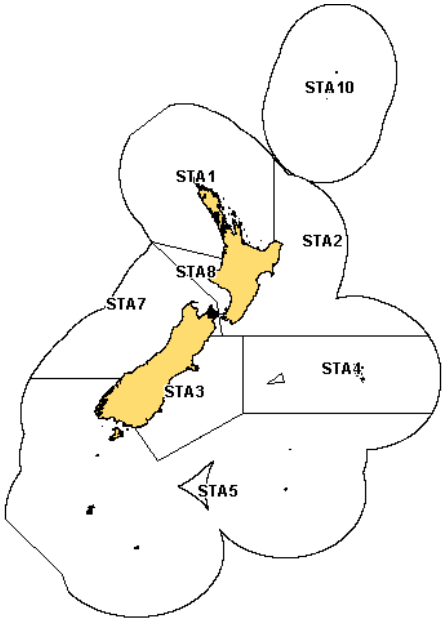
STARGAZER (STA)

(*Kathetostoma giganteum)*



1. FISHERY SUMMARY

(a) Commercial fisheries

Giant stargazer (*Kathetostoma giganteum*, Uranocopidae) is a moderate-sized benthic teleost distributed widely in New Zealand waters. It is found on muddy and sandy substrates to depths of 500 m, but is most common between 50–300 m on the continental shelf around the South Island (Anderson et al., 1998), where it supports a moderate-value, commercial trawl fishery. It is managed as eight separate Quota Management Areas (QMAs) or Fishstocks at this time: STA 1–5, 7–8, and 10.

It is caught by both directed fishing and as bycatch of fisheries targeting other species. The main target fishery is on the Stewart–Snares shelf west of Stewart Island (statistical areas 029–030). Other target fisheries exist on the west coast of the South Island and off Cape Campbell on the east coast of the South Island. It is also caught by small domestic trawl vessels targeting red cod (*Pseduophycis baccus*), tarakihi (*Nemadactylus macropterus*), flatfishes (*Colistum* spp., *Peltorhamphus* spp., and *Rhombosolea* spp.), and scampi (*Metanephrops challengeri*) on the continental shelf throughout its range, and by larger, foreign-licensed and New Zealand-chartered foreign vessels targeting barracouta (*Thyrsites atun*), jack mackerels (*Trachurus* spp.), and squids *(Nototodarus* spp.) in deeper waters, in particular on the western Chatham Rise and on the continental slope surrounding the Stewart–Snares shelf. Giant stargazer is an important bycatch of scampi fishing in STA 2–4. Catches by methods other than bottom-trawling are minimal. Reported landings from 1979 to 1987–88 are given in Table 1.

Table 1: Reported landings (t) of giant stargazer by vessel flag from 1979 to 1987–88.

	New Zealand		Foreign			New Zealand		Foreign	
Year	Domestic	Chartered	licensed	Total	Year	Domestic	Chartered	licensed	Total
1979*	387	155	159	701	1983–84†	1463	525	360	2348
1980*	723	–	–	723	1984–85†	1027	321	178	1526
1981*	1010	314	84	1408	1985–86†	1304	386	142	1832
1982*	902	340	283	1526	1986–87†	1126	379	63	1568
1983*	1189	329	465	1983	1987–88†	839	331	26	1196

* MAF data.
† FSU data.

The total catch between 1979 and 1986–87 was variable, ranging between 701–2348 t and averaging

1481 t. Different trends are apparent for domestic and foreign vessels. The domestic and chartered catch was relatively stable throughout the middle and later half of the series, which probably reflects the stability of effort in the red cod, tarakihi, flatfish, and barracouta fisheries at this time as well as better reporting compliance. However, landings by licensed foreign vessels declined steadily from a high of 465 t in 1983 to a low of 26 t in 1986–87, probably reflecting the declining importance of licensed foreign vessels in New Zealand's deepwater fisheries following the phasing-in of the QMS, which began in 1983 and which was fully implemented by 1986–87. Reported landings since 1983 by Fishstock are given in Table 2. The total catches for 1986–87 and 1987–88 in Table 1 are less than those in Table 2 because of under-reporting to the FSU during those years.

Table 2: Reported landings (t) of giant stargazer by QMS Fishstock (QMA) from 1983 to 2005–06. TACCs from 1986–87 to 2005–06 are also provided.

Fishstock	STA 1		STA 2		STA 3		STA 4		STA 5	
FMA(s)	1 & 9		2		3		4		5 & 6	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1983*	8	–	34	–	540	–	168	–	843	–
1984*	5	–	24	–	588	–	143	–	1023	–
1985*	9	–	15	–	438	–	82	–	695	–
1986*	12	–	24	–	415	–	95	–	566	–
1986–87†	10	20	31	30	644	560	72	2000	738	1060
1987–88†	3	20	46	33	783	581	110	2005	886	1144
1988–89†	3	20	41	37	675	591	134	2005	1215	1173
1989–90†	9	21	53	37	747	703	218	2009	1150	1175
1990–91†	8	21	125	37	674	734	790	2014	1061	1239
1991–92†	18	50	105	100	756	900	366	2014	1056	1500
1992–93†	19	50	115	101	811	901	231	2014	1247	1500
1993–94†	8	50	73	101	871	902	113	2014	1327	1500
1994–95†	10	50	74	101	829	902	223	2014	1216	1525
1995–96†	17	50	69	101	876	902	259	2014	1159	1525
1996–97†	22	50	77	101	817	902	149	2014	977	1525
1997–98†	29	21	54	38	667	902	263	2014	544	1264
1998–99†	27	21	46	38	641	902	137	2014	1145	1264
1999–00†	36	21	42	38	719	902	161	2014	1327	1264
2000–01†	26	21	45	38	960	902	233	2014	1439	1264
2001–02†	34	21	58	38	816	902	391	2158	1137	1264
2002–03†	31	21	41	38	863	902	308	2158	967	1264
2003–04†	23	21	27	38	578	902	186	2158	1193	1264
2004–05†	27	21	28	38	646	902	366	2158	1282	1264
2005–06†	34	21	30	38	824	902	359	2158	1347	1264

Fishstock	STA 7		STA 8		STA 10		Total	
FMA(s)	7		8		10			
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1983*	323	–	3	–	0	–	1919	–
1984*	444	–	3	–	0	–	2230	–
1985*	328	–	4	–	0	–	1571	–
1986*	362	–	3	–	0	–	1477	–
1986–87†	487	450	7	20	0	10	1990	4150
1987–88†	505	493	5	20	0	10	2338	4306
1988–89†	520	499	5	20	0	10	2593	4355
1989–90†	585	525	1	22	0	10	2763	4502
1990–91†	762	528	6	22	0	10	3426	4605
1991–92†	920	700	18	22	0	10	3239	5296
1992–93†	861	702	5	22	0	10	3289	5300
1993–94†	715	702	4	50	0	10	3111	5329
1994–95†	730	702	7	50	0	10	3089	5354
1995–96†	877	702	4	50	0	10	3261	5354
1996–97†	983	702	10	50	0	10	3034	5354
1997–98†	564	702	10	22	0	10	2132	4973
1998–99†	949	702	2	22	0	10	2946	4973
1999–00†	1184	702	3	22	0	10	3472	4973
2000–01†	1440	702	4	22	0	10	4146	4973
2001–02†	802	702	4	22	0	10	3238	5117
2002–03†	957	997	4	22	0	10	3171	5412
2003–04†	934	997	6	22	0	10	2947	5412
2004–05†	1028	997	5	22	0	10	3381	5412
2005–06†	1010	997	3	22	0	10	3606	5412

* FSU data.

† QMS data.

After 1983, the catch began to increase rapidly, reaching 3426 t in 1990–91, and averaging 3204 t thereafter. The increase in catch is due to a number of factors, including: (a) increased target fishing in

Southland (STA 5); (b) the availability of more quota through the decisions of the QAA; (c) better management of quotas by quota owners; (d) quota trading in STA 3, 4, 5 and 7; (e) changes in fishing patterns in the Canterbury Bight (STA 3) and the west coast of the South Island (STA 7); (f) a possible increase in abundance of stargazer in STA 7; and (g) increases in the STA 3, 5, and 7 TACCs introduced under the Adaptive Management Programme (AMP) in the 1991–92 fishing year.

The AMP is a management regime within the QMS for data-poor New Zealand Fishstocks that are likely to be able to sustain increased exploitation. Under the AMP, quota owners collect additional data from the fishery (typically fine-scale catch-effort data and rudimentary but necessary biological data such as fish length and sex) in return for an increased TACC. Under the AMP, TACCs for five giant stargazer Fishstocks (STA 1–3, 5, and 7) were increased at the start of the 1991–92 fishing year, and a sixth (STA 8) was increased in 1993–94. However, the TACCs for Fishstocks STA 1–3, 5, and 8 reverted to their pre-AMP levels in 1997–98, following the removal of these fishstocks from the AMP in July 1997 because of the failure of quota owners to meet the data-collection requirements of the AMP. In recent years, landings in three of these Fishstocks (STA 1–2 and 5) have exceeded their reduced, post-AMP TACCs; although of these, STA 5 is the only one with a TACC greater than 40 t at this time. STA 7 was reviewed in 1998 and retained in the AMP until the end of the 2001–02 fishing year. The TACC in STA 7 was further increased to 997 t at the start of the 2002–03 fishing year within a TAC of 1000 t (which includes a 2 t recreational and a 1 t customary allowance). It was reviewed again in 2002 and retained in the AMP for a third five-year term until the end of 2006–07.

Of the eight Fishstocks, the most important, in terms of the recorded landed catch, are STA 5, STA 7, and STA 3 (where landings since 1990–91 have averaged 1157 t, 780 t, and 778 t, respectively) with smaller contributions from STA 2 and STA 4 Although a high TACC is set for STA 4 compared with the other seven Fishstocks, it has never been approached or exceeded. Most of the STA 4 catch is caught as bycatch of fishing directed at other target species. A high recorded landed catch in 1990–91 (790 t) was due to exploratory fishing for these target species, this has since declined. The recorded landed catch has averaged 278 t per fishing year since then. Increased catches in STA 2 from 1990–91 were due to the development of the scampi fishery in this Fishstock.

As noted, the TACC in STA 7 was increased to 700 t in 1991–92 under the terms of the AMP. The TACC was overcaught in nearly every subsequent fishing year up to 2002–03, when the TACC was further increased to 997 t. Landings reached a high of 1440 t in 2000–01, before dropping back to 800 t in 2001–02. These high recorded landings resulted mainly from the use of bycatch trades with barracouta and flatfishes. With the removal of the bycatch trade system in October 2001, fishers now face the penalty of high deemed-values for any overcatch, and it is likely that these penalties have been the cause of the reduction in the overcatch in this Fishstock.

The landings data (Table 1 and Table 2) probably include an unknown amount of catch from other uranoscopid species misidentified as *K. giganteum*. Fishers in STA 1–3 and 8 are known to have reported brown (*Gnathagnus innotabilis*) and spotted stargazer (*Genyagnus monopterygius*) as *K. giganteum* in the past. Landings in STA 4 and 5 probably include an unknown amount of an undescribed sister species, banded stargazer (*Kathetostoma* sp.). Although the true extent of misreporting due to misidentification is unknown, it is likely to be small.

(b) Recreational fisheries

Stargazer were not reported as being caught by recreational fishers in surveys conducted in the Ministry of Fisheries South region in 1991–92, Central region in 1992–93 and North region in 1993–94. In a Ministry of Fisheries national survey in 1996, a few giant stargazers was reported in STA 1 and 3, with an estimated take of 1000 fish in STA 1 and less than 500 fish taken in STA 3 (Bradford, 1998). No giant stargazer catch was recorded for the recreational fishers during the 1999–2000 national diary survey (Boyd & Reilly, 2005).

(c) Maori customary fisheries

No quantitative information is available on the level of Maori customary take.

(d) Illegal catch

No quantitative information is available on the level of illegal catch.

(e) Other sources of mortality

No quantitative information is available on the level of other sources of mortality.

2. BIOLOGY

As noted, giant stargazer is found throughout the New Zealand EEZ. It is most plentiful around the South Island (STA 3, 5, & 7) and at the Mernoo Bank and west of the Chatham Islands on the Chatham Rise (STA 4).

Using data collected from the west coast South Island trawl survey series (Drummond & Stevenson, 1995a, 1995b, 1996; Stevenson 1998; Stevenson & Hanchet, 2000; Stevenson, 2002, 2004), Manning (2006a) found that giant stargazer reach sexual maturity at a length of about 40–55 cm in total length (TL), depending on sex, at an age of between 5–7 years. Age and growth studies suggest that some individuals reach a maximum age of at least 25 years (Sutton, 1999; Manning & Sutton, 2004; Sutton, 2004; Manning & Sutton, 2006b, 2006a), although otolith growth zones are yet to be validated.

Using maximum-likelihood methods, Manning & Sutton (2004) found that giant-stargazer growth differs significantly between the east, south, and west coasts of the South Island. They suggested that these differences represented different biological stock units in these areas, although the true stock structure is unclear (Tate, 1987). Manning (2005) investigated the effect of assuming alternative growth models with different functional forms on the data and conclusions presented by Manning & Sutton (2004). His results were consistent with the earlier results.

M was estimated using the equation $M = \ln 100 / t_{\max}$, where $t_{\max}$ is the maximum age to which 1% of the population survives in an unexploited stock. Using an unvalidated maximum age of 26 years, yields $M = 0.18$. Preliminary results of the STA 7 quantitative stock that is underway at this time suggest that 0.18 is an underestimate of the unknown true value. A revised estimate based on applying Hoenig's (1983) regression to the age composition data from the west coast South Island survey series suggested that a value of 0.23 is more reasonable (Manning, 2006a). Although the west coast South Island age composition data were collected from an exploited stock, 0.23 is considered to be closer to the true value than 0.18.

Stargazer have an annual reproductive cycle with a winter spawning season. Spawning probably occurs in mid and outer shelf waters all around New Zealand. The generalised spawning date assumed in the age and growth studies cited above is 1 July in any given calendar year.

Biological parameters relevant to the stock assessment are given in Table 3.

Table 3: Estimates of giant stargazer biological parameters

Fishstock	Estimate			Source
1. Natural mortality				
STA 5	0.20			Sutton (2004)
STA 7	0.18			Manning (2006a)
2. Weight = a(length)^b (weight in g; length in cm total length)				
STA 3	Males	Females	All fish	
a	–	–	0.015	S. McClatchie (unpub. data)
b	–	–	3.01	
STA 5				
a	–	–	0. 024	G. McGregor (unpub. data)
b	–	–	2.92	
STA 7				
a	0.008	0.008	0.007	Manning & Sutton (2006a)
b	3.18	3.21	3.23	
3. Length at maturity (cm total length)				
STA 7	Males	Females		Manning (2006a)
l50	40.98	54.37		
l95	14.90	11.24		
4. Age at maturity (years)				
STA 7	Males	Females		Manning (2006a)
a50	5.53	7.23		
a95	4.38	4.34		
5. Von Bertalanffy length-at-age model parameter estimates				
STA3	Males	Females		
K (yr^{-1})	0.2	0.14		Sutton (1999)
L_∞ (cm)	61.49	78.11		
t_0 (yr)	-0.97	-1.25		
STA5				
K (yr^{-1})	0.19	0.18		Sutton (1999)
L_∞ (cm)	59.12	73.92		
t_0 (yr)	-1.19	-0.22		
STA5				
K (yr^{-1})	0.18	0.17		Sutton (2004)
L_∞ (cm)	60.76	72.61		
t_0 (yr)	-1.16	-0.02		
STA 7				
K (yr^{-1})	0.15	0.13		Manning & Sutton (2006a); a revision of
L_∞ (cm)	71.00	85.74		earlier results presented by Manning &
t_0 (yr)	-0.664	-0.666		Sutton (2004)

3. STOCKS AND AREAS

There are no new data that would alter the stock boundaries given in previous assessment documents.

It is not known if there is more than one giant stargazer stock in New Zealand. The present QMAs were used as a basis for Fishstocks, except for QMAs 5 and 6, which were combined. The basis for choosing these boundaries was a general review of the distribution and relative abundance of stargazer within the fishery.

As noted, growth appears do differ significantly between the east, south, and west coasts of the South Island (Manning & Sutton, 2004; Manning, 2005). This is consistent with the Fishstock boundaries in use at this time.

4. STOCK ASSESSMENT

There are no new data that are available at this time that would alter the yield estimates given in the 1997 Plenary Report. The yield estimates are based on commercial landings data.

(a) Estimates of fishery parameters and abundance

(i) Trawl surveys

Indices of relative biomass are available from recent *Tangaroa* and *Kaharoa* trawl surveys (Table 4).

Table 4: Relative biomass indices of stargazer and coefficients of variation (CV) for east coast North Island (ECNI), east coast South Island (ECSI) – winter and summer, Chatham Rise, west coast South Island (WCSI) and the Stewart-Snares Island survey areas assuming areal availability, vertical availability and vulnerability equal 1.0. Note: because trawl survey biomass estimates are relative indices, comparisons between different seasons (e.g., summer and winter ECSI) are not strictly valid.

Species	Region	Fishstock	Year	(Trip Code)	Relative biomass (t)	CV (%)
Giant stargazer	ECNI	STA 2	1993	KAH9304	184	22
	Inshore		1994	KAH9402	58	47
			1995	KAH9502	44	35
			1996	KAH9602	57	17
	ECNI	STA 2	1993	KAH9301	250	16
	(Scampi)		1994	KAH9401	215	20
			1995	KAH9501	122	17
	ECSI	STA 3	1991	KAH9105	600	17
	(Winter)		1992	KAH9205	669	16
			1993	KAH9306	609	14
			1994	KAH9406	462	15
			1996	KAH9606	465	11
	ECSI	STA 3	1996	KAH9618	897	12
	(Summer)		1997	KAH9704	543	11
			1998	KAH9809	999	10
			1999	KAH9917	472	14
			2000	KAH0014	214	16
	Chatham Rise	STA 4	1992	TAN9106	2 570	11
			1993	TAN9212	2 560	13
			1994	TAN9401	2 853	12
			1995	TAN9501	1 429	13
			1996	TAN9601	3 039	16
			1997	TAN9701	2 328	15
			1998	TAN9801	1 702	14
			1999	TAN9901	1 903	13
			2000	TAN0001	2 148	13
			2001	TAN0101	1 772	16
			2002	TAN0201	2 195	16
			2003	TAN0301	1 380	15
			2004	TAN0401	2625	17
	WCSI	STA 7	1992	KAH9204	1 302	12
			1994	KAH9404	1 350	17
			1995	KAH9504	1 551	16
			1997	KAH9701	1 450	15
			2000	KAH0004	1 023	12
			2003	KAH0304	827	15
			2005	KAH05	1 429	19
	Stewart-Snares	STA 5	1993	TAN9301	2 650	20
			1994	TAN9402	3 755	11
			1995	TAN9502	2 452	11
			1996	TAN9604	1 733	11
Banded stargazer	Stewart-Snares	BGZ 5	1993	TAN9301	409	27
			1994	TAN9402	250	21
			1995	TAN9502	316	29
			1996	TAN9604	232	34

(ii) CPUE analysis

STA 2 and 3

CPUE indices calculated for STA 2 (Vignaux, 1997), STA 3 (SEFMC, 2002; SeaFIC, 2005a) and STA 7 (SeaFIC, 2002, 2003b, 2005b) have been based on bycatch fisheries. The Inshore and AMP Fishery Assessment Working Groups have had concerns over using bycatch fisheries to monitor stargazer abundance in these areas due to the low proportion of the total QMR landings used in the analyses, and possible changes in recording and fishing practices. In 2002, the AMP FAWG accepted an interim decision rule based on CPUE indices for bycatch of STA 3 in the RCO 3 trawl fishery (Figure 1) (SEFMC, 2002). The standardized CPUE trend was updated to 2003/04 in 2005 (SeaFIC, 2003a), based on tows targeting red cod, barracouta and tarakihi.

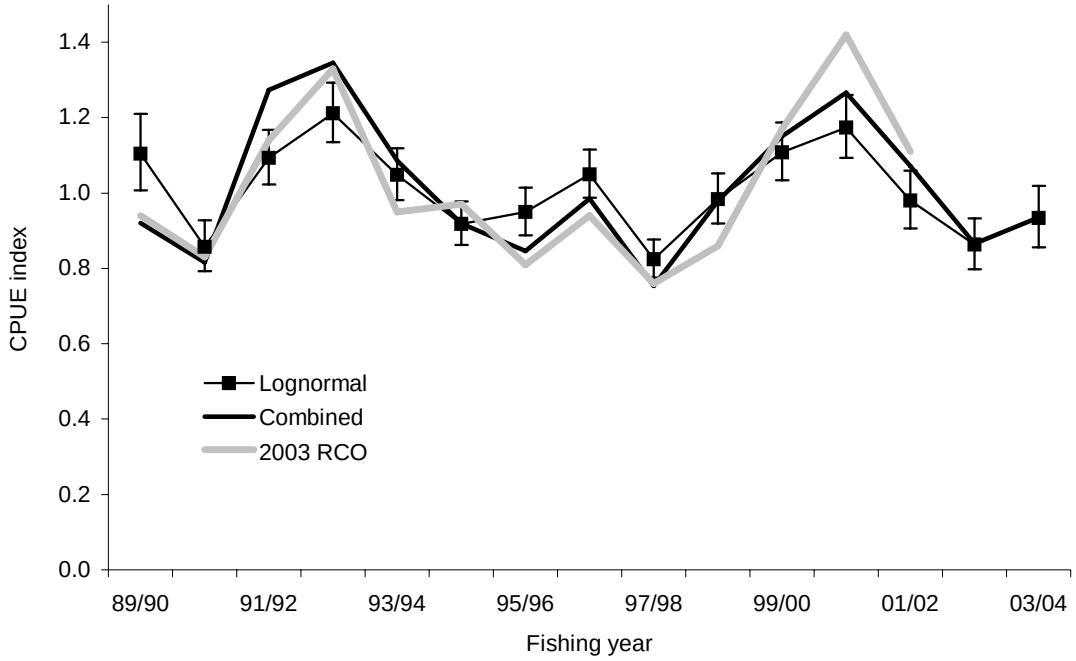


Figure 1: Comparison of three CPUE series for STA 3: [square markers] lognormal analysis of the MIX fishery; [thick line] combined lognormal and binomial model for the MIX fishery; [grey line] lognormal model from 2003 RCO analysis. The MIX analysis was based on tows targeting RCO, BAR and TAR. Target species was offered to the model as an explanatory variable.

STA 4

Stargazer in STA 4 are taken as a bycatch of the fisheries for hoki, ling, silver warehou, squid, barracouta, red cod and scampi on the Chatham Rise, as bycatch of a barracouta fishery near the Chatham Islands, and in a small targeted stargazer fishery north of the Chatham Islands.

An unstandardised CPUE analysis of stargazer in these fisheries, singly and in appropriate combinations, showed no clear trend (Table 5). The stargazer CPUE is strongly correlated with the stargazer catch, suggesting that it is influenced by being in or out of the top five species reported on fishing returns. The unstandardised CPUE indices of the stargazer bycatch are not considered reliable, and are not used in stock assessment. Further, the Working Group noted the localised nature of the fishing effort in STA 4 and that fishing occurs in two geographically distinct locations, one around the Chatham Islands and the other to the west, adjacent to eastern STA 3. The Working Group agreed that the catch statistics from statistical areas 19, 21 and 23 (in STA 3) should be considered in any STA 4 analysis.

Table 5: Summary of unstandardised CPUE indices* for stargazer as a bycatch in STA 4† target fisheries.

Years	Hoki	Ling	S. warehou	Squid	Barracouta	Red cod	Scampi	Combined‡
1989–90	0.14	0.72	0.31	1.00	0.29	0.86	–	0.34
1990–91	0.88	0.83	1.15	1.26	0.56	1.03	0.06	0.87
1991–92	0.39	0.56	0.61	0.47	0.66	0.97	0.04	0.46
1992–93	0.32	0.89	0.33	0.80	0.62	0.32	0.07	0.37
1993–94	0.22	0.27	0.40	0.53	0.68	0.55	0.07	0.38
1994–95	0.54	2.56	0.65	0.48	0.59	0.43	0.10	0.61
1995–96	0.38	0.41	0.43	0.54	0.39	0.67	0.09	0.44

* Catch per tow, for tows in which stargazer were reported caught.
† Statistical areas 021 and 023 (STA 3) and 401 and 407 (STA 4), covering the western end of Chatham Rise.
‡ Hoki, ling, silver warehou, squid, barracouta, red cod, but not scampi.

STA 5

About 80% of the STA 5 catch is caught by small (< 43 m) inshore bottom-trawl vessels targeting giant stargazer. The remainder of the catch is caught mostly by large (≥ 43 m), deepwater bottom-trawl vessels targeting other species such as barracouta, jack mackerels, and squids. Catches by methods other than bottom-trawling are very small.

Vignaux (1997) was the first to present standardised CPUE indices for STA 5. Data were analysed from the 1991–92 to 1995–96 fishing years only and the indices she presented showed no trend. Her analysis was superseded by that of Phillips (2001), who analysed data from the 1989–90 to 1999–00 fishing years. He used a log-normal generalised linear model to describe non-zero estimated catches reported by both the inshore and deepwater fleets. However, the indices he presented also showed no trend and were rejected as a relative abundance index by the New Zealand Inshore Fisheries Working Group (Inshore FAWG).

Manning (2006b) updated Phillips' (2001) analysis with four more fishing years of data and used a different data processing method. His analysis spanned the 1989–90 to 2003–04 fishing years, and he groomed and restratified the catch-effort data in his series tripwise, allocating the groomed landed catch for each trip to the recomputed effort strata using Starr's (2003) method for processing MFish catch-effort and landings data, as implemented by Manning et al. (2004). His analysis also rigorously considered and accounted for changes in stargazer conversion factors over time, which neither Vignaux's (1997) nor Phillips' (2001) analyses did.

Manning (2006b) fitted a suite of different generalised-linear-models (GLMs) to different subsets of the groomed dataset. The model, accepted by the Inshore FAWG as the best indication of STA 5 relative abundance, was a log-normal GLM fitted to non-zero records associated with small, inshore bottom-trawl vessels where giant stargazer was recorded as the target species, where the vessels had a consistent presence in the fishery (i.e., those vessels active in the fishery for five years or more with ten or more associated records per fishing year; a so-called "core" vessel subset), and where the response variable was defined as giant stargazer *catch* rather than *catch-per-unit-effort* (model fit 2.4). The canonical indices obtained from this model suggest that stargazer abundance in STA 5 has remained static, or at worst, declined only slightly over the data series (Figure 2). The trend in the standardised CPUE indices between the 1992–3 to 1995–96 fishing years appears consistent with stargazer relative biomass estimates from research trawl surveys of the Stewart–Snares shelf carried out by RV *Tangaroa*, 1993–1996 (Figure 2) (Hurst & Bagley, 1994; Bagley & Hurst, 1995, 1996a, 1996b; Hurst & Bagley, 1997). The peak then declined in the standardised CPUE and trawl survey relative biomass indices may, however, reflect a change in catchability rather than in stock abundance.

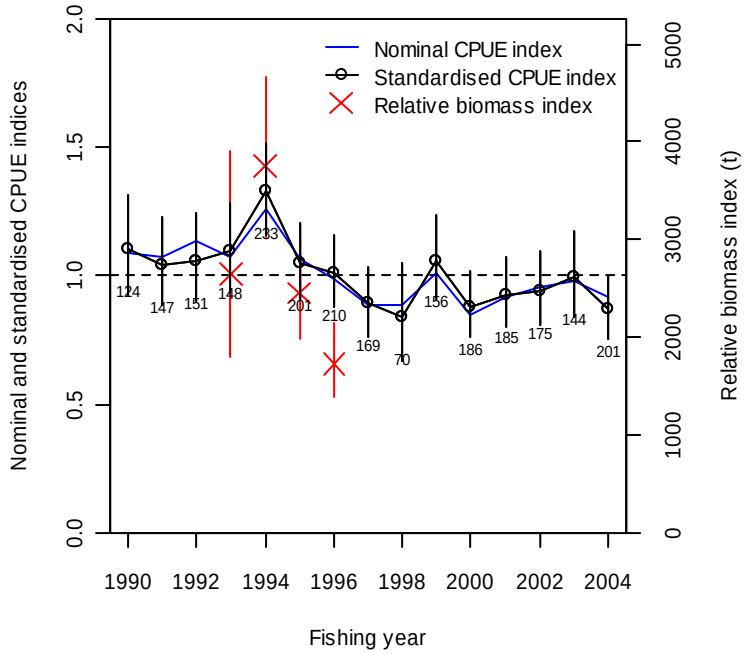


Figure 2: **The standardised CPUE indices from the fit of model 2.4 presented by Manning (2006a). The nominal CPUE and trawl survey relative biomass estimates from the SCSI survey series by RV Tangaroa (1993–1996) have been overlaid for comparison. The nominal CPUE and trawl survey relative biomass indices have been rescaled so that all three series can be displayed on the same plot.**

(b) Biomass estimates

STA 2

An age structured model using deterministic recruitment was fitted to the abundance indices from the ECNI inshore and the ECNI scampi trawl surveys results (Table 4). The declines in the indices suggest that the current exploitation rate is very high, but the model results are determined by the choice of maximum allowable exploitation rate. An upper bound of 80% for the catch/biomass ratio was used in the base case, but this is considered unrealistically high, because stargazer is mainly caught as a bycatch of other fisheries and because the ECNI inshore trawl surveys suggest that there are parts of the stock not being fished. The virgin biomass estimated by the model of 563 t is therefore considered a minimum estimate of virgin biomass.

STA 7

An age-structured model partitioned by age (0–25 years) and sex was fitted to the WCSI trawl survey relative abundance indices (1992–2005), WCSI survey proportions-at-age data (1992–2005), and WCSI fishery catch-at-age data (2005 only) (Manning, 2006a). The stock boundary assumed in the model included the west coast of the South Island, Tasman and Golden Bays, but not eastern Cook Strait (a catch history was compiled for the model stock that excluded eastern Cook Strait). A summary of the model's annual cycle is given in Table 6. Three sets of preliminary model results comprising a total of 23 different model runs were presented during 2006, but a final assessment model was not agreed on by the Inshore FAWG. The Inshore FAWG agreed to defer the final assessment until 2007–08, after the 2007 West Coast South Island survey relative biomass, survey proportions-at-age, and fishery proportions-at-age data become available.

Table 6: The STA 7 model's annual cycle (Manning, 2006a). Processes within each time step are listed in the time step in which they occur in particular order (e.g., in time step 3, new recruits enter the model partition first followed by the application of natural and fishing mortality to the partition). *M*, the proportion of natural mortality assumed during each time step. *F*, the nominal amount of fishing mortality assumed during each time step as a proportion of the total catch in the stock area. Age, the proportion of fish growth that occurs during each time step in each model year.

			Proportions			
Time step	Duration	Processes applied	M	F	Age	Observations
1	Oct–Jun	Mortality (M , F)	0.75	0.77	1.00	Survey relative biomass Survey proportions-at-age Survey length-at-age Fishery catch-at-age Fishery relative abundance
2	Jun (instantaneous)	Spawning Age incrementation	0.00	0.00	0.00	Nil
3	Jun–Sep	Recruitment Mortality (M , F)	0.25	0.23	0.00	Fishery catch-at-age

Considering that a final model has not yet been decided on, and maximum-sustainable yields and stock-status projections for the final model have not yet been carried out (these have been done for the base case or initial model but should not be viewed as anything other than preliminary results), the stock appears to be at or above its maximum sustainable yield. Comparing all model runs presented to date, current biomass ($\boldsymbol{B}_{2005}$) as a percentage of virgin or unfished biomass ($\boldsymbol{B}_0$) is very likely to be at least 27%, and more probably in the range of 35–45% (Table 7; Figure 3).

Table 7: MCMC initial and current biomass estimates for the STA 7 model runs R3.1 to R3.4 (Manning 2006a). B_0, virgin or unfished biomass; B_{2005}, mid-year biomass in 2005 (current biomass); (B_0 / B_{2005}) %, B_0 as a percentage of B_{2005}; Min, minimum; Max, maximum; Q_i, ith quantile. The interval ($Q_{0.025}$, $Q_{0.975}$) is a Bayesian credibility interval (a Bayesian analogue of frequentist confidence intervals).

	R3.1			R3.2		
	B_0	B_{2005}	$(B_0 / B_{2005})\%$	B_0	B_{2005}	$(B_0 / B_{2005})\%$
Min	7211	1576	21.86	7867	1749	22.18
$Q_{0.025}$	7526	1984	26.18	7983	1951	24.35
Median	8011	2570	32.16	8262	2249	27.22
Mean	8033	2606	32.33	8281	2264	27.30
$Q_{0.975}$	8671	3413	39.51	8673	2671	30.83
Max	9187	3945	43.71	9218	3195	34.75

	R3.3			R3.4		
	B_0	B_{2005}	$(B_0 / B_{2005})\%$	B_0	B_{2005}	$(B_0 / B_{2005})\%$
Min	6888	3122	42.36	6644	3002	43.60
$Q_{0.025}$	7980	4685	58.48	7035	3655	51.24
Median	11167	8666	77.49	8140	5168	63.65
Mean	11958	9467	77.06	8455	5493	64.05
$Q_{0.975}$	20536	19146	94.17	11593	9104	78.50
Max	32287	30926	104.27	20964	18805	89.70

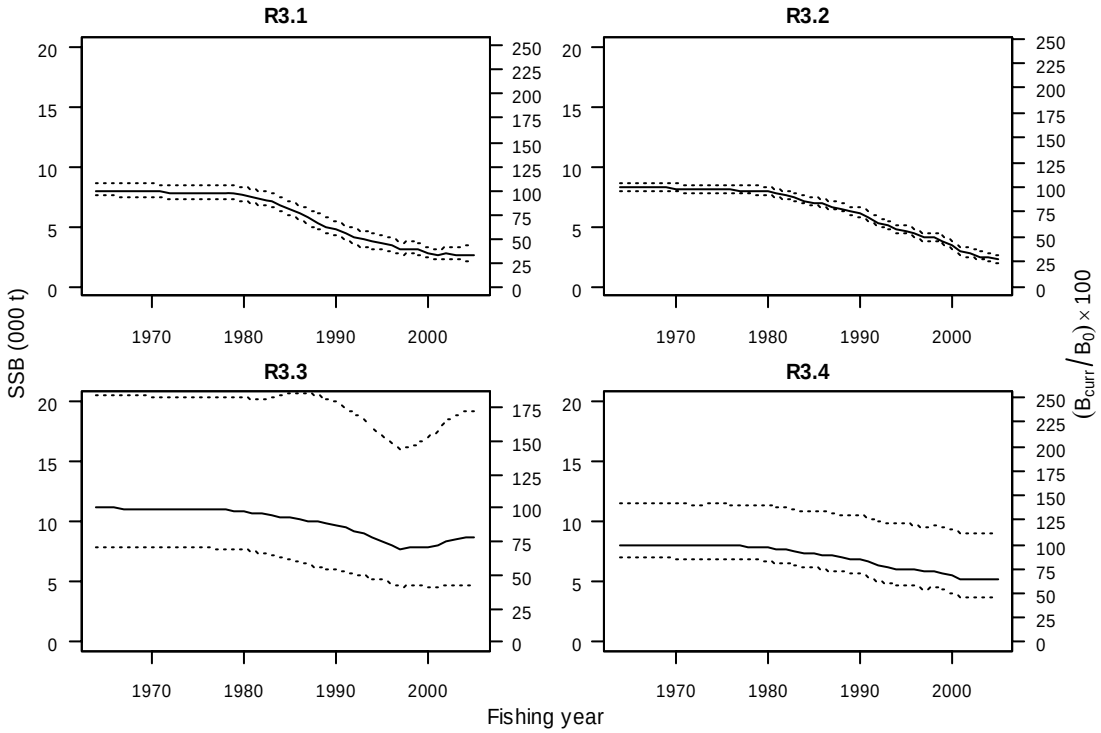


Figure 3: Biomass trajectories for runs R3.1 to R3.4 calculated from the corresponding MCMC samples of each model run's posterior distribution. The solid line is the median current spawning-stock biomass (SSB) in a given fishing year. The dotted lines indicate the 95% plausibility region about the median biomass. Note the different scales on the y-axis of each plot.

Estimates of current biomass are not yet available for any Fishstocks.

(c) Estimation of Maximum Constant Yield (MCY)

(i) Chatham Rise (STA 4) and Southland and Sub-Antarctic (STA 5)

In previous assessments MCY was estimated from the absolute biomass estimates from trawl surveys. This method is now considered obsolete and the yield estimates are not reported here.

(ii) Other areas

MCY was estimated using the equation, MCY = cY_{av} (Method 4). The landings data from 1981–86 were relatively stable and were used to estimate Y_{av}. The parameter c was set equal to 0.8 based on the estimate of M = 0.23.

The estimates of MCY were:

STA 1:	0.8 *	5.8 t	=	5 t	
STA 2:	0.8 *	21.8 t	=	17 t	(rounded to 20 t)
STA 3:	0.8 *	492.3 t	=	394 t	(rounded to 390 t)
STA 7:	0.8 *	346.6 t	=	277 t	(rounded to 280 t)
STA 8:	0.8 *	4.8 t	=	4 t	(rounded to 5 t)

These estimates of MCY are likely to be conservative because of under-reporting in the past and are highly uncertain. These estimates of MCY have not changed since the 1989 Plenary Report.

The level of risk to the stock by harvesting the population at the estimated MCY value cannot be determined.

(d) Estimation of Current Annual Yield (CAY)

Estimates of current biomass are not yet available and CAY cannot yet be estimated for any giant stargazer Fishstock.

Yield estimates are summarised in Table 8.

Table 8: Giant stargazer yield estimates (t).

Parameter	Fishstock	Yield estimate
MCY	STA 1	5
	STA 2	20
	STA 3	390
	STA 4	Cannot be determined
	STA 5	Cannot be determined
	STA 7	280
	STA 8	5
CAY	All	Cannot be determined

(e) Other yield estimates and stock assessment results

For STA 2, long-term yields are of the order of 50–60 t based on the minimum virgin biomass estimated by the model. No other yield estimates are yet available.

(f) Other factors

The use of a single conversion factor for deepwater and inshore vessels has resulted in about a 5–10% under-estimate pre 1990–91 of the reported greenweight landings. In 1990–91, separate deepwater and inshore conversion factors were introduced.

The TACC in STA 4 has been under-caught because it is apparently uneconomic to target stargazer except near the Chatham Islands. It is a bycatch in the trawl fisheries for hoki, ling, silver warehou, squid, red cod and scampi on the Chatham Rise.

Stargazer landings have been influenced by changes in fishing patterns and fishing methods in the target species fisheries and indirectly by the abundance of those target species. Landings have also been influenced by changes in reporting behaviour for the different species. Stargazers were also taken historically in large quantities by foreign licensed and chartered trawlers fishing offshore grounds for other species (see Table 1). Because stargazer is mainly a bycatch, there is likely to be under-reporting in these data. Therefore, any estimate of MCY based on catch data is likely to be conservative.

5. ANALYSIS OF ADAPTIVE MANAGEMENT PROGRAMMES (AMP)

The Ministry of Fisheries revised the AMP framework in December 2000. The AMP framework is intended to apply to all proposals for a TAC or TACC increase, with the exception of fisheries for which there is a robust stock assessment. In March 2002, the first meeting of the new Adaptive Management Programme Working Group was held. Two changes to the AMP were adopted:

- a new checklist was implemented with more attention being made to the environmental impacts of any new proposal
- the annual review process was replaced with an annual review of the monitoring requirements only. Full analysis of information is required a minimum of twice during the 5 year AMP.

STA 3

The STA 3 TACC was increased from 734 t to 900 t under the AMP, beginning in the 1991–92 fishing year. The previous 5-year AMP term for STA 3 ended in September 2003 with the current one beginning in October of that year. A formal proposal was not required for the current term as the

AMP FAWG supported the continuation of the AMP (March 2003) and no change was requested to the TACC.

Mid-term Review of STA 3 AMP in 2005

In 2005 the AMP FAWG reviewed the performance of the STA 3 AMP after two years in the current 5-year term and 12 years at the higher TACC (SeaFIC, 2005a). The WG noted that:

Characterisation

- Almost 95% of the annual STA 3 landings are caught by bottom trawling. Most of the catch is taken in the mixed species bottom trawl fishery targeting RCO (40%), BAR (13%) and TAR (6%) and in the bottom trawl fisheries targeting FLA (12%) and Hoki (11%).
- The annual reported catch dropped from 863 t in 2002/03 to 578 t in 2003/04; the lowest since 1986. Anecdotal evidence suggests that there was likely to have been a drop in market demand for this product in 2003/04.

Abundance Index

- When the East Coast South Island trawl survey was discontinued (after 2001), standardized CPUE based on non-zero STA 3 catches in the RCO 3 bottom trawl fishery was accepted as an alternative index of abundance. Industry expanded the model in 2005 to include catches made whilst targeting BAR and TAR. Target was offered as an explanatory variable (MIX model).
- Standardized CPUE showed cyclical trends with an overall pattern that was essentially flat (1989/90 – 2003/04). Trends were very similar to those of the previous analysis based on RCO only. The variance and diagnostics were acceptable. The current analysis also included improvements to the grooming procedure.
- Inshore and offshore strata were combined for the current analysis. Owing to possible confounding effects introduced by inter-annual patterns of fishing behaviour, the offshore strata should be excluded from future CPUE standardization.
- The decision rule for STA 3 is based on the mean CPUE index between 1991/92 and 2000/01. The current index is almost twice the 50% threshold.
- Possible changes to the conversion factor (as encountered with SPO 3) would, however, have biased the CPUE trends. This should be investigated before the full-term review.
- Industry also provided two additional standardized CPUE trends based on STA 3 catches in the FLA and HOK fisheries. The HOK index depicted an increasing trend while the FLA index showed a sharp increase in 2000/01 followed by a strong decline. Given that FLA and HOK fisheries operate at the lower and upper limits of the depth distribution of STA 3, the MIX model is believed to better represent abundance of STA 3.
- Relative biomass indices from annual trawl surveys on the western end of Chatham rise (west of 180˚) showed no overall trend. It is not clear whether this index represents a consistent index of the population biomass or a variable portion within the survey area because the survey only begins its coverage at 200 m, which does not cover the full depth range for stargazer. Representative distribution of STA for recent surveys should also be provided in future presentations but this cannot address the coverage of depths more shallow than 200 m.

STA 3 Decision Rule

- If the CPUE biomass index based on the target RCO 3 trawl fishery falls below a threshold of 50% of the mean biomass index between 1991–92 and 2000–01, then the AMP FAWG will review the current stock status information for STA 3 to determine if the Fishstock has dropped below the level which will support the MSY. However, the AMP FAWG will consider all available data when this AMP is reviewed.
- The 2003/04 relative index was almost twice the threshold value.

Environmental Considerations

- STA 3 is taken as a bycatch in the mixed species bottom trawl fishery. This fishery has had a long history and the increase in STA 3 TACC may not have resulted in new areas fished or significant increases in effort.
- On the other hand the introduction of closed areas (voluntary or statutory) is likely to have displaced some effort and this should be addressed in future presentations.

Log Book Programme

- Given the uncertainty regarding standardized CPUE as an index of abundance, patterns in age/size structure of the catch are useful for both validating and interpreting CPUE trends.
- The east coast South Island bottom trawl fishery logbook programme was initially developed to sample elephantfish and no vessel reported stargazer during the 2002/03 fishing year.
- One vessel measured 160 fish that were taken during 8 tows of a single trip which took place in 2003/04.
- The AMP FAWG reported in 2004 that "Appropriate logbook coverage for STA 3 should be initiated as soon as possible". Log book coverage remains inadequate and should be increased to appropriate levels as soon as possible.

Conclusion

- Assuming that the standardized CPUE indices of the mixed model do track STA 3 abundance, the stock does not appear to have declined since it was introduced into the AMP 13 years ago.
- There is no biological information to corroborate this conclusion as the trawl sampling programme has not yet been implemented.
- It is not known where the stock is in relation to B_{MSY}.
- Future CPUE standardization should exclude offshore strata.
- Maps of STA distribution should in future be presented in conjunction with the relative biomass indices generated by the Chatham Rise trawl survey.

Annual Review of STA 3 AMP in 2007

In 2007 the AMP FAWG reviewed the performance of the STA 3 AMP after 4 years in the current 5-year term and 13 years at the higher TACC (Starr et al., 2007a). The WG noted that:

Background

- The previous 5 year AMP term for STA 3 ended in September 2003 with the current AMP beginning in October of that year. A formal proposal was not required for the current term as the AMP FAWG supported the continuation of the AMP (March 2003) and no change was requested to the TACC.
- The original AMP proposal included log-book coverage of ELE and STA caught in the target RCO 3 bottom trawl fishery.
- At the full-term review of the previous AMP term (March 2003), the AMP FAWG suggested that the biological monitoring of this Fishstock be revised due to the discontinuation of the east coast South Island trawl survey and requested logbook coverage of RCO 3 bottom trawl fishery.

Logbook programme

- Covered 29 trawl tows and sampled 312 fish for length and sex.
- In 2005 the AMP FAWG concluded that "Logbook coverage remains inadequate and should be increased to appropriate levels as soon as possible". This conclusion remains unchanged.

STA 7

The STA 7 TACC was first increased under the AMP from 734 t to 900 t, beginning in the 1991–92 fishing year. The TACC was further increased to 997 t (TAC 1000 t) in October 2003.

Full-term Review of STA 7 AMP in 2007

In 2007 the AMP FAWG reviewed the performance of the AMP after 5 years (Starr et al., 2007b). The WG noted:

Fishery Characterization

- The STA7 TACC was increased from 528 t to 700 t in 1991/92 under an AMP. Two proposals were made in 2002 to increase this TACC, and the TACC was increased to 997 t in October 2002, with an additional 3 t for non-commercial catch, giving a total TAC of 1000 t.
- Catches exceeded the TACC in this fishery from entry into the QMS in 1986/87 until implementation of the most recent TACC increase in 2002/03, except in 1997/98 when a decline in the Asian market caused catches to dip below the TACC. In particular, catches escalated dramatically from 1997/98 to reach about double the TACC in 2000/01.
- Active management intervention (stopping of bycatch trading, implementation of the ACE provisions of the Fisheries Act and implementation of ramped deemed values) caused an even more dramatic drop in catches to just above the TACC level in 2001/02. Following the increase in TACC to 997 t in 2002/03, catches have remained near the TACC level.
- The Working Group noted that the ~50% drop in catch in 2001/02 in response to changes in the ACE and deemed value systems indicated a particularly strong ability to actively target or avoid stargazer in this fishery. It is certainly clear that the rapid increase in stargazer occurred in the 'barracouta' target fishery, probably due to the fact that barracouta was the cheapest quota to obtain at the time.
- Catch reporting in this fishery is poor, with estimated catches averaging 50% of landed catch, and landings exceeding estimated catches by up to 6 times. The WG also noted some bizarre changes in conversion factors. RDM will be asked whether these are data capture errors, or actual entries on return forms.
- 97% of STA 7 are caught in bottom trawls, with 80% of the trawl landings coming from the southern half of the South Island west coast (Areas 032 to 034). Small amounts of catches are made by setnet or mid-water trawl. The trawl fishery catches STA year-round, whereas setnet fishery catches are mainly made from July to September. Seasons differ by area, with the Cook Strait mainly being fished in summer, whereas the southern areas are fished all year.
- Stargazer are mainly reported from the barracouta targeted trawl fishery, but data presented at previous meetings showed that no barracouta were caught when the large catches of stargazers were made.
- There has been a recent increase in STA catches in the tarakihi, red cod and stargazer targeted trawl fisheries, particularly in the southern areas. The bycatch of stargazer in the barracouta target fishery, has decreased in recent years, possibly due to regulation changes which reduced the incentive to declare this species as the target. Setnet STA catches are mainly made while targeting ling.

CPUE Analysis

- Three fishery definitions were used in developing standardised CPUE indices for STA7: Trawl fishery targeting STA, BAR, RCO or TAR on the WCSI; the same mixed bottom trawl fishery in the Cook Strait; and the flatfish targeted WCSI trawl fishery.
- CPUEs for these fishery definitions were standardised using a lognormal model based on non-zero catches. In additional, a binomial model was used to investigate the effect of changing proportion of non-zero catches.
- Standardisation had very little effect on the indices for the mixed target trawl fisheries relative to the unstandardised index. The standardised WCSI MIX index shows a steady increase to a peak in 2000/01, followed by a sharp drop to near the long-term average, coinciding with the drop in

catches. The Cook Strait index shows a flat, stable trend across most of the series, but also with a sharp peak in 2000/01. It seems likely that the CPUE peaks and subsequent drop in catch rates relate more to targeting practices than to abundance.

- The FLA target index shows a steady increase from 1993/94 to a very strong peak in 1999/00, followed by a rapid decline back to the lowest levels by 2003/04. These changes are too large to relate to proportional changes in abundance, and may relate more to changes in availability to the near-shore flatfish fleet, fishing on the inshore edge of the stargazer depth distribution.
- The Working Group noted that the rapid doubling and halving of catch rates in the standardised CPUE indices cannot reflect proportional changes in abundance, and was rather an indication of very strong changes in fleet behaviour and targeting practices. This makes it difficult to decide what confidence to place in the indices.
- The group did note, however, that rapid changes in CPUE in the shallow flatfish fishery could reflect changes in availability of stargazer to this fleet, on the edge of the stargazer depth distribution.
- The strong effect that management changes (the introduction of ACE and changes in deemed values), and targeting responses by the industry, have likely had on CPUE were emphasized. The Working Group considered CPUE after these changes in 2000 to be less reliable and probably not comparable with CPUE prior to 2000.
- The Working Group again noted problems in interpreting reasons for the increase in non-zero catches in many fisheries, and confirmed that the binomial analyses should be accorded very little weight.
- In overview, the overlay of the trawl fishery indices seems to suggest fluctuations (related to targeting?) around a fairly flat trend across the series.

Trawl Surveys

- The west coast trawl surveys are considered to be more reliable as indicators of abundance than those conducted on the east coast. Eight surveys have now been conducted from 1992 to 2007.
- Trawl survey estimates suggested a substantial decline in STA abundance in 2000, and again in 2003, after a period of stable estimates from 1992 - 1997, prompting concern that the stock was declining.
- However, estimates for 2005 and 2007 are again at or above the average of the 1992 to 1997 historic estimates. These recent estimates indicate that the low levels in 2000 and 2003 may have been due to catchability changes, as has occurred in the east coast survey.
- The overall trawl survey series indicates that the stock has remained stable at a fairly constant level, which seems to support indications in the trawl CPUE indices of a stable long-term trend.

Logbook Programme

- Coverage of the west coast South Island trawl fishery is good, but there no biological data for stargazer are being collected.

Effects of Fishing

- Hector's dolphins aggregate in two areas of STA 7, Westport and Hokitika. However, there have been no known interactions between these trawl fisheries and dolphins off the WCSI. The Challenger Code of Practice states that trawlers are required not to haul nets when dolphins are present.
- Seabirds do occasionally get caught in BAR targeted fisheries in which STA 7 is caught. During 2005/06, 24 seabird captures were observed on 277 BAR trawls; an incidence rate was estimated to be 6.5%. However, observer coverage is inadequate to provide reliable estimates of effects of fishing across the fishery.
- The Working Group noted that fishers are able to target stargazer, which has lead to changes in fleet behaviour, probably related to changing fishing area and depth. This suggests that seabed effects, at least, may have changed. Changes such as this need to be measured and reported on.

Conclusions

- The results of the trawl surveys indicate that the STA 7 stock has remained stable since 1992. The standardised CPUE indices presented do not change that conclusion.

6. STATUS OF THE STOCKS

No estimates of current and reference biomass are available.

STA 1

The TACC for STA 1 was increased from 21 t to 50 t in the 1991–92 fishing year under the AMP. In 1997, the TACC was reduced to 21 t upon its removal from the programme. Recent catches have exceeded this level. It is not known if recent catch levels and current TACC are sustainable or if they are at levels that will allow the stocks to move towards a size that will support the MSY.

STA 2

The TACC for STA 2 was increased from 37 t to 100 t in the 1991–92 fishing year under the AMP. Landings in the early 1990s peaked in the range of 105–125 t, but have subsequently declined. Recent relative abundance indices from both the ECNI inshore trawl survey and the ECNI scampi trawl survey are lower than those in 1993. The 1997 assessment suggested that the exploitation rate was very high, but the model results were determined by the choice of maximum allowable exploitation rate. An upper bound of 80% for the catch/biomass ratio was used in the base case, but this was considered unrealistically high.

The TACC was reduced back to 38 t in the 1997–98 fishing year, upon the removal of STA 2 from the programme. Landings have been slightly above the TACC in recent years. It is not known whether recent catches and the current TACC are sustainable or whether they would allow the stock to move towards a size that would support the MSY.

STA 3

STA 3 is being managed within an AMP with a decision rule relating to a biomass index and the review of a range of information to ascertain stock status. The TACC for STA 3 was increased from 734 t to 900 t in the 1991–92 fishing year under the AMP. In 2001, the Plenary agreed that the decision rule needed to be replaced, as the ECSI summer trawl survey had been discontinued. A new decision rule based on the CPUE biomass index in the target RCO 3 trawl fishery was proposed as an interim decision rule until the new trawl survey is established. This decision rule was not triggered in 2005, as CPUE remained at almost twice the threshold value.

Relative biomass indices for stargazer from the annual trawl survey of the western end of the Chatham Rise have remained stable. It is not known if recent catch levels and the current TACC are sustainable in the long-term, or whether they are at levels that will allow the stock to move towards a size that would support the maximum sustainable yield.

STA 4

Stargazers in this Fishstock occur mainly on the Chatham Rise and on the shelf around the Chatham Islands, but are sparsely distributed over the rest of the Rise. In most of this Fishstock they may not be economic to target. However, if fishing is overly concentrated in those areas where stargazer can be targeted, such as close to the Chatham Islands, there are concerns that local depletion may occur.

The current TACC of 2014 t for STA 4 was based on a yield estimate from a single trawl survey in 1983. This method is now considered obsolete. Recent catches have been substantially less than the TACC; the stock appears to have been lightly fished and is still likely to be in the fishing down phase. It is not known if catches at the level of the current TACC would be sustainable or would allow the stock to move towards a size that will support the MSY.

STA 5

The TACC for STA 5 was increased from 1239 t to 1500 t in the 1991–92 fishing year under the AMP. Landings increased to 1327 t in 1993–94, declined to 544 t in 1997–98, but have subsequently increased. The TACC was reduced to 1264 t in 1997, upon the removal of STA 5 from the AMP. This new TAC is at the level of recent catches, and is probably sustainable. It is not known if recent catch levels and current TACC are at levels that will allow the stock to move towards a size that will support the MSY.

STA 7

The TACC for STA 7 was increased from 700 t to 997 t from 1st October 2002. STA 7 is being managed within an AMP with a decision rule relating to a biomass index from trawl surveys and a review of other data. Despite the biomass index in the 2003 trawl survey being 41% below the average biomass index between 1992–97, the results of a preliminary stock assessment suggest that STA 7 is at or above the level that will support MSY.

STA 8

The TACC for STA 8 increased from 22 t to 50 t in the 1993–94 fishing year under the AMP. Landings increased to 18 t in 1991–92 but have since declined to less than 5 t. The TACC was reduced back to 22 t in 1997, upon the removal of STA 8 from the programme. It is not known if recent catch levels and current TACC are sustainable or if they are at levels that will allow the stock to move towards a size that will support the MSY.

Yield estimates, TACCs, and reported landings for the 2005/06 fishing year are summarised in Table 9.

Table 9: Summary of yields (t), TACC (t), and reported landings (t) of giant stargazer for the most recent fishing year.

Fishstock	QMA		MCY	TACC	landings
STA 1	Auckland (East and West)	1 & 9	5	21	34
STA 2	Central (East)	2	20	38	30
STA 3	South-East (Coast)	3	390	902	824
STA 4	South-East (Chatham)	4	–	2158	359
STA 5	Southland and Sub-Antarctic	5 & 6	–	1264	1347
STA 7	Challenger	7	280	997	1010
STA 8	Central (West)	8	5	22	3
STA 10	Kermadec	10	–	10	0
Total			–	5412	3607

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