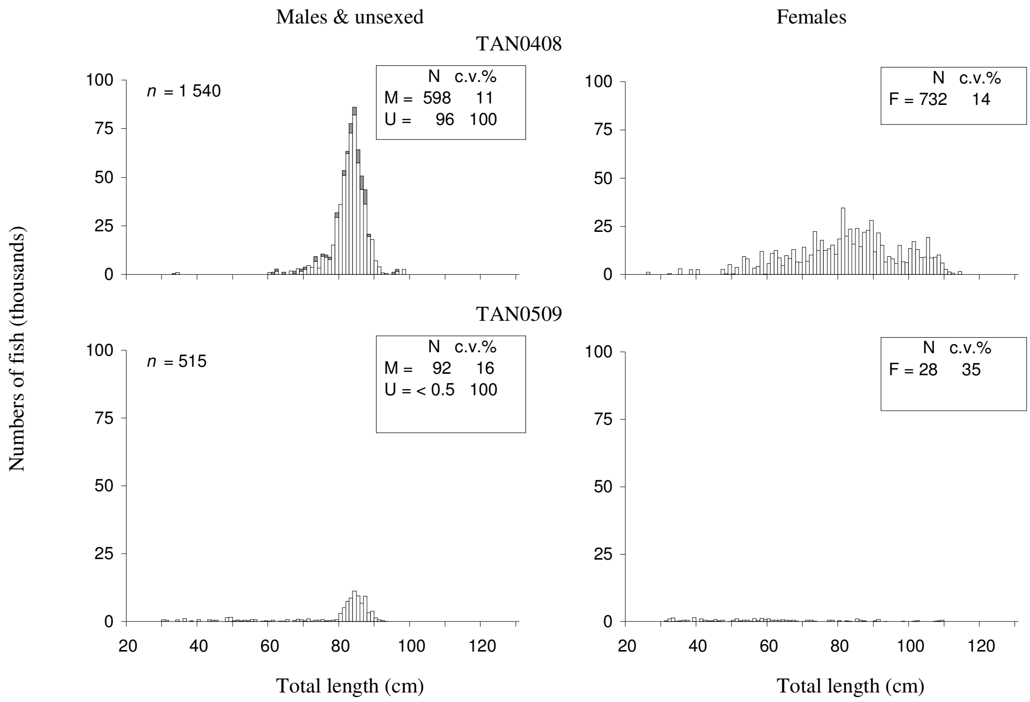


Figure 12: – continued

Chatham Rise survey series

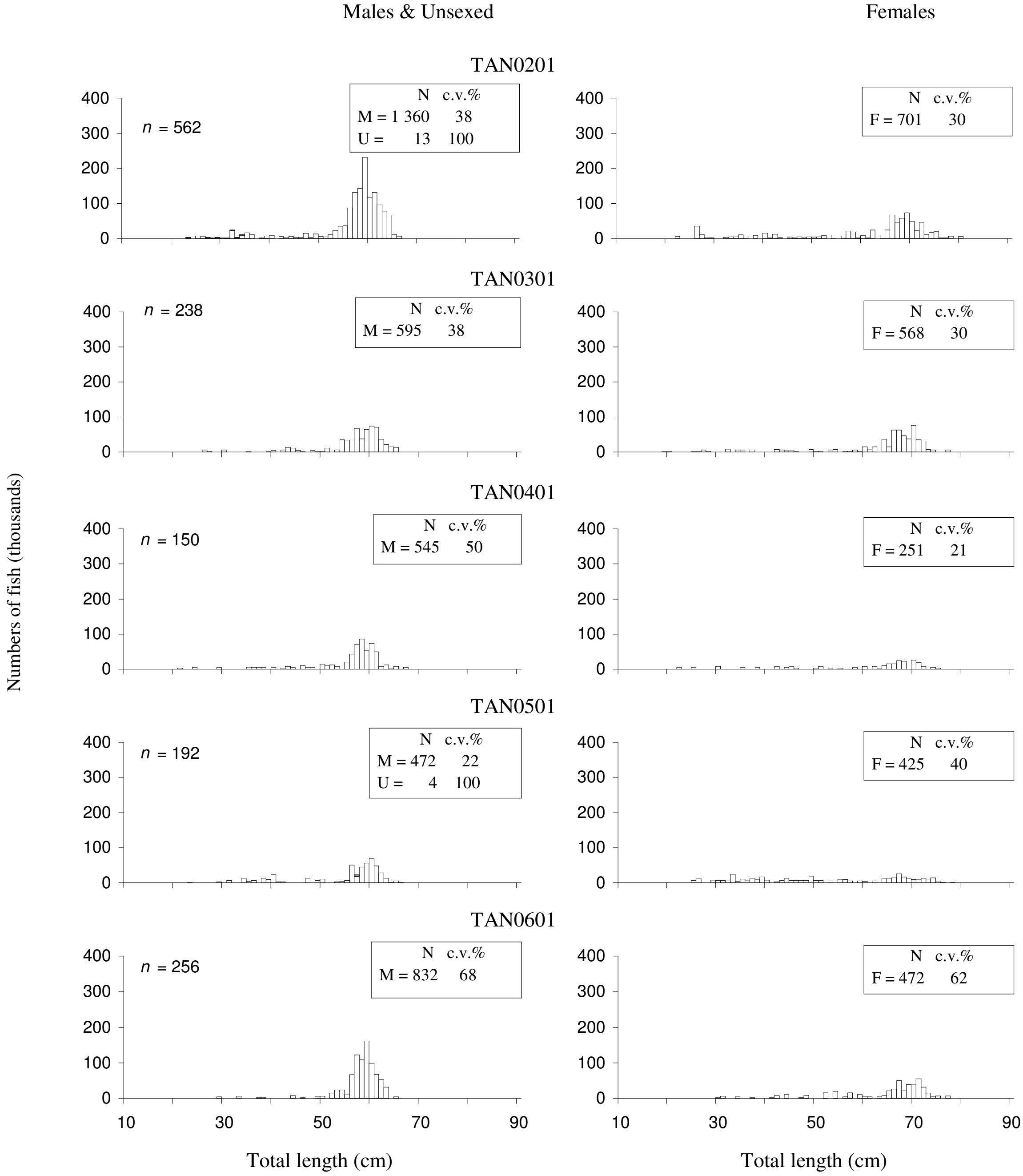


Figure 13: Scaled length frequencies for Baxter's dogfish from trawl surveys where more than 100 fish were measured. N, scaled number of fish (thousands); M, males; F, females; U (shaded), unsexed; n, number of fish measured. Areas and survey series are given in Appendix 2.

Sub-Antarctic survey series

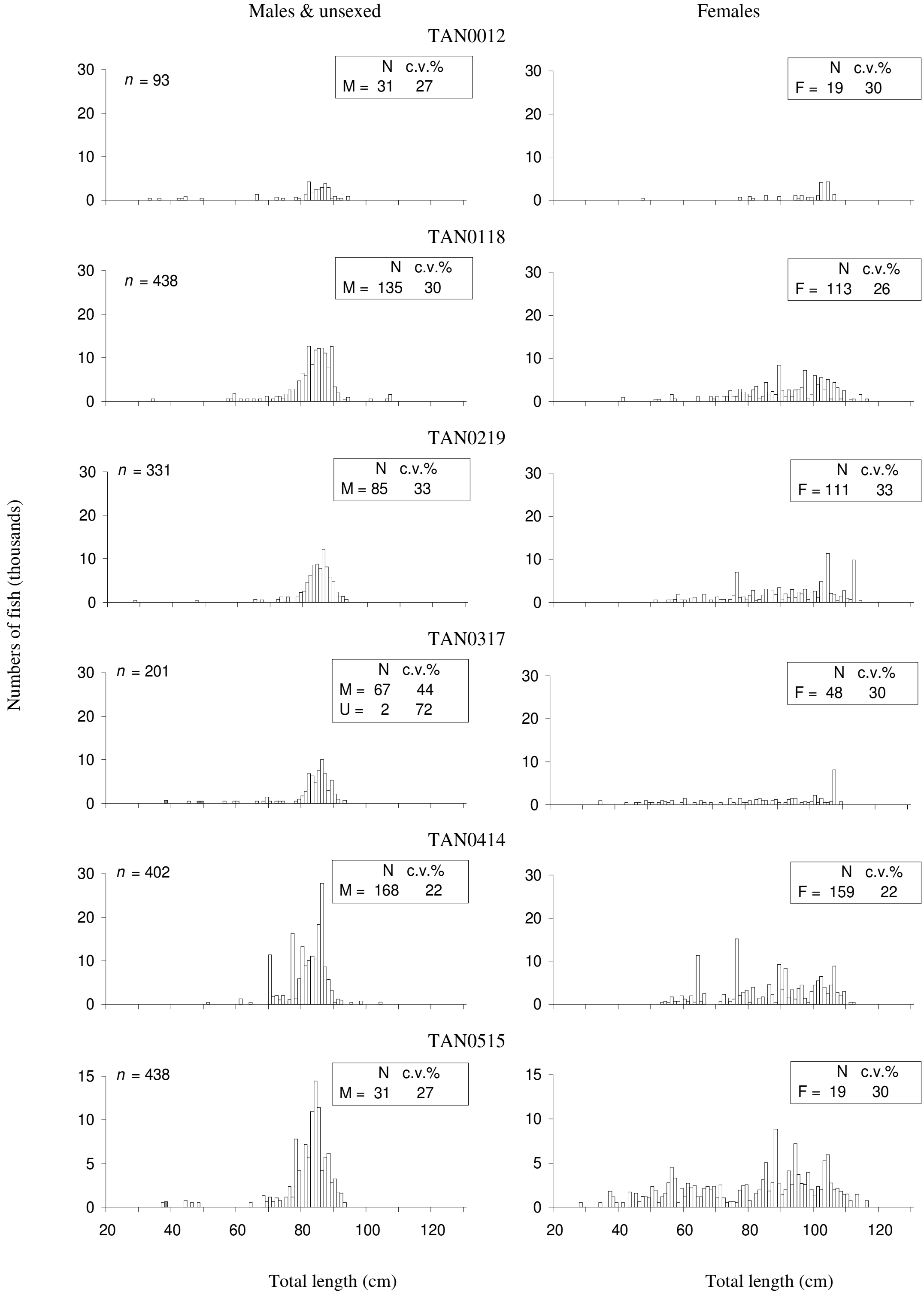


Figure 13: – continued.

Northwest Chatham Rise survey series

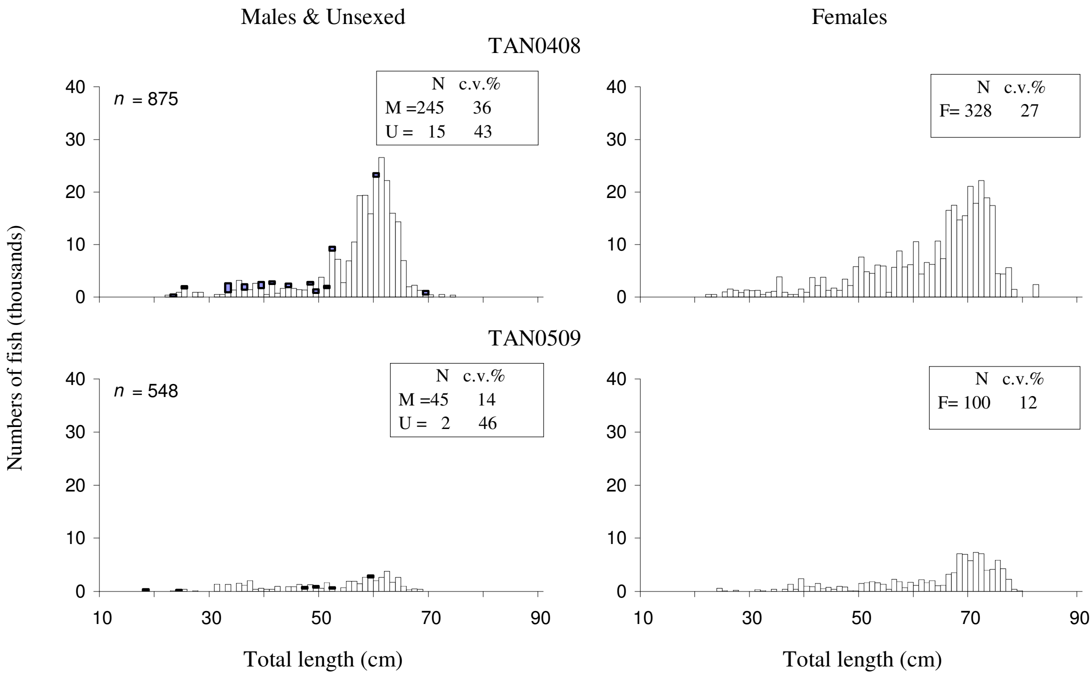


Figure 13: – continued.

4.3.3 Longnose velvet dogfish

Scaled length frequencies from the Chatham Rise 2002 –2006 (Figure 14) are similar in sex ratio and size composition, but show little signal suggestive of movement of size classes through the population.

Chatham Rise survey series

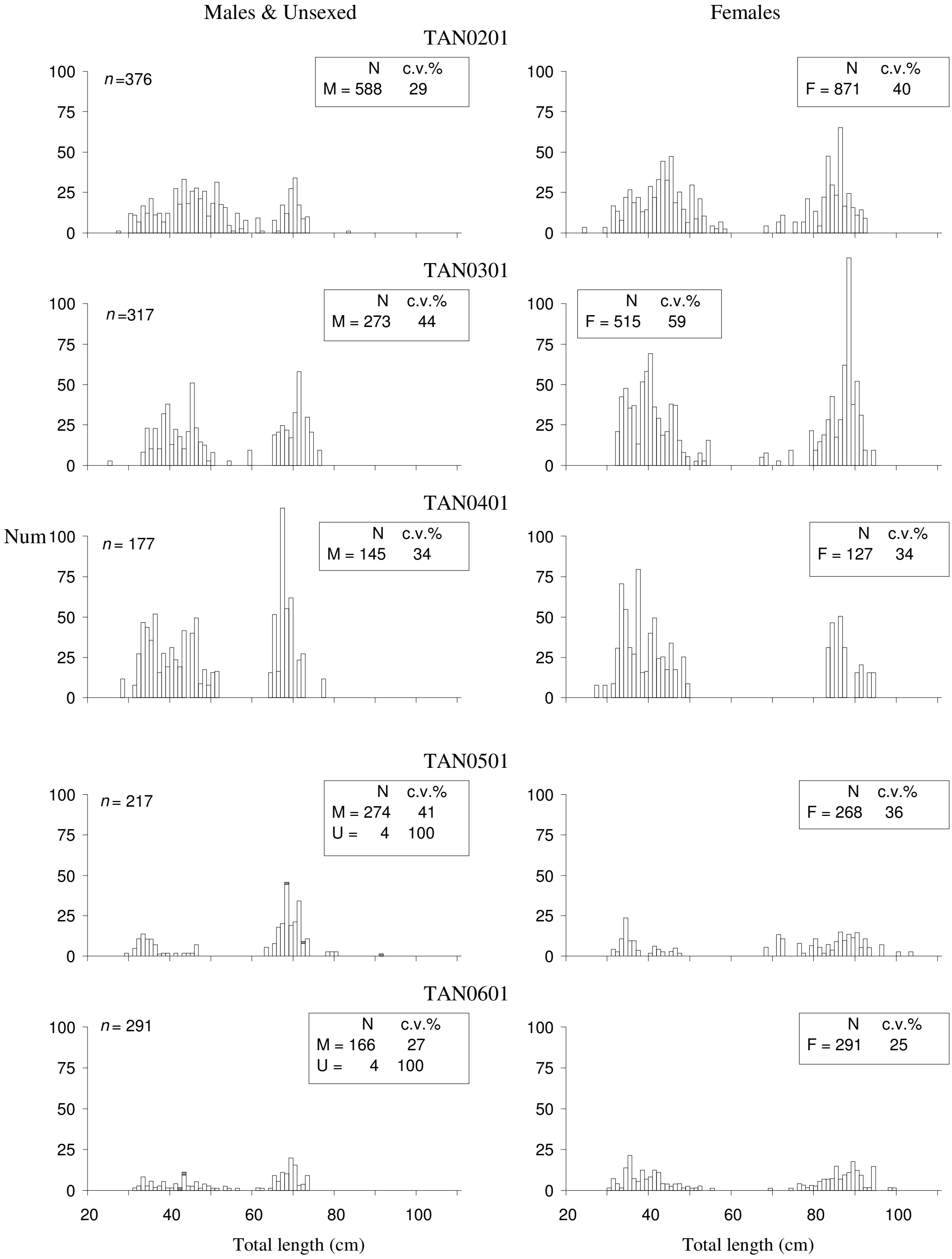


Figure 14: Scaled length frequencies for longnose velvet dogfish from trawl surveys where more than 100 fish were measured. N, scaled number of fish (thousands); M, males; F, females; U (shaded) unsexed; n, number of fish measured. Areas and survey series are given in Appendix 2.

Sub-Antarctic survey series

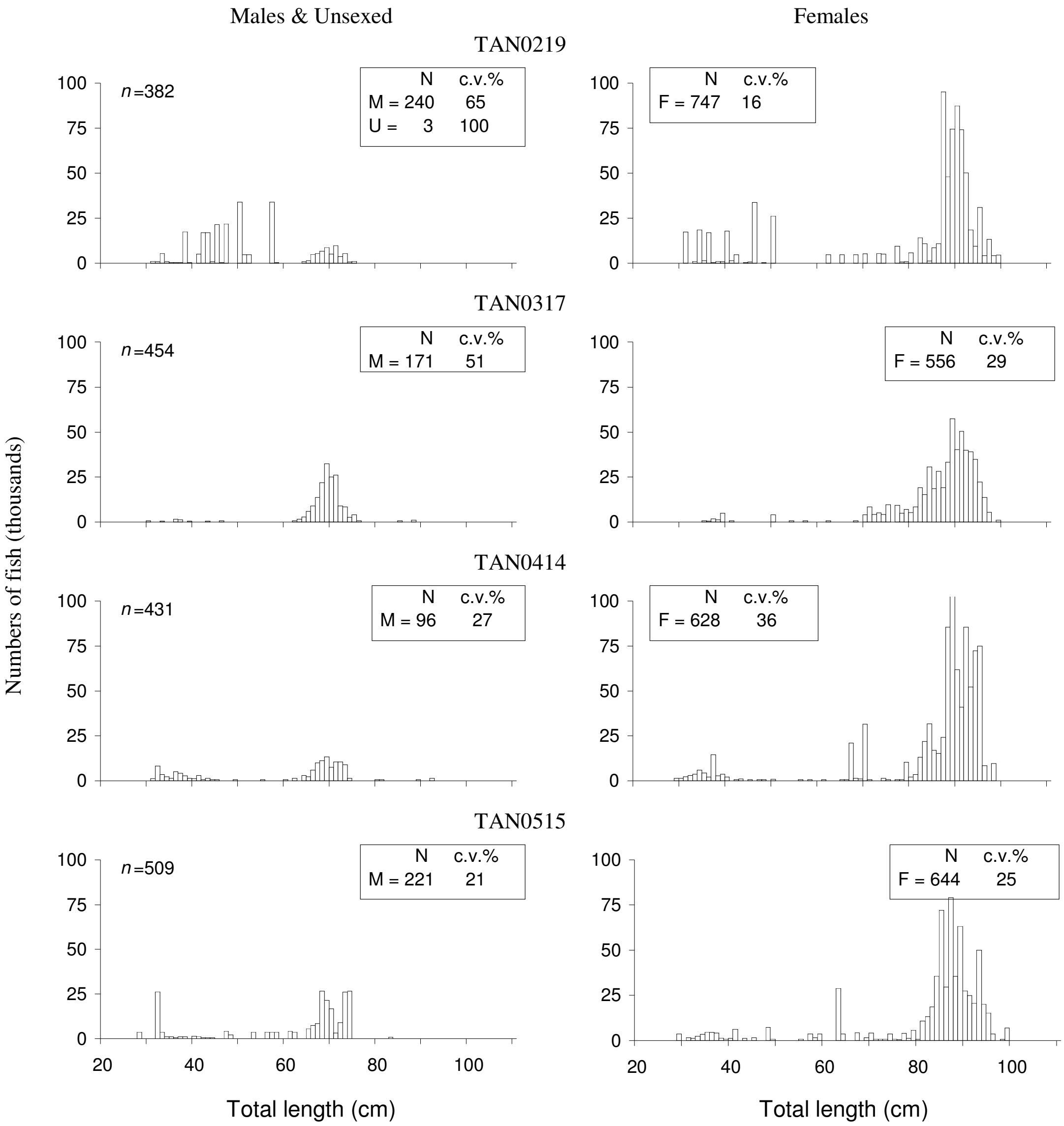


Figure 14: – continued

Northwest Chatham Rise survey series

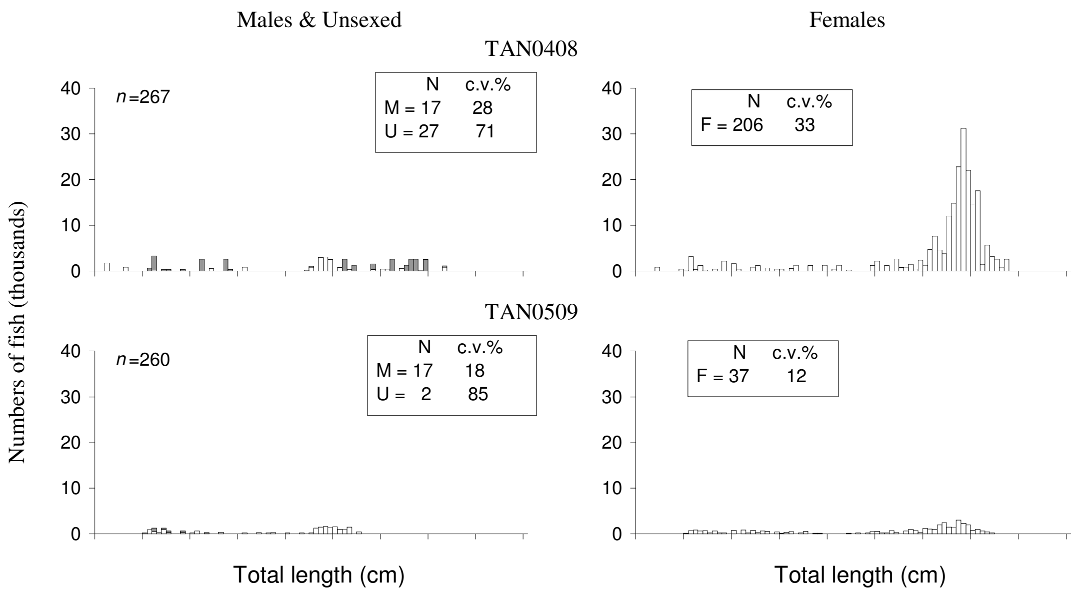


Figure 14: – continued.

5. DISCUSSION

Deepwater squaloid sharks are widely distributed through the deeper waters of the New Zealand EEZ (Anderson et al. 1998, 2001a, Blackwell & Stevenson 2003), and represent a moderately abundant, but relatively poorly known, fisheries resource. As they are relatively difficult to identify, catch and effort data from the commercial fishery poorly define their distribution and relative abundance. Trawl survey data and Observer data are generally of better quality, but are essentially limited to areas where existing deepwater fisheries have been established. The usefulness of the Observer database is limited by the large number of records where generic codes have been used. Little information is therefore available to adequately describe population trends in such widely distributed species and the results presented should be interpreted with caution.

Deepwater sharks also occur over seamounts (Tracey et al. 2004). Owston's dogfish, longnose velvet dogfish, and shovelnose dogfish were among 10 species that were reported from 9 of 10 seamounts examined in the EEZ. Baxter's dogfish was among the 6 species that occurred at 8 seamounts, while seal shark and leafscale gulper shark were among the 5 species that occurred at 7 seamounts. Lucifer dogfish was mainly found on the East Cape seamounts.

Distribution patterns are largely determined by depth and water temperature/latitude preferences (Francis et al. 2002). Shovelnose dogfish and seal shark occur over a wide depth range (600–1200 m), while longnose velvet dogfish, Owston's dogfish, and leafscale gulper shark are uncommon in deeper waters (over 600 m), and Baxter's dogfish is rarely reported in depths less than 600 m (McClatchie et al. 1996, Wetherbee 2000, Bull et al. 2001, Francis et al. 2002), These depth preferences largely determine the relative occurrence of deepwater sharks in middle-depths and deepwater target trawl fisheries on the Chatham Rise, and these patterns appear consistent between trawl survey and OP databases. Shovelnose dogfish was the dominant shark caught in the middle depths (600–800 m) hoki trawl fishery (Wetherbee 2000, Bull et al. 2001, Livingston et al. 2003). Seal shark was the dominant shark in the deeper water (750–1500 m) orange roughy fishery between 1985–86 and 2000–01, and Baxter's dogfish was the dominant shark in the deepwater (750–1500 m) oreo fishery during this period (Blackwell & Stevenson 2003).

Deepwater sharks are relatively long lived, have low fecundity, and are generally considered to be potentially vulnerable to overfishing (Last & Stevens 1994). While catch rates of deepwater shark species declined off New South Wales between the 1970s and the 1990s (Andrew et al. 1997, Stevens et al. 2000, Graham et al. 2001, Daley et al. 2002), previous examination of trends in catch and effort and relative biomass estimates from trawl surveys (Blackwell & Stevenson 2003, Livingston et al. 2003) did not indicate a similar general decline in relative abundance of these deepwater sharks in New Zealand waters between 1983 and 2003, although a decline in relative abundance was suggested for Baxter's dogfish on the south Chatham Rise.

After 2003 data are essentially confined to the middle depths of the Chatham Rise and the Sub-Antarctic, which cover only a small portion of the widespread distribution of these species. Relative biomass indices for shovelnose dogfish, Baxter's dogfish, and longnose velvet dogfish from the northeast Chatham Rise and from the Sub-Antarctic surveys generally showed little trend between 2003 and 2006, which is not consistent with trends from Australian waters, or from the New Zealand commercial fisheries data.

While the mid-slope fish fauna of southeastern Australia and the Chatham Rise are very similar, data from the commercial fishery may be influenced by differences in fishing patterns. In Australia, deepwater sharks, including *Centrophorus* spp., are targeted mainly for livers in the mixed Southern Shark fishery in 200–650 m. Others including *Deania calcea* and *Centroscymnus* spp. are targeted in the mixed species South East Trawl fishery in 650–1200 m for livers and flesh products.

In New Zealand, deepwater sharks are generally taken as a minor bycatch of deepwater trawl fishing for hoki, orange roughy, and oreos. As a result, the associated bycatch of deepwater sharks in these fisheries may be relatively low, due to the focused nature of fishing on spawning aggregations of the target species (Koslow et al. 1994, Daley et al. 1998, Francis et al. 2002, Livingston et al. 2003, Tracey et al. 2004).

Trends in the commercial fishery data for deepwater dogfish are unreliable. The catch and landings data remain inaccurate, inconsistent among data sources, and underestimate actual catch. The apparent decline in overall catch after 2001–02 may be may be misleading. Reported catches before 1999 are likely to grossly under-report actual deepwater shark catches, while the reported declines in more recent catches are likely to be confounded with the removal of catches of other shark species (such as pelagic sharks) through better reporting and more accurate species identification of deepwater sharks. The reported catches of seal shark and shovelnose dogfish remained relatively stable, or appeared to increase, and insufficient information was available for the other deepwater shark species to determine trends. These data were also influenced by inaccurate estimation of dumped catch, and possible inconsistencies in the application of the conversion factors used to estimate greenweight catches (Francis 1998, Blackwell & Stevenson 2003, Blackwell et al. 2005). Caution is advised in interpreting these trends.

A higher level of species identification would be expected from the Scientific Observer Programme, but these data were also confounded by poor species identification and mis-reporting, and by between-year variability in observer coverage of the target hoki, orange roughy, and oreo fisheries, especially outside the Chatham Rise. These data are derived from tows targeted at high concentrations of the target fish, instead of from randomly allocated stations, and may provide biased estimates of bycatch and relative abundance of deepwater sharks. Trends that are not supported by data derived from random trawl surveys should be interpreted with caution.

Trawl fishing in the deep waters of the New Zealand coastal shelf and slope is known to influence the structure of demersal communities (Clark et al. 2000a, Stevens et al. 2000, Anderson et al. 2001b), yet deepwater sharks appear to be relatively resilient to the high levels of fishing effort associated with the target hoki and orange roughy fisheries on the Chatham Rise (Livingston et al. 2003) and the Sub-Antarctic (Blackwell & Stevenson 2003). Livingston et al. (2003) reviewed commercial catch and OP data from the target hoki fishery on the northeast Chatham Rise. Shovelnose dogfish and longnose velvet dogfish relative abundance increased between 1984 and 1994, while little change occurred for leafscale gulper shark, Owston’s dogfish, or seal shark. A decline in Baxter’s dogfish contrasted with an increase in relative abundance on the south Chatham Rise between 1991 and 1995. The recent trawl survey indices are consistent with these earlier data, and suggest little change has occurred between 1994 and 2005 for these species.

Deepwater sharks are generally considered to have low productivity and fecundity (Wetherbee 2000) and remain potentially vulnerable to overfishing (Andrew et al. 1997), so continued monitoring of catch and effort data is recommended. The poor quality of data from the commercial fishery during the review period is of concern, particularly as an identification guide for these species is now available (Tracey & Shearer 2002). The continued use of generic species codes in both the commercial fishery and the Scientific

Observer Programme effectively precluded the identification and interpretation of trends among these species.

Since the review period, recent developments have improved our knowledge of deepwater sharks. Recent research has reviewed species interactions in the deepwater environment (Tuck et al. 2009), and a management plan has been introduced for all shark species (Ministry of Fisheries 2008). The earlier identification guide to deepwater sharks (Tracey et al. 2002) has now been expanded to include most middle depths and deepwater commercial target and bycatch fish species (McMillan et al. 2009). The NABIS metadatabase provides improved access to distribution and relative abundance of these deepwater shark species, initially at least for shovelnose dogfish and seal shark.

Improved knowledge and more accurate species identification will improve data quality of both commercial fishery data and the Scientific Observer database, whilst reduced useage of the generic shark codes is consistent with the action plan for shark species.

6. RECOMMENDATIONS

- Continue to monitor catch, effort and survey data.
- Promote better species identification of deepwater sharks by commercial fishers and Scientific Observers, through more widespread use of identification guides to deepwater fish species.
- Promote the minimal use of generic codes for deepwater sharks.

7. ACKNOWLEDGMENTS

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Appendix 1: Summary of estimated catch (t) of deepwater sharks from TCEPR and CELR reports combined by nominated target species. BSH, seal shark; CSQ, leafscale gulper shark; ETB, Baxter's dogfish; SND, shovelnose dogfish; DWD, deepwater dogfish (unspecified); OSD, other sharks and dogfish (unspecified). Recent data from MFish extract, February 2007, data before 2001–01 after Blackwell & Stevenson (2003). Note: No landings were reported for Owston's dogfish (CYO) or longnose velvet dogfish (CYP).

Fishing year					1989–90			
Target species	Species code	BSH	CSQ	ETB	SND	DWD	OSD	Total
Hoki	HOK	1	0	0	119	2	151	273
Orange roughy	ORH	69	0	0	4	11	68	152
Other		19	0	0	7	0	67	93
Ling	LIN	47	0	0	1	0	3	51
Oreo (all)	BOE, OEO.SSO	12	0	0	0	0	11	23
Squid	SQU	0	0	0	0	0	13	13
Groper	HAP	4	0	0	0	0	2	6
Total		152	0	0	131	13	315	611

Fishing year					1990/91			
Target species	Species code	BSH	CSQ	ETB	SND	DWD	OSD	Total
Other		21	0	0	1	0	85	107
Hoki	HOK	1	0	0	1	6	79	86
Orange roughy	ORH	38	0	0	13	0	29	80
Ling	LIN	69	0	0	0	0	8	77
Oreo (all)	BOE, OEO,SSO	15	0	0	3	0	0	18
Squid	SQU	0	0	0	0	0	13	13
Bluenose	BNS	4	0	0	0	0	1	5
Total		148	0	0	18	6	215	386

Fishing year					1991–92			
Target species	Species code	BSH	CSQ	ETB	SND	DWD	OSD	Total
Ling	LIN	75	0	0	0	0	22	97
Other		38	3	0	0	0	56	97
Squid	SQU	0	0	0	0	0	84	84
Orange roughy	ORH	0	0	0	0	0	60	60
Hoki	HOK	2	0	0	0	0	30	32
Total		115	3	0	0	0	252	370

Fishing year					1992–93			
Target species	Species code	BSH	CSQ	ETB	SND	DWD	OSD	Total
Ling	LIN	100	0	0	1	1	39	141
Hoki	HOK	1	0	0	1	0	118	120
Other		73	0	0	0	1	46	120
Orange roughy	ORH	1	0	0	0	1	58	60
Seal shark	BSH	19	0	0	0	1	0	20
Bluenose	BNS	5	0	0	1	0	2	8
Groper	HPB	4	0	0	0	0	3	7
Total		203	0	0	3	4	266	476

Fishing year					1993–94			
Target species	Species code	BSH	CSQ	ETB	SND	DWD	OSD	Total
Ling	LIN	127	0	0	1	0	71	199
Other		95	0	0	1	0	49	145
Hoki	HOK	1	0	0	0	1	89	91
Orange roughy	ORH	2	0	0	0	2	36	40
Seal shark	BSH	7	0	0	0	0	0	7
Total		232	0	0	2	3	245	482

Appendix 1: – continued

Fishing year					1994–95			
Target species	Species code	BSH	CSQ	ETB	SND	DWD	OSD	Total
Ling	LIN	147	0	0	2	0	70	219
Hoki	HOK	0	0	0	0	1	117	118
Orange roughy	ORH	70	0	0	0	5	34	109
Other		30	0	0	10	1	41	82
Bluenose	BNS	6	0	0	0	0	9	15
Groper	HPB	5	0	0	0	0	4	9
Oreo (all)	BOE, OEO, SSO	3	0	0	0	0	5	8
Sth blue whiting	SBW	0	0	0	0	0	0	0
TCEPR subtotal		261	0	0	12	7	280	560

Fishing year					1995–96			
Target species	Species code	BSH	CSQ	ETB	SND	DWD	OSD	Total
Ling	LIN	108	7	0	3	1	73	192
Other		66	1	0	21	3	66	157
Hoki	HOK	1	0	0	1	4	130	136
Orange roughy	ORH	1	0	0	0	3	21	25
Bluenose	BNS	7	0	0	0	0	3	10
Groper	HPB	5	0	0	0	0	5	10
Total		188	8	0	25	11	298	530

Fishing year					1996–97			
Target species	Species code	BSH	CSQ	ETB	SND	DWD	OSD	Total
Ling	LIN	151	10	0	10	0	104	275
Hoki	HOK	11	0	0	0	13	127	151
Other		38	0	0	14	0	41	93
Orange roughy	ORH	11	0	0	0	0	39	50
Groper	HPB	15	0	0	0	0	4	19
Oreo (all)	BOE, OEO, SSO	9	0	0	0	9	0	18
Squid	SQU	0	0	0	0	0	5	5
Total		235	10	0	24	22	320	610

Fishing year					1997–98			
Target species	Species code	BSH	CSQ	ETB	SND	DWD	OSD	Total
Hoki	HOK	22	0	2	<1	3	259	286
Ling	LIN	157	5	0	24	1	39	226
Orange roughy	ORH	23	0	3	<1	3	55	83
Oreo (all)	BOE, OEO, SSO	7	0	0	0	11	51	69
Other		22	0	0	1	0	43	66
Bluenose	BNS	9	0	0	0	0	0	9
Total		240	5	5	25	18	447	740

Fishing year					1998–99			
Target species	Species code	BSH	CSQ	ETB	SND	DWD	OSD	Total
Hoki	HOK	142	0	0	24	18	428	612
Ling	LIN	135	1	0	8	0	73	217
Orange roughy	ORH	46	0	4	2	21	44	117
Other		19	0	0	2	1	53	75
Oreo (all)	BOE, OEO, SSO	12	0	15	0	8	14	49
Bluenose	BNS	6	0	0	0	0	6	12
Groper	HPB	8	0	0	0	0	4	12
Hake	HAK	0	0	0	0	0	9	9
Total		368	1	19	36	48	631	1103

Fishing year					1999–00			
Target species		BSH	CSQ	ETB	SND	DWD	OSD	Total
Hoki	HOK	199	0	0	49	4	440	692
Orange roughy	ORH	58	0	0	0	31	59	148
Ling	LIN	92	0	0	8	0	41	141
Other	SQU	39	0	0	6	2	60	107
Oreo (all)	BOE, OEO, SSO	38	0	4	0	22	41	105
Bluenose	BNS	7	0	0	2	0	5	14
Groper	HPB	8	0	0	0	0	4	12
		441	0	4	65	59	650	1219

Appendix 1: – continued

Fishing year		2000–01						
Target species		BSH	CSQ	ETB	SND	DWD	OSD	Total
Hoki	HOK	209	0	0	119	18	491	836
Ling	LIN	160	0	0	3	0	63	226
Orange roughy	ORH	34	0	7	4	97	21	163
Oreo	OEO	14	0	32	0	73	11	130
Other		26	0	1	0	0	40	67
Bluenose	BNS	12	0	0	0	0	1	13
Squid	SQU	0	0	0	0	0	11	11
Groper	HPB	6	0	0	0	0	4	10
Hake	HAK	1	0	0	0	0	7	8
Total		462	0	40	126	188	648	1463

Fishing year		2001/02						
Target species	Species code	BSH	CSQ	ETB	SND	DWD	OSD	Total
Hoki	HOK	268	0	0	174	5	298	745
Orange roughy	ORH	58	0	0	10	118	37	223
Oreo	OEO, SSO	11	0	0	0	26	36	73
Squid	SQU	0	0	0	0	0	13	13
White warehou	WWA	0	0	0	0	0	7	7
Total		337	0	0	184	149	391	1061

Fishing year		2002/03						
Target species	Species code	BSH	CSQ	ETB	SND	DWD	OSD	Total
Hoki	HOK	123	0	0	81	24	306	534
Orange roughy	ORH	94	0	0	21	93	76	284
Oreo	OEO, SSO	14	0	0	0	33	27	74
Total		231	0	0	102	150	409	892

Fishing year		2003/04						
Target species	Species code	BSH	CSQ	ETB	SND	DWD	OSD	Total
Hoki	HOK	157	0	0	84	43	301	585
Orange roughy	ORH	81	0	0	0	64	66	211
Oreo	OEO, SSO	21	0	0	0	32	26	79
Squid	SQU	0	0	0	0	0	22	22
Hake	HAK	0	0	0	0	0	6	6
Total		259	0	0	84	139	421	903

Fishing year		2004/05						
Target species	Species code	BSH	CSQ	ETB	SND	DWD	OSD	Total
Hoki	HOK	100	0	0	62	15	147	324
Orange roughy	ORH	39	0	0	28	68	45	180
Oreo	OEO, SSO	16	0	0	0	17	14	47
Squid	SQU	0	0	0	0	0	6	6
Alfonsino	BYX	0	0	0	0	0	12	12
Cardinal	CDL	0	0	0	0	0	5	5
Hake	HAK	0	0	0	0	5	0	5
White warehou	WWA	0	0	0	0		6	6
Total		155	0	0	90	105	235	585

Fishing year		2005/06						
Target species	Species code	BSH	CSQ	ETB	SND	DWD	OSD	Total
Oreo	BOE, OEO, SSO	17	0	0	0	18	59	94
Hake	HAK	0	0	0	0	5	10	15
Hoki	HOK	99	0	0	76	22	129	326
Ling	LIN	0	0	0	0	0	19	19
Orange roughy	ORH	61	0	0	30	53	82	226
Squid	SQU	0	0	0	0	0	8	8
Total		177	0	0	106	98	307	688

Appendix 2: Records of deepwater sharks from trawl surveys, 2002 to 2006, where areas are defined in the *trawl* database

Trip code	Areas	Number of stations where reported	Number of length frequencies recorded		
			Males	Females	Total
Shovelnose dogfish					
TAN0213	Southwest Chatham Rise	2			4
TAN0219	Sub-Antarctic*	21	180	151	331
TAN0301	Chatham Rise	33	354	509	865
TAN0317	Sub-Antarctic*	9	121	77	201
TAN0401	Chatham Rise, Mernoo Bank	39	321	383	713
TAN0408	Northeast Chatham Rise	55	674	821	1 540
TAN0414	Sub-Antarctic*	18	208	194	402
TAN0501	Chatham Rise	39	358	432	793
TAN0509	Northwest Chatham Rise	71	394	120	515
TAN0515	Sub-Antarctic*	17	150	244	395
TAN0601	Chatham Rise	41	437	381	822
Baxter's dogfish					
TAN0213	Southwest Chatham Rise	21	230	165	435
TAN0219	Sub-Antarctic*	36	187	178	365
TAN0301	Chatham Rise	19	123	115	238
TAN0317	Sub-Antarctic*	26	130	189	319
TAN0401	Chatham Rise, Mernoo Bank	18	97	53	150
TAN0408	Northeast Chatham Rise	54	373	489	877
TAN0414	Sub-Antarctic*	38	176	180	373
TAN0501	Chatham Rise	18	96	95	192
TAN0509	Northwest Chatham Rise	80	157	385	548
TAN0515	Sub-Antarctic*	43	172	168	341
TAN0601	Chatham Rise	17	159	97	256
Owston's dogfish					
TAN0219	Sub-Antarctic*	10	64	13	77
TAN0301	Chatham Rise	3	18	5	23
TAN0317	Sub-Antarctic*	5	12	19	31
TAN0401	Chatham Rise, Mernoo Bank	2	16	9	28
TAN0408	Northeast Chatham Rise	32	32	35	69
TAN0414	Sub-Antarctic*	5	5	17	22
TAN0501	Chatham Rise	6	24	20	44
TAN0509	Northwest Chatham Rise	69	160	106	267
TAN0515	Sub-Antarctic*	10	37	61	99
TAN0601	Chatham Rise	6	7	10	17
Longnose velvet dogfish					
TAN0213	Southwest Chatham Rise	7	1	3	9
TAN0219	Sub-Antarctic*	22	165	209	382
TAN0301	Chatham Rise	16	124	208	332
TAN0317	Sub-Antarctic*	16	208	246	454
TAN0401	Chatham Rise, Mernoo Bank	9	93	84	177
TAN0408	Northeast Chatham Rise	41	28	214	267
TAN0414	Sub-Antarctic*	20	152	279	431
TAN0501	Chatham Rise	15	104	110	217
TAN0509	Northwest Chatham Rise	69	77	175	260
TAN0515	Sub-Antarctic*	27	117	394	511
TAN0601	Chatham Rise	12	112	177	291

* Includes the areas Puysegur, Auckland Island Rise, Campbell Island Rise, Pukaki Rise, and Stewart-Snares Shelf

Appendix 2: – continued

Trip code	areas	Number of stations where reported	of length frequencies recorded Males	Females	Total
Leafscale gulper shark					
TAN0219	Sub-Antarctic*	18	40	41	82
TAN0301	Chatham Rise	10	7	8	15
TAN0317	Sub-Antarctic*	12	12	16	28
TAN0401	Chatham Rise, Mernoo Bank	7	2	12	14
TAN0408	Northeast Chatham Rise	8	3	22	25
TAN0414	Sub-Antarctic*	14	66	80	149
TAN0501	Chatham Rise	18	9	24	33
TAN0509	Northwest Chatham Rise	34	17	51	68
TAN0515	Sub-Antarctic*	22	34	43	79
TAN0601	Chatham Rise	12	4	15	19
Seal shark					
TAN0219	Sub-Antarctic*	9	4	6	10
TAN0301	Chatham Rise	27	23	32	55
TAN0317	Sub-Antarctic*	5	3	12	15
TAN0401	Chatham Rise, Mernoo Bank	28	20	46	66
TAN0408	Northeast Chatham Rise	11	5	8	15
TAN0414	Sub-Antarctic*	12	12	15	27
TAN0501	Chatham Rise	27	17	27	46
TAN0509	Northwest Chatham Rise	5	3	7	10
TAN0515	Sub-Antarctic*	13	6	18	24
TAN0601	Chatham Rise	20	5	28	33

* Includes the areas Puysegur, Auckland Island Rise, Campbell Island Rise, Pukaki Rise, and Stewart-Snares Shelf

Appendix 3: Length-weight relationship parameters used to scale length frequencies. Length and weight data for the nominated surveys were derived from previous surveys that provided the most complete length and weight data over the widest range of lengths to provide the most accurate regression equation for each species. The location data for recent surveys are provided in Appendix 2. Data for earlier surveys were provided by Blackwell & Stevenson (2003).

$W = a L^b$ where W is weight (g) and L is length (cm);

Species	*a*	*b*	n	Data source
TAN0012				
SND	0.001	3.288	227	TAN0012, TAN0515
TAN0118				
SND	0.001	3.288	227	TAN0118, TAN0515
TAN0213				
ETB	0.003	3.106	213	TAN0213
BSH	0.001	3.324	166	TAN0219, TAN0301, TAN0317, TAN0401, TAN0408, TAN0501, TAN.0509
CSQ	0.001	3.459	341	TAN0219, TAN0301, TAN0317, TAN0401, TAN408, TAN0414, TAN0501, TAN0515
CYO	0.002	3.215	83	TAN0208
CYP	0.001	3.406	273	TAN0208
ETB	0.001	3.454	660	TAN0208
SND	0.001	3.193	138	TAN0208
TAN0301				
CYP	0.001	3.315	231	TAN0317
ETB	0.004	3.075	124	TAN0301
SND	0.001	3.194	378	TAN0501
TAN0317				
CYP	0.001	3.315	231	TAN0317
ETB	0.004	3.075	124	TAN0301
SND	0.001	3.216	1213	TAN0408
TAN0401				
CYP	0.004	3.050	267	TAN0408
ETB	0.003	3.157	796	TAN0408
SND	0.001	3.216	1213	TAN0408
TAN0408				
CYP	0.004	3.050	267	TAN0408
ETB	0.003	3.157	796	TAN0408
SND	0.001	3.216	1213	TAN0408
TAN0414				
CYP	0.001	3.338	293	TAN0414
ETB	0.003	3.127	305	TAN0414
SND	0.001	3.216	1213	TAN0408
TAN0501				
CYP	0.003	3.094	260	TAN0509
ETB	0.002	3.254	548	TAN0509
SND	0.002	3.065	515	TAN0501

Appendix 3: – continued

Species	*a*	*b*	n	Data source
TAN0509				
CYP	0.003	3.094	260	TAN0509
ETB	0.002	3.254	548	TAN0509
SND	0.002	3.065	515	TAN0509
TAN0515				
CYP	0.002	3.250	296	TAN0515
ETB	0.002	3.291	287	TAN0515
SND	0.001	3.288	227	TAN0515
TAN0601				
CYP	0.001	3.269	90	TAN0601
ETB	0.002	3.291	287	TAN0515
SND	0.002	3.136	445	TAN0601