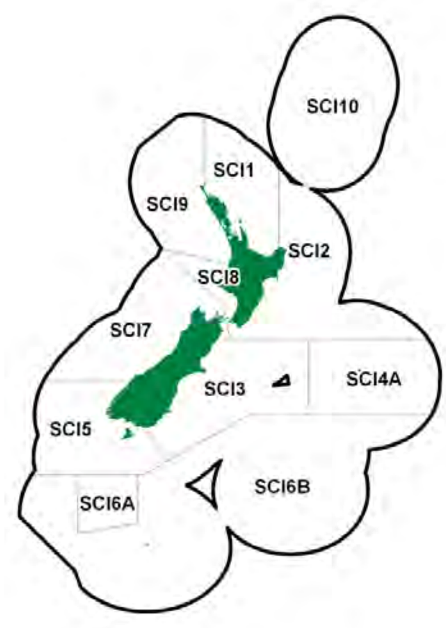
SCAMPI (SCI)

(*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. The TACs and TACCs by Fishstock as of 1 October 2021 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 as of 1 October 2021.

		Allowances			
Fishstock	TAC	Customary	Recreational	Other*	TACC
SCI 1	139	0	0	7	132
SCI 2	161	0	0	8	153
SCI 3	428	0	0	20	408
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 and, until the 1999–2000 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—i.e., there were no individual allocations (Figure 1).

Estimated landings and TACCs are given by scampi QMA for 1986–87 to 2018–19 in Table 2.

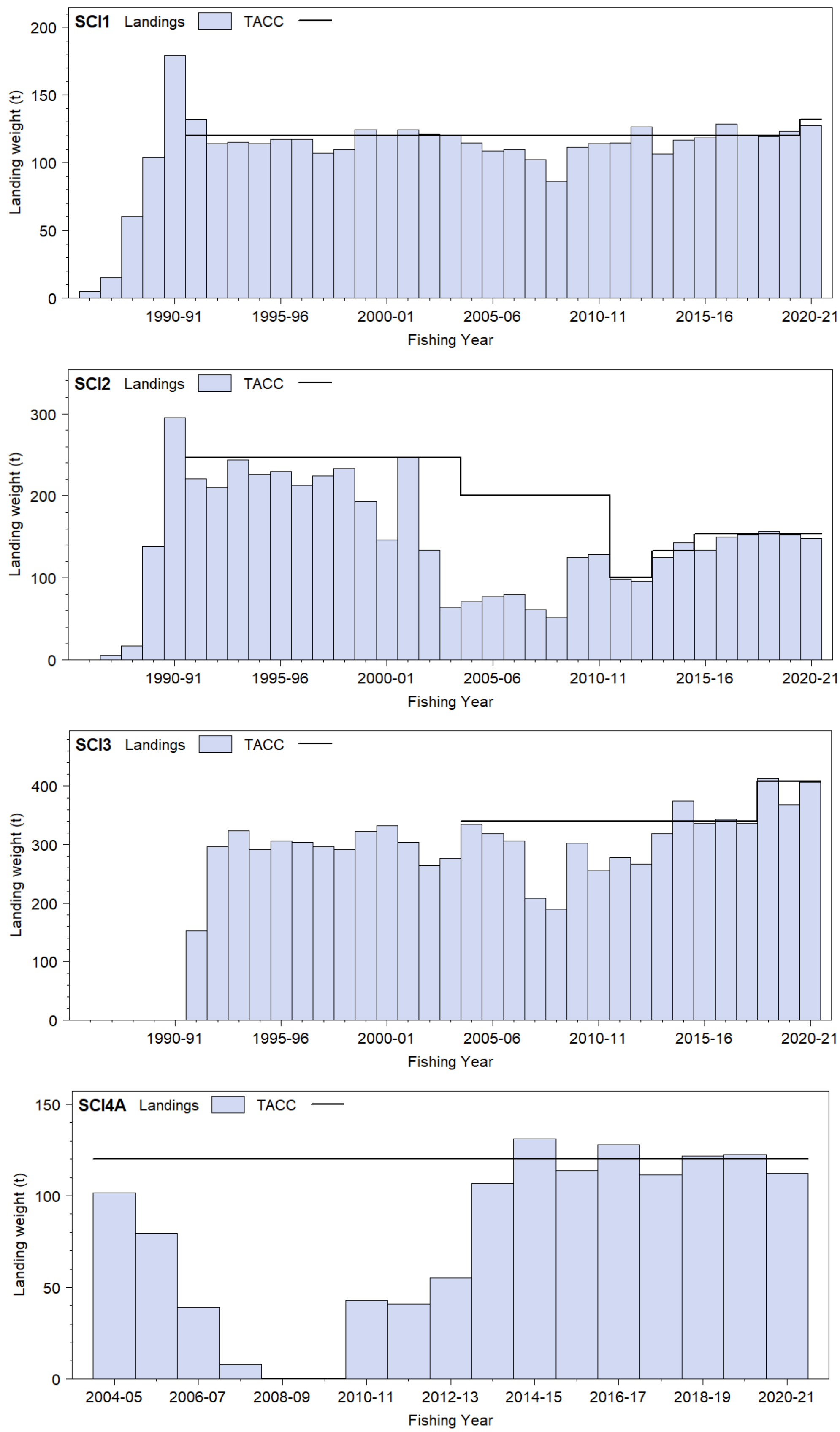


Figure 1: Reported commercial landings and TACCs (or catch limits prior to 2004–05) for the five main SCI stocks from fishing years 1986–87 to present. SCI 1 Bay of Plenty, SCI 2 Wairarapa coast, SCI 3 Chatham Rise, and SCI 4A Chatham Islands. [Continued on next page]

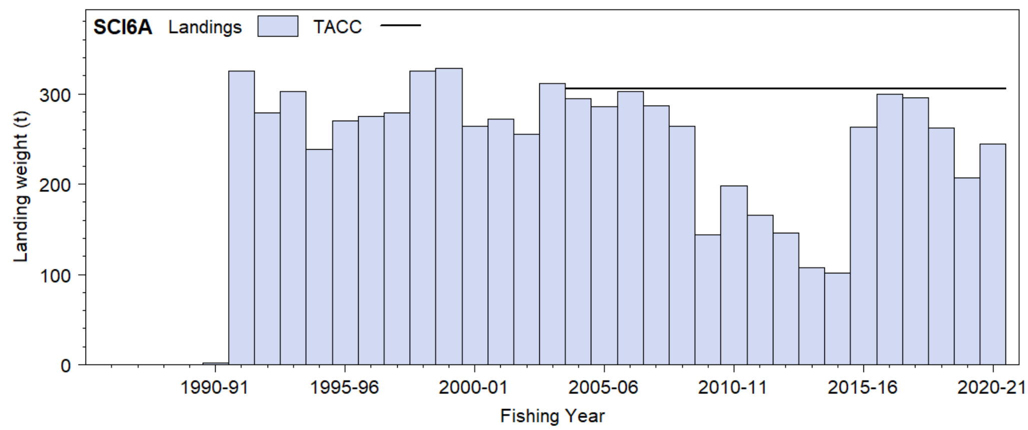


Figure 1: [Continued] Reported commercial landings and TACCs (or catch limits prior to 2004–05) for the five main SCI stocks from fishing years 1986–87 to present: SCI 6A Auckland Islands.

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 forms and data reported electronically, Fisheries New Zealand 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 TCEPR data, which has previously been found to match landings well. [Continued on next page]

		SCI 1		SCI 2		SCI 3		SCI 4A		SCI 5
Fishing year	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
2013–14	107	120	125	133	319	340	107	120	< 1	40
2014–15	117	120	143	133	374	340	131	120	< 1	40
2015–16	118	120	134	153	336	340	114	120	< 1	40
2016–17	129	120	150	153	344	340	129	120	< 1	40
2017–18	120	120	152	153	337	340	111	120	< 1	40
2018–19	119	120	157	153	413	408	122	120	< 1	40
2019–20	123	120	152	153	369	408	123	120	< 1	40
2020–21	127	132	148	153	406	408	112	120	<1	40

Table 2: [Continued]

	SCI 6A		SCI 6B		SCI 7		SCI 8		SCI 9	
Fishing year	**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
2013–14	107	306	< 1	50	4	75	0	5	< 1	35
2014–15	102	306	< 1	50	9	75	0	5	< 1	35
2015–16	263	306	< 1	50	9	75	0	5	< 1	35
2016–17	300	306	< 1	50	3	75	0	5	< 1	35
2017–18	295	306	< 1	50	4	75	0	5	< 1	35
2018–19	262	306	0	50	1	75	0	5	< 1	35
2019–20	207	306	< 1	50	< 1	75	0	5	< 1	35
2020–21	245	306	0	50	1	75	0	5	<1	35

Fishing has been conducted by 20–40 m vessels using light, bottom trawl gear but over the last ten years all vessels are less than 32 m long. All vessels use multiple rigs of two or three nets of very a 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 350–550 m in SCI 6A (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 Māori customary fisheries
There is no customary fishery for scampi.

1.4 Illegal catch
There is no quantitative information on the level of illegal catch. It is assumed to be zero.

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. Catch rates are typically higher during the hours of daylight than night, and patterns vary seasonally between sexes and areas, dependent on the moult cycle.

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 (approximately age 3 to 4 years). 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. Males grow to a larger size than females. 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 in the UK and Australia. Many more females than males were recaptured, and small males were almost entirely absent from the recapture sample. The reasons for this are not understood but may relate to the timing of moulting in relation to the study and tag retention. 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 (y^{-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)

Note: 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, and these estimates should not be regarded as definitive. In particular, the rearing temperature was 12 ºC compared with about 10 ºC 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). *Nephrops 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 six release events (March 2007, 2008, 2009, 2013, 2016, and 2019). 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. Studies using newer mitochondrial DNA and microsatellite approaches are underway and are likely to be more sensitive to differences between stocks. 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

Tables and accompanying text in this section have been updated for the 2022 Fishery Assessment Plenary where possible. A more detailed summary from an issue-by-issue perspective is available in the Aquatic Environment and Biodiversity Annual Review 2021 (Fisheries New Zealand 2021), online at https://www.mpi.govt.nz/dmsdocument/51472-Aquatic-Environment-and-Biodiversity-Annual-Review-AEBAR-2021-A-summary-of-environmental-interactions-between-the-seafood-sector-and-the-aquatic-environment.

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 of 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 Bycatch (fish and invertebrates)

In the 2002–03 to 2015–16 fishing years, total annual bycatch was estimated to range from 2400–5600 t compared with total landed scampi catches of 550–893 t, and scampi accounted for 19% of the total estimated catch by weight from all observed tows (Anderson & Edwards 2018). Nearly 500 bycatch species or species groups were identified by observers, and the main bycatch species were javelinfish (18%), rattails (12%), and sea perch (10%), which were mostly discarded (Figure 2). Smaller catches of hoki (5%), ling (4%), and dark ghost shark (3%) were also recorded. Invertebrate species made up a much smaller fraction of the bycatch overall (about 7%), with crustaceans (3%), echinoderms (2%), and squid (0.9%) being the main invertebrate bycatch species groups.

Total annual discard estimates from 2002–03 to 2015–16 showed no trend over time, ranging from a low of 940 t in 2003–04 to 4070 t in the following year (Anderson & Edwards 2018). Non-QMS species were the main group discarded, often at a magnitude of two to three times that of QMS species discards. Annual estimated discards of scampi were generally low but exceeded 10 t in two years (2002–03 and 2009–10). The species discarded in the greatest amounts were those caught in the greatest amounts, javelinfish (95%), rattails (91%), and sea perch (68%). From 2002–03 to 2015–16, the overall discard fraction value was 3.6 kg, with little trend over time. Discards ranged from 1.2 to 4.9 kg of discarded fish for every 1 kilogram of scampi caught.

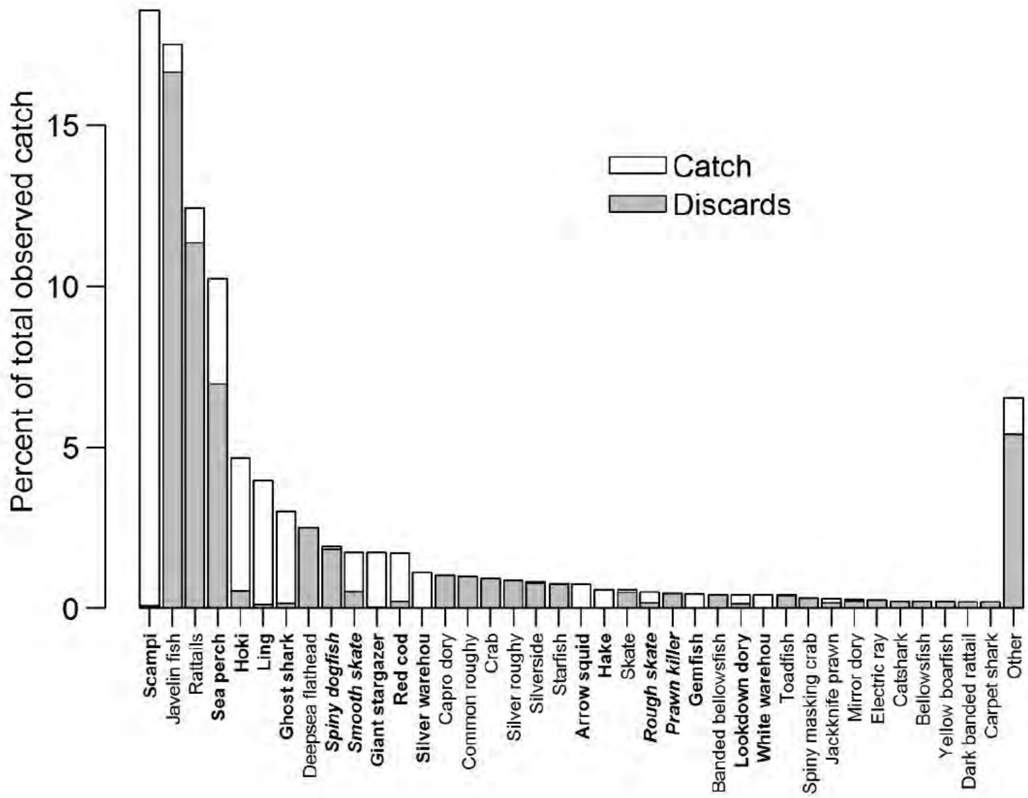


Figure 2: Percentage of the total catch contributed by the main bycatch species (those representing 0.02% or more of the total catch) in the observed portion of the target scampi trawl fishery for fishing years 2002–03 to 2015–16, and the percentage discarded. The Other category is the sum of all bycatch species representing less than 0.02% of the total catch (Anderson & Edwards 2018).

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). Risk assessments results, which also include estimation of cryptic mortality, are also presented here when relevant.

Marine mammal captures

Scampi trawlers occasionally catch marine mammals, including New Zealand sea lions (rāpoka), *Phocarctos hookeri,* and New Zealand fur seals (which were classified as 'Nationally Vulnerable' and 'Not Threatened', respectively, under the New Zealand Threat Classification System in 2013, Baker et al 2016).

In the 2017–18 fishing year there were two observed New Zealand sea lion captures in scampi trawl fisheries, and one in 2018–19 (Table 4). Captures in previous years all occurred near the Auckland Islands in SCI 6A (Thompson et al 2011).

Since the 2002–03 fishing year there have been 10 observed New Zealand fur seal captures in scampi trawl fisheries, based on an average of 9% observer coverage (Table 5). Since 2002–03, only about 0.7% of the estimated total fur seal captures in all commercial fisheries have been taken in scampi fisheries; these have been on the western Chatham Rise and off the Auckland Islands.

Capture rates for both sea lions and fur seals have been low and have fluctuated without obvious trend.

Table 4: Number of tows (commercial and observed) by fishing year, observed and estimated New Zealand sea lion captures, and capture rate in scampi trawl fisheries, 2002–03 to 2019–20 (Abraham et al 2021). Estimates are available online at https://protectedspeciescaptures.nz/PSCv6/released/. Observed and estimated protected species captures in this table derive from the PSC database version PSCV6.

	Fishing effort			Obs. captures		Est. captures		Est. capture rate	
Fishing year	Tows	No. Obs	% obs	Captures	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	5 130	512	10.0	0	0.00	7	2-15	0.14	0.04-0.29
2003–04	3 753	412	11.0	3	0.73	10	5-18	0.27	0.13-0.48
2004–05	4 648	143	3.1	0	0.00	8	2-16	0.17	0.04-0.34
2005–06	4 867	331	6.8	1	0.30	8	3-16	0.17	0.06-0.33
2006–07	5 135	389	7.6	1	0.26	8	3-16	0.16	0.06-0.31
2007–08	4 804	524	10.9	0	0.00	8	2-15	0.16	0.04-0.31
2008–09	3 975	396	10.0	1	0.25	10	3-18	0.24	0.08-0.45
2009–10	4 248	348	8.2	0	0.00	5	1-11	0.12	0.02-0.26
2010–11	4 447	536	12.1	0	0.00	7	2-15	0.16	0.04-0.34
2011–12	4 509	459	10.2	0	0.00	7	2-14	0.15	0.04-0.31
2012–13	4 565	270	5.9	0	0.00	6	1-12	0.13	0.02-0.26
2013–14	4 421	254	5.7	0	0.00	5	1-11	0.11	0.02-0.25
2014–15	4 423	342	7.7	0	0.00	3	0-8	0.07	0-0.18
2015–16	5 210	144	2.8	0	0.00				
2016–17	4 707	447	9.5	0	0.00				
2017–18	4 345	545	12.5	2	0.37				
2018–19	4 377	679	15.5	1	0.15				
2019–20	4 562	528	11.6	0	0.00				

Table 5: Number of tows (commercial and observed) by fishing year, observed and estimated New Zealand fur seal captures, and capture rate in scampi trawl fisheries, 2002–03 to 2019–20 (Abraham et al 2021). Estimates are available online at https://protectedspeciescaptures.nz/PSCv6/released/. Observed and estimated protected species captures in this table derive from the PSC database version PSCV6.

	Fishing effort			Obs. captures		Est. captures		Est. capture rate	
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2002–03	5 130	512	10.0	2	0.39	8	2–18	0.15	0.04–0.35
2003–04	3 753	412	11.0	1	0.24	5	1–14	0.15	0.03–0.37
2004–05	4 648	143	3.1	0	0.00	13	2–37	0.27	0.04–0.80
2005–06	4 867	331	6.8	0	0.00	7	1–20	0.15	0.02–0.41
2006–07	5 135	389	7.6	0	0.00	7	1–20	0.14	0.02–0.39
2007–08	4 804	524	10.9	1	0.19	8	2–20	0.16	0.04–0.42
2008–09	3 975	396	10.0	1	0.25	5	1–13	0.13	0.03–0.33
2009–10	4 248	348	8.2	1	0.29	8	2–20	0.18	0.05–0.47
2010–11	4 447	536	12.1	0	0.00	4	0–12	0.09	0.00–0.27
2011–12	4 509	459	10.2	1	0.22	7	2–18	0.16	0.04–0.40
2012–13	4 565	270	5.9	0	0.00	5	0–15	0.11	0.00–0.33
2013–14	4 421	254	5.7	0	0.00	4	0–12	0.08	0.00–0.27
2014–15	4 423	342	7.7	1	0.29	7	2–20	0.17	0.05–0.45
2015–16	5 210	144	2.8	0	0.00	5	0–14	0.09	0.00–0.27
2016–17	4 707	447	9.5	1	0.22	6	1–16	0.13	0.02–0.34
2017–18	4 345	545	12.5	0	0.00	3	0–10	0.08	0.00–0.23
2018–19	4 377	679	15.5	0	0.00				
2019–20	4 562	528	11.6	1	0.19				

Seabird captures

Observed seabird capture rates in scampi fisheries have ranged from about 1 to 20 per 100 tows and fluctuate without obvious trend (Table 6). In the 2017–18 fishing year there were 19 observed captures of birds in scampi trawl fisheries, with 130 (95% c.i.: 99–165) estimated captures, with the estimates made using a consistent modelling framework (Abraham et al 2016, Abraham & Richard 2017, 2018; Table 6). There were 11 observed captures in the 2016–17, with estimates of total captures of 127 (95% c.i.: 95–163, Table 6). The estimates are based on relatively low observer coverage and include all bird species and should, therefore, be interpreted with caution. The average observed capture rate in scampi trawl fisheries for 2002–03 to 2019–20 (all areas combined) is about 4 birds per 100 tows, a moderate rate relative to trawl fisheries for squid (12.94 birds per 100 tows) and hoki (2.3-2.9 birds per 100 tows) over the same years.

Observed seabird captures in the SCI target trawl fishery since 2002–03 have been dominated by four species: Salvin's and white-capped albatrosses make up 44% and 28% of the albatrosses captured, respectively; white-chinned petrel, flesh-footed shearwater, and common diving petrel make up 29%, 23%, and 19% of other birds, respectively. The total and fishery risk ratios are presented in Table 7. Most of the captures occur near the Auckland Islands (39%), in the Bay of Plenty (36%), or on the Chatham Rise (21%). 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 6: Number of tows by fishing year and observed seabird captures in scampi trawl fisheries, 2002–03 to 2019–20. 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 by Abraham & Richard (2020) and are available online at https://protectedspeciescaptures.nz/PSCv6/released/. Observed and estimated protected species captures in this table derive from the PSC database version PSCV6.

	Fishing effort			Obs. captures		Est. captures		Est. capture rate	
Fishing year	Tows	No. Obs	% obs	Captures	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	5 130	512	10.0	7	1.37	140	94–198	2.73	1.83–3.86
2003–04	3 753	412	11.0	7	1.70	105	68–153	2.81	1.81–4.08
2004–05	4 648	143	3.1	9	6.29	145	102–197	3.12	2.19–4.24
2005–06	4 867	331	6.8	11	3.32	152	106–209	3.12	2.18–4.29
2006–07	5 135	389	7.6	24	6.17	153	109–204	2.98	2.12–3.97
2007–08	4 804	524	10.9	11	2.10	126	87–176	2.62	1.81–3.66
2008–09	3 975	396	10.0	19	4.80	135	96–184	3.41	2.42–4.63
2009–10	4 248	348	8.2	5	1.44	111	72–158	2.61	1.69–3.72
2010–11	4 447	536	12.1	109	20.34	240	196–297	5.41	4.41–6.68
2011–12	4 509	459	10.2	9	1.96	125	86–173	2.78	1.91–3.84
2012–13	4 565	270	5.9	6	2.22	132	91–183	2.89	1.99–4.01
2013–14	4 421	254	5.7	7	2.76	129	89–177	2.93	2.01–4.00
2014–15	4 423	342	7.7	8	2.34	120	82–166	2.71	1.85–3.75
2015–16	5 210	144	2.8	3	2.08	152	108–204	2.92	2.07–3.92
2016–17	4 707	447	9.5	12	2.68	127	89–173	2.70	1.89–3.68
2017–18	4 345	545	12.5	19	3.49	131	94–177	3.01	2.16–4.07
2018–19	4 377	679	15.5	17	2.50	115	80–156	2.63	1.83–3.56
2019–20	4 562	528	11.6	9	1.70	117	81–162	2.57	1.78–3.55

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, 2006–07 to 2016–17, showing seabird species with a risk ratio of at least 0.001 of PST. The risk ratio is an estimate of aggregate potential fatalities (inclusive of cryptic mortality) across trawl and longline fisheries relative to the Population Sustainability Threshold, PST (from Richard et al 2017 and Richard et al 2020, where full details of the risk assessment approach can be found). The 2018–19 and 2019–20 data were unavailable at the time of publication. The DOC threat classifications are shown (Robertson et al 2017 at http://www.doc.govt.nz/documents/science-and-technical/nztcs19entire.pdf).

		Risk ratio			
Species name	PST (mean)	SCI target trawl*	Total	Risk category	DOC Threat Classification
Salvin's albatross	3 460	0.077	0.65	High	Threatened: Nationally Critical
Flesh-footed shearwater	1 450	0.033	0.49	High	Threatened: Nationally Vulnerable
Northern Buller's albatross	1 640	0.030	0.26	Medium	At Risk: Naturally Uncommon
Black petrel	447	0.011	1.23	Very high	Threatened: Nationally Vulnerable
Northern giant petrel	337	0.008	0.15	Medium	At Risk: Naturally Uncommon
New Zealand white-capped albatross	10 800	0.008	0.29	Medium	At Risk: Declining
Southern Buller's albatross	1 360	0.007	0.37	High	At Risk: Naturally Uncommon
White-chinned petrel	25 800	0.006	0.07	Low	At Risk: Declining
Chatham Island albatross	428	0.003	0.28	High	At Risk: Naturally Uncommon
Campbell black-browed albatross	2 000	0.003	0.05	Low	At Risk: Naturally Uncommon

* SCI target trawl from Richard et al (2017).

4.4 Benthic interactions

The spatial extent of seabed contact by trawl fishing gear in New Zealand's EEZ and Territorial Sea has been estimated and mapped in numerous studies for trawl fisheries targeting deepwater species (Baird et al 2011, Black et al 2013, Black & Tilney 2015, Black & Tilney 2017, Baird & Wood 2018, and Baird & Mules 2019, 2021a, 2021b), species in waters shallower than 250 m (Baird et al. 2015, Baird & Mules 2020a), and all trawl fisheries combined (Baird & Mules 2021a, 2021b). The most recent assessment of the deepwater trawl footprint was from 1989–90 to 2018–19 (Baird & Mules 2021b).

During 1989–90 to 2018–19, about 135 300 scampi bottom trawls were reported on TCEPRs, TCERs, and ERS (Baird & Mules 2021b). The total footprint generated from these tows was estimated at about 20 938 km^2. This footprint represented coverage of 0.5% of the seabed of the combined EEZ and the Territorial Sea areas; 1.5% of the 'fishable area', that is, the seabed area open to trawling, in depths of less than 1600 m. For the 2018–19 fishing year, 5375 scampi bottom tows had an estimated footprint of 4598 km^2 which represented coverage of 0.1% of the EEZ and Territorial Sea and 0.3% of the fishable area (Baird & Mules 2021b).

The overall trawl footprint for scampi (1989–90 to 2018–19) covered < 1.0% of seabed in depths less than 200 m, 9.6% in 200–400 m, and 3.5% of 400–600 m seafloor (Baird & Mules 2021b). The scampi footprint contacted < 0.1%, 2.2%, and 1% of those depth ranges, respectively, in 2018–19 (Baird & Mules 2021b). The BOMEC areas with the highest proportion of area covered by the scampi footprint were classes H (Chatham Rise) and L (deeper waters off the Stewart-Snares shelf and around the main sub-Antarctic islands). In 2018–19, the scampi footprint covered ≤ 0.01% of each BOMEC class (Baird & Mules 2021b).

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 2021 (Fisheries New Zealand 2021).

4.5 Other considerations

None considered by the Aquatic Environment Working Group.

5. STOCK ASSESSMENT

In 2011 the Shellfish Fishery Assessment Working Group (SFWG) accepted the stock assessments for SCI 1 and SCI 2, undertaken using a length-based population model. A length-based assessment was also accepted for SCI 3 in 2015, and for SCI 6A in 2017. No stock assessment has been undertaken for SCI 4A, but a stock characterisation and CPUE standardisation were completed in 2019.

In 2022, the Deepwater Fisheries Assessment Working Group (DWWG) rejected an updated assessment of SCI 1 because the results were considered overly sensitive to the choice of prior for the trawl survey catchability, and to choices around data weighting and the estimation of process error. A 2022 update of the SCI 2 assessment was accepted as a quality 2 assessment because the available base case, while robust to the choice of prior for trawl survey catchability, provided insufficient exploration of differing recent trends in the trawl survey and CPUE indices.

Section 5.2 summarises the stock assessments that have to date been accepted by Fisheries New Zealand working groups.

Attempts have been made to index scampi abundance using CPUE and trawl survey indices and photographic surveys of visible scampi and scampi burrows. In 2022 the burrow count estimates were rejected by the DWWG for SCI 1 and SCI 2 due to inconsistencies in reader interpretation of burrows. All three indices were included in the length-based assessment models for SCI 3 and SCI 6A.

5.1 Estimates of fishery parameters and abundance

Standardised CPUE indices

Standardised CPUE indices are calculated for each stock every three years, as part of the stock assessment process. 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 3). The SFWG has raised concerns in the past that potential variability in catchability related to burrow emergence between years mean that standardised 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 standardised 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 mentioned in Section 3. All discussions below relate to standardised CPUE.

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 generally remained stable until 2016–17, with an increase since then. In SCI 2, CPUE increased in 1994–95, then declined steadily to 2001–02, remained at quite a low level until 2007–08, increased until 2013–14 (with CPUE comparable with that recorded in the mid–1990s), declining slightly after this to levels comparable with the late 1990s, remaining stable after 2015–16 with a slight increase in 2018–19 followed by a decline in 2019–20 and 2020–21. 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 then remained stable until increasing in 2016–17 to a level that has been maintained to 2020–21 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, with a steep increase since 2016–17. In SCI 6A, after an initial decline in the early 1990s, CPUE has fluctuated around a gradually declining trend. 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.

Trawl Surveys

Since scampi are only available to trawl catches when out of their burrows, trawl survey indices are subject to the same potential concerns as CPUE indices relating to changes in scampi emergence. 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 4a and Figure 4b. 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, whereas work to assess trawl selectivity (1996) and in support of photographic surveys (since 1998) may have been more representative of the overall area. This later index has remained relatively stable through the series. 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, whereas 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, because the other studies did not have comparable spatial coverage. The trawl survey index shows an increase from the low levels in the mid-2000s to 2015, and a slight decrease by 2018 followed by a sharp increase in 2020–21. The trends observed are similar to the trends in commercial CPUE (Figure 3) for both stocks except for the last point in SCI 2.

Surveys have been conducted in SCI 3 in 2001 (two surveys, pre- and post- fishery), 2009, 2010, 2013, 2016, and 2019. 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. These indices were analysed spatially with respect to three sub-areas that are used in the stock assessment to reflect differences in the dynamics of the fishery (Figure 5). Trawl, photographic, and CPUE data indicate a significant decline in scampi abundance between 2001 and 2009, but an increase in more recent years (Figure 6).

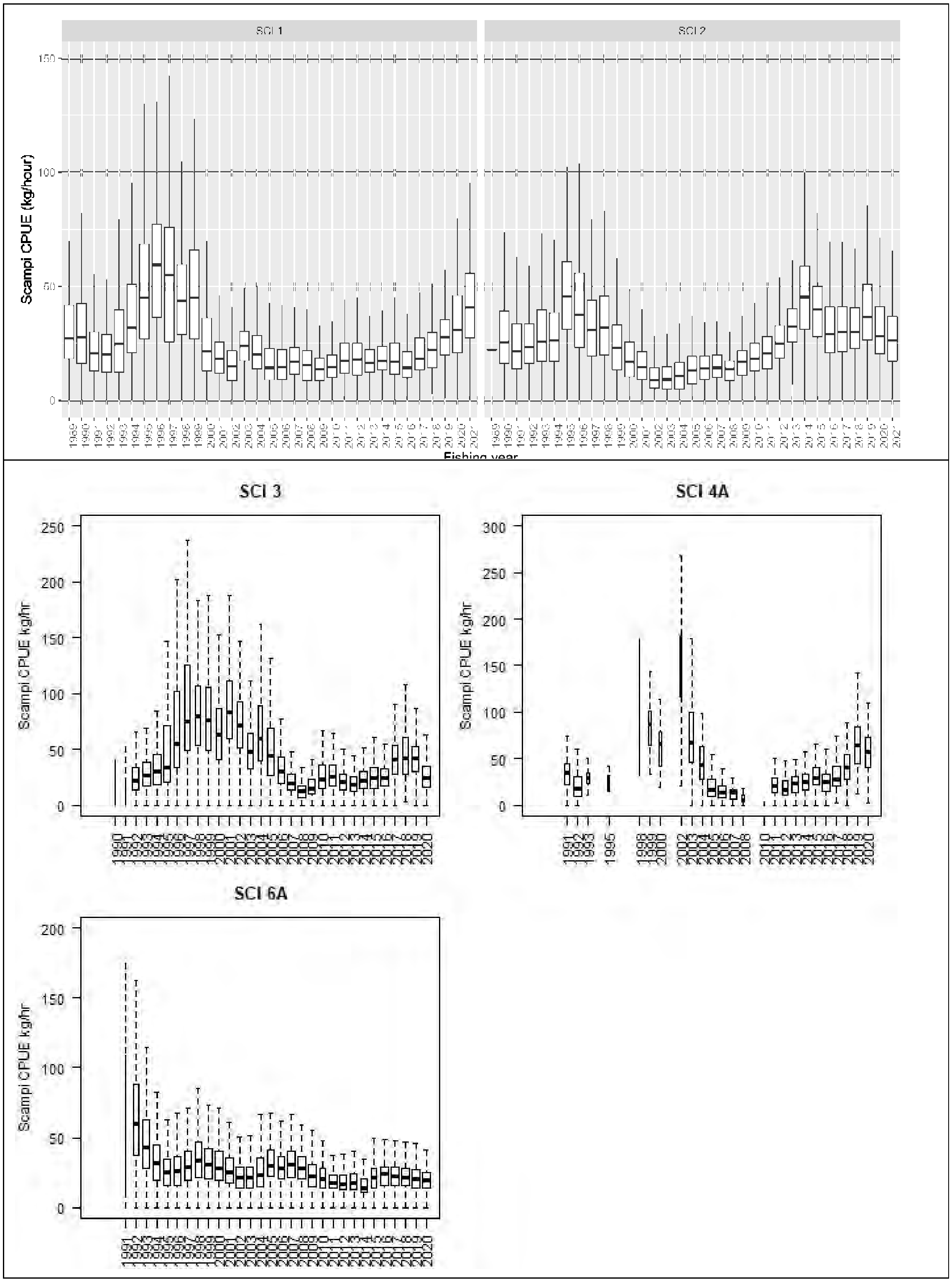


Figure 3: Box plots (with outliers removed) of individual observations of unstandardised catch rate for scampi (tow catch (kilogram) divided by tow effort (hours)) with tows of zero scampi catch excluded, by fishing year for main stocks. Box widths are proportional to square root of the number of observations. 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.

Table 8: Trawl survey indices of biomass (t) for scampi in survey strata within SCIs 1, 2, 3, and 6A. CVs of estimates in parentheses. Trawl surveys between 1998 and 2015 were conducted in support of the photographic surveys.

Year	SCI 1	SCI 2	SCI 3	SCI 6A
1993	217.3 (0.12)	238.2 (0.12)		
1994	288.2 (0.19)	170.0 (0.16)		
1995	391.6 (0.18)	216.2 (0.18)		
1996				
1997				
1998	174.0 (0.17)			
1999				
2000	181.3 (*)			
2001	179.5 (0.27)		272.5 (0.24) (strata 902–3)**	
2002	130.6 (0.24)			
2003		28.0 (*)		
2004		46.9 (0.20)		
2005		50.8 (0.35)		
2006		22.9 (0.19)		
2007				1073.5 (0.18)
2008	211.9 (*)			1229.1 (0.18)
2009			40.2 (0.37) (strata 902–3) 418.1 (0.26)	821.6 (0.09)
2010			49.0 (0.11) (strata 902–3) 596.1 (0.04)	
2011				
2012	150.0 (0.25)	164.2 (0.28)		
2013			126.5 (0.27) (strata 902–3) 551.3 (0.12)	1258.0 (0.06)
2014				
2015	118.5 (0.17)	224.5 (0.19)		
2016			139.6 (0.14) (strata 902–3) 913.1 (0.12)	593.3 (0.09)†
2017				
2018	188.6 (0.21)	183.3 (0.29)		
2019			158.3 (0.19) (strata 902–3) 1219.9 (0.06)	710.9 (0.12)†
2020				
2021	480.76 (0.23)	529.20 (0.25)		

* 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).
** SCI 3 pre-season survey.
† 2016 and 2019 surveys in SCI 6A conducted with a different vessel from previous surveys in this area.

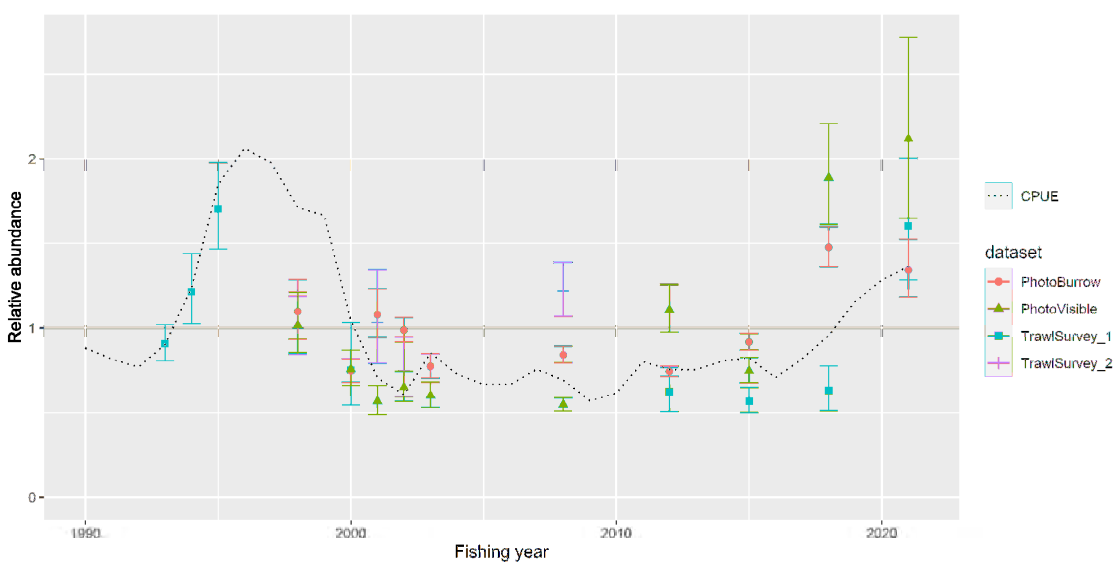


Figure 4a: Mean catch rates and relative abundance (± one standard error) of research trawling, visible animal photo survey counts, and burrow survey counts counts in the core area of SCI 1. Symbols represent different survey observations. PhotoBurrow, PhotoVisible and TrawlSurvey_1 indices were from a subset of survey strata; TrawlSurvey_2 was from all survey strata. Dotted line represents annual standardised CPUE for SCI 1.

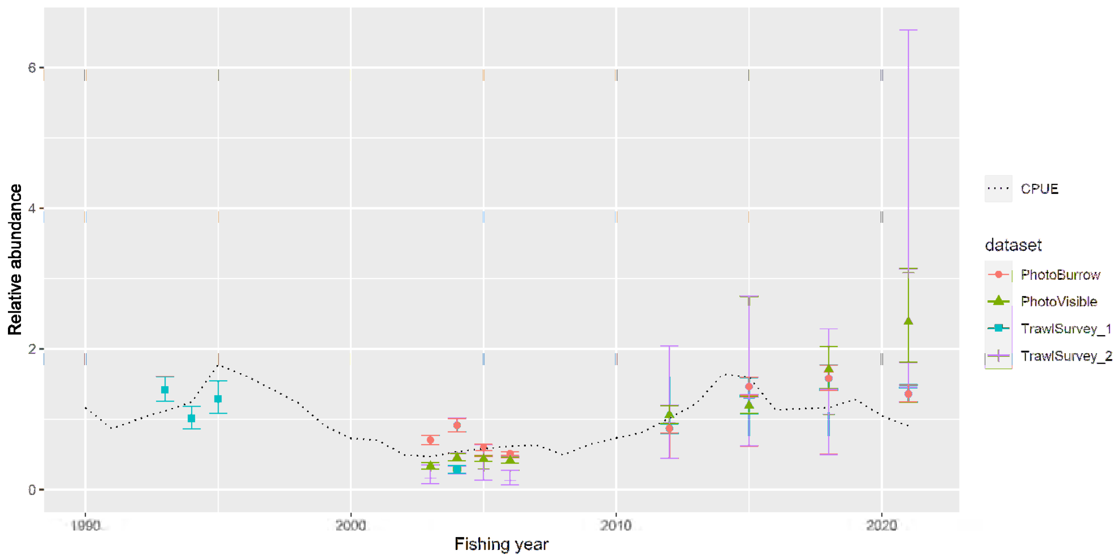


Figure 4b: Mean catch rates and relative abundance (± one standard error) of research trawling, visible animal photo survey counts, and burrow photo survey counts in SCI 2. Symbols represent different survey observations. TrawlSurvey_1 is in model timestep 1 (October-January), TrawlSurvey_2, PhotoBurrow and PhotoVisible are in model timestep 2 (February-April). Dotted line represents annual standardised CPUE for SCI 2.

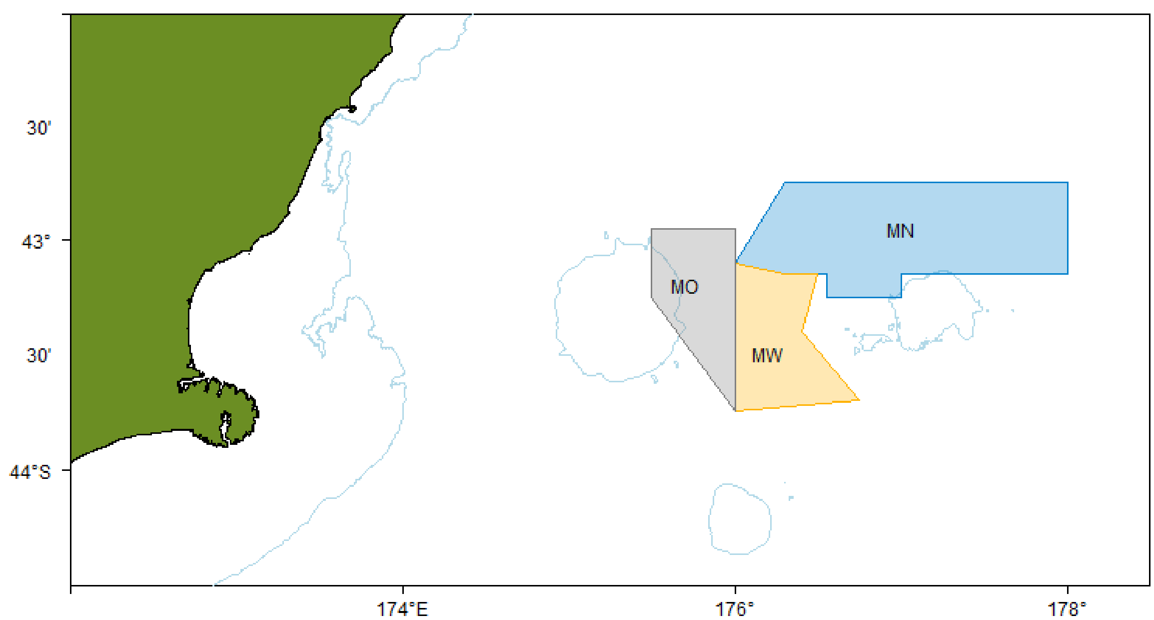


Figure 5: Subareas within SCI 3 used in the stock assessment.

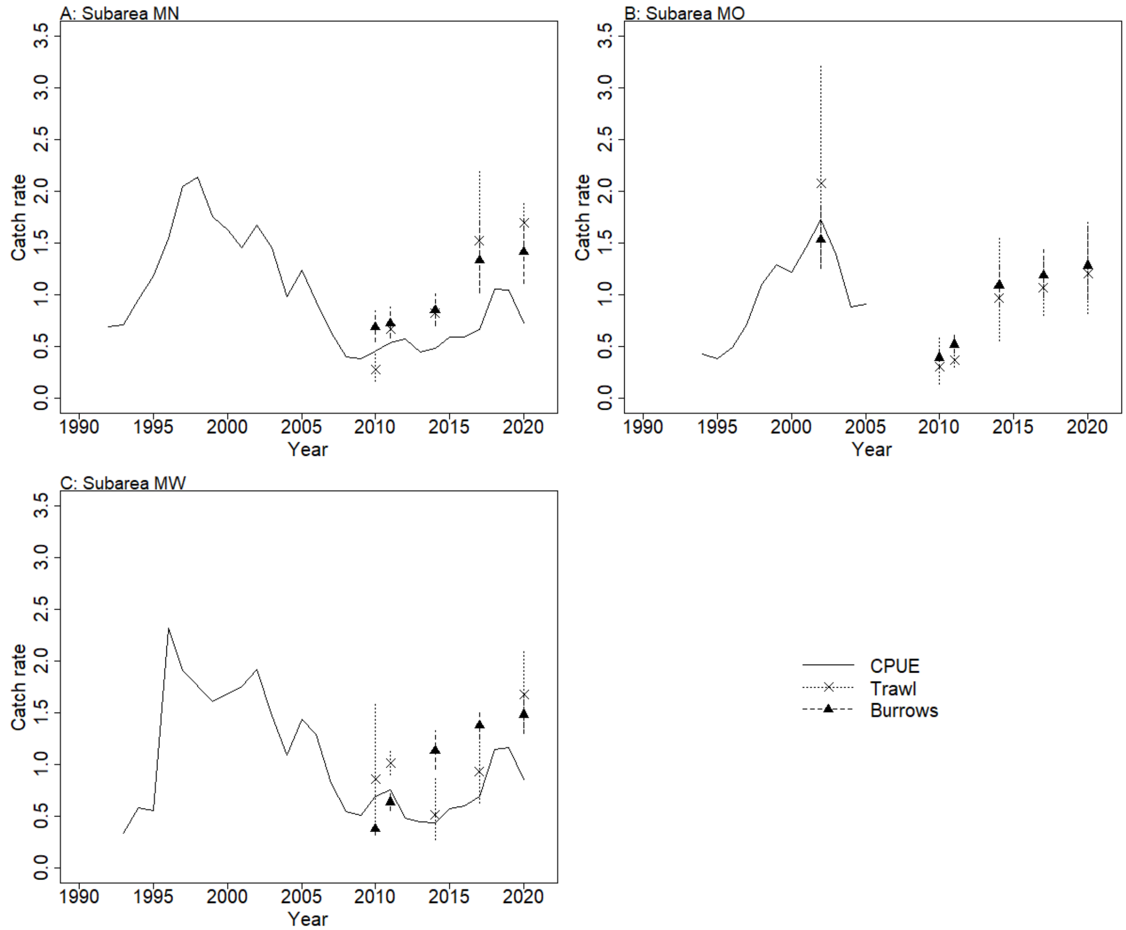


Figure 6: Catch rates (standardised CPUE) and relative abundance (± one standard error) of research trawling and photo survey counts in the core area of SCI 3 by subareas MN (A), MO (B), and MW (C). Symbols represent different aims of survey work (×- trawling within photo survey, ▲-scaled photo survey abundance). Solid line represents standardised CPUE indices as they were defined for the stock assessment model.

There have been no targeted scampi surveys of SCI 4A, but the Chatham Rise *Tangaroa* survey has conducted standardised trawl sampling in the region since 1992. Although the trawl gear used on this survey is not designed to catch scampi, it provides the only fishery-independent abundance index for this stock. Survey catch rates follow a very similar pattern to unstandardised CPUE indices (Figure 7), increasing rapidly from the early 1990s to the early 2000s, declining to 2008, and then increasing more steadily since this time.

Surveys have been conducted in SCI 6A in 2007–2009, 2013, 2016, and 2019 (although with a different vessel after 2013). The trawl component of the photo surveys suggests that the biomass has fluctuated in recent years, although modelling indicated that the fishing power of the vessel used since 2016 was substantially less than that of the vessel used in earlier years. The photographic survey (burrows) suggested a considerable decline in abundance between 2007 and 2008, an increase in 2009 back towards the 2007 level, followed by a decline to lower levels of abundance in 2013 and 2016, but an increase in 2019. Over the longer term, the CPUE data indicate fluctuations around a gradually declining trend (Figure 8).

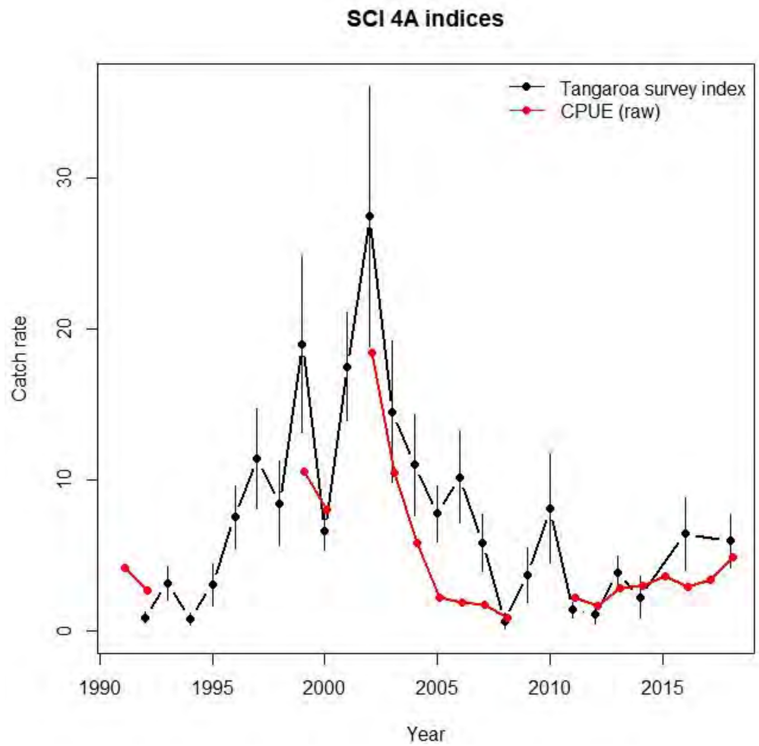


Figure 7: Mean catch rate (± one standard error) of Chatham Rise *Tangaroa* research trawling and unstandardised CPUE in the core area of SCI 4A. The CPUE index has been scaled to the geometric mean of the survey catch rates.

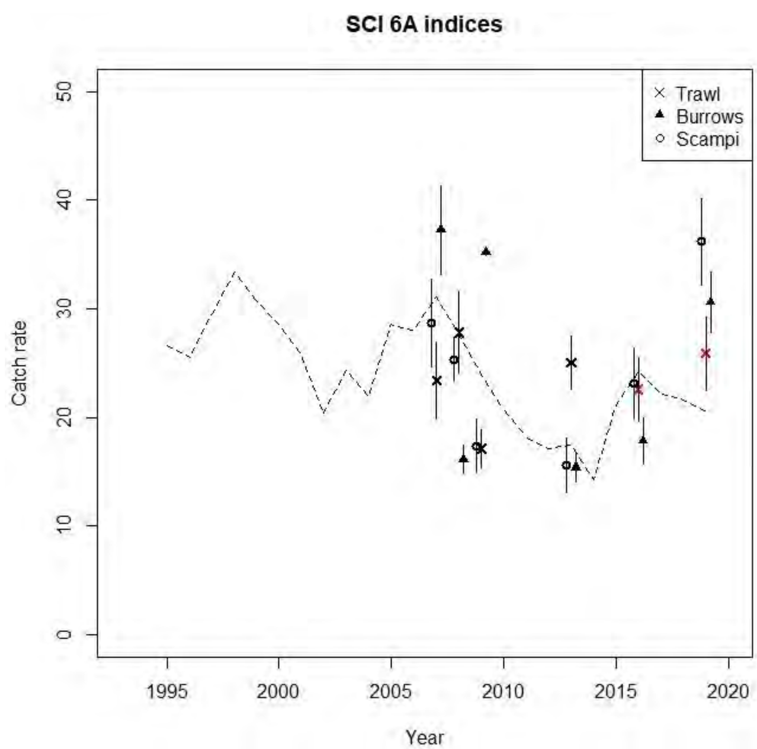


Figure 8: Mean catch rates and relative abundance (± one standard error) of research trawling and photo survey counts in the core area of SCI 6A. Symbols represent different aims of survey work (×- trawling within photo survey, ▲-scaled photo survey abundance). The last two trawl survey indices (denoted by a red ×) used a different vessel and have been scaled separately from the earlier series. The dotted line represents median of annual unstandardised CPUE for SCI 6A from Figure 3.

Photographic surveys

Photographic surveying (usually by video) has been used extensively to estimate the abundance of the European scampi *Nephrops norvegicus*. Photographic surveys indexing burrow abundance were developed as an abundance index independent of scampi emergence patterns. In New Zealand, development of photographic techniques, including surveys, has been underway since 1998. To date, nine surveys have been undertaken in SCI 1 (between Cuvier Island and White Island at a depth of 300–500 m), seven surveys have been undertaken in SCI 2 (Mahia Peninsula to Castlepoint at 200–500 m depth), six surveys have been undertaken in SCI 3 (north eastern Mernoo Bank only at 200–600 m depth), and six surveys in SCI 6A (to the east of the Auckland Islands at 350–550 m depth). The association between scampi and burrows in SCI 6A appears to be different to other areas examined.

Three indices are calculated from photographic surveys: the density of visible scampi (all visible animals, either observed within a burrow entrance (doorkeepers) or emerged from a burrow, walking free on the seabed); the density of emerged scampi (animals fully emerged from a burrow); 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). While counts of visible and emerged scampi are sensitive to burrow emergence patterns, counts of burrows are independent of this. Burrow counts are sensitive to reader interpretation however, and concerns over this led to the exclusion of the burrow indices from SCI 1 and SCI 2 assessments in 2022. Each of these can be used to estimate indices of abundance or 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 3 uses the estimated abundance of major burrow openings as an abundance index, which was also the case for SCI 1 and 2 up until the 2022 assessment, but only the emerged scampi index was used in the SCI 6A assessment.

Estimates of major burrow opening and visible scampi abundance are provided in Table 9. Acoustic tagging approaches (undertaken during surveys) have been used, in conjunction with burrow and scampi density estimates, to estimate emergence patterns and priors for scampi catchability. A revised approach to estimating priors on the basis of these data, taking greater account of uncertainty in observed burrow and animal density and emergence rates, was adopted in 2016 (Tuck et al 2015).

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 SCI 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. 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.

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 parentheses. Major burrow openings are openings on the seabed that are considered to be main entrance of a scampi burrow. Visible scampi represents all scampi seen in photographs (either in a burrow entrance, or walking free on the seabed). Burrow estimates were not used in the 2022 assessment for SCI 1 and SCI 2.

	SCI 1		SCI 2		SCI 3		SCI 6A		Comments
Year	Major openings	Visible scampi	Major openings	Visible scampi	Major openings	Visible scampi	Major openings	Visible scampi	
1998	144.3 (0.15)	24.5 (0.17)							
1999									
2000	98.2 (0.12)	18.2 (0.18)							
2001	142.0 (0.12)	13.7 (0.26)			224.0 (0.09) (strata 902–3)	48.2 (0.16) (strata 902–3)			
2002	130.0 (0.07)	15.6 (0.21)							
2003	101.8 (0.12)	14.5 (0.21)	106.2 (0.13)	10.4 (0.37)					
2004			137.2 (0.11)	14.1 (0.26)					
2005			90.0 (0.14)	13.5 (0.20)					
2006			76.6 (0.09)	13.0 (0.24)					
2007							305.5 (0.11)	60.4 (0.14)	SCI 6A estimate for main area*
2008	110.8 (0.07)	13.2 (0.13)					132.3 (0.08)	55.4 (0.08)	
2009					54.4 (0.14) (strata 902–3) 285.8 (0.07) (larger survey)	18.4 (0.17) (strata 902–3) 122.6 (0.10) (larger survey)	288.8 (0.10)	36.6 (0.14)	SCI 3, estimates provided for 2001 survey coverage (strata 902–3) and new larger survey
2010					72.0 (0.11) (strata 902–3) 378.0 (0.05) (larger survey)	8.7 (0.22) (strata 902–3) 92.8 (0.11) (larger survey)			SCI 3, estimates provided for 2001 survey coverage (strata 902–3) and new larger survey
2012	97.9 (0.05)	26.6 (0.11)	130.8 (0.09)	32.7 (0.12)					
2013					144.1 (0.11) (strata 902–3) 592.6 (0.06) (larger survey)	20.5 (0.17) (strata 902–3) 130.8 (0.09) (larger survey)	126.5 (0.09)	32.8 (0.16)	
2015	120.8 (0.06)	18.0 (0.13)	220.1 (0.06)	37.0 (0.09)					
2016					152.1 (0.10) (strata 902–3) 747.5 (0.05) (larger survey)	36.7 (0.16) (strata 902–3) 206.9 (0.08) (larger survey)	146.6 (0.12)	48.7 (0.14)	
2018	194.3 (0.05)	45.4 (0.08)	137.8 (0.07)	52.8 (0.10)					
2019					179.42 (0.15) (strata 902–3) 871.1 (0.17) (larger survey)	74.52 (0.15) (strata 902–3) 360.66 (0.07) (larger survey)	251.1 (0.09)	76.2 (0.11)	
2021	176.9 (0.09)	50.9 (0.12)	204.7 (0.07)	73.8 (0.12)					

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

5.2 Stock assessment methods

The 2022 updated assessment for SCI 1 was rejected because the results were considered overly sensitive to the choice of prior for the trawl survey catchability, and to choices around data weighting and the estimation of process error. The status of the stock was assessed using a partial-quantitative method based on all available abundance indices; trawl survey, photo survey (visible scampi), photo survey (burrow count), and CPUE.

2019: SCI 1

In 2011 the first stock assessment for SCI 1, 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, 2016, and 2019.

A number of model runs were presented, examining sensitivities to M, data weighting, and a combined area model with SCI 2 (two stock model with no migration, sharing growth and selectivity parameters). For both stocks, the absolute biomass levels and the state of the stock relative to SSB_0 was relatively consistent between models. A base model was agreed upon for SCI 1 (M=0.25 and CPUE process error fixed at 0.15) with sensitivities also presented.

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' 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–Apr	Recruitment	1.0
		Maturation	1.0
		*Growth (males)**	
		Natural mortality	0.25
		Fishing mortality	From TCEPR
3	May–Sep	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 2001, Tuck 2009) have identified significant depth and regional effects, and regional (strata) 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 in 2013. 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 (TCEPRs). 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 and time step. Although the sex ratio data suggest that the relative catchability of the sexes varies 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 the selectivity implementation used allowed the L_{50} and a_{95} selectivity parameters to be estimated as single values shared by both sexes in a particular time step, 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, because of the relative similarity in sex ratio.

Data inputs included CPUE, trawl and photographic survey indices, and associated length frequency distributions. Informed priors are available for survey catchability estimates based on acoustic tagging of scampi and investigations into burrow emergence patterns. These have been updated since the last assessment based on working group discussions.

The assessment reports SSB_0 and $SSB_{CURRENT}$ and used the ratio of current and projected spawning stock biomass ($SSB_{CURRENT}$ and SSB_{2018}) to SSB_0 as preferred indicators. Projections were conducted up to 2024 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.

2022: SCI 1

The fully quantitative assessment for SCI 1was not accepted in 2022 and is not reported here. Instead, the Plenary proposed assessing the status of the stock in a partial-quantitative method that involved examination of the trends in the available abundance indices since the 2019 assessment of the stock.

5.2.1 Standardised CPUE

A CPUE model was fitted for catch per tow with response variables *fishing_year, time-of-day, fishing_duration, statistical-area, model-timestep*. The model explained 41% of the null deviance. Alternative models were explored and presented to the DWWG, with little change to the resulting abundance index. These alternative models included using a subset of the ‘core’ vessels (10 years in the fishery as the minimum requirement rather than 5 years), catch per vessel-day rather than including fishing duration as a response variable, and attempts at classifying a vessel:gear_width categorical variable. Figure 9 shows the raw and standardised CPUE index for SCI 1.

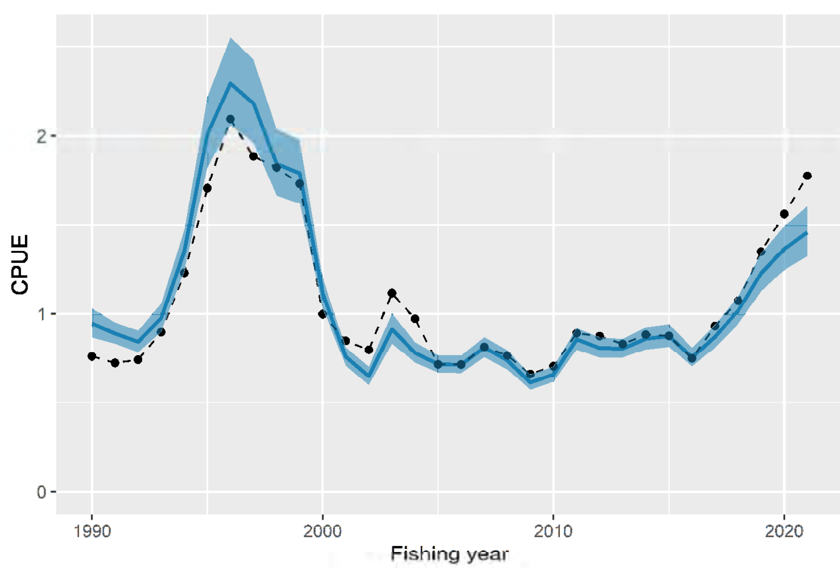


Figure 9: Standardised CPUE for SCI 1 (blue line) with 95% confidence intervals (blue shaded) and raw CPUE (black dashed line and dots).

5.2.2 Survey indices

Ten years of trawl and photo survey estimates of abundance are available. The photo survey provides two indices: major burrow counts and visible scampi counts. The major burrow counts index has the advantage of being insensitive to scampi emergence patterns and dynamics, but it suffers from subjectivity in interpreting the photos. The visible scampi counts index is less susceptible to subjectivity in interpreting the photos because the scampi are more obvious than burrows, but it is affected by emergence patterns and dynamics which will affect the abundance estimates and which we are not equipped to account for. The trawl survey is also affected by emergence of scampi and has the additional complication of catchability.

Figure 10 shows the available photo survey abundance indices for the core survey strata (longer series with the full 10 years) and the full survey area (in years 2012, 2015, 2018, and 2021). Trawl survey abundance indices are in Figure 11. The earlier years in the trawl survey included the full survey area (1993, 1994, 1995, and 2000) whereas these years only covered the core strata for the photo survey. Survey strata are shown in Figure 12.

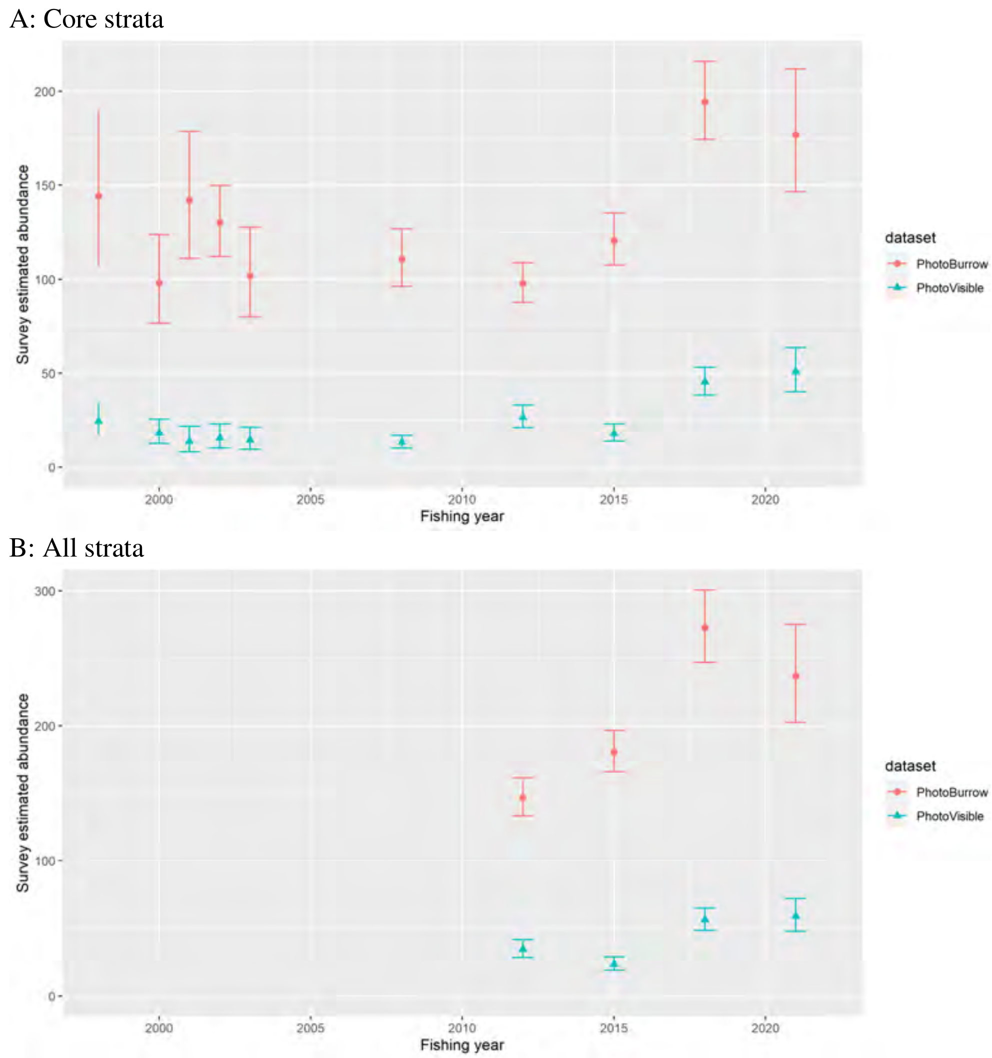


Figure 10: SCI 1 abundance indices from photo survey (+/- 1 standard error) for A: Core survey strata; B: All survey strata.

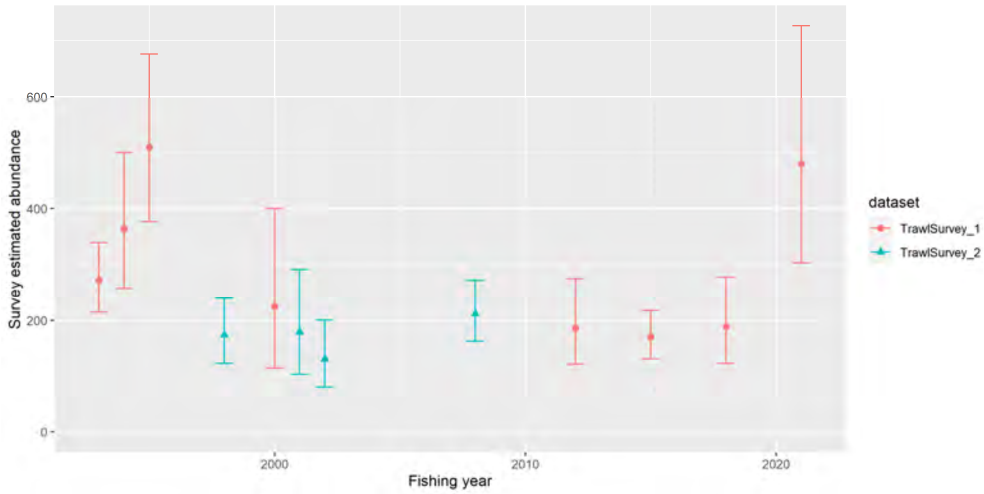


Figure 11: SCI 1 abundance indices from trawl survey (+/- 1 standard error) for: Core survey strata (TrawlSurvey_2); All survey strata (TrawlSurvey_1).

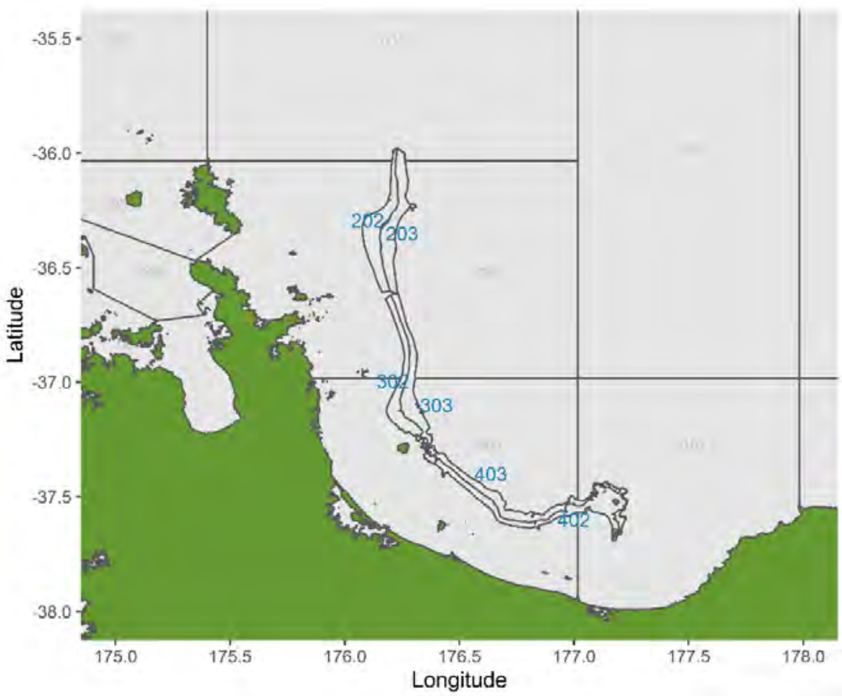


Figure 12: SCI 1 survey strata. 'Core' strata are 302, 303, 402 and 403; 'All' strata are 202, 203, 302, 303, 402, and 403.

SCI 2

In 2011 the first stock assessments for 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, 2016, 2019, and 2022.

For the 2022 assessment, a number of model runs were presented, examining sensitivities to the trawl survey *q* prior, data weighting, and combinations of including or excluding data inputs. The absolute biomass levels and the state of the stock relative to SSB_0 was relatively consistent between models. A base model and two alternatives were taken forward to MCMC, with the trawl survey *q* prior such that the mean was shifted to the lower and upper quartile for the two alternatives.

The SCI 2 model structure matches that described for SCI 1 in the previous section, including specification of the annual cycle, spawning stock recruitment, growth, maturation, and natural mortality. Model inputs also follow the same structure, except that the trawl survey indices for SCI 2 were split between time steps 1 and 2 in the SCI 2 model, whereas it was entirely in time step 1 in the SCI 1. The photo survey was not included in the 2022 SCI 2 assessment, although utility of including these data will be re-explored.

Data inputs included CPUE and trawl survey indices, and associated length frequency distributions. Informed priors are available for survey catchability estimates based on acoustic tagging of scampi and investigations into burrow emergence patterns. These have been updated since the last assessment based on working group discussions.

The assessment reports SSB_0 and $SSB_{CURRENT}$ and used the ratio of current and projected spawning stock biomass ($SSB_{CURRENT}$ and SSB_{2018}) to SSB_0 as preferred indicators.

SCI 3

In 2015 the SFWG accepted a stock assessment for SCI 3 (Tuck 2016), undertaken using the length-based population model, an updated assessment was accepted in 2018 (Tuck 2019), and in 2021 the DWWG accepted a further updated assessment (McGregor in press). A number of model runs were presented, examining sensitivities to assumptions about photo survey *q*s, whether to include the initial increasing part of the CPUE indices, process error on the CPUE indices and *M*. The absolute biomass levels were sensitive to the alternative model structures and assumptions, but the state of the stock relative to B_0 was generally consistent between models. A base model was taken with a fixed $M = 0.25$ and CPUE process error = 0.2, with sensitivities to these assumptions considered. The alternative model that omitted the initial increasing years from CPUE indices provided the most pessimistic results for the stocks, particularly for subarea MN.

The model's annual cycle is slightly adjusted from the fishing year and is divided into two time steps (Table 11). The choice of two time steps was based on the current understanding of scampi biology and the sex ratio in catches. Note that model references to 'year' refer to the modelled year and are labelled as the most recent calendar year, i.e., the modelled year 1998–99 is referred to as '1999' throughout.

Table 11: Annual cycle of the population model for SCI 3, 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	Aug–Dec	Growth (both sexes)	
		Natural mortality	0.5
		Fishing mortality	From TCEPR
2	Jan–Jul	Recruitment	1.0
		Maturation	1.0
		Natural mortality	0.5
		Fishing mortality	From TCEPR

The SCI 3 fishery is divided into three distinct areas on the Chatham Rise (an area to the east of 176º E on the Mernoo Bank – MO; an area to the west of 176º E on the Mernoo Bank – MW; and a separate region to the north east, centred about 177º E – MN) (Figure 5), and differences in management between these areas over time have led to different fishing histories. Scampi are not thought to undertake large-scale migrations, and so these three areas were considered distinct stocks within the assessment model, sharing some parameters (growth, selectivity, and catchability). The seasonal patterns of catches vary between stocks and over time and were divided among the stocks and time steps according to the proportion of estimated catches recorded on TCEPRs. 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.

As with the SCI 2 model, the SCI 3 model uses logistic length-based selectivity curves for commercial fishing, research trawl surveys, and for SCI 3 also photographic surveys, assumed constant over years and stocks, but allowed to vary with sex and time step. Data inputs for each stock included CPUE, trawl and photographic survey indices, and associated length frequency distributions.

The assessment reported B_0 and B_{2021} (at both the sub-area and overall FMA level) and used the ratio of current and projected spawning stock biomass (B_{2021} and B_{2025}) to B_0 as preferred indicators. Projections were conducted up to 2025 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.

SCI 4A

In 2019 a CPUE standardisation was conducted for SCI 4A (Tuck 2020a). A targeted scampi fishery started in 1991 and was intermittent through the 1990s and early 2000s, but has been more consistent since 2011. Fishing effort increased from very low levels in 2010 to a peak in 2015 (comparable with previous high levels in this fishery in the early 1990s and mid 2000s), but declines to about half this level by 2018. Scampi have been caught in low numbers across most of the SCI 4A area within the depth range (200–600 m), but the targeted fishery has focused on two distinct patches, one to the north and one to the west of the Chatham Islands (fished between 2005 and 2007). Catch rates appear similar between the two patches, and there are insufficient observer samples to examine length composition by patch. Overall observer coverage has been low (4% of scampi target tows) but varies considerably between years. Scampi length data were not recorded on the earliest *Tangaroa* surveys but have been routinely recorded since 1997. Size-at-female maturity estimated from the proportion of ovigerous females was comparable with other stocks (L_{50} = 38.2 mm).

SCI 6A

In 2016 the Plenary accepted a stock assessment for SCI 6A, undertaken using the length-based population model, and an updated assessment was accepted in 2019 (Tuck 2021). Preliminary models suggested a discrepancy between photo survey (increasing) and CPUE (decreasing) indices, which led to a reconsideration of the most appropriate index to be used from the photographic survey. The previously used visible scampi index includes both emerged animals and doorkeepers. Doorkeepers may include a high proportion of very small scampi that do not appear in commercial catches (and therefore may provide a useful index of recruitment). Also the length composition of scampi from photographs is unlikely to be representative of these smaller individuals (because they are often not visible enough to measure). An emerged animal index was considered more appropriate to use within the assessment model and was more consistent with the CPUE index. A number of model runs were presented, including a base model (M=0.25; survey q prior mean=0.582, CV=0.21; CPUE, trawl and photo survey) and examining sensitivities to two alternative prior distributions for survey catchability (mean=0.3 and 0.8), two alternative values of M (0.20 and 0.3), and CPUE only and CPUE excluded models. Estimates of absolute biomass and stock status were sensitive to q priors and exclusion of abundance indices, but less sensitive to M. All models including the CPUE data suggested *SSB* has fluctuated around a gradually declining trend through the history of the fishery, whereas the CPUE excluded model suggests *SSB* declined to around 2000, but has slightly increased since this time. The DWWG agreed that the base, low q, low M, and CPUE excluded models represented the range of possibilities of the status of the SCI 6A stock, with the CPUE excluded model considered less likely.

The model's annual cycle is slightly adjusted from the fishing year and is divided into three time steps (Table 12). The choice of the three time steps was based on the current understanding of scampi biology and the sex ratio in catches. Note that model references to 'year' refer to the modelled year, and are labelled as the most recent calendar year, i.e., the modelled year 1998–99 is referred to as '1999' throughout.

Table 12: Annual cycle of the population model for SCI 6A, 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	Mid Nov–mid Apr	Growth (both sexes)	
		Maturation	1.0
		Natural mortality	0.417
		Fishing mortality	From TCEPR
2	mid Apr–Jun	Recruitment	1.0
		Natural mortality	0.208
		Fishing mortality	From TCEPR
3	Jul–mid Nov	Natural mortality	0.375
		Fishing mortality	From TCEPR

The SCI 6A fishery occurs southeast of the Auckland Islands (between 166° E and 168° E, and between 50° 15′ S and 51° 15′ S). Scampi are not thought to undertake large scale migrations, and this is considered to be a distinct stock, for which a simplified single area model was developed in 2016. Catches generally occur throughout the year and were divided among the time steps according to the proportion of estimated catches recorded on TCEPRs. Recreational catch, customary catch, discards, and illegal catch are thought to be zero and are therefore ignored in the model. 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 were assumed to recruit to the model at 10 mm, with the mean expectation of recruitment success predicted by a Beverton-Holt stock-recruitment relationship. Length-at-recruitment was defined by a normal distribution with mean of 10 mm OCL and a CV of 0.4. There was no penalty on year class strength. Growth is estimated in the model from tag recapture data.

The model used logistic length-based selectivity curves for commercial fishing and research trawl surveys, which were assumed to be constant over years but allowed to vary with sex and time step. Although the sex ratio data suggest that the relative catchability of the sexes varies 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 the selectivity implementation used allowed the L_{50} and a_{95} selectivity parameters to be estimated as single values shared by both sexes in a particular time step, but allowed for different availability between the sexes through estimation of different a_{max} values for each sex. A combined sex double normal selectivity curve was used when fitting photo survey length frequency data for visible scampi.

The assessment reported SSB_0 and $SSB_{CURRENT}$ and used the ratio of current and projected spawning stock biomass ($SSB_{CURRENT}$ out to SSB_{2025}) to SSB_0 as preferred indicators. Projections were conducted up to 2025 for two future catch scenarios. The probability of exceeding the default Harvest Strategy Standard target and limit reference points are reported.

5.3 Stock assessment results

2019: SCI 1

For SCI 1, model outputs suggest that spawning stock biomass increased to a peak in about 1995, declined to the early 2000s and has remained relatively stable since this time. The *SSB* in SCI 1 in 2018 was estimated to be 72%–76% of SSB_0 (Table 13, Figure 13). Historical changes in biomass in SCI 1 appear to be related to fluctuations in recruitment rather than catches, and likelihood profiles suggest that the priors have more influence than the abundance indices in determining SSB_0. Estimated year class strength seems to be driven largely by the abundance indices with little signal from the length frequency distributions. Investigations into the sensitivity of excluding the survey indices showed that removing the photo survey increased the estimate of SSB_0, whereas removing the trawl survey had a lesser opposite effect, although stock trajectory and current status ($SSB_{CURRENT}/SSB_0$) was only slightly affected.

Table 13: Results from MCMC runs showing SSB_0, $SSB_{CURRENT}$, and $SSB_{CURRENT}/SSB_0$ estimates for the base model (M=0.25, CV=0.15) and sensitivities for SCI 1.

Model	M=0.25, CV=0.15	M=0.25, CV=0.25	M=0.2, CV=0.15	M=0.2, CV=0.25
SSB_0	4 620	4 650	4 627	4 777
$SSB_{CURRENT}$	3 498	3 539	3 368	3 521
$SSB_{CURRENT}/SSB_0$	0.76	0.76	0.72	0.74

The default management target for scampi of 40% B_0 is below the range of % B_0 estimated for SCI 1.

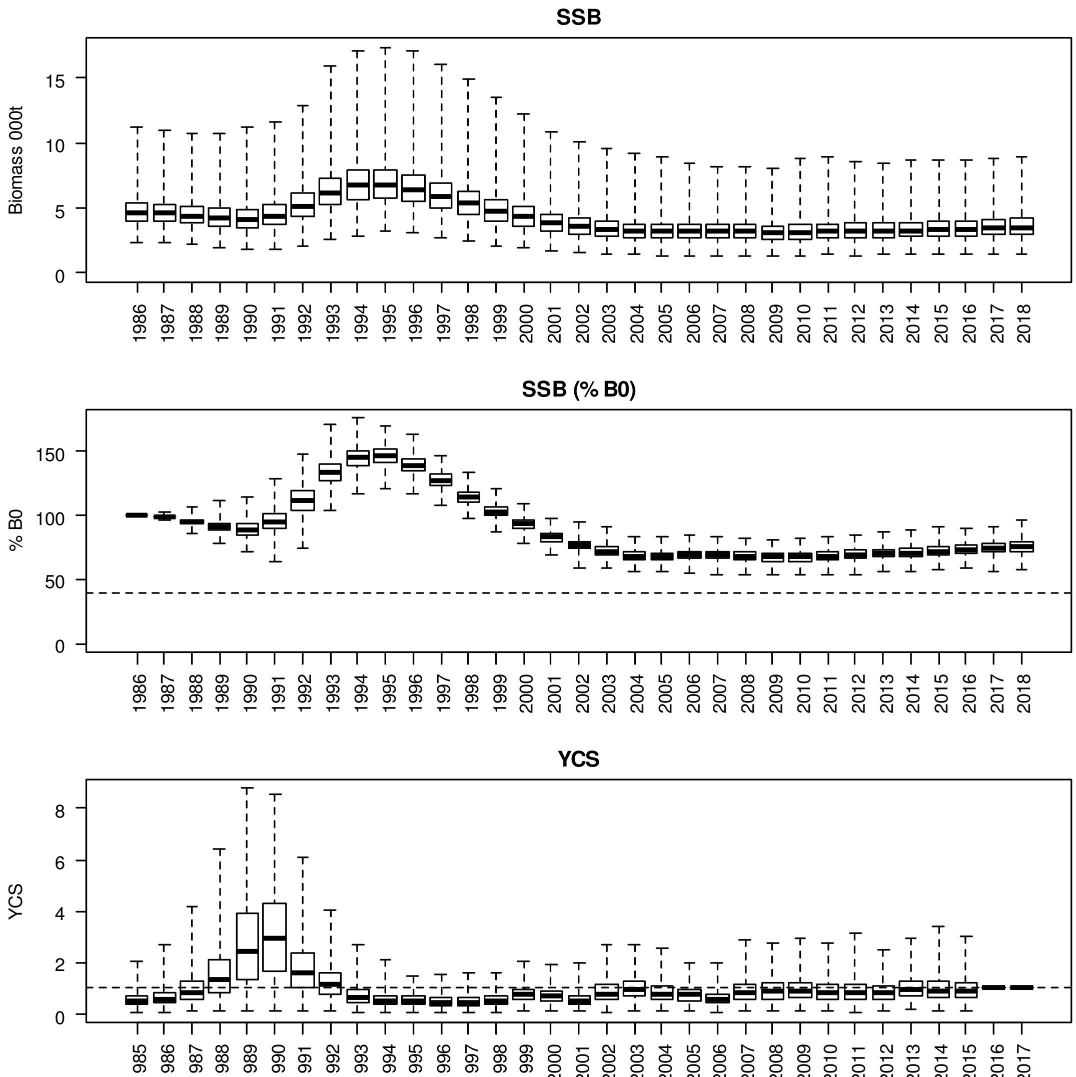


Figure 13: Posterior trajectory from SCI 1 base model (M=0.25, CV=0.15) of spawning stock biomass and YCS. Upper plot shows boxplots of *SSB* and the middle plot shows *SSB* as a percentage of B_0. On the middle plot, target reference points are shown as the grey dashed line. Box shows the median of the posterior distribution (horizontal bar), the 25th and 75th percentiles (box), with the whiskers representing the full range of the distribution.

2022: SCI 1

The available abundance indices for SCI 1 suggest the stock is higher or as high as it has been over the period 2001 to 2021. CPUE had in a large peak in the mid-late 1990s, followed by a decline until 2001 then a stable period from 2001 to 2017, which was also the lowest period for this index. The CPUE index then increased from 2017 until 2021. The trawl survey indices also showed a stable period from 1998 through to 2018. This stable period began earlier than the CPUE which was still declining until 2001 and ended slightly later than the CPUE which was increasing by 2017. There were no surveys in 2019 and 2020, and the 2021 estimate showed a large increase in estimated abundance, more extreme than seen in the CPUE. The photo survey suggested 2018 was a high point in the series, with 2021 either similarly high (visible scampi) or slightly lower (burrow count).

SCI 2

A 2022 update of the SCI 2 assessment was accepted as a quality 2 assessment, because the available base case, while robust to the choice of prior for trawl survey catchability, provided insufficient exploration of differing recent trends in the trawl survey and CPUE indices. For SCI 2, model outputs suggest that spawning stock biomass decreased slightly until 1990, increased to a peak in the early 1990s, declined to the early 2000s, increased slightly until about 2008, but increased more rapidly to 2013, declined until 2019 after which it has been fairly flat; however, the model was essentially averaging between the most recent high trawl survey estimate and a decreasing CPUE index. The *SSB* in SCI 2 in 2021 was estimated to be 70%–74% SSB_0 (Table 14, Figure 14).

Table 14: Results from MCMC runs showing SSB_0, $SSB_{CURRENT}$, and $SSB_{CURRENT}$/ SSB_0 estimates for the base and sensitivities of the trawl survey *q* prior for SCI 2.

Model	*Base*	q-*lower*	*q-upper*
SSB_0	2 354	2 501	2 322
$SSB_{CURRENT}$	1 664	1 846	1 632
$SSB_{CURRENT}/SSB_0$	0.71	0.74	0.70

The default management target for scampi of 40% B_0 is below the range of % B_0 estimated for SCI 2.

SCI 3

For SCI 3, a base model was taken with fixed $M = 0.25$ and CPUE process error = 0.2, with sensitivities to these assumptions considered. SSB trajectories and 5-year projections are shown for the MN (Figure 15), MO (Figure 16), and MW (Figure 17) subareas, with the combined SCI 3 trajectory presented in Figure 18. Subarea and overall SCI 3 data are summarised in Table 15. Model outputs suggest that SCI 3 spawning stock biomass (*SSB*) increased to a peak in about 1999, declined to 2010, and then remained more stable, increasing after 2014 (Figure 18). The *SSB* in SCI 3 in 2021 was estimated to be 88% (95% CI 61–121%) of B_0 at the FMA level for the base case, with median estimates ranging between 0.82 to 0.94 for the three sensitivities (Figure 18, **Error! Reference source not found.**15).

The default management target for scampi of 40% B_0 is below the range of % B_0 estimated for the SCI 3 base model, or any of the sensitivities (Figure 18, Table 15).

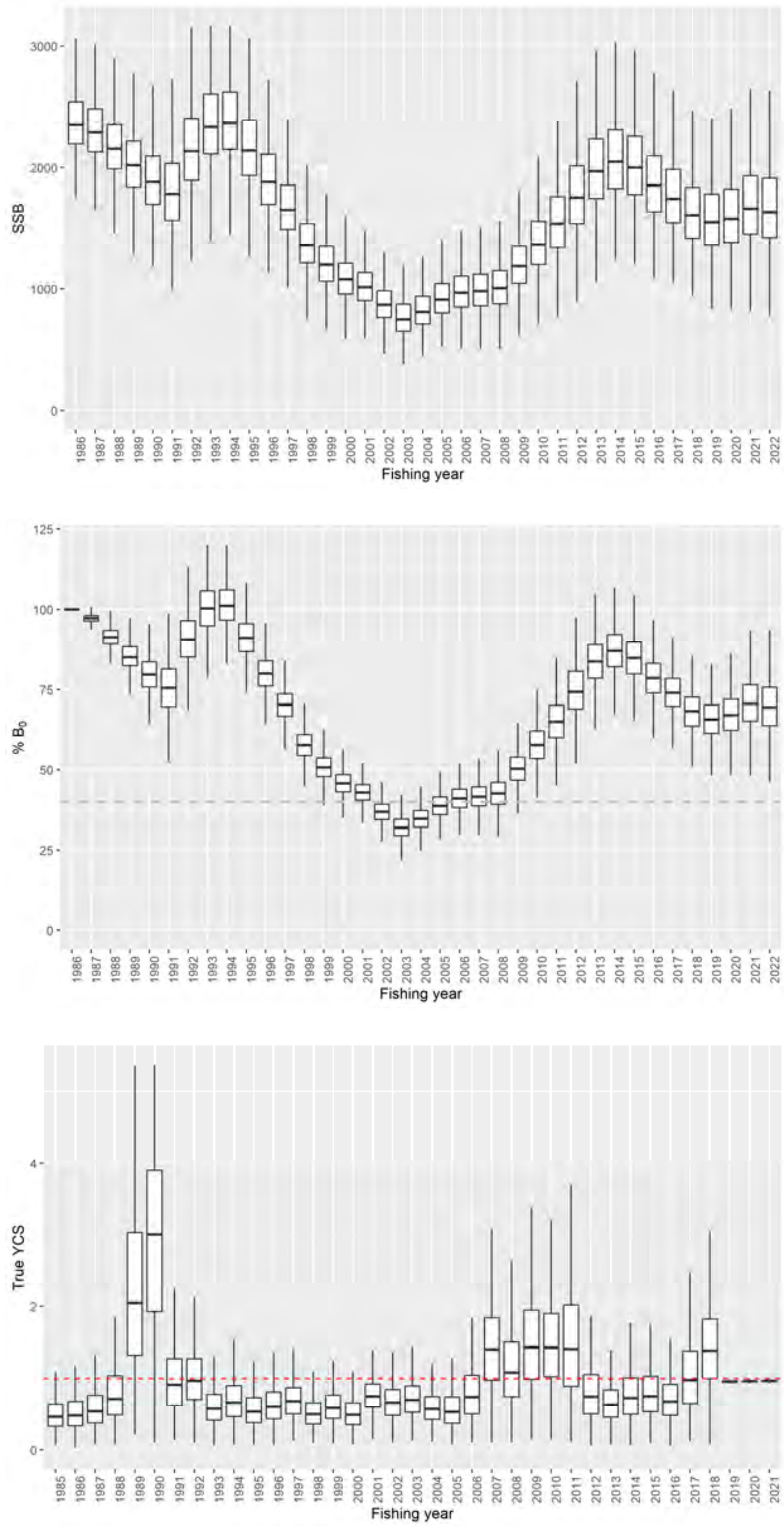


Figure 14: Posterior trajectory from the SCI 2 base model of spawning stock biomass and YCS. Upper plot shows boxplots of *SSB* and middle plot shows *SSB* as a percentage of B_0. On middle plot, target reference points are shown as the grey dashed line. Box shows the median of the posterior distribution (horizontal bar), the 25th and 75th percentiles (box), with the whiskers representing the full range of the distribution.

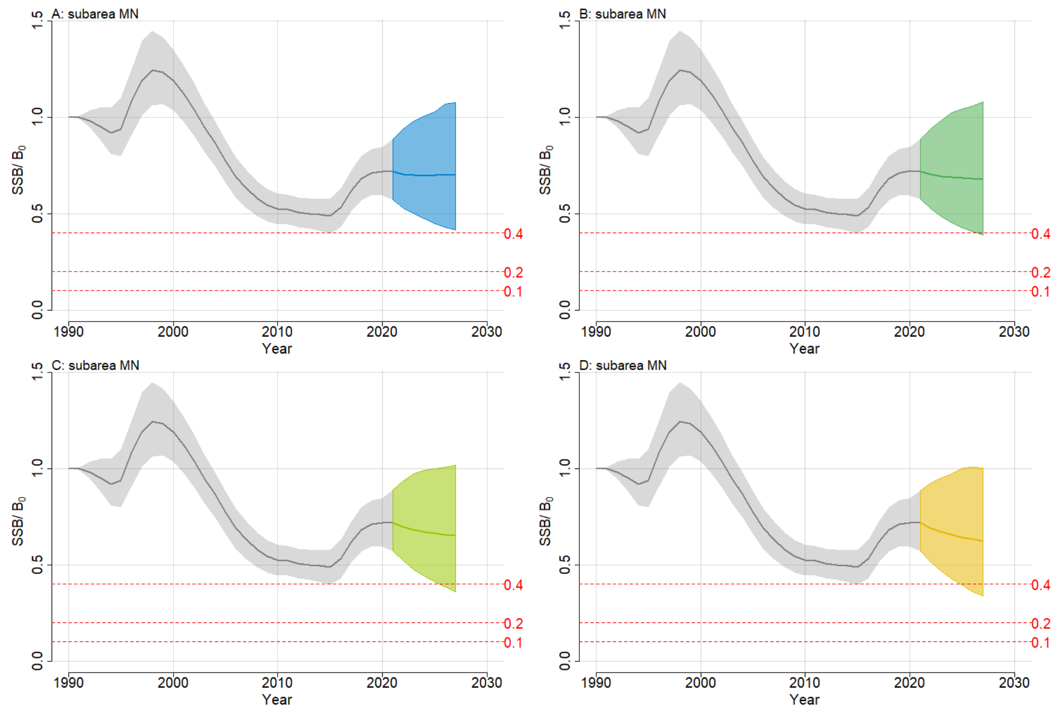


Figure 15: Posterior trajectory from subarea MN in SCI 3 base model (*M*=0.25) of spawning stock biomass, including 5-year projections out to 2026. Solid line shows the median of the posterior distribution, and the shaded polygons the 95th percentiles. Horizontal red lines show reference points 0.1, 0.2, 0.4 B_0.

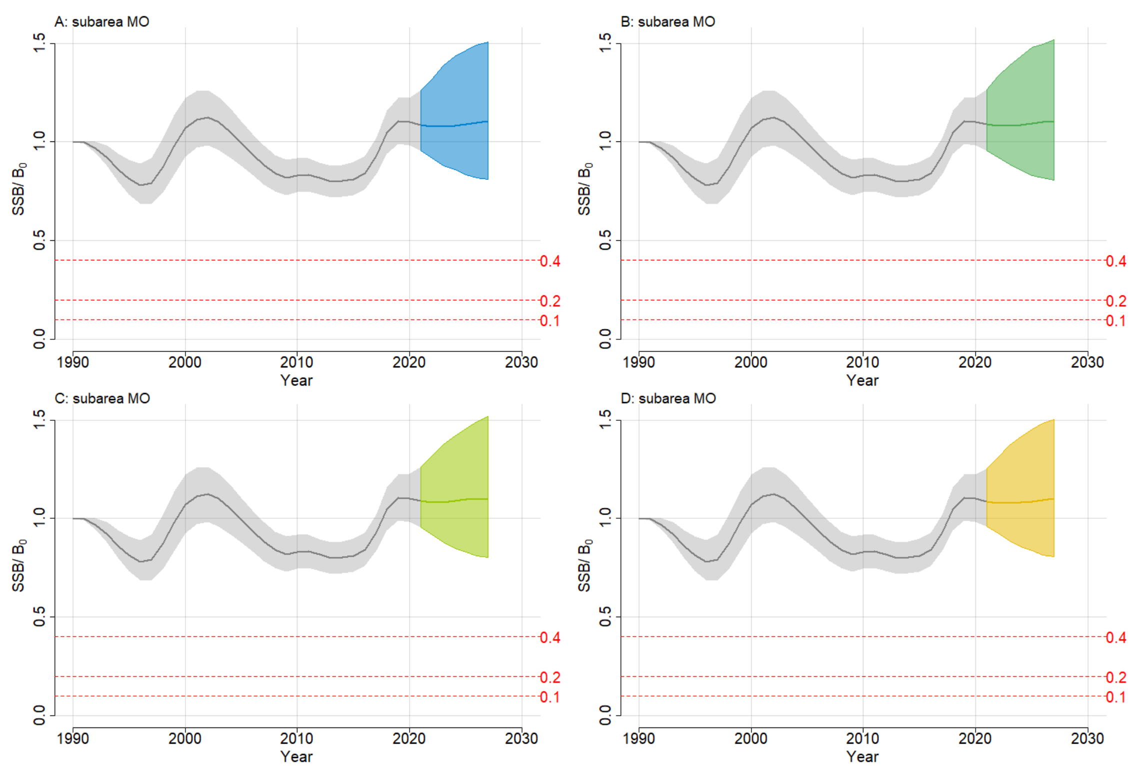


Figure 16: Posterior trajectory from subarea MO in SCI 3 base model (*M*=0.25) of spawning stock biomass, including 5-year projections out to 2026. Solid grey line shows the median of the posterior distribution, and the shaded polygons the 95th percentiles. Horizontal red lines show reference points 0.1, 0.2, 0.4 B_0.

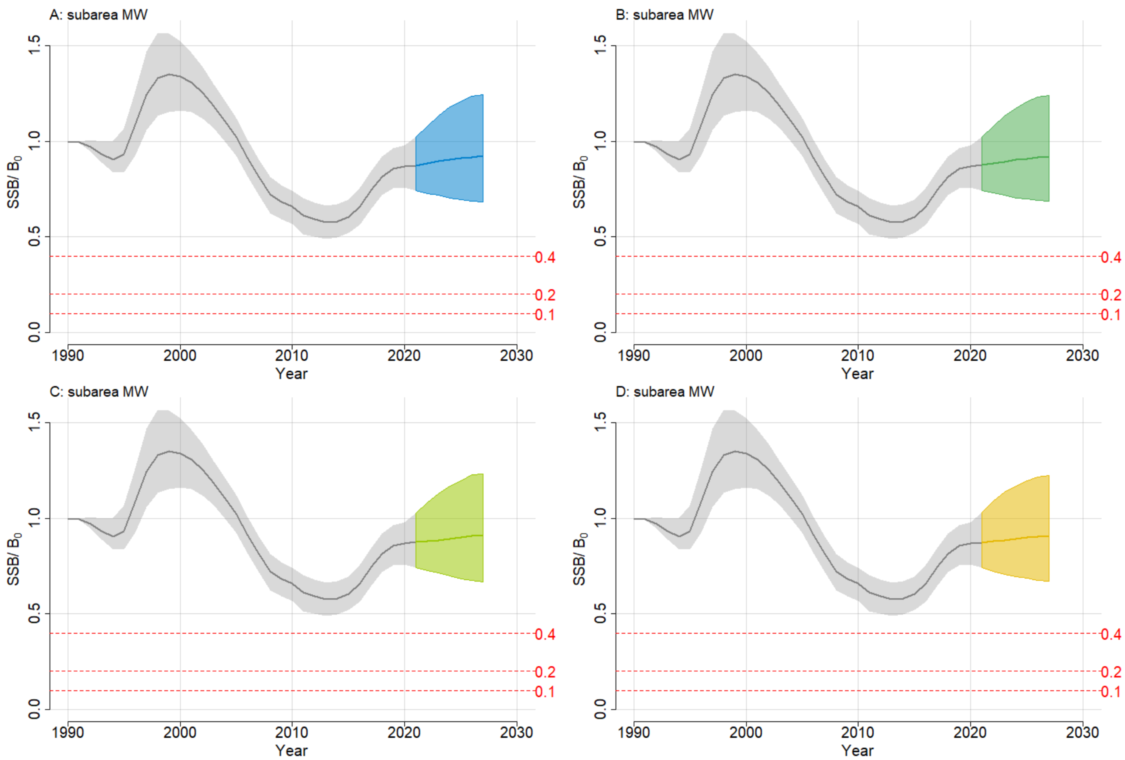


Figure 17: Posterior trajectory from subarea MW in SCI 3 base model (M=0.25) of spawning stock biomass, including 5-year projections out to 2026. Solid grey line shows the median of the posterior distribution, and the shaded polygons the 95th percentiles. Horizontal red lines show reference points 0.1, 0.2, 0.4 B_0.

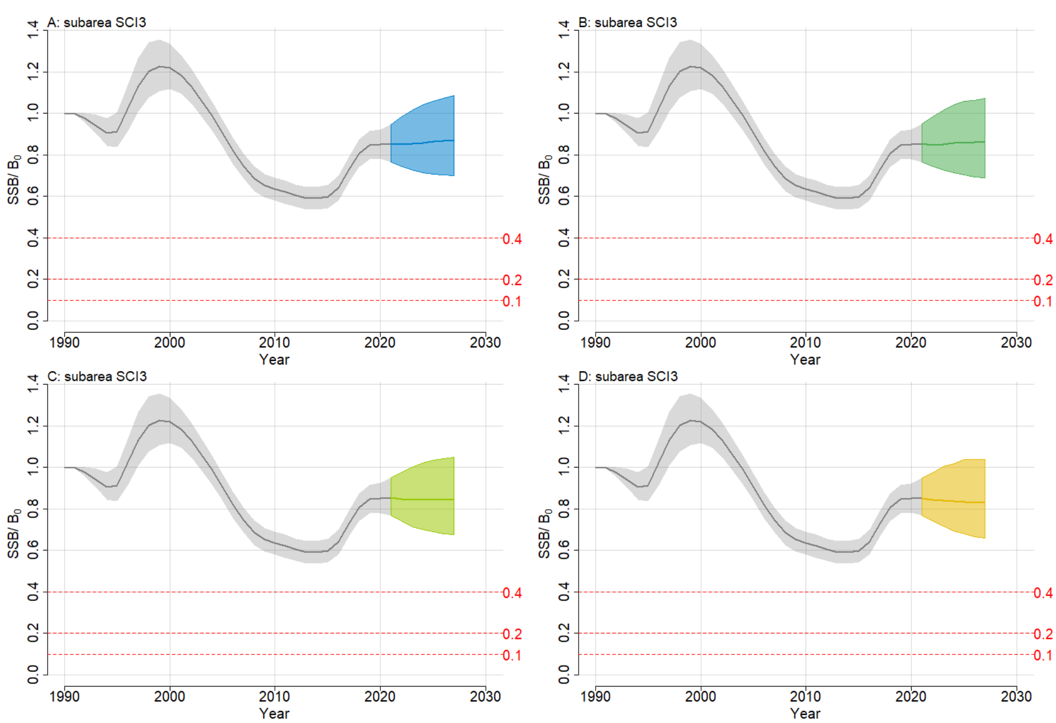


Figure 18: Posterior trajectory from SCI 3 base model (M=0.25) of spawning stock biomass, including 5-year projections out to 2026. Solid grey line shows the median of the posterior distribution, and the shaded polygons the 95th percentiles. Horizontal red lines show reference points 0.1, 0.2, 0.4 B_0.

Table 15: Results from MCMC runs showing B_0, B_{2021}/ B_0 estimates (t) for the base model and four sensitivities for SCI3.

	MN	MO	MW	SCI 3
Base, M=0.25				
SSB_0	4 622 (3 389, 6 769)	2 109 (1 299, 3 574)	3 524 (2 100, 6 120)	10 506 (8 080, 13 987)
SSB_{2021}	3 333 (2 001, 5 660)	2 288 (1 348, 4 012)	3 092 (1 691, 5 644)	9 016 (6 429, 12 589)
SSB_{2021}/ SSB_0	0.72 (0.57, 0.89)	1.08 (0.96, 1.26)	0.87 (0.74, 1.02)	0.88 (0.61, 1.21)
P(SSB_{2021} > 40% SSB_0)	1	1	1	1
P(SSB_{2021} < 20% SSB_0)	0	0	0	0
Sensitivity: M=0.20	MN	MO	MW	SCI 3
SSB_0	4 719 (3 596, 6 714)	2 154 (1 359, 3 628)	3 095 (1 984, 5 290)	10 207 (8 072, 13 350)
SSB_{2021}	3 177 (1 968, 5 307)	2 329 (1 405, 4 081)	2 600 (1 462, 4 788)	8 371 (6 165, 11 689)
SSB_{2021}/ SSB_0	0.67 (0.53, 0.82)	1.08 (0.97, 1.22)	0.84 (0.71, 0.97)	0.84 (0.57, 1.17)
P(SSB_{2021} > 40% SSB_0)	1	1	1	1
P(SSB_{2021} < 20% SSB_0)	0	0	0	0
Sensitivity: *M=0.30*	MN	MO	MW	SCI 3
SSB_0	4 549 (3 211, 7 038)	2 112 (1 233, 3 712)	3 959 (2 261, 7 006)	10 841 (7 999, 15 406)
SSB_{2021}	3 448 (2 019, 6 158)	2 301 (1 294, 4 203)	3 552 (1 882, 6 598)	9 492 (6 616, 14 276)
SSB_{2021}/ SSB_0	0.75 (0.59, 0.94)	1.09 (0.93, 1.3)	0.9 (0.75, 1.06)	0.9 (0.63, 1.24)
P(SSB_{2021} > 40% SSB_0)	1	1	1	1
P(SSB_{2021} < 20% SSB_0)	0	0	0	0
Sensitivity: *Cut CPUE*	MN	MO	MW	SCI 3
SSB_0	3 653 (2 736, 5 421)	1 762 (1 053, 2 988)	2 383 (1 569, 4 347)	7 999 (6 146, 10 849)
SSB_{2021}	2 380 (1 376, 4 240)	2 064 (1 194, 3 635)	1 936 (1 127, 3 854)	6 580 (4 612, 9 573)
SSB_{2021}/ SSB_0	0.65 (0.48, 0.83)	1.17 (1.03, 1.36)	0.81 (0.68, 0.97)	0.82 (0.53, 1.3)
P(SSB_{2021} > 40% SSB_0)	1	1	1	1
P(SSB_{2021} < 20% SSB_0)	0	0	0	0
Sensitivity: *q photo same*	MN	MO	MW	SCI 3
SSB_0	6 242 (3 907, 11 249)	3 619 (2 045, 6 668)	8 367 (4 734, 15 835)	18 271 (10 844, 33 304)
SSB_{2021}	4 946 (2 526, 10 095)	3 943 (2 214, 7 338)	7 804 (4 302, 14 704)	16 644 (9 380, 32 134)
SSB_{2021}/ SSB_0	0.79 (0.63, 0.97)	1.09 (0.95, 1.26)	0.93 (0.81, 1.07)	0.94 (0.67, 1.2)
P(SSB_{2021} > 40% SSB_0)	1	1	1	1
P(SSB_{2021} < 20% SSB_0)	0	0	0	0

SCI 4A

Standardised CPUE indices were estimated for the whole SCI 4A region and for the (core) patch to the north, on the basis of TCEPR records from vessels that had been active in the respective areas for at least 5 years. Both indices showed very similar patterns to the unstandardised CPUE data (Figure 3), increasing rapidly from the early 1990s to a peak in 2002, declining rapidly to 2005 and then more slowly to 2008, and then increasing steadily since this time. The standardised CPUE indices (only core area presented) show a very similar pattern to the Chatham Rise *Tangaroa* survey index for scampi (Figure 19).

Mean size in observed catches was markedly higher between 2003 and 2005 compared with other years, but length composition data from the Chatham Rise *Tangaroa* trawl survey did not show any patterns over time. The patchiness of observer sampling over time and the trawl gear used on the middle depths survey adds uncertainty about the representativeness of both data sets.

SCI 6A

For SCI 6A, a base model and three sensitivities were presented. Base model outputs suggest that spawning stock biomass (*SSB*) fluctuated around a declining trend between 1991 and 2013, increased slightly after this and has remained stable since 2016. The low *M* and low *q* models indicate very similar stock trends, but with the low *M* model estimating a slightly lower stock status throughout the fishery, and the low *q* model a higher SSB_0 and higher stock status throughout the fishery, and a slightly increasing trend in the most recent years. The model excluding the CPUE data estimated a different trend, with *SSB* declining to the early 2000s, and then showing a slightly increasing trend. The *SSB* in SCI 6A in 2019 was estimated to be 53% of SSB_0 for the base and between 47 and 66% of SSB_0 for the range of sensitivities considered (**Error! Reference source not found.**16, Figure 20). Historical changes in biomass in SCI 6A appear to be related to small fluctuations in recruitment rather than catches, but landings have been lower than the TACC in recent years, coinciding with an increase in recent year class strengths. All four of the models considered produce estimates of current stock status which are above the default management target of 40% B_0.

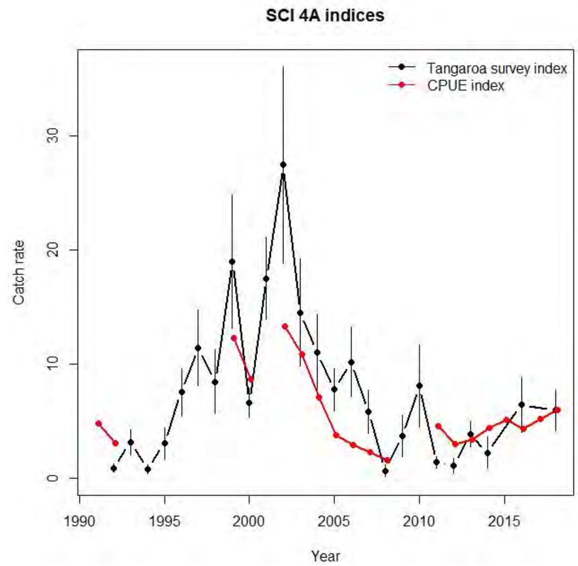


Figure 19: Mean catch rate (± one standard error) of Chatham Rise *Tangaroa* survey index and standardised CPUE in the core area of SCI 4A. The CPUE index has been scaled to the geometric mean of the survey catch rates.

Table 16: Results from MCMC runs showing B_0, B_{curr} and B_{curr}/B_0 for four alternative models for SCI 6A.

Model	Base	Low *q*	Low *M*	CPUE excluded
B_0	3 661	5 847	3 906	4 005
B_{2019}	1 950	3 994	1 849	2 623
B_{2019}/B_0	0.53	0.68	0.47	0.66

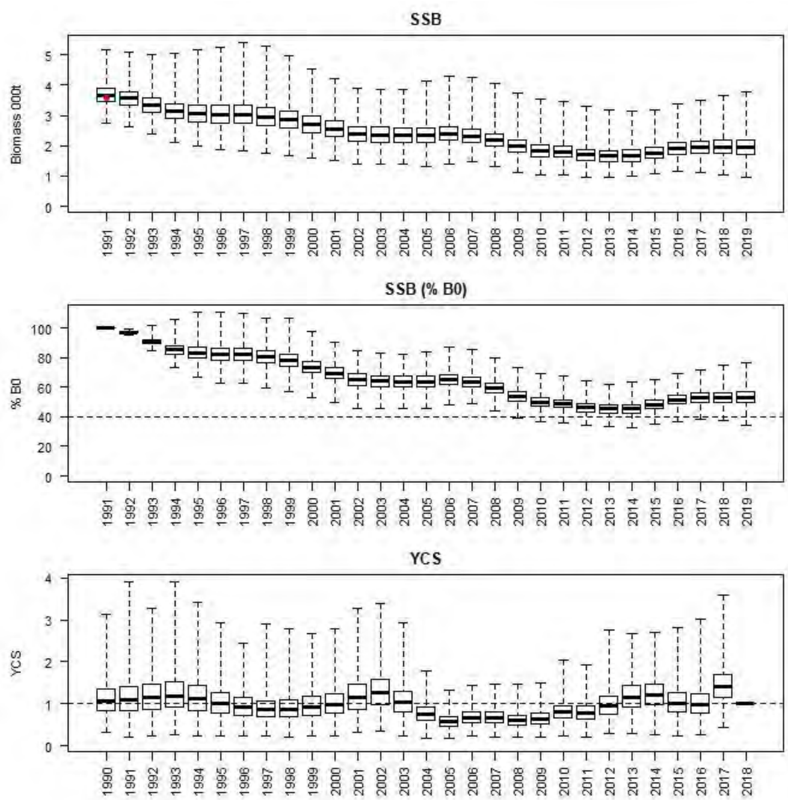


Figure 20: Posterior trajectory from the base SCI 6A model of spawning stock biomass and YCS. Upper plot shows boxplots of *SSB*, and the middle plot shows *SSB* as a percentage of B_0. On the middle plot, the 40% SSB_0 target reference point is shown as a dashed line. Box shows the median of the posterior distribution (horizontal bar), the 25th and 75th percentiles (box), with the whiskers representing the full range of the distribution. The 2018 year class was not estimated.

5.4 Yield estimates and projections

SCI 1

No yield estimates and projection are available for SCI 1.

SCI 2

Projections were not carried out for the SCI 2 assessment model due to the conflict in recent trends of the CPUE and trawl survey abundance indices and the quality 2 rating.

SCI 3

Projections were examined for the base model, with recruitment sampled from the most recent 10 years of estimated recruitment, and with constant annual catch remaining at current levels (status quo; average of the last 5 years excluding 2020), at the TACC, or increasing to 10% or 20% above the current TACC. Median estimates of stock status from the projections are presented in Table 17 and suggested that under the current TACC scenario the stock would be around 87% B_0 by 2025. Medians from the sensitivities ranged from 86% to 87%. Alternative projections with recruitment sampled from all estimated years produced similar results. These are presented in the Fisheries Assessment Report for this stock assessment (McGregor in press).

On the basis of the outputs for the base model for SCI 3, and the annual catches examined, the probability of *SSB* being below either the soft or hard limit is zero, and the probability of remaining above the 40% B_0 target remains very high over the next 5 years (Table 18).

Table 17: Results from MCMC runs showing B_0, B_{2021}, and B_{2025} estimates at varying catch levels for SCI 3 for the base model.

Catch		MN	MW	MO	SCI 3
366 tonnes (5 year average	B_0	4622	3524	2109	10506
excluding 2020, and status quo)	B_{2021}	3328	3096	2296	8965
	B_{2021}/B_0	1.02	1.02	0.88	1.02
	B_{2025}/B_0	0.70	0.91	1.09	0.86
	B_{2025}/B_{2021}	0.97	1.04	1.00	1.01
408 tonnes (TACC)	B_{2025}/B_0	0.69	0.91	1.09	0.86
	B_{2025}/B_{2021}	0.95	1.04	1.00	1.00
449 tonnes (+10% TACC)	B_{2025}/B_0	0.66	0.90	1.10	0.85
	B_{2025}/B_{2021}	0.92	1.03	1.00	0.99
490 tonnes (+20% TACC)	B_{2025}/B_0	0.64	0.90	1.09	0.83
	B_{2025}/B_{2021}	0.89	1.03	1.00	0.98

Table 18: Results from MCMC runs the base model and three sensitivities for SCI 3, showing probabilities of projected spawning stock biomass exceeding the default Harvest Strategy Standard target reference point and being below the limit reference points. [Continued on next page]

Base: (M=0.25)	366 tonnes (average)				408 tonnes (TACC)			
	MN	MW	MO	SCI 3	MN	MW	MO	SCI 3
P(B_{2025}< 10% B_0)	0	0	0	0	0	0	0	0
P(B_{2025}< 20% B_0)	0	0	0	0	0	0	0	0
P(B_{2025}> 40% B_0)	1	0.99	1	1	1	0.99	1	1
P(B_{2025}> B_{2021})	0.5	0.42	0.66	0.55	0.52	0.39	0.65	0.52
	449 tonnes (+10% TACC)				490 tonnes (+20% TACC)			
	MN	MW	MO	SCI 3	MN	MW	MO	SCI 3
P(B_{2025}< 10% B_0)	0	0	0	0	0	0	0	0
P(B_{2025}< 20% B_0)	0	0	0	0	0	0	0	0
P(B_{2025}> 40% B_0)	1	0.98	1	1	1	0.97	1	1
P(B_{2025}> B_{2021})	0.51	0.31	0.61	0.44	0.51	0.26	0.6	0.38
Cut CPUE: (M=0.25)	366 tonnes (average)				408 tonnes (TACC)			
	MN	MW	MO	SCI 3	MN	MW	MO	SCI 3
P(B_{2025}< 10% B_0)	0	0	0	0	0	0	0	0
P B_{2025} < 20% B_0)	0	0	0	0	0	0	0	0
P(B_{2025}> 40% B_0)	1	0.95	1	1	1	0.93	1	1
P(B_{2025}> B_{2021})	0.55	0.43	0.72	0.59	0.52	0.35	0.69	0.51

Table 18 [continued]

	449 tonnes (+10% TACC)				490 tonnes (+20% TACC)			
	MN	MW	MO	SCI 3	MN	MW	MO	SCI 3
P(B_{2025}< 10% B_0)	0	0	0	0	0	0	0	0
P(B_{2025}< 20% B_0)	0	0	0	0	0	0	0	0
P(B_{2025}> 40% B_0)	1	0.9	1	1	1	0.86	1	1
P(B_{2025}> B_{2021})	0.55	0.29	0.68	0.46	0.55	0.22	0.67	0.39

Sens M: (M=0.20)	366 tonnes (average)				408 tonnes (TACC)			
	MN	MW	MO	SCI 3	MN	MW	MO	SCI 3
P(B_{2025}< 10% B_0)	0	0	0	0	0	0	0	0
P(B_{2025}< 20% B_0)	0	0	0	0	0	0	0	0
P(B_{2025}> 40% B_0)	1	0.99	1	1	1	0.98	1	1
P(B_{2025}> B_{2021})	0.57	0.43	0.77	0.63	0.57	0.37	0.76	0.58

	449 tonnes (+10% TACC)				490 tonnes (+20% TACC)			
	MN	MW	MO	SCI 3	MN	MW	MO	SCI 3
P(B_{2025}< 10% B_0)	0	0	0	0	0	0	0	0
P(B_{2025}< 20% B_0)	0	0	0	0	0	0	0	0
P(B_{2025}> 40% B_0)	1	0.96	1	1	1	0.95	1	1
P(B_{2025}> B_{2021})	0.59	0.29	0.73	0.49	0.59	0.25	0.71	0.43

Sens M: (M=0.30)	366 tonnes (average)				408 tonnes (TACC)			
	MN	MW	MO	SCI 3	MN	MW	MO	SCI 3
P(B_{2025}< 10% B_0)	0	0	0	0	0	0	0	0
P(B_{2025}< 20% B_0)	0	0	0	0	0	0	0	0
P(B_{2025}> 40% B_0)	1	0.99	1	1	1	0.99	1	1
P(B_{2025}> B_{2021})	0.47	0.42	0.57	0.5	0.45	0.37	0.56	0.45

	449 tonnes (+10% TACC)				490 tonnes (+20% TACC)			
	MN	MW	MO	SCI 3	MN	MW	MO	SCI 3
P(B_{2025}< 10% B_0)	0	0	0	0	0	0	0	0
P(B_{2025}< 20% B_0)	0	0	0	0	0	0	0	0
P(B_{2025}> 40% B_0)	1	0.98	1	1	1	0.98	1	1
P(B_{2025}> B_{2021})	0.45	0.29	0.54	0.39	0.44	0.26	0.53	0.36

Sens: q photo same	366 tonnes (average)				408 tonnes (TACC)			
	MN	MW	MO	SCI 3	MN	MW	MO	SCI 3
P(B_{2025}< 10% B_0)	0	0	0	0	0	0	0	0
P(B_{2025}< 20% B_0)	0	0	0	0	0	0	0	0
P(B_{2025}> 40% B_0)	1	1	1	1	1	1	1	1
P(B_{2025}> B_{2021})	0.52	0.46	0.62	0.6	0.51	0.4	0.61	0.55

	449 tonnes (+10% TACC)				490 tonnes (+20% TACC)			
	MN	MW	MO	SCI 3	MN	MW	MO	SCI 3
P(B_{2025}< 10% B_0)	0	0	0	0	0	0	0	0
P(B_{2025}< 20% B_0)	0	0	0	0	0	0	0	0
P(B_{2025}> 40% B_0)	1	1	1	1	1	0.99	1	1
P(B_{2025}> B_{2021})	0.51	0.37	0.58	0.52	0.51	0.32	0.6	0.49

SCI4A

No yield estimates and projection are available for SCI 4A.

SCI 6A

Projections were examined for the base model with constant annual catch remaining at current levels (status quo; average catch 2016 to 2019), or at the current TACC. Future recruitments were resampled from the last 10 estimated years (2008–2017). Median estimates of stock status from the projections are presented in Table 19 and suggest that under a TACC scenario the stock would remain above 50% SSB_0 by 2025.

The estimated probability of *SSB* being below either of the limits is zero, and the probability of remaining above the 40% B_0 target remains high through to 2025 (Table 20).

Table 19: Results from MCMC runs showing *SSB_0*, *SSB_{2019}*, and *SSB* projection estimates for future years at varying catch levels for the base model for SCI 6A.

	Status quo (278 t)		TACC (306 t)	
SSB_0		3 661		3 661
SSB_{2019}		1 950		1 950
SSB_{2019}/SSB_0		0.53		0.53
	Status (proportion of SSB_0)	Status (proportion of SSB_{2019})	Status (proportion of SSB_0)	Status (proportion of SSB_{2019})
SSB_{2020}	0.55	1.03	0.55	1.03
SSB_{2021}	0.56	1.06	0.56	1.04
SSB_{2022}	0.56	1.05	0.55	1.03
SSB_{2023}	0.55	1.04	0.54	1.00
SSB_{2024}	0.54	1.02	0.52	0.98
SSB_{2025}	0.53	1.00	0.51	0.95

Table 20: Results from MCMC runs for the base for SCI 6A, showing probabilities of projected spawning stock biomass exceeding the default Harvest Strategy Standard target and limit reference points.

	Status quo (278 t)				TACC (306 t)			
	Pr < 10% SSB_0	Pr < 20% SSB_0	Pr > 40% SSB_0	Pr > SSB_{2019}	Pr < 10% SSB_0	Pr < 20% SSB_0	Pr > 40% SSB_0	Pr > SSB_{2019}
2020	0.00	0.00	1.00	0.84	0.00	0.00	1.00	0.82
2021	0.00	0.00	0.99	0.76	0.00	0.00	0.99	0.69
2022	0.00	0.00	0.98	0.68	0.00	0.00	0.96	0.60
2023	0.00	0.00	0.95	0.61	0.00	0.00	0.92	0.52
2024	0.00	0.00	0.93	0.55	0.00	0.00	0.88	0.45
2025	0.00	0.00	0.89	0.49	0.00	0.00	0.83	0.39

5.5 Future research considerations

For all stocks

- Re-examine spatial and temporal patterns in grade length and sex composition (in the light of continued grade data collection by observers) with a view to reconstructing historical length composition data.
- Conduct additional tagging to improve growth estimates.
- Consider the incidence and distribution of *Microsporidian* spp. and its effects on survival and growth rates of scampi (both tagged individuals and in general).
- Explore evidence for the effects of recent fishing activity on catch rate, through flattening of bioturbation mounds and improved seabed contact (increased catchability) or disturbance of scampi leading to reduced emergence (reduced catchability).
- Examine recruitment patterns in more detail by obtaining better information on size composition. This could be accomplished by:
    - re-examining the photo survey data to allocate the animals seen into size ranges and differentiating doorkeepers from emerged animals;
    - investigating the utility of grade data for elucidating recruitment patterns;
    - investigating the potential for developing a juvenile index from ling and sea perch stomach contents.
- Improve the coverage and representativeness of observer data.

For SCI 1

- Consider combining the SCI 1 and 2 models (separate stocks but sharing of information, in particular around trawl survey catchability).
- Further analyse growth parameterisation and the influence on the assessment model's ability to fit the size composition data.
- Review the necessity for a highly informed trawl survey *q* prior.
- Review the utility of the photo survey and the interpretation of the images in generating abundance indices for the various scampi stock assessments.
- Review the selectivity ogive structures, in particular with respect to the model timesteps and the commercial size structure.

- Review the potential impact of changes in emergence and catchability.
- Explore CPUE standardisations, including spatial patterns and vessel overlap. Consider interviewing fleet managers and skippers about gear changes over time.

For SCI 2

- Investigate the conflict between the declining CPUE series from 2019 to 2021 and the significant increase in the trawl survey abundance in 2021.

For SCI 3

- Test for the possibility that it is the abundance indices rather than the length frequency data that are driving differences in year class strength in the three sub-regions: use the same abundance indices in all three models so that the only difference between the three is the length frequency data. This will determine whether the abundance indices or the length frequency data are the driving factors in determining year class strength.

For SCI4A

- Consider establishing reference points based on CPUE information.
- Consider designing and conducting a trawl survey in this area.

For SCI 6A

- Explore development of a 2-stock, 2-area model, splitting the fishery by depth to account for differences in length structure and growth

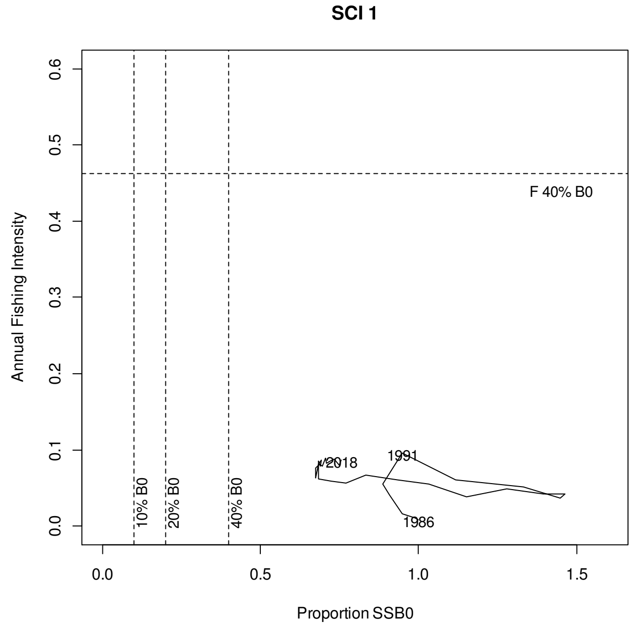
6. STATUS OF THE STOCKS

Stock Structure Assumptions
Assessments have been conducted for areas considered to be the core regions of SCI 1, SCI 2, SCI 3, and SCI 6A.

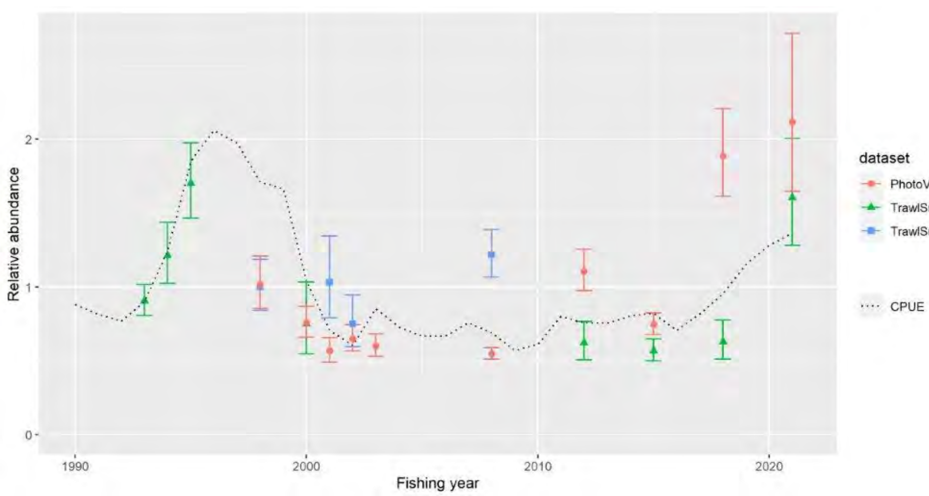
- **SCI 1**

Stock Status	
Year of Most Recent Assessment	2019; Preliminary 2022 results
Assessment Runs Presented	Base case; Updated abundance indices for 2022
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	2019: Very Likely (> 90%) to be at or above target 2022: Updated abundance indices indicate increases since 2019
Status in relation to Limits	2019: Exceptionally Unlikely (< 1%) to be below the soft or hard limits 2022: Updated abundance indices indicate increases since 2019
Status in relation to Overfishing	2019: Overfishing is Very Unlikely (< 10%) to be occurring 2022: Overfishing is Very Unlikely (< 10%) to be occurring

Historical Stock Status Trajectory and Current Status



2019: Trajectories of biomass as a proportion of B_0 and annual equivalent fishing intensity for SCI 1 (M=0.25, CV=0.15).



2022: Mean catch rates and relative abundance (+/- one standard error) of research trawling and photo survey counts for SCI 1. TrawlSurvey_1 is whole survey area, TrawlSurvey_2 and PhotoVisible are from the core survey strata, with PhotoVisible the visible scampi index). Dotted line represents median of annual unstandardised CPUE for SCI 1.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	2019: Spawning stock biomass increased to a peak in about 1995, declined to the early 2000s, and then remained relatively stable since this time. The 2018 photo survey showed a slight increase in the biomass and the CPUE showed a slight increase too. Trawl survey indices remained stable between 2000 and 2018. 2022: The Standardised CPUE index has increased steadily since 2016. The trawl survey index has more than doubled since 2018. The visible scampi index has more than tripled since 2015.

Recent Trend in Fishing Intensity or Proxy	2019: Fishing intensity fluctuated without trend since the early 1990s. 2022: Fishing intensity has probably declined since 2016 based on increasing abundance indices and little increase in catch.
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis	
Stock Projections or Prognosis	
Probability of Current Catch or TACC causing biomass to remain below or to decline below Limits	2019: Soft Limit: Exceptionally Unlikely (< 1%) 2019: Hard Limit: Exceptionally Unlikely (< 1%) 2022: Soft Limit: Very Unlikely (< 10%) 2022: Hard Limit: Very Unlikely (< 10%)
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Overfishing: Very Unlikely (< 10%)

Assessment Methodology and Evaluation		
Assessment Type	2019: Level 1 - Full Quantitative Stock Assessment 2022: Preliminary results	
Assessment Method	2019: Length-based Bayesian Model 2022: Updated abundance series for 2022	
Assessment Dates	Latest assessment: 2019 Preliminary results: 2022	Next assessment: November 2022
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank): 2019	- Standardised catch and effort data (TCEPR) - Length frequency data from FNZ observer sampling - Photographic survey abundance index - Trawl survey abundance index - Length frequency data from research sampling - Length frequency predicted from burrow sizes	1 – High Quality 2 – Medium or Mixed Quality: data not representative in some years 1 – High Quality 1 – High Quality 1 – High Quality 2 – Medium or Mixed Quality: estimation of length structure uncertain, and not fitted well in model
Main data inputs (rank): 2022	- Standardised catch and effort data (TCEPR) - Photographic visible scampi survey abundance index - Trawl survey abundance index	1 – High Quality 1 – High Quality 1 – High Quality
Data not used (rank): 2022	Photographic survey burrow indices	2 – Medium or Mixed Quality: inconsistencies in burrow count interpretation

Changes to Model Structure and Assumptions: 2019	- Revised catchability priors developed
Major Sources of Uncertainty	2019: - Growth, burrow occupancy and catchability - Early CPUE (potential time varying *q*) - Early (large) YCSs - Absolute biomass determined by the *q* prior - Calculation of equivalent annual *F*s and reference points

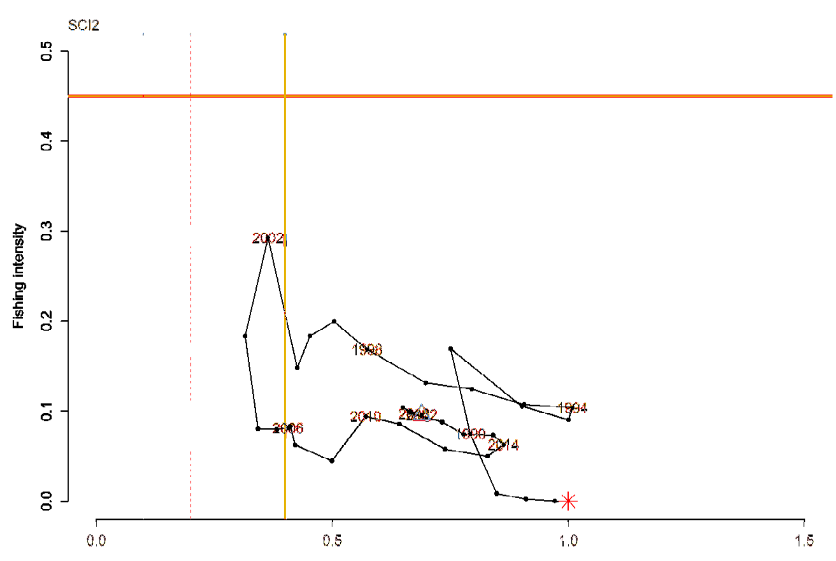
Qualifying Comments
2022: All abundance indices included in this assessment are sensitive to any changes in scampi emergence behaviour and consequent catchability (by trawl) or observability (in photographs). There are indications from model fits in 2019 that catchability varies between years.

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

- **SCI 2**

Stock Status	
Year of Most Recent Assessment	2022
Assessment Runs Presented	Base case
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 or hard limits
Status in relation to Overfishing	Overfishing is Very Unlikely (< 10%) to be occurring.

Historical Stock Status Trajectory and Current Status



Trajectories of biomass as a proportion of B_0 and annual equivalent fishing intensity for SCI 2.

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 increased steadily between 2008 and 2014, declining slightly since then.
Recent Trend in Fishing Intensity or Proxy	Fishing mortality increased through the 1990s, peaking in 2002, but declined considerably 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 up to 2024 under TACC and increased catches.
Probability of Current Catch or TACC causing biomass to remain below or to decline below Limits	Soft Limit: Very Unlikely (< 10%) Hard Limit: Very Unlikely (< 10%)
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Overfishing: Very Unlikely (< 10%)

Assessment Methodology and Evaluation		
Assessment Type	Level 1 - Full Quantitative Stock Assessment	
Assessment Method	Length-based Bayesian Model	
Assessment Dates	Latest assessment: 2022	Next assessment: 2025
Overall assessment quality rank	2 – Medium or Mixed Quality: conflicts between abundance indices were not adequately explored	
Main data inputs (rank)	- Standardised catch and effort data (TCEPR)	1 – High Quality
	- Length frequency data from FNZ 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
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	- Revised catchability priors developed	
Major Sources of Uncertainty	- Growth, burrow occupancy and catchability - Early CPUE (potential time varying q) - Early and recent (large) YCSs - Absolute biomass determined by the q prior - Calculation of equivalent annual Fs and reference points - Conflict exist between recent CPUE and trawl survey indices and therefore recent abundance trajectories are more uncertain than the model results indicate	

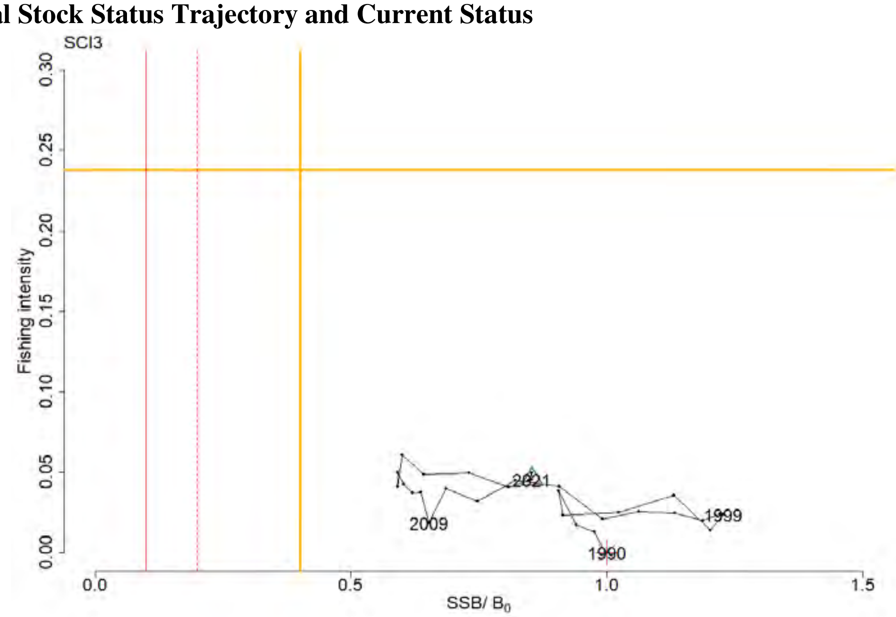
Qualifying Comments
-

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

- **SCI 3**

Stock Status	
Year of Most Recent Assessment	2021
Assessment Runs Presented	Bayesian length-based model, base model: M=0.25, CPUE CV=0.2
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	B_{2021} was estimated to be 88% B_0. Very Likely (> 90%) to be at or above the target.
Status in relation to Limits	B_{2021} is Exceptionally Unlikely (< 1%) to be below the soft or hard limits
Status in relation to Overfishing	Overfishing is Exceptionally Unlikely (< 1%) to be occurring

Historical Stock Status Trajectory and Current Status



Trajectories of biomass as a proportion of B_0 and annual equivalent fishing intensity for SCI 3.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Recent biomass has increased and then stabilised since about 2018.
Recent Trend in Fishing Intensity or Proxy	Fishing intensity has been low and without trend throughout the time series
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 for the next 5 years under current catches (TACC) and increases in TACC of up to 20%.
Probability of Current Catch or TACC causing biomass to remain below or to decline below Limits	Soft Limit: Very Unlikely (< 10%) Hard Limit: Exceptionally Unlikely (< 1%)
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Very Unlikely (< 10%)

Assessment Methodology and Evaluation		
Assessment Type	Level 1 - Full Quantitative Stock Assessment	
Assessment Method	Length-based Bayesian model	
Assessment Dates	Latest assessment: 2021	Next assessment: 2025
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	- Standardised fisheries CPUE index of abundance - Length frequency data from FNZ observer sampling - Photographic survey abundance index - Trawl survey abundance index - Length frequency data from research sampling - Length frequency predicted from burrow sizes	1 – High Quality 2 – Medium or Mixed Quality: data not representative in some years 1 – High Quality 1 – High Quality 1 – High Quality 1 – High Quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	- Revised trawl survey q priors - Shared or separate photo qs between areas - Separate trawl qs between areas - Used photo q priors developed for SCI 1 & 2	
Major Sources of Uncertainty	- Growth, burrow occupancy and catchability - Early CPUE (potential time varying q) - Early (large) YCSs - Absolute biomass determined by the q prior - Calculation of equivalent annual Fs and reference points	

Qualifying Comments
Model scaling is highly dependent on the q priors without much updating by posteriors. Their influence should be investigated further. CPUE is highly influential and may be driving recruitment. This contributes to generating large early YCS(s) that are not fully supported by data.

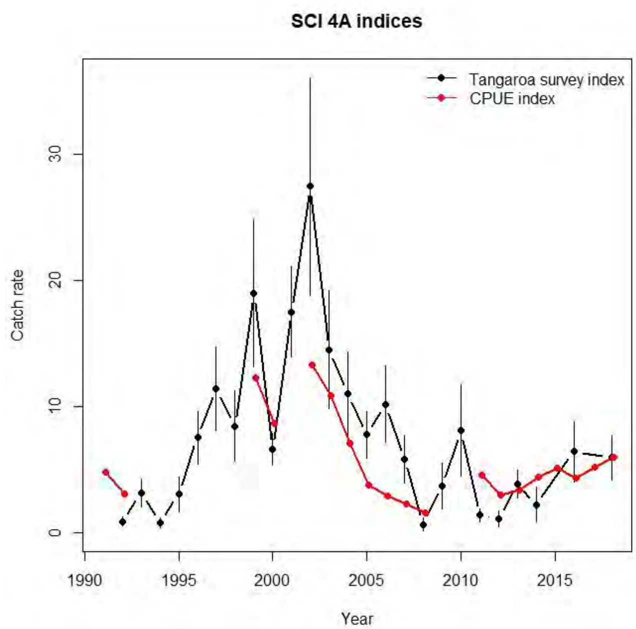
Fishery Interactions
Main QMS bycatch species include ling, hoki, sea perch, red cod, silver warehou, and giant stargazer. Discards are dominated by rattails, javelinfish, skates and crabs, ling, red cod, hoki, spiny dogfish, and sea perch. Interactions with seabirds have been recorded. A wide range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

- **SCI 4A**

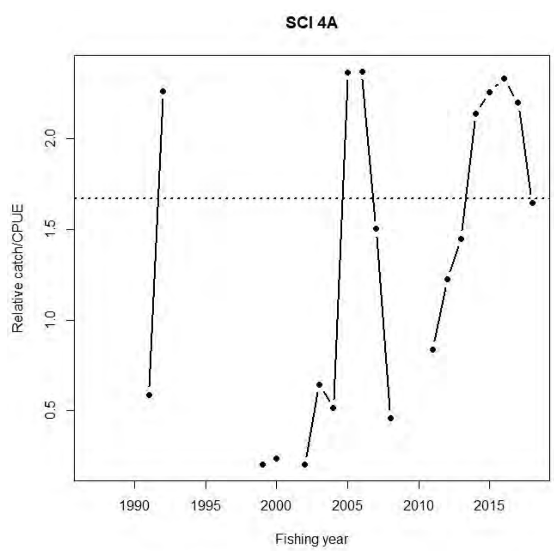
Stock Status	
Year of Most Recent Assessment	2019
Assessment Runs Presented	Standardised CPUE

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	Unknown
Status in relation to Limits	Unknown
Status in relation to Overfishing	Unknown

Historical Stock Status Trajectory and Current Status



Trajectories of CPUE and *Tangaroa* trawl survey catch rate for SCI 4A.



Relative fishing pressure for SCI 4A based on the ratio of QMR/MHR landings relative to the SCI 4A CPUE series which has been normalised so that its geometric mean=1.0. Horizontal dotted line is the geometric mean fishing pressure from 20010–11 to 2017–18.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	CPUE shows an increasing trend between 2012 and 2018.
Recent Trend in Fishing Intensity or Proxy	Recent relative exploitation rate has been higher than the series mean, but has decreased from a recent peak since 2016.
Other Abundance Indices	The Chatham Rise *Tangaroa* trawl survey index shows a very similar pattern to the standardised CPUE index.
Trends in Other Relevant Indicators or Variables	Fishing effort increased from 2012–2015 but declined to the 2012 level by 2018.

Projections and Prognosis	
Stock Projections or Prognosis	Unknown
Probability of Current Catch or TACC causing biomass to remain below or to decline below Limits	Unknown
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Unknown

Assessment Methodology and Evaluation		
Assessment Type	Level 2 - Partial Quantitative Stock Assessment	
Assessment Method	Standardised CPUE	
Assessment Dates	Latest assessment: 2019	Next assessment: Unknown
Overall assessment quality rank	1 – High Quality. The Shellfish WG agreed the CPUE index was a credible measure of abundance	
Main data inputs	- Standardised catch and effort data (TCEPR) - Length frequency data from FNZ observer sampling - Trawl survey abundance index - Length frequency data from trawl survey abundance index	1 – High Quality 2 – Medium or Mixed Quality: variable representativeness of sampling 1 – High Quality 2 – Medium or Mixed Quality: uncertain representativeness of sampling and small sample sizes
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	-	

Qualifying Comments
The Chatham Rise *Tangaroa* survey records relatively low catches of scampi, and though it provides the only fishery-independent index for scampi in SCI 4A, it was not designed to target this species.

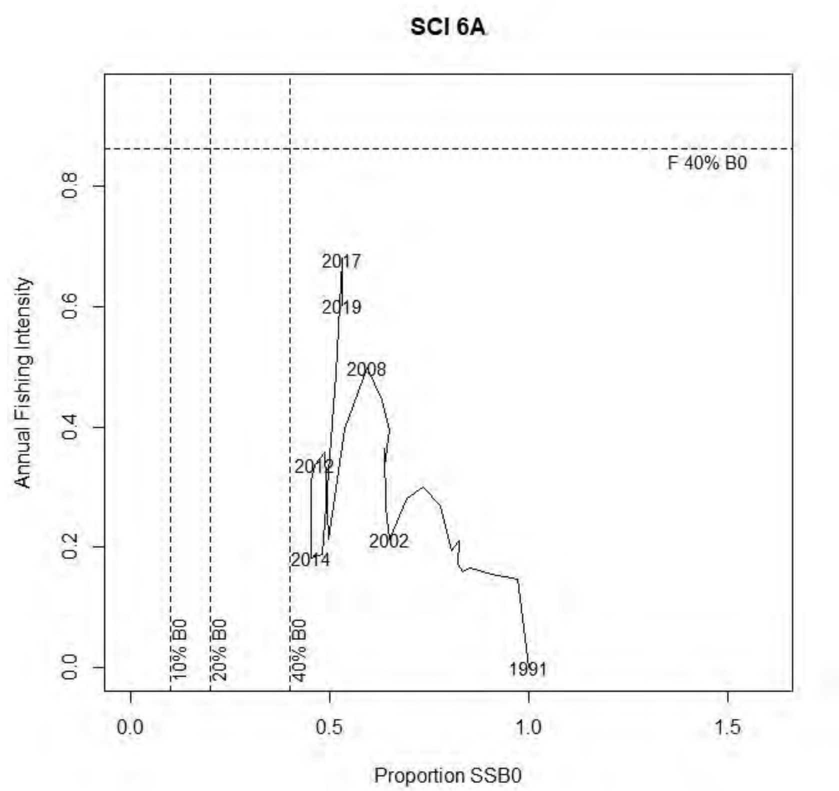
Fishery Interactions
Main QMS bycatch species include ling, hoki, sea perch, red cod, silver warehou, and giant stargazer. Discards are dominated by rattails, javelinfish, skates and crabs, ling, red cod, hoki, spiny dogfish, and sea perch. Interactions with seabirds and mammals (fur seals and sea lions)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

- **SCI 6A**

Stock Status	
Year of Most Recent Assessment	2020

Assessment Runs Presented	Bayesian length based model with *M*=0.25, informed survey catchability priors, and survey and CPUE abundance indices (base model run)
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 the target
Status in relation to Limits	Exceptionally Unlikely (< 1%) to be below the soft or hard limits
Status in relation to Overfishing	Overfishing is Exceptionally Unlikely (< 1%) to be occurring

Historical Stock Status Trajectory and Current Status



Trajectories of biomass as a proportion of SSB_0 and annual equivalent fishing intensity for SCI 6A.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Estimated spawning stock biomass has been stable for the last 4 years.
Recent Trend in Fishing Intensity or Proxy	Fishing mortality showed an increasing trend between 2014 and 2019.
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% SSB_0 through to 2025 at current levels of catch and the TACC. Projected stock status when catches are at the TACC level is predicted to be about 51% B_0 in 2025.

Probability of Current Catch or TACC causing biomass to remain below or to decline below Limits	Soft Limit: Exceptionally Unlikely (< 1%) Hard Limit: Exceptionally Unlikely (< 1%)
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Overfishing Exceptionally Unlikely (< 1%)

Assessment Methodology and Evaluation		
Assessment Type	Level 1 - Full Quantitative Stock Assessment	
Assessment Method	Length-based Bayesian model	
Assessment Dates	Latest assessment: 2020	Next assessment: 2023
Overall assessment quality rank	1 – High Quality	
Main data inputs	- Standardised catch and effort data (TCEPR) - Length frequency data from FNZ observer sampling - Photographic survey abundance index - Trawl survey abundance index - Length frequency data from trawl survey abundance index - Length frequency data from photos of visible scampi - Growth rates predicted from tag release recapture data	1 – High Quality 2 – Medium or Mixed Quality: variable representativeness of sampling 1 – High Quality 1 – High Quality 1 – High Quality 2 – Medium or Mixed Quality: high level of uncertainty 2 – Medium or Mixed Quality: limited recaptures and within a limited time span
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	Revised prior distributions estimated for survey catchability Model was fitted to emerged abundance index rather than the visible index	
Major Sources of Uncertainty	- Growth, differential selectivity by sex, and sex ratios - Relationship between CPUE and abundance (potential time varying *q*) -YCS estimation	

Qualifying Comments
Photo surveys in SCI 6A observe a higher 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 in other areas.

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

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