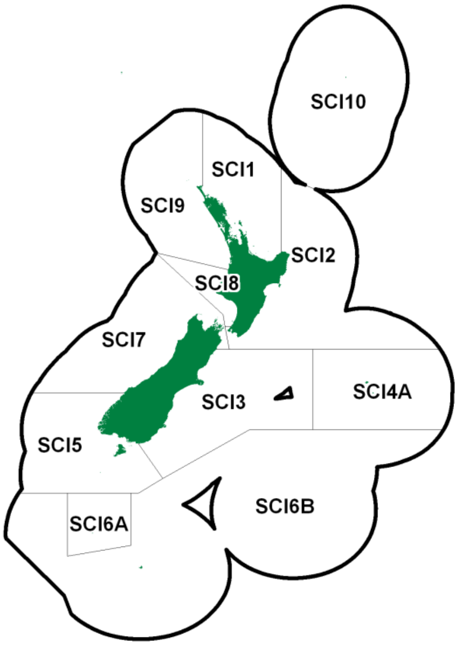
SCAMPI (SCI)

(*Metanephrops challengeri*)



1. FISHERY SUMMARY

Scampi were introduced into the QMS on 1 October 2004. At this time, management areas for scampi on the Chatham Rise (SCI 3 and 4) and in the Sub-Antarctic (SCI 6A and 6B) were substantially modified. Current TACs and TACCs by Fishstock are shown in Table 1.

Table 1: Total allowable catches (TAC, t) allowances for customary fishing, recreational fishing, and other sources of mortality (t) and Total Allowable Commercial Catches (TACC, t) declared for scampi.

		Allowances			
Fishstock	TAC	Customary	Recreational	Other*	TACC
SCI 1	126	0	0	6	120
SCI 2	140	0	0	7	133
SCI 3	357	0	0	17	340
SCI 4A	126	0	0	6	120
SCI 5	42	0	0	2	40
SCI 6A	321	0	0	15	306
SCI 6B	53	0	0	3	50
SCI 7	79	0	0	4	75
SCI 8	5	0	0	0	5
SCI 9	37	0	0	2	35
SCI 10	0	0	0	0	0

1.1 Commercial fisheries

Target trawl fisheries for scampi developed first in the late 1980s. Access was restricted and, until the 1999–00 fishing year, there were restrictions on the vessels that could be used in each stock. Between October 1991 and September 2002, catches were restrained using a mixture of competitive and individually allocated catch limits but between October 2001 and September 2004, all scampi fisheries were managed using competitive catch limits (Table 2, Figure1).

Table 2. Estimated commercial landings (t) from the 1986–87 to present (based on management areas in force since introduction to the QMS in October 2004) and catch limits (t) by Fishstock (from CLR and TCEPR, MFish landings and catch effort databases, early years may be incomplete). No limits before 1991–92 fishing year, (†) catch limits allocated individually until the end of 2000–01. *Note that management areas SCI 3, 4A, 6A and 6B changed in October 2004, and the catch limits applied to the old areas are not relevant to the landings, which have been reallocated to the revised areas on a pro-rata basis in relation to the TECPR data, which has previously been found to match landings well.

	SCI 1		SCI 2		SCI 3		SCI 4A		SCI 5	
	Landings	Limit (†)/TACC	Landings	Limit (†)/TACC	Landings	Limit (†)/TACC	Landings	Limit (†)/TACC	Landings	Limit (†)/TACC
1986–87	5	–	0	–	0	–	0	–	0	–
1987–88	15	–	5	–	0	–	0	–	0	–
1988–89	60	–	17	–	0	–	0	–	0	–
1989–90	104	–	138	–	0	–	0	–	0	–
1990–91	179	–	295	–	0	–	32	–	0	–
1991–92	132	120	221	246	153	–	78	–	0	60
1992–93	114	120	210	246	296	–	11	–	2	60
1993–94	115	120	244	246	324	–	0	–	1	60
1994–95	114	120	226	246	292	–	0	–	0	60
1995–96	117	120	230	246	306	–	0	–	0	60
1996–97	117	120	213	246	304	–	0	–	2	60
1997–98	107	120	224	246	296	–	0	–	0	60
1998–99	110	120	233	246	292	–	28	–	30	60
1999–00	124	120	193	246	322	–	23	–	9	40
2000–01	120	120	146	246	333	–	0	–	7	40
2001–02	124	120	247	246	304	–	30	–	< 1	40
2002–03	121	120	134	246	264	–	79	–	7	40
2003–04	120	120	64	246	277	–	41	–	5	40
2004–05	114	120	71	200	335	340	101	120	1	40
2005–06	109	120	77	200	319	340	79	120	< 1	40
2006–07	110	120	80	200	307	340	39	120	< 1	40
2007–08	102	120	61	200	209	340	8	120	< 1	40
2008–09	86	120	52	200	190	340	1	120	< 1	40
2009–10	111	120	125	200	302	340	< 1	120	< 1	40
2010–11	114	120	128	100	256	340	43	120	< 1	40
2011–12	114	120	99	100	278	340	41	120	< 1	40
2012–13	126	120	96	100	300	340	55	120	<1	40

	SCI 6A		SCI 6B		SCI 7		SCI 8		SCI 9	
	Landings	Limit (†)/TACC	Landings	Limit (†)/TACC	Landings	Limit (†)/TACC	Landings	Limit (†)/TACC	Landings	Limit (†)/TACC
1986–87	0	–	0	–	0	–	0	–	0	–
1987–88	0	–	0	–	0	–	0	–	0	–
1988–89	0	–	0	–	0	–	0	–	0	–
1989–90	0	–	0	–	0	–	0	–	0	–
1990–91	2	–	0	–	0	–	0	–	0	–
1991–92	325	–	0	–	0	75	0	60	0	60
1992–93	279	–	0	–	2	75	0	60	2	60
1993–94	303	–	0	–	0	75	0	60	1	60
1994–95	239	–	0	–	2	75	0	60	0	60
1995–96	270	–	0	–	1	75	0	60	0	60
1996–97	275	–	0	–	0	75	0	60	0	60
1997–98	279	–	0	–	0	75	0	60	0	60
1998–99	325	–	< 1	–	1	75	0	60	< 1	60
1999–00	328	–	0	–	1	75	0	5	0	35
2000–01	264	–	0	–	< 1	75	0	5	0	35
2001–02	272	–	0	–	< 1	75	0	5	0	35
2002–03	255	–	0	–	< 1	75	0	5	0	35
2003–04	311	–	0	–	1	75	0	5	0	35
2004–05	295	306	0	50	1	75	0	5	0	35
2005–06	286	306	0	50	1	75	0	5	0	35
2006–07	302	306	0	50	< 1	75	0	5	0	35
2007–08	287	306	0	50	1	75	0	5	0	35
2008–09	264	306	< 1	50	1	75	0	5	0	35
2009–10	144	306	0	50	2	75	0	5	0	35
2010–11	198	306	< 1	50	4	75	0	5	0	35
2011–12	166	306	< 1	50	6	75	0	5	< 1	35
2012–13	146	306	0	50	7	75	0	5	<1	35

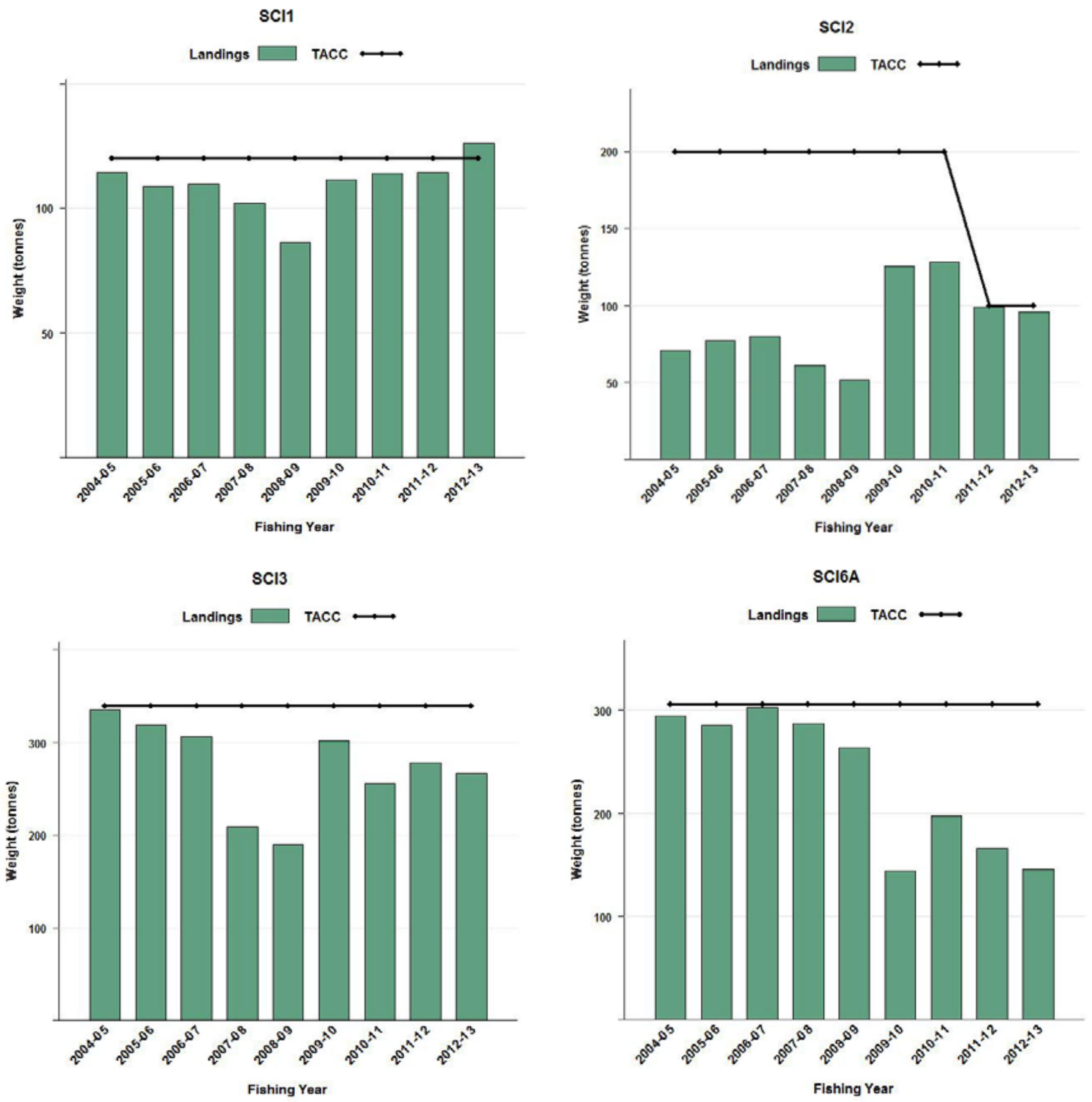


Figure 1: Historical landings and TACCs for the four main SCI stocks from fishing years 2004-05 to present. SCI 1, SCI 2 , SCI 3 and SCI 6A.

Fishing is conducted by 20–40 m vessels using light bottom trawl gear. All vessels use multiple rigs of two or three nets of very low headline height. The main fisheries are in waters 300–500 m deep in SCI 1 (Bay of Plenty), SCI 2 (Hawke Bay, Wairarapa Coast), SCI 3 (Mernoo Bank) SCI 4A (western Chatham Rise and Chatham Islands) and SCI 6 (Sub-Antarctic). Some fishing has been reported on the Challenger Plateau outside the EEZ. Minimal fishing for scampi has taken place in SCI 5, 6B, 7, 8 and 9.

1.2 Recreational fisheries
There is no recreational fishery for scampi.

1.3 Maori customary fisheries
There is no customary fishery for scampi.

1.4 Illegal catch
There is no quantitative information on the level of illegal catch.

1.5 Other sources of mortality
Other sources of fishing related mortality in scampi could include incidental effects of trawl gear on the animals and their habitat.

2. BIOLOGY

Scampi are widely distributed around the New Zealand coast, principally in depths between 200 and 500 m on the continental slope. Like other species of *Metanephrops* and *Nephrops*, *M. challengeri* builds a burrow in the sediment and may spend a considerable proportion of time within this burrow. From trawl catch rates, it appears that there are daily and seasonal cycles of emergence from burrows onto the sediment surface.

Scampi moult several times per year in early life and probably about once a year after sexual maturity (at least in females). Early work suggested that female *M. challengeri* achieve sexual maturity at about 40 mm orbital carapace length (OCL) in the Bay of Plenty and on the Chatham Rise, about 36 mm OCL off the Wairarapa coast, and about 56 mm OCL around the Auckland Islands. Examination of ovary maturity on more recent trawl surveys suggest that 50% of females were mature at 30 mm OCL in SCI 1 and 2, and at about 38 mm in SCI 6A. The peak of moulting and spawning activity seems to occur in spring or early summer. Larval development of *M. challengeri* is probably very short, and may be less than three days in the wild. The abbreviated larval phase may, in part, explain the low fecundity of *M. challengeri* compared with *N. norvegicus* (that of the former being about 10–20% that of the latter).

Relatively little is known of the growth rate of any of the *Metanephrops* species in the wild. Tagging of *M. challengeri* to determine growth rates was undertaken in the Bay of Plenty in 1995, and the bulk of recaptures were made late in 1996. About 1% of tagged animals were recaptured, similar to the average return rate of similar tagging studies for scampi and prawns overseas. Many more females than males were recaptured, and small males were almost entirely absent from the recapture sample. Scampi captured and tagged at night were much more likely to be recaptured than those exposed to sunlight. Estimates from this work of growth rate and mortality for females are given in Table 3. The data for males were insufficient for analysis, although the average annual increment with size appeared to be greater than in females.

Table 3: Estimates of biological parameters.

Population	Estimate		Source
1. Weight = a(orbital carapace length)^b (weight in g, OCL in mm)			
All males: SCI 1	a = 0.000373	b = 3.145	Cryer & Stotter (1997)
Ovigerous females: SCI 1	a = 0.003821	b = 2.533	Cryer & Stotter (1997)
Other females: SCI 1	a = 0.000443	b = 3.092	Cryer & Stotter (1997)
All females: SCI 1	a = 0.000461	b = 3.083	Cryer & Stotter (1997)
2. von Bertalanffy growth parameters			
	K (yr^{-1})	**L_∞ (OCL, mm)**	
Females: SCI 1 (tag)	0.11–0.14	48.0–49.0	Cryer & Stotter (1999)
Females: SCI 2 (aquarium)	0.31	48.8	Cryer & Oliver (2001)
Males: SCI 2 (aquarium)	0.32	51.2	Cryer & Oliver (2001)
3. Natural mortality (M)			
Females: SCI 1	M = 0.20–0.25		Cryer & Stotter (1999)

Estimates of M are based on the relationship between growth rate and natural mortality, and are subject to considerable uncertainty. Analytical assessment models have been examined for M=0.2 and M=0.3.

Scampi from SCI 2 were successfully reared in aquariums for over 12 months in 1999–2000. Results from these growth trials suggested a Brody coefficient of about 0.3 for both sexes, compared with less than 0.15 from the tagging trial. Extrapolating the length-based results to age-based curves suggests that scampi are about 3–4 years old at 30 mm carapace length and may live for 15 years. There are many uncertainties with captive reared animals, however, and these estimates should not be regarded as definitive. In particular, the rearing temperature was 12º C compared with about 10º C in the wild (in SCI 1 and 2), and the effects of captivity are largely unknown.

The maximum age of New Zealand scampi is not known, although analysis of tag return data and aquarium trials suggest that this species may be quite long lived. *Metanephrops* spp in Australian waters may grow rather slowly and take up to 6 years to recruit to the commercial fishery (Rainer 1992), consistent with estimates of growth in *M. challengeri* (Table 3). *N. norvegicus* populations in some northern European populations achieve a maximum age of 15–20 years (Bell et al. 2006), consistent with the estimates of natural mortality, *M*, for *M. challengeri*.

A tagging project has been conducted in SCI 6A, with three release events (March 2007, 2008, 2009 and 2013). By April 2014, 6.3% of the 2007 releases had been recaptured, 4.6% of the 2008 releases, 6% of the 2009 releases and 2.2% of the 2013 releases. Most recaptures occur within a year of release. Tagging work has also more recently been conducted in SCI 1, 2 and 3, although recapture rates have been low. Tag recaptures are fitted within assessment models to estimate growth.

3. STOCKS AND AREAS

Stock structure of scampi in New Zealand waters is not well known. Preliminary electrophoretic analyses suggest that scampi in SCI 6A are genetically distinct from those in other areas, and there is substantial heterogeneity in samples from SCI 1, 2, and 4A. The abbreviated larval phase of this species may lead to low rates of gene mixing. Differences among some scampi populations in average size, size at maturity, the timing of diel and seasonal cycles of catchability, catch to bycatch ratios and CPUE trends also suggest that treatment as separate management units is appropriate.

A review of stock boundaries between SCI 3 and SCI 4A and between SCI 6A and SCI 6B was conducted in 2000, prior to introduction of scampi into the Quota Management System. Following the recommendation of this review, the boundaries were changed on 1 October 2004, to reflect the distribution of scampi stocks and fisheries more appropriately.

4. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

This section was last reviewed by the Aquatic Environment Working Group for the May 2012 Fishery Assessment Plenary. Tables were updated and minor corrections to the text were made for the May 2013 Fishery Assessment Plenary. This summary is from the perspective of the scampi fishery; a more detailed summary from an issue-by-issue perspective is available in the Aquatic Environment & Biodiversity Annual Review (www.mpi.govt.nz/Default.aspx?TabId=126&id=1644).

4.1 Role in the ecosystem

Scampi are thought to prey mainly on invertebrates (Meynier et al 2008) or carrion. A 3-year diet study on the Chatham Rise showed that scampi was the first, third and fourth most important item (by IRI, Index of Relative Importance) in the diet of smooth skate, ling and sea perch respectively (Dunn et al. 2009). Scampi build and maintain burrows in the sediment and this bioturbation is thought to influence oxygen and nutrient fluxes across the sediment-water boundary, especially when scampi density is high (e.g., Hughes & Atkinson 1997, who studied *Nephrops norvegicus* at densities of 1–3 m^{-2}). Observed densities from photographic surveys in New Zealand have been 0.02–0.1 m^{-2} (Tuck 2010), similar to densities of *N. norvegicus* in comparable depths.

4.2 Incidental catch (fish and invertebrates)

In the 1999–00 to 2005–06 fishing years, total annual bycatch was estimated to range from 2 910 to 8 070 t compared with total landed scampi catches of 791–1 045 t, and scampi typically represents less than 20% of the catch by weight (Ballara & Anderson 2009). The main QMS bycatch species (over 2% of the total catch) were sea perch, ling, hoki, red cod, silver warehou, and giant stargazer. The amount and composition of bycatch varies both within and between QMAs (see also Cryer 2000), being lowest in SCI 1 and SCI 6A (0.5 and 0.6 t per tow, respectively) and higher in SCI 3 and SCI 4A (1.0 and 1.1 t per tow) with SCI 2 intermediate. The most bycatch per tow is taken in SCI 5 (2.7 t per tow) but this is a very small fishery.

The non-QMS incidental catch ranges from a similar weight to the QMS bycatch (SCI 2 and 3) to about double the QMS bycatch (SCI 3 and 6A). Most of this non-QMS incidental catch is discarded on the grounds (Ballara & Anderson record 485 species as discarded). Total annual discard estimates from 1999–00 to 2005–06 ranged from 1 540 to 5 140 t and were dominated by sea perch (especially in SCI 2 and 3) javelinfish and other rattails (all areas), spiny dogfish (all areas), skates (SCI 1 and 2), crabs (SCI 6A), toadfish (SCI 3 and 6A) and flatheads (SCI 1–3) (Ballara & Anderson 2009). Discards averaged 2.5 kg per kilogram of scampi caught, typical of crustacean trawl fisheries internationally (Kelleher 2005). Bycatch and discards may have reduced since about 2005 because of modifications to the gear (Tuck, 2013), also evident in the most recent year analysed by Ballara & Anderson 2009).

The finer mesh used by scampi trawlers has the potential to catch more juvenile fish than standard finfish trawls and Cryer et al. (1999) showed raw length frequency distributions for major QMS bycatch species up to 1996–97. Small proportions of small gemfish (20–40 cm) and small hoki (30–50 cm) were recorded in SCI 1–4 in a few years, but juveniles made up a major proportion of the catch only for ling in SCI 6A where more than half of ling measured were 30–70 cm long in four of the six years studied (1990 to 1996–97).

4.3 Incidental Catch (seabirds, mammals, and protected fish)

For protected species, capture estimates presented here include all animals recovered to the deck (alive, injured or dead) of fishing vessels but do not include any cryptic mortality (e.g., seabirds struck by a warp but not brought onboard the vessel, Middleton & Abraham 2007).

Marine mammal interactions

Scampi trawlers occasionally catch marine mammals, including NZ sea lions and NZ fur seals (which were classified as “Nationally Critical” and “Not Threatened”, respectively, under the NZ Threat Classification System in 2010, Baker et al 2010).

In the 2012–13 fishing year there were no observed captures of NZ sea lion in scampi trawl fisheries (Table 4) and no estimates of total sea lion captures were made. Sea lions captured in previous years were all taken close to the Auckland Islands in SCI 6A (Thompson et al. 2011).

In the 2012–13 fishing year there was one observed capture of a NZ fur seal in scampi trawl fisheries. In the 2011–12 fishing year, there were 7 (95% c.i.: 0–26) estimated NZ fur seal captures, with the estimates made using a statistical model (Table 5). Since 2002–03, only about 0.7% of the estimated total captures of NZ fur seals have been taken in scampi fisheries; these have been on the western Chatham Rise, on the Stewart-Snares shelf, and close to the Auckland Islands.

Rates of capture for both sea lions and fur seals have been low and have fluctuated without obvious trend.

Table 4: Number of tows by fishing year and observed NZ sea lion captures in scampi trawl fisheries, 2002–03 to 2012–13. No. obs, number of observed tows; % obs, percentage of tows observed; Rate, number of captures per 100 observed tows. Estimates are based on methods described in Thompson et al (2013) and available via http://www.fish.govt.nz/en-nz/Environmental/Seabirds/. Data for 2002–03 to 2011–12 are based on data version 20130304 and provisional data for 2012–13 are based on data version 20140131.

	Fishing effort			Observed captures		Estimated interactions		
	Tows	No. obs	% obs	Captures	Rate	Mean	95% c.i.	% included
2002–03	5 130	512	10.0	0	0.00	8	2–16	100.0
2003–04	3 753	412	11.0	3	0.73	11	5–19	100.0
2004–05	4 658	143	3.1	0	0.00	8	2–17	100.0
2005–06	4 867	331	6.8	1	0.30	9	3–17	100.0
2006–07	5 135	389	7.6	1	0.26	9	3–17	100.0
2007–08	4 804	524	10.9	0	0.00	8	2–17	100.0
2008–09	3 975	396	10.0	1	0.25	10	4–19	100.0
2009–10	4 248	348	8.2	0	0.00	6	1–12	100.0
2010–11	4 447	536	12.1	0	0.00	8	2–16	100.0
2011–12	4 506	459	10.2	0	0.00	7	2–15	100.0
2012–13†	4 566	270	5.9	0	0.00	-	-	-

† Provisional data, no model estimates available.

Table 5: Number of tows by fishing year and observed and model-estimated total NZ fur seal captures in scampi trawl fisheries, 2002–03 to 2012–13. No. obs, number of observed tows; % obs, percentage of tows observed; Rate, number of captures per 100 observed tows, % inc, percentage of total effort included in the statistical model. Estimates are based on methods described in Thompson et al (2013) and available via http://www.fish.govt.nz/en-nz/Environmental/Seabirds/. Data for 2002–03 to 2011–12 are based on data version 20130304 and provisional data for 2012–13 are based on data version 20140131.

		Observed				Estimated		
	Tows	No. obs	% obs	Captures	Rate	Captures	95% c.i.	% inc.
2002–03	5 130	512	10.0	2	0.39	7	2–21	100.0
2003–04	3 753	412	11.0	1	0.24	5	1–18	100.0
2004–05	4 658	143	3.1	0	0.00	23	1–110	100.0
2005–06	4 867	331	6.8	0	0.00	7	0–27	100.0
2006–07	5 135	389	7.6	0	0.00	7	0–24	100.0
2007–08	4 804	524	10.9	1	0.19	10	1–34	100.0
2008–09	3 975	396	10.0	1	0.25	6	1–21	100.0
2009–10	4 248	348	8.2	1	0.29	6	1–19	100.0
2010–11	4 447	536	12.1	0	0.00	4	0–18	100.0
2011–12	4 506	459	10.2	1	0.22	7	1–26	100.0
2012–13†	4 566	270	5.9	0	0.00	-	-	-

† Provisional data, no model estimates available.

Seabird interactions

Observed seabird capture rates in scampi fisheries ranged from about 1 to 20 per 100 tows between 1998–99 and 2008–09 (Baird 2001, 2004 a,b,c, 2005b Thompson & Abraham, 2009, Abraham et al. 2009, Abraham & Thompson 2011, Abraham et al 2013) and have fluctuated without obvious trend. In the 2012–13 fishing year there were 5 observed captures of birds in scampi trawl fisheries. In the 2011–12 fishing year, there were 197 (95% c.i.: 128–300) estimated captures, with the estimates made using a statistical model (Abraham et al 2013; Table 6). These estimates are based on relatively low observer coverage and include all bird species and should, therefore, be interpreted with caution. The average capture rate in scampi trawl fisheries over the last ten years (all areas combined) is about 5.57 birds per 100 tows, a moderate rate relative to trawl fisheries for squid (13.79 birds per 100 tows) and hoki (2.16 birds per 100 tows) over the same years. The scampi fishery accounted for about 6% of seabird captures in the trawl fisheries modelled by Abraham et al (2013).

Table 6: Number of tows by fishing year and observed and model-estimated total NZ seabirds captures in scampi trawl fisheries, 2002–03 to 2012–13. No. obs, number of observed tows; % obs, percentage of tows observed; Rate, number of captures per 100 observed tows, % inc, percentage of total effort included in the statistical model. Estimates are based on methods described in Abraham et al (2013) and are available via http://www.fish.govt.nz/en-nz/Environmental/Seabirds/. Data for 2002–03 to 2011–12 are based on data version 20130304 and provisional data for 2012–13 are based on data version 20140131.

		Observed				Estimated		
	Tows	No. obs	% obs	Captures	Rate	Captures	95% c.i.	% inc.
2002–03	5 130	512	10.0	8	1.56	131	77 – 232	100.0
2003–04	3 753	412	11.0	8	1.94	98	58 – 158	100.0
2004–05	4 658	143	3.1	9	6.29	239	152 – 370	100.0
2005–06	4 867	331	6.8	13	3.93	217	141 – 326	100.0
2006–07	5 135	389	7.6	24	6.17	163	111 – 237	100.0
2007–08	4 804	524	10.9	11	2.10	160	104 – 243	100.0
2008–09	3 975	396	10.0	19	4.80	209	140 – 309	100.0
2009–10	4 248	348	8.2	5	1.44	160	99 – 254	100.0
2010–11	4 447	536	12.1	109	20.34	336	247 – 484	100.0
2011–12	4 506	459	10.2	9	1.96	197	128 – 300	100.0
2012–13†	4 566	270	5.9	5	1.85	-	-	-

† Provisional data, no model estimates available.

Observed seabird captures since 2002–03 have been dominated by four species: Salvin's and white-capped albatrosses make up 49% and 28% of the albatrosses captured respectively; white chinned petrel, sooty shearwaters and flesh-footed shearwaters make up 48%, 24%, and 23% of other birds respectively, and the total and fishery risk ratios are presented in Table 7. Most of the captures occur near the Auckland Islands (66%), Bay of Plenty (26%), or Chatham Rise (7%). These numbers should be regarded as only a general guide on the distribution of captures because observer coverage is not uniform across areas and may not be representative.

Table 7: Risk ratio of seabirds predicted by the level two risk assessment for the SCI target trawl fishery and all fisheries included in the level two risk assessment, 2002–03 to 2012–13, showing seabird species with a risk ratio of at least 0.001 of PBR_1. The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Potential Biological Removals, PBR_1 (from Richard and Abraham 2013 where full details of the risk assessment approach can be found). PBR_1 applies a recovery factor of 1.0. Typically a recovery factor of 0.1 to 0.5 is applied (based on the state of the population) to allow for recovery from low population sizes as quickly as possible. This should be considered when interpreting these results. The DOC threat classifications are shown (Robertson et al 2013 at http://www.doc.govt.nz/documents/science-and-technical/nztcs4entire.pdf).

		Risk ratio			
Species name	**PBR_1 (mean)**	**SCI target trawl**	**TOTAL**	**Risk category**	**DoC Threat Classification**
Black petrel	74	0.057	19.420	Very high	Threatened: Nationally Vulnerable
Salvin's albatross	975	0.395	2.756	Very high	Threatened: Nationally Critical
Flesh-footed shearwater	590	0.237	1.321	Very high	Threatened: Nationally Vulnerable
Southern Buller's albatross	513	0.016	1.292	Very high	At Risk: Naturally Uncommon
Chatham Island albatross	159	0.030	1.291	Very high	At Risk: Naturally Uncommon
New Zealand white-capped albatross	4044	0.043	0.700	Very high	At Risk: Declining
Northern Buller's albatross	617	0.027	0.678	High	At Risk: Naturally Uncommon
Cape petrel	840	0.016	0.303	High	At Risk: Naturally Uncommon
Northern royal albatross	396	0.005	0.271	Medium	At Risk: Naturally Uncommon
Westland petrel	241	0.005	0.263	Medium	At Risk: Naturally Uncommon
Northern giant petrel	217	0.058	0.215	Medium	At Risk: Naturally Uncommon
White-chinned petrel	7925	0.061	0.211	Medium	At Risk: Declining
Campbell black-browed albatross	1017	0.015	0.189	Medium	At Risk: Naturally Uncommon

4.4 Benthic interactions

Bottom trawl effort for scampi peaked in 2001–02 at over 6 500 tows (roughly 10% of all TCEPR bottom trawls in that year) but has typically been 3 500 to 5 200 tows per year since 1989–90. Most scampi catch is reported on TCEPR forms (Baird et al 2011, Black et al 2013) with most of the 1 477 reports on CELR forms being between 1998–99 and 2002–03. Since 2005–06, 100% of target scampi catch has been reported on TCEPR forms (Black et al 2013). Tows are located in Benthic Optimised Marine Environment Classification (BOMEC, Leathwick et al 2009) classes F, G (upper slope), H, J, and L (mid-slope) (Baird & Wood 2012), and 95% were between 300 and 500 m depth (Baird et al 2011).

Bottom trawling for scampi, like trawling for other species, is likely to have effects on benthic community structure and function (e.g., Cryer et al 2002 for a specific analysis and Rice 2006 for an international review) and there may be consequences for benthic productivity (e.g., Jennings et al. 2001, Hermsen et al 2003, Hiddink et al 2006, Reiss et al 2009). These consequences are not considered in detail here but are discussed in the Aquatic Environment and Biodiversity Annual Review (2012).

4.5 Other considerations

None considered by the AEWG.

5. STOCK ASSESSMENT

In 2011 the SFWG accepted the stock assessments for SCI 1 and SCI 2, undertaken using the length-based population model. Length based assessments are also under development for SCI 3 and SCI 6A. Preliminary work from the SCI6Astock assessment model suggests that currently there doesn't appear to be a sustainability risk for this stock. However, uncertainty in model fits and model outputs means results are just preliminary at this stage and have not been accepted by the SFWG. Section 5.2 discusses in detail the stock assessments that have to date been accepted by the SFWG, this includes the SCI 1 and 2 stocks.

Attempts have been made to index scampi abundance using CPUE and trawl survey indices and, more recently, photographic surveys of scampi burrows. There is some level of agreement between the relative trends shown, and all three indices are included in the length based assessment model.

5.1 Estimates of fishery parameters and abundance

Standardised CPUE indices are calculated for each stock every three years, as part of the stock assessment process. Annual unstandardised CPUE indices for each area (total catch divided by total effort in hours of trawling) are updated annually, using the data from all vessels that fished (Figure 2). The Shellfish Fishery Assessment Working Group has raised concerns in the past that potential variability in catchability between years mean that CPUE may not provide a reliable index of abundance, although consistent changes shown by different types of indices for the same area provide more confidence in the data. The indices for areas SCI 3, 4A 6A and 6B have been recalculated over the time series in light of the alterations of some stock boundaries, following the review described above. In SCI 1, CPUE increased in the early 1990s, and then declined between 1995–96 and 2001–02, showed a slight increase in 2002–03 and 2003–04, but has generally remained stable since 2001–02. In SCI 2, CPUE increased in 1994–95, then declined steadily to 2001–02, remained at quite a low level until 2007–08, but has increased slowly since then. In SCI 3, CPUE rose steadily through the early 1990s, fluctuated around a slowly declining trend in the late 1990s and early 2000s, showed a steeper decline to 2007–08, increased to 2010–11, and decreased slightly in the most recent years. In SCI 4A, CPUE observations were intermittent between 1991–92 and 2002–03, showing a dramatic increase over this period. Since 2002–03 CPUE has been far lower, but since 2010–11 data show an increase on the more recent years. In SCI 6A, after an initial decline in the early 1990s, CPUE has been relatively stable, although CPUE in the most recent years appears to be slightly lower than the longer term average. With the revision of the stock boundaries, data are only available for one year for SCI 6B, and are therefore not presented. For both SCI 5 and SCI 7, observations have been intermittent, and consistently low.

A time series of trawl surveys designed to measure relative biomass of scampi in SCI 1 and 2 ran between January 1993 and January 1995 (Table 8). Research trawling for other purposes has been conducted in both SCI 1 and SCI 2 in several other years, and catch rates from appropriate hauls within these studies have been plotted alongside the dedicated trawl survey data in Figure 3 and Figure 4. In SCI 1 the additional trawling was conducted in support of a tagging programme (in 1995 and 1996), which was conducted by a commercial vessel in the peak area of the fishery, while work to assess trawl selectivity (1996) and in support of photographic surveys (since 1998) may have been more representative of the overall area. In SCI 2 the additional trawling was conducted in support of a growth investigation using length frequency data (1999 and 2000) and in support of photographic surveys (since 2003). All the work was carried out by the same research vessel, but while the work in support of photographic surveys was carried out over the whole area, the work related to the growth investigation was concentrated in a small area in the south of the SCI 2 area. Only the additional trawl survey work in support of photographic surveys has been included in Table 8, since the other studies did not have comparable spatial coverage. The trends observed are similar to the trends in commercial CPUE (Figure 2) for both stocks.

Table 8: Trawl survey indices of biomass (t) for scampi in survey strata within SCIs 1, 2, 3 and 6A. C.V.'s of estimates in parenthesis.

	SCI 1	SCI 2	SCI 3	SCI 6A	Comments
1993	217.3 (0.12)	238.2 (0.12)			Dedicated trawl survey
1994	288.2 (0.19)	170.0 (0.16)			Dedicated trawl survey
1995	391.6 (0.18)	216.2 (0.18)			Dedicated trawl survey
1996					
1997					
1998	174.0 (0.17)				Trawling in support of photo survey
1999					
2000	181.3 (*)				Trawling in support of photo survey
2001	179.5 (0.27)		272.5 (0.24) (strata 902–3)		Trawling in support of photo survey SCI 3 pre season survey
2002	130.6 (0.24)				Trawling in support of photo survey
2003		28.0 (*)			Trawling in support of photo survey
2004		46.9 (0.20)			Trawling in support of photo survey
2005		50.8 (0.35)			Trawling in support of photo survey
2006		22.9 (0.19)			Trawling in support of photo survey
2007				1073.5 (0.18)	Trawling in support of photo survey
2008	211.9 (*)			1229.1 (0.18)	Trawling in support of photo survey
2009			40.2 (0.37) (strata 902–3) 418.1 (0.26)	821.6 (0.09)	Trawling in support of photo survey
2010			49.0 (0.11) (strata 902–3) 596.1 (0.04)		Trawling in support of photo survey
2011					
2012	150.0 (0.25)	164.2 (0.28)			Trawling in support of photo survey
2013			126.5 (0.27) (strata 902–3) 551.3 (0.12)	1258.0 (0.06)	Trawling in support of photo survey

* - where no CV is provided, one stratum had only one valid station. Strata included: SCI 1 – 302,303, 402, 403; SCI 2 – 701, 702, 703, 801, 802, 803; SCI 3 – 902, 903, 904; SCI 6A (main area) – 350 m, 400 m, 450 m, 500 m. SCI 3 survey in 2009 and 2010 split into area surveyed in 2001, and new area (strata 902A–C & 903A)

Surveys have been conducted in SCI 3 in 2001 (two surveys, pre and post fishery), 2009 and 2010. The trawl component of the surveys did not suggest any difference between the pre and post fishery periods in 2001, but the photographic survey observed more scampi burrows after the fishery. Trawl, photographic and CPUE data indicate a significant decline in scampi abundance between 2001 and 2009, but an increase in the most recent year (Figure 5).

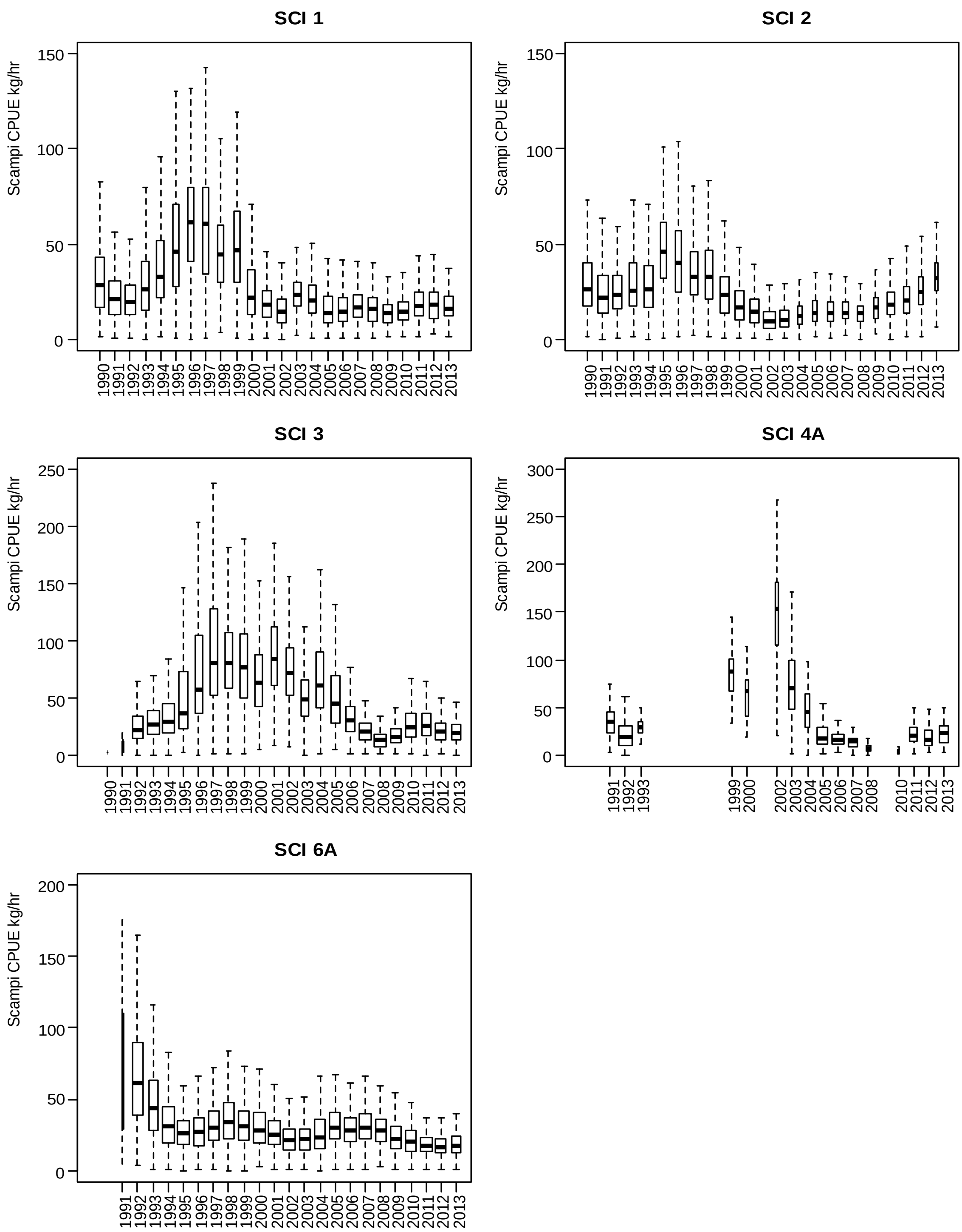


Figure 2: Box plots (with outliers removed) of individual observations of unstandardised catch rate for scampi (tow catch (kg) divided by tow effort (hours)) with tows of zero scampi catch excluded, by fishing year for main stocks. Note different scales between plots. Horizontal bars within boxes represent distribution median. Upper and lower limits of boxes represent upper and lower quartiles. Whisker extends to largest (or smallest) observation which is less than or equal (greater than or equal) to the upper quartile plus 1.5 times the interquartile range (lower quartile less 1.5 times the interquartile range). Outliers (removed from this plot) are values outside the whiskers. Box width proportional to square root of number of observations.

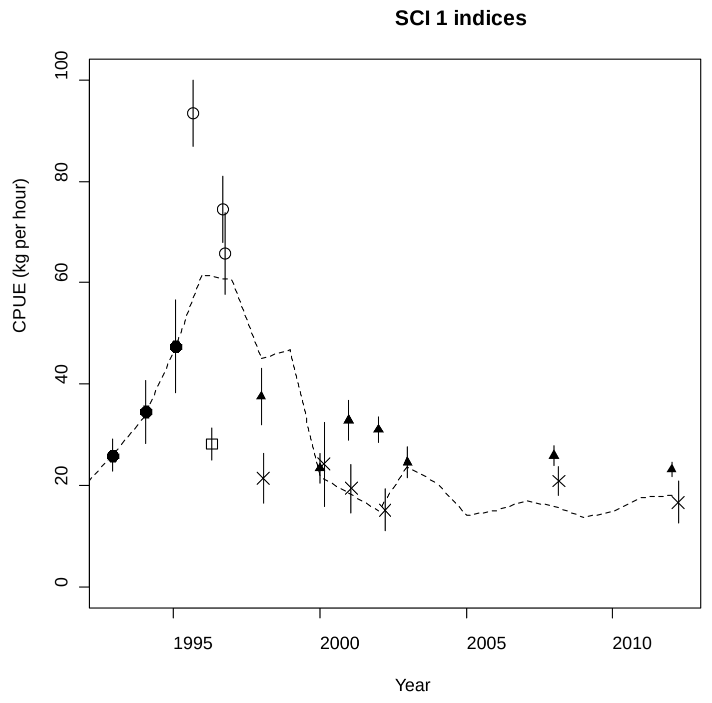


Figure 3: Mean catch rates and relative abundance (± one standard error) of research trawling and photo survey counts in the core area of SCI 1. Symbols represent different aims of survey work (● – trawl survey, ○ – tagging work, □ – trawl selectivity, ×- trawling within photo survey, ▲-scaled photo survey abundance). Dotted line represents median of annual unstandardised CPUE for SCI 1 from Figure 2.

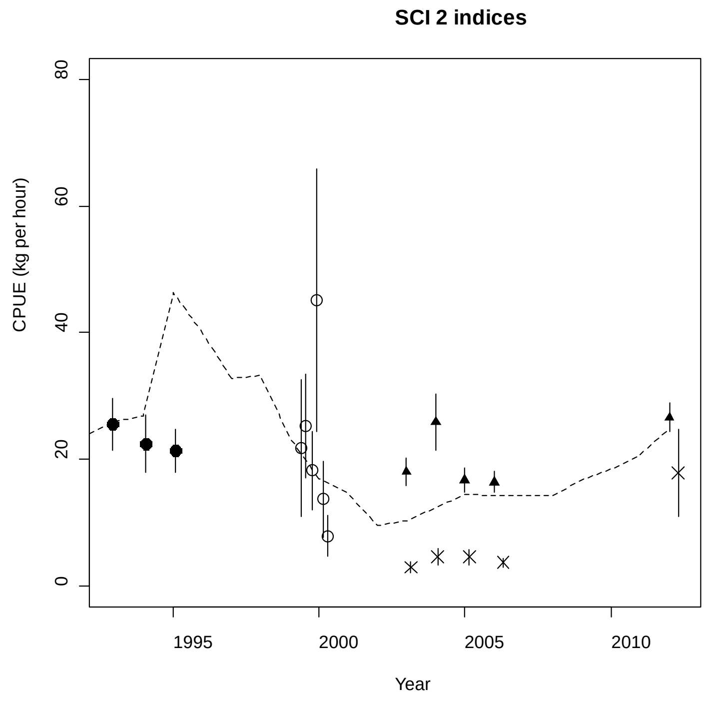


Figure 4: Mean catch rates and relative abundance (± one standard error) of research trawling and photo survey counts in the core area of SCI 2. Symbols represent different aims of survey work (● – trawl survey, ○ – tagging work, ×- trawling within photo survey, ▲-scaled photo survey abundance). Dotted line represents median of annual unstandardised CPUE for SCI 2 from Figure 2.

Table 9: Photographic survey estimates of abundance (millions) based on major openings and visible scampi in survey strata within SCIs 1, 2, 3 and 6A. CVs of estimates in parenthesis.

	SCI 1		SCI 2		SCI 3		SCI 6A		Comments
	Major openings	Visible scampi	Major openings	Visible scampi	Major openings	Visible scampi	Major openings	Visible scampi	
1998	155.1 (0.15)	27.9 (0.22)							
1999									
2000	96.7 (0.13)	18.2 (0.18)							
2001	135.9 (0.12)	12.3 (0.26)			267.3 (0.09) (strata 902–3) 443.8 (0.17) (strata 902–3)	72.9 (0.16) (strata 902–3) 77.5 (0.14) (strata 902–3)			SCI 3, two surveys in 2001, Aug/Sept and Oct
2002	128.2 (0.08)	16.7 (0.21)							
2003	101.9 (0.12)	14.4 (0.21)	161.6 (0.12)	10.0 (0.39)					
2004			210.8 (0.17)	20.6 (0.28)					
2005			152.5 (0.11)	14.6 (0.20)					
2006			134.2 (0.10)	13.3 (0.23)					
2007							360.9 (0.10)	57.1 (0.13)	SCI 6A estimate for main area*
2008	100.8 (0.08)	12.5 (0.13)					117.0 (0.07)	49.6 (0.08)	
2009					61.1 (0.20) (strata 902–3) 260.6 (0.08) (larger survey)	23.6 (0.17) (strata 902–3) 124.8 (0.10) (larger survey)	268.3 (0.06)	34.3 (0.15)	SCI 3, estimates provided for 2001 survey coverage (strata 902–3) and new larger survey
2010					74.6 (0.11) (strata 902–3) 348.0 (0.05) (larger survey)	10.9 (0.23) (strata 902–3) 91.4 (0.10) (larger survey)			SCI 3, estimates provided for 2001 survey coverage (strata 902–3) and new larger survey
2012	95.8 (0.06)	23.9 (0.09)	168.9 (0.09)	32.0 (0.11)					
2013							179.0 (0.08)	31.54 (0.15)	

* - SCI 6A estimate provided for main area as future surveys may not survey secondary area. SCI 1 estimate provided for strata 302, 303, 402, 403.

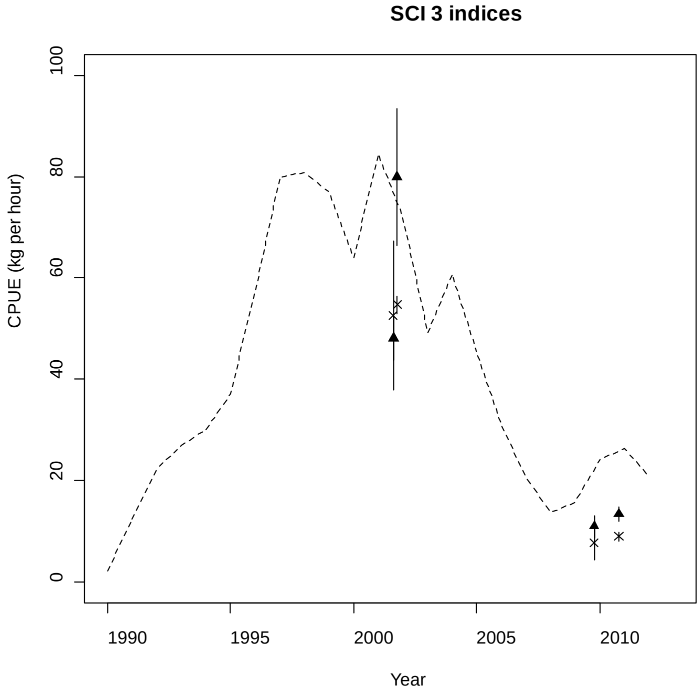


Figure 5: Mean catch rates and relative abundance (± one standard error) of research trawling and photo survey counts in the core area of SCI 3. Symbols represent different aims of survey work (×- trawling within photo survey, ▲-scaled photo survey abundance). Dotted line represents median of annual unstandardised CPUE for SCI 3 from Figure 2.

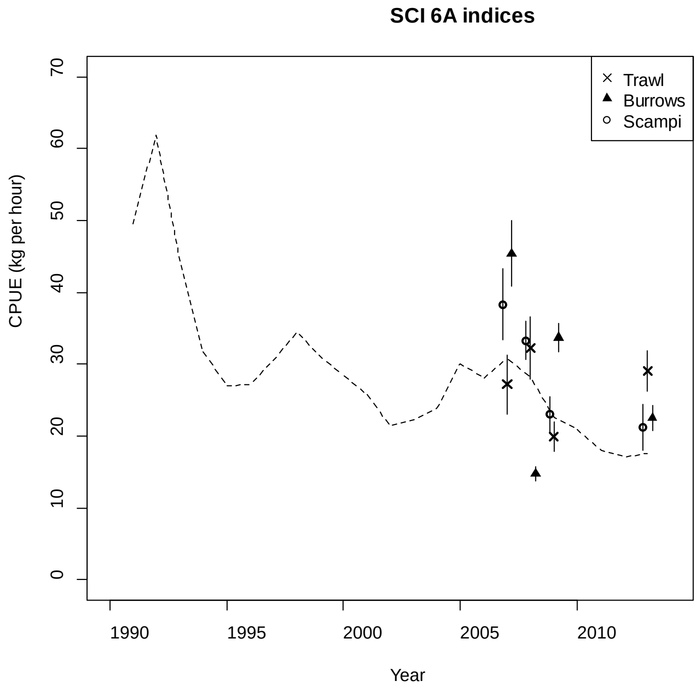


Figure 6: Mean catch rates and relative abundance (± one standard error) of research trawling and photo survey counts in the core area of SCI 6A. Symbols represent different aims of survey work (×- trawling within photo survey, ▲-scaled photo survey abundance). Dotted line represents median of annual unstandardised CPUE for SCI 6A from Figure 2.

Surveys have been conducted in SCI 6A in 2007–2009 and 2013. The trawl component of the surveys suggests that the biomass has remained relatively stable in recent years, the biomass estimate declining in 2009, but the 2013 estimate being comparable to those in 2007 and 2008. The photographic survey suggested a considerable decline in abundance between 2007 and 2008, but an increase towards the 2007 level in 2009. Over the longer term, the CPUE data indicate that following a rapid decline in the early 1990s, abundance may have declined since 1995 (Figure 6).

Photographic surveying (usually by video) has been used extensively to estimate the abundance of the European scampi *Nephrops norvegicus*. In New Zealand, development of photographic techniques, including surveys, has been underway since 1998. To date, seven surveys have been undertaken in SCI 1 (between Cuvier Island and White Island at a depth of 300 to 500 m), four surveys have been undertaken in SCI 3 (northeastern Mernoo Bank only, 200 to 600 m depth), five surveys have been undertaken in SCI 2 (Mahia Peninsula to Castle Point 200 to 500 m depth), and four surveys in SCI 6A (to the east of the Auckland Islands, 350–550 m depth). The association between scampi and burrows in SCI 6A appears to be different to other areas examined, and it is uncertain whether the relationship between scampi and burrow abundance is constant between areas, or whether the marked decline in burrow abundance observed between 2007 and 2009 in SCI 6A (Table 9) reflects scampi abundance (particularly when trawl survey catch rates increased as seen in Table 8).

Two indices are calculated from photographic surveys: the density of visible scampi and the density of major burrow openings (counts of which are now consistent among experienced readers, and repeatable, following development of a between reader standardisation process). Both of these can be used to estimate indices of biomass, using estimates of mean individual weight or the size distribution of animals in the surveyed population. The Bayesian length based assessment model used for SCI 1 and SCI 2 uses the estimated abundance of major burrow openings as an abundance index, but visible scampi may be considered a more appropriate index in other stocks.

Estimates of major burrow opening and visible scampi abundance are provided in Table 9.

Length frequency distributions from trawl surveys and from scientific observers do not show a consistent increase in the proportion of small individuals in any SCI stock following the development of significant fisheries for scampi. Analyses of information from trawl survey and scientific observers in SCI 1 and 6A up to about 1996 suggested that the proportion of small animals in the catch declined markedly in both areas, despite the fact that CPUE declined markedly in SCI 6A and increased markedly in SCI 1. Where large differences in the length frequency distribution of scampi measured by observers have been detected (as in SCIs 1 and 6A), detailed analysis has shown that the spatial coverage of observer samples has varied with time, and this may have influenced the nature of the length frequency samples. Observer sampling practices may have also introduced bias or increased uncertainty. The length composition of scampi is known to vary with depth and geographical location, and fishers may deliberately target certain size categories.

Some commercial fishers reported that they experienced historically low catch rates in SCI 1 and 2 between 2001 and 2004. They further suggest that this reflects a decrease in abundance of scampi in these areas. Other fishers consider that catch rates do not necessarily reflect changes in abundance because they are influenced by management and fishing practices.

5.2 Stock Assessment Methods

In 2011 the SFWG accepted the stock assessments for SCI 1 and SCI 2, undertaken using the length-based population model that had been under development for several years (Tuck & Dunn 2012), and updated assessments were accepted in 2013. A number of model runs were presented, examining sensitivities to M, selectivity in the fishery, the assumption of equilibrium conditions at the start of the fishery, and data weighting (SCI 2). For both assessments, the absolute biomass levels were sensitive to M, but the state of the stock relative to B_0 was consistent between models. Domed selectivity for the fishery improved fits to length frequencies slightly, and increased weighting in the CPUE data resulted in slightly lower estimates of B_0 and B_{2012}, but none of the sensitivity analyses changed perceptions of stock status. Base models were agreed upon with M=0.3, although outputs from M=0.2 models are also presented. In addition, for SCI 2 a further model was investigated in which one selectivity parameter was constrained, to allow calculation of Equivalent Annual Fs. Other outputs from the model were not sensitive to this constraint.

The model's annual cycle is based on the fishing year and is divided into three time-steps (Table 10). The choice of three time steps was based on the current understanding of scampi biology and the sex ratio in catches. Note that model references to "year" within this report refer to the modelled or fishing year, and are labelled as the most recent calendar year, i.e., the fishing year 1998–99 is referred to as “1999” throughout.

Table 10: Annual cycle of the population model for SCI 1, showing the processes taking place at each time step, their sequence within each time step, and the available observations. Fishing and natural mortality that occur together within a time step occur after all other processes, with 50% of the natural mortality for that time step occurring before and 50% after the fishing mortality.

Step	Period	Process	Proportion in time step
1	Oct–Jan	Growth (both sexes)	
		Natural mortality	0.33
		Fishing mortality	From TCEPR
2	Feb–April	Recruitment	1.0
		Maturation	1.0
		*Growth (males)**	
		Natural mortality	0.25
		Fishing mortality	From TCEPR
3	May–Sept	Natural mortality	0.42
		Fishing mortality	From TCEPR

* - the main period of male moulting appears to be from February to April. In the model both sexes are assumed to grow at the start of step 1, and this male growth period (February to April) is ignored.

Investigations into factors affecting scampi catch rates and size distributions (Cryer & Hartill 2000, Tuck 2010) have identified significant depth and spatial effects, and spatial and depth stratification were applied in previous models. Preliminary examination of patterns in CPUE indices and other input data suggested that this may not be necessary, and a simplified single area model was developed. Catches generally occur throughout the year, and were divided among the time-steps according to the proportion of estimated catches recorded on Trawl Catch, Effort, and Processing Returns (TCEPR). Recreational catch, customary catch, and illegal catch are ignored. The maximum exploitation rate (i.e., the ratio of the maximum catch to biomass in any year) is not known, but was constrained to no more than 0.9 in a time-step. Individuals are assumed to recruit to the model at age 1, with the mean expectation of recruitment success predicted by a Beverton Holt stock-recruitment relationship. Length at recruitment is defined by a normal distribution with mean of 10 mm OCL with a CV of 0.4. Relative year class strengths are encouraged to average 1.0. Growth is estimated in the model, fitting to the tag (Cryer & Stotter 1997, Cryer & Stotter 1999) and aquarium data (Cryer & Oliver 2001) from SCI 1 and SCI 2.

The model uses logistic length-based selectivity curves for commercial fishing, research trawl surveys and photographic surveys, assumed constant over years but allowed to vary with sex, time step and spatial strata (where included). While the sex ratio data suggest that the relative catchability of the sexes vary through the year (hence the model time structure adopted), there is no reason to suggest that (assuming equal availability) selectivity-at-size would be different between the sexes. Therefore a new selectivity implementation was developed within CASAL, one that allowed the L_{50} and a_{95} selectivity parameters to be estimated as single values shared by both sexes in a particular time step and spatial stratum, but allowed for different availability between the sexes through estimation of different a_{max} values for each sex. In SCI 1 and SCI 2 selectivity is assumed to be the same in time steps 1 and 3, owing to the relative similarity in sex ratio.
Data inputs included CPUE, trawl and photographic survey indices, and associated length frequency distributions.

The assessment reported B_0 and $B_{current}$ and used the ratio of current and projected spawning stock biomass ($B_{current}$ and B_{2018}) to B_0 as preferred indicators. Projections were conducted up to 2018 on the basis of a range of catch scenarios. The probability of exceeding the default Harvest Strategy Standard target and limit reference points are reported.

5.3 Stock Assessment Results

For SCI 1, model outputs suggest that spawning stock biomass (SSB) increased to a peak in about 1994, declined to the early 2000s, and has remained relatively stable since this time. The SSB in SCI 1 in 2012 is estimated to be 68–71% of B_0 (Figure 7, Table 11). For SCI 2, model outputs suggest that spawning stock biomass (SSB) decreased slightly until 1990, increased to a peak in the early

1990s, declined to the early 2000s, increased slightly until about 2008, but has increased more rapidly since this time. The SSB in SCI 2 in 2012 is estimated to be 64%–74% of B_0 (Figure 8, Table 13).

The default management target for scampi of 40% B_0 is below the range of % B_0 estimated for both stocks. On the basis of the outputs for SCI 1, and annual catches at the TACC (120 tonnes), the probability of SSB in SCI 1 being below either of the limits by 2018 is very low, and for all catches examined, the probability of remaining above the 40% B_0 target remains high (Table 12). For SCI 2, on the basis of annual catches at the TACC (100 tonnes), the probability of SSB being below either of the limits is very low. For the annual catches examined, the probability of SSB remaining above the 40% B_0 target remains high until 2018 (Table 14).

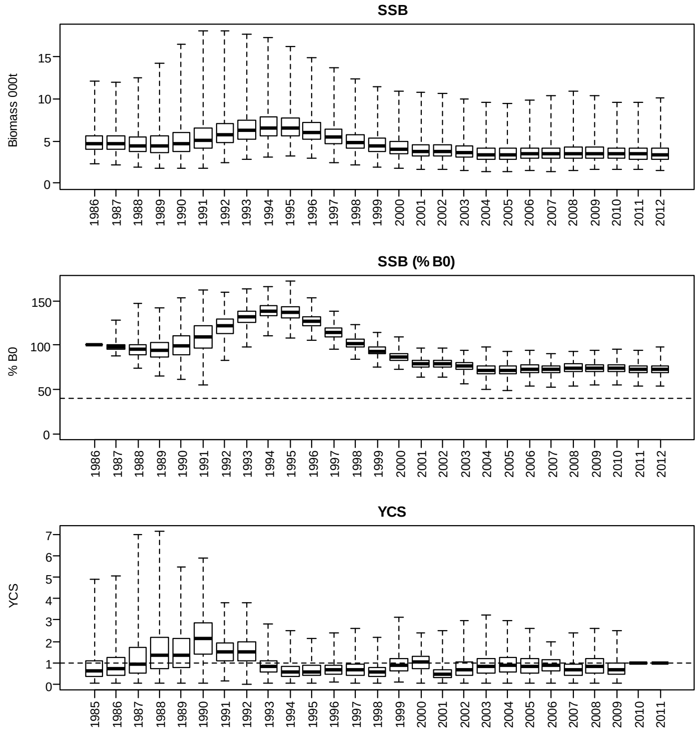


Figure 7: Posterior trajectory from SCI 1 base model (M=0.3) of spawning stock biomass and YCS. Upper plot shows boxplots of SSB, while the middle plot shows SSB as a percentage of B_0. On the middle plot, target and limit reference points are shown in grey solid and dashed lines. Box shows the median of the posterior distribution (horizontal bar), the 25th and 75th percentiles (box), with the whiskers representing the full range of the distribution.

Table 11: Results from MCMC runs showing B_0, B_{curr} B_{2016} and B_{2018} estimates at varying catch levels for SCI 1.

Catch level	Model	M=0.2	M=0.3
	B_0	4 444	4 681
	B_{curr}	3 003	3 294
	B_{curr}/B_0	0.68	0.71
100 tonnes	B_{2016}/B_0	0.66	0.71
	B_{2016}/B_{curr}	0.97	1.00
	B_{2018}/B_0	0.65	0.71
	B_{2018}/B_{curr}	0.97	1.00
110 tonnes	B_{2016}/B_0	0.65	0.70
	B_{2016}/B_{curr}	0.96	0.99
	B_{2018}/B_0	0.64	0.70
	B_{2018}/B_{curr}	0.95	0.98
120 tonnes	B_{2016}/B_0	0.65	0.70
(TACC)	B_{2016}/B_{curr}	0.96	0.98
	B_{2018}/B_0	0.64	0.70
	B_{2018}/B_{curr}	0.95	0.97
130 tonnes	B_{2016}/B_0	0.64	0.68
	B_{2016}/B_{curr}	0.95	0.96
	B_{2018}/B_0	0.63	0.68
	B_{2018}/B_{curr}	0.93	0.96
140 tonnes	B_{2016}/B_0	0.63	0.69
	B_{2016}/B_{curr}	0.93	0.97
	B_{2018}/B_0	0.62	0.68
	B_{2018}/B_{curr}	0.91	0.96

Table 12: Results from MCMC runs for SCI 1, showing probabilities of projected spawning stock biomass exceeding the default Harvest Strategy Standard target and limit reference points.

	100 tonnes	110 tonnes	120 tonnes (TACC)	130 tonnes	140 tonnes
M=0.2					
2016					
P(SSB<10% B0)	0.00	0.00	0.00	0.00	0.00
P(SSB<20% B0)	0.00	0.00	0.00	0.00	0.00
P(SSB>40% B0)	1.00	1.00	1.00	1.00	1.00
P(B2016 < B2012)	0.60	0.63	0.65	0.69	0.72
2018					
P(SSB<10% B0)	0.00	0.00	0.00	0.00	0.00
P(SSB<20% B0)	0.00	0.00	0.00	0.00	0.00
P(SSB>40% B0)	1.00	0.99	0.98	0.98	0.98
P(B2018 < B2012)	0.59	0.63	0.64	0.69	0.74
M=0.3					
2016					
P(SSB<10% B0)	0.00	0.00	0.00	0.00	0.00
P(SSB<20% B0)	0.00	0.00	0.00	0.00	0.00
P(SSB>40% B0)	1.00	1.00	0.99	0.99	0.99
P(B2016 < B2012)	0.49	0.54	0.54	0.59	0.58
2018					
P(SSB<10% B0)	0.00	0.00	0.00	0.00	0.00
P(SSB<20% B0)	0.00	0.00	0.00	0.00	0.00
P(SSB>40% B0)	0.99	0.99	0.99	0.99	0.98
P(B2018 < B2012)	0.51	0.54	0.55	0.59	0.59

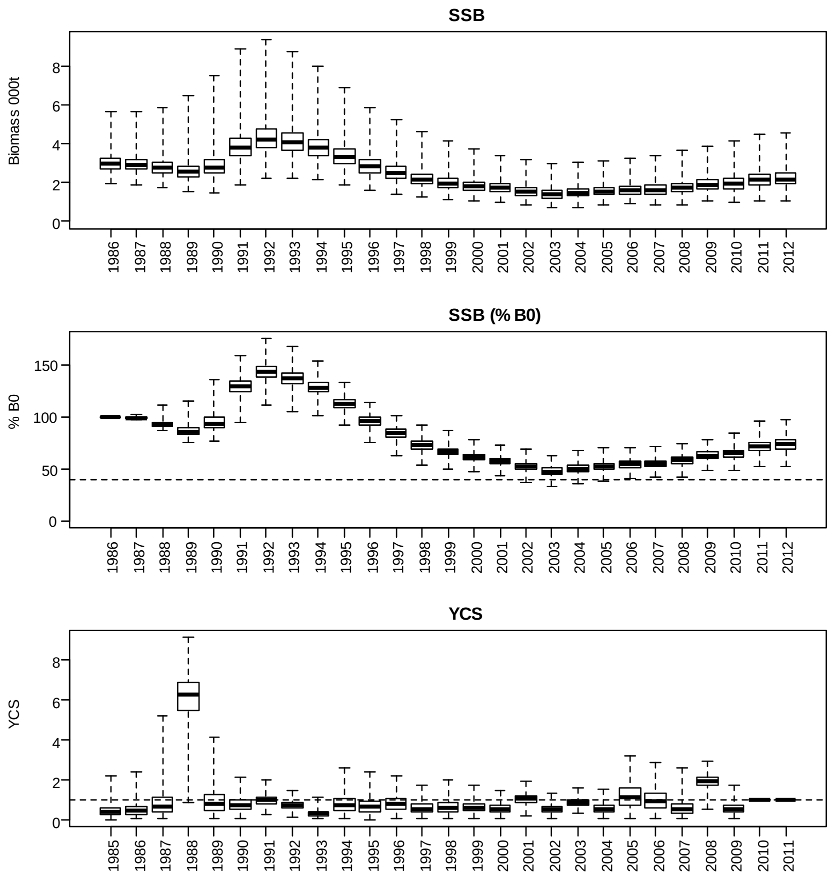


Figure 8: Posterior trajectory from the SCI 2 base model (*M*=0.3) of spawning stock biomass and YCS. Upper plot shows boxplots of SSB, while middle plot shows SSB as a percentage of B_0. On middle plot, target and limit reference points are shown in grey solid and dashed lines. Box shows the median of the posterior distribution (horizontal bar), the 25th and 75th percentiles (box), with the whiskers representing the full range of the distribution.

Table 13: Results from MCMC runs showing B_0, B_{curr}, B_{2016} and B_{2018} estimates at varying catch levels for SCI 2.

Catch	Model	*M*=0.2	*M*=0.3
	B_0	2 959	2 953
	B_{curr}	1 880	2 168
	B_{curr}/B_0	0.63	0.74
100 tonnes	B_{2016}/B_0	0.63	0.72
(TACC)	B_{2016}/B_{curr}	0.99	0.98
	B_{2018}/B_0	0.63	0.71
	B_{2018}/B_{curr}	1.00	0.98
110 tonnes	B_{2016}/B_0	0.62	0.72
	B_{2016}/B_{curr}	0.98	0.97
	B_{2018}/B_0	0.62	0.71
	B_{2018}/B_{curr}	0.97	0.97
120 tonnes	B_{2016}/B_0	0.61	0.70
	B_{2016}/B_{curr}	0.96	0.96
	B_{2018}/B_0	0.60	0.69
	B_{2018}/B_{curr}	0.95	0.94
130 tonnes	B_{2016}/B_0	0.60	0.69
	B_{2016}/B_{curr}	0.95	0.94
	B_{2018}/B_0	0.59	0.67
	B_{2018}/B_{curr}	0.93	0.93
140 tonnes	B_{2016}/B_0	0.59	0.68
	B_{2016}/B_{curr}	0.93	0.93
	B_{2018}/B_0	0.58	0.66
	B_{2018}/B_{curr}	0.91	0.90

Table 44: Results from MCMC runs for SCI 2, showing probabilities of projected spawning stock biomass exceeding the default Harvest Strategy Standard target and limit reference points.

	100 tonnes (TACC)	110 tonnes	120 tonnes	130 tonnes	140 tonnes
M=0.2					
2016					
P(SSB<10% B0)	0.00	0.00	0.00	0.00	0.00
P(SSB<20% B0)	0.00	0.00	0.00	0.00	0.00
P(SSB>40% B0)	0.99	0.99	0.98	0.98	0.97
P(B2016 < B2012)	0.52	0.56	0.59	0.64	0.67
2018					
P(SSB<10% B0)	0.00	0.00	0.00	0.00	0.00
P(SSB<20% B0)	0.00	0.00	0.00	0.00	0.00
P(SSB>40% B0)	0.97	0.96	0.94	0.93	0.92
P(B2018 < B2012)	0.51	0.55	0.59	0.63	0.66
M=0.3					
2016					
P(SSB<10% B0)	0.00	0.00	0.00	0.00	0.00
P(SSB<20% B0)	0.00	0.00	0.00	0.00	0.00
P(SSB>40% B0)	1.00	1.00	0.99	0.99	0.98
P(B2016 < B2012)	0.55	0.56	0.60	0.62	0.66
2018					
P(SSB<10% B0)	0.00	0.00	0.00	0.00	0.00
P(SSB<20% B0)	0.00	0.00	0.00	0.00	0.00
P(SSB>40% B0)	0.99	0.99	0.98	0.97	0.97
P(B2018 < B2012)	0.55	0.56	0.60	0.64	0.67

Biomass estimates for SCI also include estimates made using the area swept method from trawl surveys (Table 8). Trawl survey estimates can be considered to be minimum estimates of biomass as it is unlikely that there will be any herding effect of sweeps and bridles. Vertical availability to trawls can be expected to be less than 1 as many scampi will be found in burrows during the day. A preliminary estimate of scampi abundance for an area off the Auckland Islands has been generated from tag return data, although it should be noted that this programme was not designed to estimate biomass and violates many of the assumptions of the Petersen method. The estimated density of scampi for the Petersen method was similar to that estimated for visible scampi over the whole survey area from the photographic survey, although no account was taken of mortality or tag loss.

5.4 Other yield estimates and stock assessment results

There are no other yield estimates.

6. STATUS OF THE STOCKS

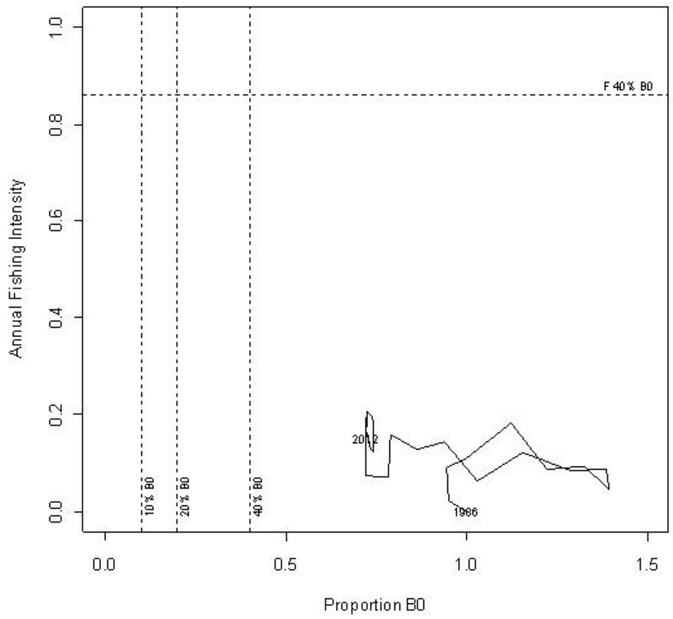
Stock Structure Assumptions

Assessments have been conducted for areas considered to be the core regions of SCI 1 and SCI 2 (accounting for 96.5% of scampi landings in each fishery).

- **SCI 1**

Stock Status	
Year of Most Recent Assessment	2013
Assessment Runs Presented	Bayesian length based model with *M*=0.3
Reference Points	Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: $F_{40\%B0}$
Status in relation to Target	Likely (> 60%) to be at or above target
Status in relation to Limits	Very Unlikely (< 10%) to be below the soft or hard limits
Status in relation to Overfishing	Overfishing is Very Unlikely (< 10%) to be occurring

Historical Stock Status Trajectory and Current Status



Annual equivalent fishing intensity plotted as a function of proportion of B_0 for SCI 1 (*M*=0.3). (Model with L_{50} for selectivity fixed in second time step).

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Spawning stock biomass increased to a peak in about 1995, declined to the early 2000s, and has remained relatively stable since this time.
Recent Trend in Fishing Mortality or Proxy	Fishing intensity has fluctuated without trend since the early 1990s.
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis	
Stock Projections or Prognosis	The stock is predicted to remain above 40% B_0 up to 2018 under current catches and TACC.
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Very Unlikely (< 10%) Hard Limit: Very Unlikely (< 10%)

Probability of Current Catch or TACC causing Overfishing to commence	Overfishing: Unlikely (< 40%)	
Assessment Methodology and Evaluation		
Assessment Type	Level 1 - Full Quantitative Stock Assessment	
Assessment Method	Length-based Bayesian Model	
Assessment Dates	Latest assessment: 2013	Next assessment: 2016
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	- Standardised catch and effort data (TCEPR) from MPI	1 – High Quality
	- Length frequency data from MPI observer sampling	2 – Medium or Mixed Quality: data not representative in some years
	- Photographic survey abundance index	1 – High Quality
	- Trawl survey abundance index	1 – High Quality
	- Length frequency data from research sampling	1 – High Quality
	- Length frequency predicted from burrow sizes	2 – Medium or Mixed Quality: estimation of length structure uncertain, and not fitted well in model
Data not used (rank)	-	
Changes to Model Structure and Assumptions	- Model simplified to use only a single spatial strata, and fit to an annual CPUE index (rather than indices for each time step) Change in weighting of abundance indices	
Major Sources of Uncertainty	- Growth, burrow occupancy and catchability	

Qualifying Comments
Priors are overly important in determining B_0 as there are inconsistence signals from the data. Fits to CPUE are also poor.

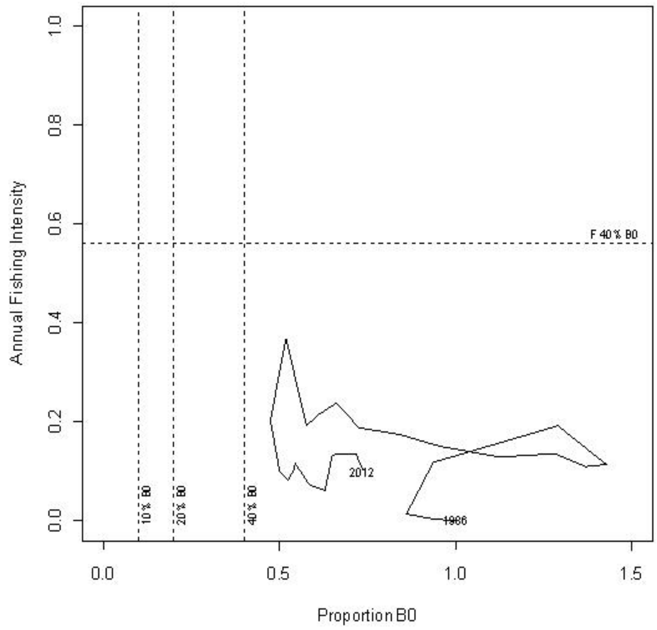
Fishery Interactions
Main QMS bycatch species include ling, hoki, sea perch, red cod, silver warehou and giant stargazer. Discards dominated by rattails, javelinfish, skates and crabs, ling, red cod, hoki, spiny dogfish and sea perch. There have been interactions with seabirds recorded. A wide range of benthic invertebrate species are taken as bycatch.

Research needs
The q priors and weighting of abundance indices need to be reviewed.

- **SCI 2**

Stock Status	
Year of Most Recent Assessment	2013
Assessment Runs Presented	Bayesian length based model without (model 4C) spatial structure
Reference Points	Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: $F_{40\%B0}$
Status in relation to Target	Very Likely (> 90%) to be at or above target
Status in relation to Limits	Very Unlikely (< 10%) to be below the soft limit Exceptionally Unlikely (< 1%) to be below the hard limit
Status in relation to Overfishing	Overfishing is Very Unlikely (< 10%) to be occurring

Historical Stock Status Trajectory and Current Status



Annual equivalent fishing intensity plotted as a function of proportion of B_0 for SCI 2 (M=0.3).

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Biomass increased during the early 1990s, but declined steadily after this until the early 2000s. Biomass has increased steadily since 2008.
Recent Trend in Fishing Mortality or Proxy	Fishing mortality increased through the 1990s, peaking in the early 2000s, but declined considerable by 2005, and has fluctuated without trend since this time.
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis		
Stock Projections or Prognosis	The stock is predicted to remain well above 40% B_0 under recent catches and TACCs.	
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Very Unlikely (< 10%) Hard Limit: Very Unlikely (< 10%)	
Probability of Current Catch or TACC causing Overfishing to commence	Overfishing: Unlikely (< 40%)	
Assessment Methodology and Evaluation		
Assessment Type	Level 1 - Full Quantitative Stock Assessment	
Assessment Method	Length-based Bayesian Model	
Assessment Dates	Latest assessment: 2013	Next assessment: 2016
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	- Standardised catch and effort data (TCEPR) from MPI - Length frequency data from MPI observer sampling - Photographic survey abundance index - Trawl survey abundance index	1 – High Quality 2 – Medium or Mixed Quality: data not representative in some years 1 – High Quality 1 – High Quality

	- Length frequency data from research sampling - Length frequency predicted from burrow sizes	1 – High Quality 2 – Medium or Mixed Quality: estimation of length structure uncertain
Data not used (rank)	-	
Changes to Model Structure and Assumptions	- Model simplified to use only a single spatial strata, and fit to an annual CPUE index (rather than indices for each time step)	
Major Sources of Uncertainty	- Growth, burrow occupancy and catchability	

Qualifying Comments
Stock status has changed considerably since the 2011 assessment due to increases in all abundance indices, which the model interprets as above average recent recruitment.

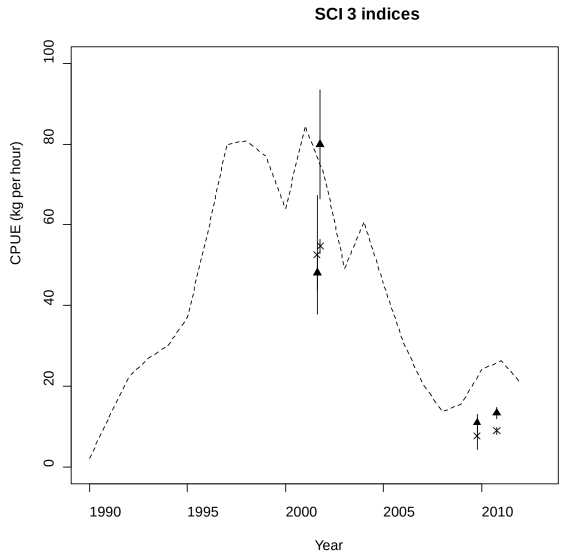
Fishery Interactions
Main QMS bycatch species include ling, hoki, sea perch, red cod, silver warehou and giant stargazer. Discards dominated by rattails, javelinfish, skates and crabs, ling, red cod, hoki, spiny dogfish and sea perch. There have been interactions with seabirds recorded. A wide range of benthic invertebrate species are taken as bycatch.

Research needs
The q priors and weighting of abundance indices need to be reviewed.

- **SCI 3**

Stock Status	
Year of Most Recent Assessment	No accepted assessment
Assessment Runs Presented	-
Reference Points	Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Unknown
Status in relation to Limits	Unknown

Historical Stock Status Trajectory and Current Status



Mean catch rates and relative abundance (± one standard error) of research trawling and photo survey counts in the core area of SCI 3. Symbols represent different aims of survey work (×- trawling within photo survey, ▲-scaled photo survey abundance). Dotted line represents median of annual unstandardised CPUE for SCI 3.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	CPUE, trawl survey and photo survey data suggest the stock declined between 2001 and 2009, but increased in 2010. CPUE data suggest abundance may have increased through the early 1990s, peaked from mid 1990s to early 2000s, and then declined 2007, and then increased to 2011.
Recent Trend in Fishing Mortality or Proxy	Unknown
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis		
Stock Projections or Prognosis	Quantitative stock projections are unavailable.	
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unknown Hard Limit: Unknown	
Assessment Methodology and Evaluation		
Assessment Type	Level 2 – Partial Quantitative Stock Assessment	
Assessment Method	Abundance indices from CPUE, trawl and photo surveys	
Assessment Dates	Latest assessment: 2012	Next assessment: 2015
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	- Standardised catch and effort data (TCEPR) from MPI - Length frequency data from MPI observer sampling - Photographic survey abundance index - Trawl survey abundance index - Length frequency data from research sampling	1 – High Quality 1 – High Quality 1 – High Quality 1 – High Quality 1 – High Quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	- Relationship between CPUE and abundance, growth, burrow occupancy, emergence and catchability	

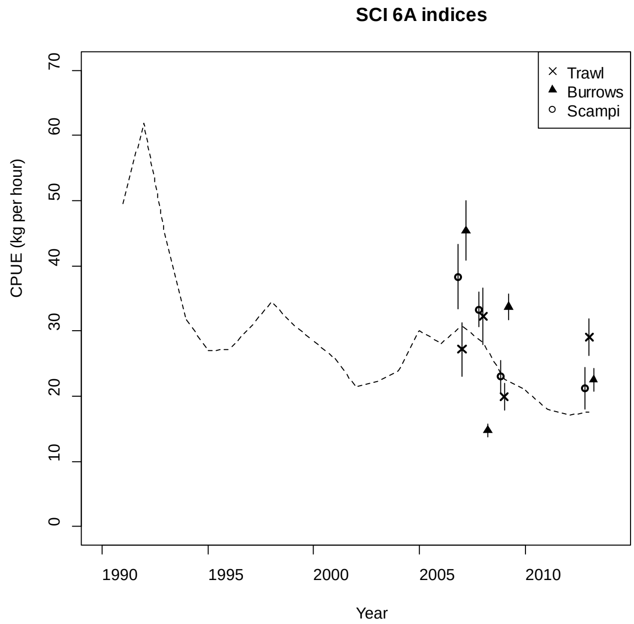
Qualifying Comments
Scampi catches from SCI 3 are taken from three relatively distinct areas near the Mernoo Bank on the Chatham Rise. Trends in CPUE from these areas both increase and then decrease, but peaked in different years (1997 and 2001). Where available, the CPUE for the most recent years suggests an increase. The extended period of higher CPUE shown from this area may be an artefact of the fishing activity moving location. CPUE index previously considered to be potentially strongly influenced by changes in catchability, and therefore not reliable as an index of abundance. Re-examination of the data has addressed some of the concerns, and the consistency between indices and also with similar species, may indicate the index is not as implausible as first considered.

Fishery Interactions
Main QMS bycatch species include ling, hoki, sea perch, red cod, silver warehou and giant stargazer. Discards dominated by rattails, javelinfish, skates and crabs, ling, red cod, hoki, spiny dogfish and sea perch. There have been interactions with seabirds recorded. A wide range of benthic invertebrate species are taken as bycatch.

- **SCI 6A**

Stock Status	
Year of Most Recent Assessment	No accepted assessment
Assessment Runs Presented	-
Reference Points	Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Unknown
Status in relation to Limits	Unknown

Historical Stock Status Trajectory and Current Status



Mean catch rates and relative abundance (± one standard error) of research trawling and photo survey counts in the core area of SCI 6A. Symbols represent different aims of survey work (×- trawling within photo survey, ▲-scaled photo survey abundance). Dotted line represents median of annual unstandardised CPUE for SCI 6A.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	CPUE data suggest the stock may have declined in the early years of the fishery, but has remained at a relatively stable level since the mid 1990s. Photo and trawl survey data (2007–2009, 2013) suggest the stock has remained relatively stable in recent years.
Recent Trend in Fishing Mortality or Proxy	Catches and stock abundance appear to have remained relatively stable in recent years, suggesting exploitation rates have been relatively stable.
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis	
Stock Projections or Prognosis	Quantitative stock projections are unavailable
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unknown Hard Limit: Unknown

Assessment Methodology and Evaluation		
Assessment Type	Level 2 – Partial Quantitative Stock Assessment	
Assessment Method	- Abundance indices from CPUE, trawl and photo surveys	
Assessment Dates	Latest assessment: 2014 (CPUE analysis), 2013 (photo survey)	Next assessment: 2016 (CPUE and assessment model), 2013 (photo survey)
Overall assessment quality rank	2 – Medium or Mixed Quality	
Main data inputs	- Standardised catch and effort data (TCEPR) from MPI - Length frequency data from MPI observer sampling - Photographic survey abundance index - Trawl survey abundance index - Length frequency data from research sampling	1 – High Quality 1 – High Quality 1 – High Quality 1 – High Quality 1 – High Quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	- Length based model currently under development	
Major Sources of Uncertainty	- Relationship between CPUE and abundance, growth, burrow occupancy, emergence and catchability	

Qualifying Comments
Preliminary work from the SCI6Astock assessment model suggests that currently there doesn't appear to be a sustainability risk for this stock However, uncertainty in model fits and model outputs means results are just preliminary at this stage and have not been accepted by the SFWG. Photo surveys in SCI 6A observe a high number of scampi out of burrows, relative to burrows counted, than has been observed in other areas. This may be related to animal size or sediment characteristics. If emergence is greater, this may imply that scampi in SCI 6A are more vulnerable to trawling than other areas. CPUE index previously considered to be potentially strongly influenced by changes in catchability, and therefore not reliable as an index of abundance. Re-examination of the data has addressed some of the concerns, and the consistency between indices and also with similar species, may indicate that the index is not as implausible as first considered.

Fishery Interactions
Main QMS bycatch species include ling, hoki, sea perch, red cod, silver warehou and giant stargazer. Discards dominated by rattails, javelinfish, skates and crabs, ling, red cod, hoki, spiny dogfish and sea perch. There have been interactions with seabirds and mammals (fur seals and sealions) recorded. A wide range of benthic invertebrate species are taken as bycatch.

7. FOR FURTHER INFORMATION

Abraham, E. R., Pierre, J. P., Middleton, D. A., Cleal, J., Walker, N. A., & Waugh, S. M. (2009). Effectiveness of fish waste management strategies in reducing seabird attendance at a trawl vessel. *Fisheries Research*, *95*(2), 210-219.

Abraham, E R; Thompson, F N (2011) Summary of the capture of seabirds, marine mammals, and turtles in New Zealand commercial fisheries, 1998–99 to 2008–09. *New Zealand Aquatic Environment and Biodiversity Report No. 80*.

Finlay N. Thompson, Edward R. Abraham, Katrin Berkenbusch (2011). Marine mammal bycatch in New Zealand trawl fisheries, 1995–96 to 2009–10. Final Research Report for Ministry for Primary Industries project PRO2010-01 (Unpublished report held by the Ministry for Primary Industries, Wellington). 68 pages.

Abraham, E R; Thompson, F N; Berkenbusch, K (2013) Estimated capture of seabirds in New Zealand trawl and longline fisheries, 2002–03 to 2010–11. Final Research Report for Ministry for Primary Industries project PRO2010-01 (Unpublished report held by Ministry for Primary Industries, Wellington).

Baird, S. J. (Ed.). (2001). *Report on the International Fishers' Forum on Solving the Incidental Capture of Seabirds in Longline Fisheries, Auckland, New Zealand, 6-9 November 2000*. Department of Conservation

Baird, S J (2004a) Estimation of the incidental capture of seabird and marine mammal species in commercial fisheries in New Zealand waters, 1999–2000. *New Zealand Fisheries Assessment Report 2004/41*. 56 p.

Baird, S J (2004b) Incidental capture of seabird species in commercial fisheries in New Zealand waters,2000–01. *New Zealand Fisheries Assessment Report 2004/58*. 63 p.

Baird, S J (2004c) Incidental capture of seabird species in commercial fisheries in New Zealand waters, 2001–02. *New Zealand Fisheries Assessment Report 2004/60*.51 p.

Baird, S J (2005a) Incidental capture of New Zealand fur seals (*Arctocephalus forsteri*) in commercial fisheries in New Zealand waters, 2002–03. *New Zealand Fisheries Assessment Report 2005/13*. 36 p.

Baird, S J (2005b) Incidental capture of seabird species in commercial fisheries in New Zealand waters, 2002–03. *New Zealand Fisheries Assessment Report* 2005/12. 50 p.

Baird, S J; Doonan, I J (2005) *Phocarctos hookeri* (New Zealand sea lions): incidental captures in New Zealand commercial fisheries during 2000–01 and in-season estimates of captures during squid trawling in SQU 6T in 2002. *New Zealand Fisheries Assessment Report 2005/17*. 20 p.

Baird, S J; Smith, M H (2007) Incidental capture of New Zealand fur seals (*Arctocephalus forsteri*) in commercial fisheries in New Zealand waters, 2003–04 to 2004–05. *New Zealand Aquatic Environment and Biodiversity Report* No. 14. 98 p.

Baird, S J; Wood, B A (2012) Extent of coverage of 15 environmental classes within the New Zealand EEZ by commercial trawling with seafloor contact. *New Zealand Aquatic Environment and Biodiversity Report* No. 89. 43 p.

Baird, S J; Wood, B A & Bagley, N. W. (2011) Nature and extent of commercial fishing effort on or near the seafloor within the New Zealand 200 n. mile Exclusive Economic Zone, 1989–90 to 2004–05. *New Zealand Aquatic Environment and Biodiversity Report* 73. 143 p.

Baker, C S; Chilvers, B L; Constantine, R; DuFresne, S; Mattlin, R H; van Helden, A; Hitchmough, R (2010) Conservation status of New Zealand marine mammals (suborders Cetacea and Pinnipedia), 2009. *New Zealand Journal of Marine and Freshwater Research* 44: 101–115.

Ballara, S L; Anderson, O F (2009). Fish discards and non-target fish catch in the trawl fisheries for arrow squid and scampi in New Zealand waters. New Zealand Aquatic Environment and Biodiversity Report No. 38. 102 p.

Bell, M C; Redant, F; Tuck, I D (2006) *Nephrops species. Lobsters: Biology, management, Aquaculture and Fisheries*. B. Phillips. Oxford, Blackwell Publishing**.** pp 412–461.

Black, J; Wood, R; Berthelsen, T; Tilney, R (2013) Monitoring New Zealand's trawl footprint for deepwater fisheries: 1989–1990 to 2009–2010. *New Zealand Aquatic Environment and Biodiversity Report* No. 110. 57 p.

Chapman, C J (1979) Some observations on populations of Norway Lobster, *Nephrops norvegicus* (L.), using diving, television, and photography. *Rapports et process verbeaux de la Reunion Conseil international pour l'Exploration de la Mer* 175:127–133.

Chapman, C J (1980) Ecology of juvenile and adult Nephrops. In: *The biology and management of lobster*, Vol. 1. pp 143–178. (S. Cobb; B. Phillips, eds.), Academic Press, New York.

Chapman, C J; Howard, F G (1979) Field observations on the emergence rhythm of the Norway Lobster *Nephrops norvegicus*, using different methods. *Marine Biology* 51:157–165.

Chapman, C J; Howard, F.G. (1988) Environmental influences on Norway lobster (*Nephrops norvegicus*) populations and their implications for fishery management. *Symposium of the Zoological Society, London* 59:343–353.

Cryer, M (2000) A consideration of current management areas for scampi in QMAs 3, 4, 6A and 6B. Final Research Report for Ministry of Fisheries Research Project MOF199904K, Objective 1. (Unpublished report held by Ministry for Primary Industries, Wellington.)

Cryer, M; Coburn, R (2000) Scampi assessment for 1999. *New Zealand Fisheries Assessment Report 2000/7*. 60 p.

Cryer, M; Coburn, R; Hartill, B; O'Shea, S; Kendrick, T; Doonan, I (1999) Scampi stock assessment for 1998 and an analysis of the fish and invertebrate bycatch of scampi trawlers. New Zealand Fisheries Assessment Research Document 1999/4. 75 p. (Unpublished report held by NIWA library, Wellington.)

Cryer, M; Doonan, I; Coburn, R; Hartill, B (1998) Scampi assessment for 1997. New Zealand Fisheries Assessment Research Document 1998/28. 78 p. (Unpublished report held by NIWA library, Wellington.)

Cryer, M; Dunn, A; Hartill, B (2004) Length-based population model for scampi (*Metanephrops challengeri*) in the Bay of Plenty (QMA 1). *New Zealand Fisheries Assessment Report 2005/27*. 55 p.

Cryer, M; Hartill, B (1998) Final Research Report to Ministry of Fisheries on an experimental comparison of trawl and photographic methods of estimating the biomass of scampi. Final Research Report for Project SCI9701. 26 p. (Unpublished report held by Ministry for Primary Industries, Wellington.)

Hartill, B., & Cryer, M. (2000). *A review of the adequacy of the current observer coverage and practices for scampi*. Final Research Report for Ministry of Fisheries Research Roject MOF1999104J. 46 p.(Unpublished report held by Ministry of Fisheries, Wellington.).

Cryer, M; Hartill, B (2001) Scampi assessment for 2000 and unstandardised CPUE 1988–89 to 1999–00. Draft FAR dated December 2000, held by Ministry for Primary Industries, Wellington.

Cryer, M; Hartill, B; Drury, J; Armiger, H J; Smith, M D; Middleton, C J (2003) Indices of relative abundance for scampi, *Metanephrops challengeri*, based on photographic surveys in QMA 1 (1998–2003) and QMA 2 (2003). Final Research Report for Project SCI2002/01 (Objectives 1–3). 18 p, held by Ministry for Primary Industries, Wellington.

Cryer, M; Hartill, B; Drury, J; Tuck, I; Cadenhead, H J; Smith, M D; Middleton, C J (2002) Indices of relative abundance for scampi, *Metanephrops challengeri*, based on photographic surveys in QMA 1, 1998–2002. Final Research Report for Projects SCI2000/02 (Objectives 1 & 2) and SCI2001/01 (Objectives 1 & 2), dated November 2002, held by Ministry for Primary Industries, Wellington.

Cryer, M; Hartill, B W; O'Shea, S (2002) Modification of marine benthos by trawling: toward a generalization for the deep ocean? Ecological Applications 12: 1824–1839.

Cryer, M; Hartill, B; O'Shea, S (2005) Deepwater trawl fisheries modify benthic community structure in similar ways to fisheries in coastal systems. *American Fisheries Society Symposium* 41: 695–696.

Cryer, M; Oliver, M (2001) Estimating age and growth in New Zealand scampi, *Metanephrops challengeri*. Final Research Report for Ministry of Fisheries Project SCI9802 (Objective 2). (Unpublished report held by Ministry for Primary Industries, Wellington.)

Cryer, M; Stotter, D R (1997) Trawling and tagging of scampi off the Alderman Islands, western Bay of Plenty, September 1995 (KAH9511). *New Zealand Fisheries Data Report* No. 84. 26 p.

Cryer, M; Stotter, D R (1999) Movements and growth rates of scampi inferred from tagging, Aldermen Islands, western Bay of Plenty. *NIWA Technical Report* No. 49. 35 p.

Cryer, M; Vignaux, M; Gilbert, D J (1995) Assessment of the scampi fishery for 1995. Draft N.Z. Fisheries Assessment Research Document (Unpublished report held by Ministry for Primary Industries, Wellington.)

Dunn, M., P. Horn, A. Connell, D. Stevens, J. Forman, M. Pinkerton, L. Griggs, P. Notman, and B. Wood. 2009) Ecosystem-scale trophic relationships: diet composition and guild structure of middle-depth fish on the Chatham Rise. Final Research Report for Ministry of Fisheries Research Project, ZBD2004-02. (Unpublished report held by Ministry for Primary Industries, Wellington.)

Farmer, A S D (1974) Reproduction in *Nephrops norvegicus* (Decapoda: Nephropidae). Journal of Zoology, London 174:161–183.

Fenaughty, C (1989) Reproduction in *Metanephrops challengeri*. (Unpublished report held by Ministry for Primary Industries, Wellington.)

Hartill, B; Cryer, M (2001) Unstandardised CPUE indices for scampi 1988–2001. Final Research Report for Project SCI2001/02, dated November 2001. (Unpublished report held by Ministry for Primary Industries, Wellington.)

Hartill, B; Cryer, M (2002) Unstandardised CPUE indices for scampi 1988–2002. Final Research Report for Project SCI2001/02 (Objective 2), dated December 2002. (Unpublished report held by Ministry for Primary Industries, Wellington.)

Hartill, B; Cryer, M (2004) Unstandardised scampi CPUE indices update for scampi 1988–2003. Final Research Report for Ministry of Fisheries Research Project SCI2001/02, Obj. 2. 35 p. (Unpublished report held by Ministry for Primary Industries, Wellington.)

Hartill, B; Cryer, M; MacDiarmid, A D (2004) Reducing bycatch in scampi trawl fisheries. Draft New Zealand Fisheries Assessment Report dated December 2004. (Unpublished report held by Ministry for Primary Industries, Wellington.)

Hartill, B; Tuck, I D (2010) Potential utility of scampi processor grade data as a source of length frequency data. Final Research Report for Ministry of Fisheries Project SCI2007-03. (Unpublished report held by Ministry for Primary Industries, Wellington.)

Hermsen, J M; Collie, J S; Valentine, P C (2003) Mobile fishing gear reduces benthic megafaunal production on Georges Bank. *Marine Ecology Progress Series* 260: 97–108.

Hiddink, J G; Jennings, S; Kaiser, M J; Queiros, A M; Duplisea, D E; Piet, G J (2006) Cumulative impacts of seabed trawl disturbance on benthic biomass, production, and species richness in different habitats. *Canadian Journal of Fisheries and Aquatic Sciences* 63:721–36.

Hore A J (1992) Management of the New Zealand Scampi Fishery: an interim report to the Director General of Agriculture and Fisheries. Unpublished Report. MAF Fisheries, Wellington. (Unpublished report held by Ministry for Primary Industries, Wellington.)

Hughes, D; Atkinson, R (1997) A towed video survey of megafaunal bioturbation in the north-eastern Irish Sea. *Journal of the Marine Biological Association of the United Kingdom* 77(3): 635–653.

Jennings, S; Dinmore, T A; Duplisea, D E; Warr, K J; Lancaster, J E (2001) Trawling disturbance can modify benthic production processes. *Journal of Animal Ecology* 70: 459–475.

Kelleher, K (2005) Discards in the world's marine fisheries. An update. *FAO Fisheries Technical Paper* 470. 131 p.

Leathwick, J R; Rowden, A; Nodder, S; Gorman, R; Bardsley, S; Pinkerton, M; Baird, S J; Hadfield, M; Currie, K; Goh, A (2009) Benthic-optimised marine environment classification for New Zealand waters. Final Research Report project BEN2006/01. 52 p. (Unpublished report held by Ministry for Primary Industries, Wellington.)

MacKenzie, D; Fletcher, D (2006) Characterisation of seabird captures in NZ fisheries. Final Research Report for Ministry of Fisheries project ENV2004/04. 99 p. (Unpublished report held by Ministry for Primary Industries, Wellington.)

Meynier, L., P. C. H. Morel, D. D. S. Mackenzie, A. MacGibbon, B. L. Chilvers, and P. J. Duignan (2008) Proximate composition, energy content, and fatty acid composition of marine species from Campbell Plateau, New Zealand. *New Zealand Journal of Marine and Freshwater Research* 42(4): 425–437.

Middleton, D A J; Abraham, E R (2007) The efficacy of warp strike mitigation devices: Trials in the 2006 squid fishery. Final Research Report for research project IPA2006/02. (Unpublished report held by Ministry for Primary Industries, Wellington).

Rainer, S F (1992) Growth of Australian scampi, *Metanephrops australiensis*. The fisheries biology of deepwater crustacea and finfish on the continental slope of Western Australia. S. F. Rainer. Final Report FRDC Project 1988/74.

Reiss, Henning, Simon PR Greenstreet, Katrin Sieben, Siegfried Ehrich, Gerjan J. Piet, Floor Quirijns, Leonie Robinson, Wim J. Wolff, and Ingrid Kröncke (2009) Effects of fishing disturbance on benthic communities and secondary production within an intensively fished area. *Marine Ecology Progress Series* 394: 201–213.

Rice, J (2006) Impacts of Mobile Bottom Gears on Seafloor Habitats, Species, and Communities: A Review and Synthesis of Selected International Reviews. Canadian Science Advisory Secretariat Research Document 2006/057. 35 p. (available from http://www.dfo-mpo.gc.ca/CSAS/Csas/DocREC/2006/RES2006_057_e.pdf)

Richard, Y; Abraham, E R (2013). Risk of commercial fisheries to New Zealand seabird populations. *New Zealand Aquatic Environment and Biodiversity Report No. 109*. 58 p.

Thompson, F. N., & Abraham, E. R. (2009). *Six Monthly Summary of the Capture of Protected Species in New Zealand Commercial Fisheries, Summer 2007-08*. Ministry of Fisheries

Thompson, F N; Berkenbusch, K; Abraham, E R (2013). Marine mammal bycatch in New Zealand trawl fisheries, 1995–96 to 2010–11. *New Zealand Aquatic Environment and Biodiversity Report No. 105*. 73 p.

Tuck, I D (2007) A medium term research plan for scampi (*Metanephrops challengeri*). Final Research Report for Ministry of Fisheries Research Project SAP200607. (Unpublished report held by Ministry for Primary Industries, Wellington.)

Tuck, I D (2010) Scampi burrow occupancy, burrow emergence, and catchability, *New Zealand Fisheries Assessment Report 2010/13*.

Tuck, I D (2013) Characterisation and length-based population model for scampi (*Metanephrops challengeri*) on the Mernoo Bank (SCI 3). *New Zealand Fisheries Assessment Report 2013/24*. 165p.

Tuck, I; Cryer, M; Hartill, B; Drury, J; Armiger, H; Smith, M; Parkinson, D; Middleton, C (2006) Measuring the abundance of scampi - Indices of abundance for scampi, Metanephrops challengeri, based on photographic surveys in SCI 2 (2003–2005). Final Research Report for Ministry of Fisheries Research Project SCI2004/01 (Objectives 1 & 2). (Unpublished report held by Ministry for Primary Industries, Wellington.)

Tuck, I D; Dunn, A (2009) Length-based population model for scampi (*Metanephrops challengeri*) in the Bay of Plenty (SCI 1) and Wairarapa / Hawke Bay (SCI 2). Final Research Report for Ministry of Fisheries research projects SCI2006-01 & SCI2008-03W. (Unpublished report held by Ministry for Primary Industries, Wellington.)

Tuck, I D; Dunn, A (2012) Length-based population model for scampi (*Metanephrops challengeri*) in the Bay of Plenty (SCI 1), Wairarapa / Hawke Bay (SCI 2), and Auckland Islands (SCI 6A). *New Zealand Fisheries Assessment Report 2012/01.*

Tuck, I D; Hartill, B; Drury, J; Armiger, H; Smith, M; Parkinson, D (2006) Measuring the abundance of scampi – Indices of abundance for scampi, *Metanephrops challengeri*, based on photographic surveys in SCI 2 (2003–2006). Final Research Report for Ministry of Fisheries Research Project SCI2005-01 (Objective 1). (Unpublished report held by Ministry for Primary Industries, Wellington.)

Tuck, I D; Hartill, B; Parkinson, D; Harper, S; Drury, J; Smith, M; Armiger, H (2009) Estimating the abundance of scampi - Relative abundance of scampi, *Metanephrops challengeri*, from a photographic survey in SCI 1 and SCI 6A (2008). Final Research Report for Ministry of Fisheries research project SCI2007-02. (Unpublished report held by Ministry for Primary Industries, Wellington.)

Vignaux, M; Gilbert, D J (1993) A production model for the QMA 1 scampi fishery 1989–1991. New Zealand Fisheries Assessment Research Document 1993/18. (Unpublished report held by NIWA library, Wellington.)

Vignaux, M; Gilbert, D J (1994) A production model for the QMA 1 scampi fishery 1989–1992. New Zealand Fisheries Assessment Research Document 1994/8. (Unpublished report held by NIWA library, Wellington.)

Wear, R G (1976) Studies on the larval development of *Metanephrops challengeri* (Balss, 1914) (Decapoda, Nephropidae). Crustaceana 30:113–122.