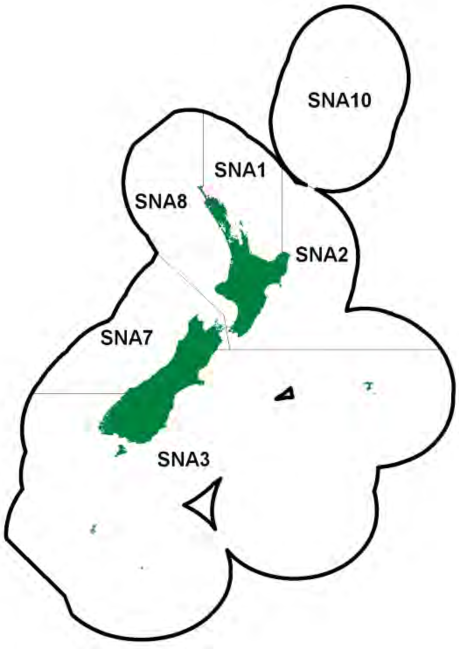
INTRODUCTION – SNAPPER (SNA)

(*Chrysophrys auratus*)
Tamure, Kouarea



1. INTRODUCTION

Specific Working Group reports, describing/including stock assessments, are given separately for SNA 1, SNA 2, SNA 7 and SNA 8. The TACC for SNA 3 and SNA 10 are 32 t and 10 t respectively, with minimal annual landings (less than 1 t or zero t in most years) reported from these stocks.

1.1 Commercial fisheries

Snapper fisheries are one of the largest and most valuable coastal fisheries in New Zealand. The commercial fisheries, which began their development in the late 1800s, expanded in the 1970s with increased catches by trawl and Danish seine. Following the introduction of pair trawling in most areas, landings peaked in 1978 at 17 500 t (Table 1). Pair trawling was the dominant method, accounting for on average 75% of the annual SNA 8 catch from 1976 to 1989. In the 1980s an increasing proportion of the SNA 1 catch was taken by longlining as the Japanese "iki jime" market was developed. By the mid-1980s catches had declined to 8500–9000 t, and some stocks showed signs of overfishing. The fisheries had become more dependent on the recruiting year classes as stock size decreased. With the introduction of the QMS in 1986, TACCs in all Fishstocks were set at levels intended to allow for some stock rebuilding. Decisions by the Quota Appeal Authority saw TACCs increase to over 6000 t for SNA 1 by the fishing year 1990–91, and from 1330 t to 1594 t for SNA 8 by 1989–90 (Table 2).

In 1986–87, landings from the two largest Fishstocks (i.e., SNA 1 and SNA 8) were less than their respective TACCs (Table 2) but catches subsequently increased in 1987–88 to the level of the TACCs (Figure 1). Landings from SNA 7 remained below the TACC after introduction to the QMS, and in 1989–90 the TACC was reduced to 160 t. Changes to TACCs that took effect from 1 October 1992 resulted in a reduction for SNA 1 from 6010 t to 4938 t, an increase for SNA 2 from 157 t to 252 t, and a reduction for SNA 8 from 1594 t to 1500 t.

Table 1: Reported landings (t) for the main QMAs from 1931 to 1990.

Year	SNA 1	SNA 2	SNA 7	SNA 8	Year	SNA 1	SNA 2	SNA 7	SNA 8
1931–32	3 355	0	69	140	1961	5 887	589	583	1 178
1932–33	3 415	0	36	159	1962	6 502	604	582	1 352
1933–34	3 909	21	65	213	1963	6 967	636	569	1 456
1934–35	4 317	168	7	190	1964	7 269	667	574	1 276
1935–36	5 387	149	10	108	1965	7 991	605	780	1 182
1936–37	6 369	78	194	103	1966	8 762	744	1 356	1 831
1937–38	5 665	114	188	85	1967	9 244	856	1 613	1 477
1938–39	6 145	122	149	89	1968	10 328	765	1 037	1 491
1939–40	5 918	100	158	71	1969	11 318	837	549	1 344
1940–41	5 100	103	174	76	1970	12 127	804	626	1 588
1941–42	4 791	148	128	62	1971	12 709	861	640	1 852
1942–43	4 096	74	65	57	1972	11 291	878	767	1 961
1943–44	4 456	60	29	75	1973	10 450	798	1 258	3 038
1944	4 909	49	96	69	1974	8 769	716	1 026	4 340
1945	4 786	59	118	124	1975	6 774	732	789	4 217
1946	5 150	77	232	244	1976	7 743	732	1 040	5 326
1947	5 561	36	475	251	1977	7 674	374	714	3 941
1948	6 469	53	544	215	1978	9 926	454	2 720	4 340
1949	5 655	215	477	277	1979	10 273	662	1 776	3 464
1950	4 945	285	514	318	1980	7 274	636	732	3 309
1951	4 173	265	574	364	1981	7 714	283	592	3 153
1952	3 665	220	563	361	1982	7 089	160	591	2 636
1953	3 581	247	474	1 124	1983	6 539	160	544	1 814
1954	4 180	293	391	1 093	1984	6 898	227	340	1 536
1955	4 323	309	504	1 202	1985	5 876	208	270	1 866
1956	4 615	365	822	1 163	1986	5 969	255	253	959
1957	5 129	452	1 055	1 472	1987	4 016	122	210	1 072
1958	5 007	483	721	1 128	1988	5 038	165	193	1 565
1959	5 607	372	650	1 114	1989	5 754	227	292	1 571
1960	5 889	487	573	1 202	1990	5 826	429	200	1 551

Notes:
1. The 1931–1943 years are April–March but from 1944 onwards are calendar years.
2. The 'QMA totals' are approximations derived from port landing subtotals, as follows: SNA 1, Mangonui to Whakatane; SNA 2 Gisborne to Wellington/Makara; SNA 7, Marlborough Sounds ports to Greymouth; SNA 8 Paraparaumu to Hokianga.
3. Before 1946 the 'QMA' subtotals sum to less than the New Zealand total because data from the complete set of ports are not available. Subsequent minor differences result from small landings in SNA 3, not listed here.
4. Data up to 1985 are from fishing returns: data from 1986 to 1990 are from Quota Management Reports.
5. Data for the period 1931 to 1982 are based on reported landings by harbour and are likely to be underestimated as a result of under-reporting and discarding practices. Data include both foreign and domestic landings.

Table 2: Reported landings (t) of snapper by Fishstock from 1983–84 to present and gazetted and actual TACCs (t) for 1986–87 to present. QMS data from 1986–present. [Continued on next page]

Fishstock	SNA 1		SNA 2		SNA 3		SNA 7		SNA 8	
FMAs	1		2		3, 4, 5, 6		7		8, 9	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1983–84†	6 539	–	145	–	2	–	375	–	1 725	–
1984–85†	6 898	–	163	–	2	–	255	–	1 546	–
1985–86†	5 876	–	177	–	0	–	188	–	1 828	–
1986–87	4 016	4 710	130	130	< 1	32	257	330	893	1 331
1987–88	5 038	5 098	152	137	1	32	256	363	1 401	1 383
1988–89	5 754	5 614	210	157	< 1	32	176	372	1 527	1 508
1989–90	5 826	5 981	364	157	< 1	32	294	151	1 551	1 594
1990–91	5 273	6 002	428	157	< 1	32	160	160	1 659	1 594
1991–92	6 176	6 010	373	157	< 1	32	148	160	1 459	1 594
1992–93	5 427	4 938	324	252	< 1	32	165	160	1 543	1 500
1993–94	4 847	4 938	307	252	< 1	32	147	160	1 542	1 500
1994–95	4 857	4 938	308	252	< 1	32	150	160	1 436	1 500
1995–96	4 938	4 938	280	252	< 1	32	146	160	1 558	1 500
1996–97	5 047	4 938	351	252	< 1	32	162	160	1 613	1 500
1997–98	4 525	4 500	286	252	< 1	32	182	200	1 589	1 500
1998–99	4 412	4 500	283	252	2	32	142	200	1 636	1 500
1999–00	4 509	4 500	390	252	< 1	32	174	200	1 604	1 500
2000–01	4 347	4 500	360	252	< 1	32	156	200	1 631	1 500
2001–02	4 374	4 500	252	252	1	32	141	200	1 577	1 500
2002–03	4 487	4 500	334	315	< 1	32	187	200	1 558	1 500
2003–04	4 469	4 500	339	315	< 1	32	215	200	1 667	1 500
2004–05	4 641	4 500	399	315	< 1	32	178	200	1 663	1 500
2005–06	4 539	4 500	389	315	< 1	32	166	200	1 434	1 300
2006–07	4 429	4 500	329	315	< 1	32	248	200	1 327	1 300
2007–08	4 548	4 500	328	315	< 1	32	187	200	1 304	1 300
2008–09	4 543	4 500	307	315	< 1	32	205	200	1 345	1 300
2009–10	4 465	4 500	296	315	< 1	32	188	200	1 280	1 300
2010–11	4 516	4 500	320	315	< 1	32	206	200	1 313	1 300
2011–12	4 614	4 500	358	315	< 1	32	216	200	1 360	1 300

Table 2 [Continued]:

Fishstock	SNA 1		SNA 2		SNA 3		SNA 7		SNA 8	
FMAs	1		2		3, 4, 5, 6		7		8, 9	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
2012–13	4 457	4 500	310	315	< 1	32	211	200	1 331	1 300
2013–14	4 459	4 500	313	315	< 1	32	210	200	1 275	1 300
2014–15	4 479	4 500	271	315	< 1	32	210	200	1 272	1 300
2015–16	4 408	4 500	321	315	< 1	32	189	200	1 328	1 300
2016–17	4 620	4 500	373	315	< 1	32	263	250	1 334	1 300
2017–18	4 567	4 500	373	315	< 1	32	263	250	1 288	1 300
2018–19	4 437	4 500	364	315	< 1	32	257	250	1 293	1 300
2019–20	4 460	4 500	330	315	< 1	32	289	250	1 347	1 300
2020–21	4 579	4 500	321	315	< 1	32	337	350	1 295	1 300
2021–22	4 296	4 500	337	315	< 1	32	361	350	1 720	1 600
2022–23	4 474	4 500	339	315	< 1	32	518	450	1 728	1 600

Fishstock	SNA 10			
QMAs	10		Total	
	Landings	TACC	Landings§	TACC
1983–84†	0	–	9 153	–
1984–85†	0	–	9 228	–
1985–86†	0	–	8 653	–
1986–87	0	10	5 314	6 540
1987–88	0	10	6 900	7 021
1988–89	0	10	7 706	7 691
1989–90	0	10	8 034	7 932
1990–91	0	10	7 570	7 944
1991–92	0	10	8 176	7 962
1992–93	0	10	7 448	6 858
1993–94	0	10	6 842	6 883
1994–95	0	10	6 723	6 893
1995–96	0	10	6 924	6 893
1996–97	0	10	7 176	6 893
1997–98	0	10	6 583	6 494
1998–99	0	10	6 475	6 494
1999–00	0	10	6 669	6 494
2000–01	0	10	6 496	6 494
2001–02	0	10	6 342	6 494
2002–03	0	10	6 563	6 557
2003–04	0	10	6 686	6 557
2004–05	0	10	6 881	6 557
2005–06	0	10	6 527	6 357
2006–07	0	10	6 328	6 357
2007–08	0	10	6 367	6 357
2008–09	0	10	6 399	6 357
2009–10	0	10	6 230	6 357
2010–11	0	10	6 355	6 357
2011–12	0	10	6 547	6 357
2012–13	0	10	6 309	6 357
2013–14	0	10	6 256	6 357
2014–15	0	10	6 232	6 357
2015–16	0	10	6 247	6 357
2016–17	0	10	6 590	6 407
2017–18	0	10	6 490	6 407
2018–19	0	10	6 351	6 407
2019–20	0	10	6 425	6 407
2020–21	0	10	6 532	6 507
2021–22	0	10	6 714	6 807
2022–23	0	10	7 059	6 907

† FSU data. SNA 1 = Statistical Areas 001–010; SNA 2 = Statistical Areas 011–016; SNA 3 = Statistical Areas 018–032; SNA 7 = Statistical Areas 017, 033–036, 038; SNA 8 = Statistical Areas 037, 039–048.

From 1 October 1997 the TACC for SNA 1 was reduced to 4500 t, within an overall TAC of 7550 t, and the TACC for SNA 7 was increased to 200 t within an overall TAC of 306 t. In SNA 2, the bycatch of snapper in the tarakihi, red gurnard, and other fisheries resulted in overruns of the snapper TACC in all years from 1987–88 up to 2000–01. From 1 October 2002, the TACC for SNA 2 was increased from 252 t to 315 t, within a total TAC of 450 t. Nevertheless the 315 t TACC has regularly been over-caught since, except in the fishing years 2008–09 to 2009–10 and 2012–13 to 2014–15. In 2016–17, the TAC for SNA 7 was increased from 306 t to 545 t, including an increase in the TACC from 200 t to 250 t. The SNA 7 TACC was increased again in 2020–21 to 350 t. From 1 October 2005 the TACC for SNA 8 was reduced to 1300 t within a TAC of 1785 t, and later increased from 2021 to 1600 t within a TAC of 3065 t following a rebuild of the stock. Table 3 shows the TACs, TACCs, and allowances for each

Fishstock from 1 October 2020. All commercial fisheries have a minimum legal size (MLS) for snapper of 25 cm.

Table 3: TACs, TACCs, and allowances (t) for snapper by Fishstock from 1 October 2020.

Fishstock	TAC	TACC	Customary allowance	Recreational allowance	Other mortality
SNA 1	8 050	4 500	50	3 050	450
SNA 2	450	315	14	90	31
SNA 3		32	–	–	–
SNA 7	645	350	20	250	25
SNA 8	3 065	1 600	100	1 205	160
SNA 10		10	–	–	–

Foreign fishing

Japanese catch records and observations made by New Zealand naval vessels indicate that significant quantities of snapper were taken from New Zealand waters by Japanese vessels from the late 1950s until 1977. There are insufficient data to quantify historical Japanese catch tonnages for the respective snapper stocks. However, trawl catches have been reported by area from 1967 to 1977, and longline catches from 1975 to 1977 (Table 4). These data were supplied to the Fisheries Research Division of MAF in the late 1970s; however, the data series is incomplete, particularly for longline catches.

Table 4: Reported landings (t) of snapper from 1967 to 1977 by Japanese trawl and longline fisheries. These landings are included in Table 1.

Year	(a) Trawl	Trawl catch (all species)	Total snapper trawl catch	SNA 1	SNA 7	SNA 8
1967		3092	30	NA	NA	NA
1968		19 721	562	1	17	309
1969		25 997	1 289	–	251	929
1970		31 789	676	2	131	543
1971		42 212	522	5	115	403
1972		49 133	1 444	1	225	1 217
1973		45 601	616	–	117	466
1974		52 275	472	–	98	363
1975		55 288	922	26	85	735
1976		133 400	970	NA	NA	676
1977		214 900	856	NA	NA	708
Year	**(b) Longline**		**Total Snapper**	**SNA 1**	**SNA 7**	**SNA 8**
1975			1 510	761	–	749
1976			2 057	930	–	1 127
1977			2 208	1 104	–	1 104

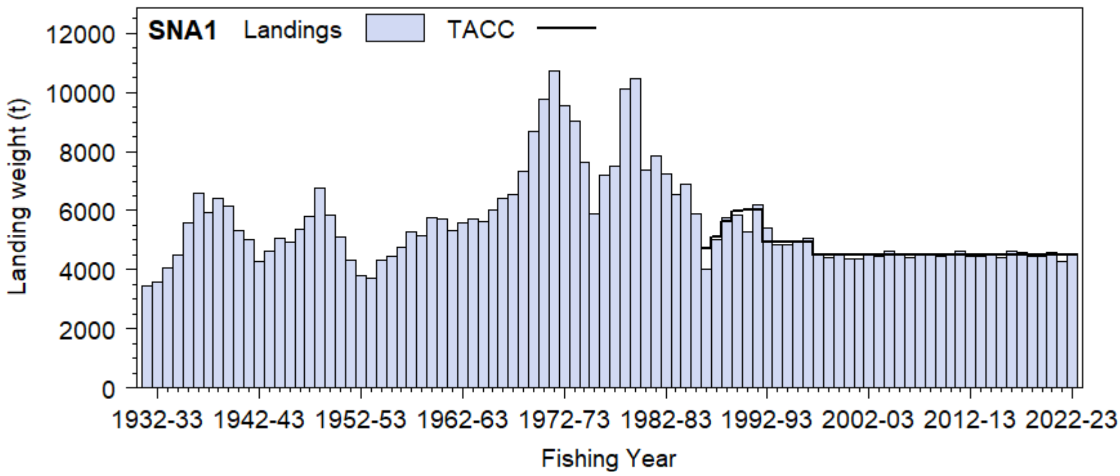


Figure 1: Total reported landings and TACCs for the four main SNA stocks. SNA 1 (Central East). [Continued on next page]

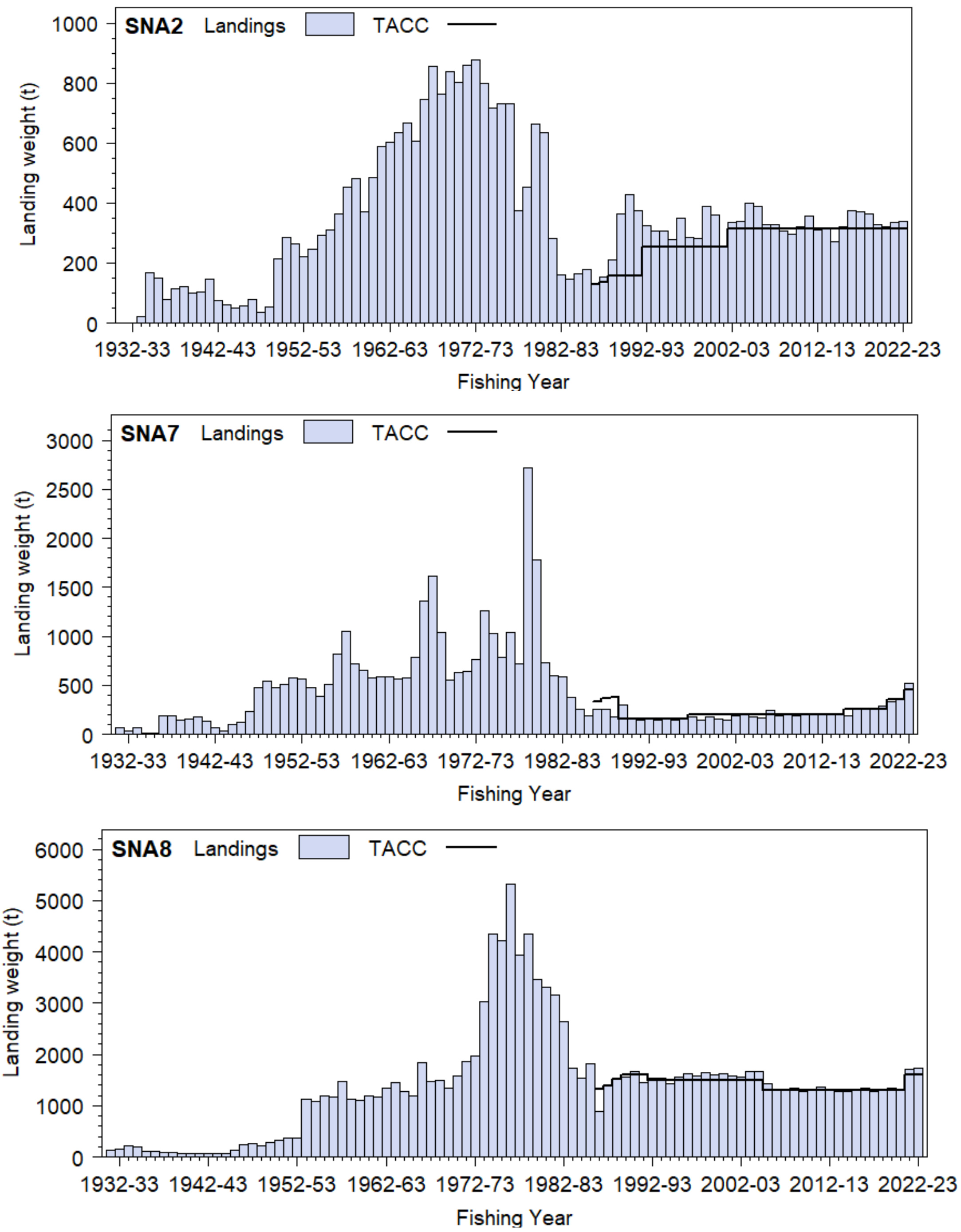


Figure 1 [Continued]: Total reported landings and TACC for the four main SNA stocks. SNA 2 (Central East) and SNA 7 (Challenger) and SNA 8 (Central Egmont).

1.2 Recreational fisheries

The snapper fishery is the largest recreational fishery in New Zealand. It is the major target species on the northeast and northwest coasts of the North Island and is targeted seasonally around the rest of the North Island and the top of the South Island. The current allowances within the TAC for each Fishstock are shown in Table 3.

1.2.1 Management controls

The two main methods used to manage recreational harvests of snapper are minimum legal size limits (MLS) and daily bag limits. Both have changed over time (Table 5). The number of hooks permitted on a recreational longline was reduced from 50 to 25 in 1995.

Table 5: Changes to minimum legal size limits (MLS) and daily bag limits used to manage recreational harvesting levels in snapper stocks, 1985–2014.

Stock	MLS	Bag limit	Introduced
SNA 1	25	30	1/01/1985
SNA 1	25	20	30/09/1993
SNA 1	27	15	1/10/1994
SNA 1	27	9	13/10/1995
SNA 1	30	7	1/04/2014
SNA 2	25	30	1/01/1985
SNA 2	27	10	1/10/2005
SNA 3	25	30	1/01/1985
SNA 3	25	10	1/10/2005
SNA 7	25	30	1/01/1985
SNA 7 (excl Marlborough Sounds)	25	10	1/10/2005
SNA 7 (Marlborough Sounds)	25	3	1/10/2005
SNA 8	25	30	1/01/1985
SNA 8 (FMA 9 only)	25	20	30/09/1993
SNA 8 (FMA 9 only)	27	15	1/10/1994
SNA 8	27	10	1/10/2005

1.2.2 Estimates of recreational harvest

There are two broad approaches to estimating recreational fisheries harvest: the use of onsite or access point methods where fishers are surveyed or counted at the point of fishing or access to their fishing activity; and, offsite methods where some form of post-event interview and/or diary are used to collect data from fishers.

The first estimates of recreational harvest were calculated using an onsite approach, a tag ratio method for SNA 1, in the mid-1980s (Table 6). A tonnes per tag ratio was obtained from commercial tag return data and this tonnage was multiplied by the number of tags returned by recreational fishers to estimate recreational harvest tonnages. The tag ratio method requires that all tagged fish caught by recreational fishers are recorded, or at least that the under-reporting rate of recreational fishers is the same as that of commercial fishers. This was assumed, although no data were available to test the assumption. If the recreational under-reporting rate was greater than that of the commercial fishers a negative bias would result. In SNA 8 there was evidence that many tags recovered by commercial fishing were reported as recreational catch during the 1991 tag recapture phase, which would give a positive bias to estimates.

The next method used to generate recreational harvest estimates was the offsite regional telephone and diary survey approach: MAF Fisheries South (1991–92), Central (1992–93), and North (1993–94) regions (Teirney et al 1997). Estimates for 1996 came from a national telephone and diary survey (Bradford 1998). Another national telephone and diary survey was carried out in 2000 (Boyd & Reilly 2002) and a rolling replacement of diarists in 2001 (Boyd et al 2004) allowed estimates for a further year (population scaling ratios and mean weights were not re-estimated in 2001). Other than for the 1991–92 MAF Fisheries South survey, the diary method used mean weights of snapper obtained from fish measured at boat ramps.

The harvest estimates provided by the telephone/diary surveys are no longer considered reliable for various reasons. With the early telephone/diary method, fishers were recruited to fill in diaries by way of a telephone survey that also estimates the proportion of the population that is eligible (likely to fish). A ‘soft refusal’ bias in the eligibility proportion arises if interviewees who do not wish to co-operate falsely state that they never fish. The proportion of eligible fishers in the population (and, hence, the harvest) is thereby under-estimated. Pilot studies for the 2000 telephone/diary survey suggested that this effect could occur when recreational fishing was established as the subject of the interview at the outset. Another equally serious cause of bias in telephone/diary surveys was that diarists who did not immediately record their day’s catch after a trip sometimes overstated their catch or the number of trips made. There is some indirect evidence that this may have occurred in all the telephone/diary surveys (Wright et al 2004).

The recreational harvest estimates provided by the 2000 and 2001 telephone/diary surveys are thought to be implausibly high for many species including snapper, which led to the development of an alternative maximum count aerial-access onsite method that provides a more direct means of estimating recreational harvests for suitable fisheries. The maximum count aerial-access approach combines data collected concurrently from two sources: a creel survey of recreational fishers returning to a subsample of ramps throughout the day; and an aerial survey count of vessels observed to be fishing at the approximate time of peak fishing effort on the same day. The ratio of the aerial count in a particular area to the number of interviewed parties who claimed to have fished in that area at the time of the overflight was used to scale up harvests observed at surveyed ramps, to estimate harvest taken by all fishers returning to all ramps. The methodology is further described by Hartill et al (2007).

This aerial-access method was first employed in the Hauraki Gulf in 2003–04 and was then extended to survey the wider SNA 1 fishery in 2004–05 and was used in 2011–12 and 2017–18 to corroborate concurrent national panel surveys. This approach has also been used to estimate recreational harvests from SNA 7 (2005–06 and 2015–16 fishing years) and SNA 8 (2006–07). The Marine Amateur Fisheries and Snapper Working Groups both concluded that this approach generally provided reliable estimates of recreational harvest for these fish stocks.

In response to the cost and scale challenges associated with onsite methods, in particular the difficulties in sampling other than trailer boat fisheries, offsite approaches to estimating recreational fisheries harvest have been revisited. This led to the implementation of a national panel survey during the 2011–12 fishing year (Wynne-Jones et al 2014). The panel survey used face-to-face interviews of a random sample of 30 390 New Zealand households to recruit a panel of fishers and non-fishers for a full year. The panel members were contacted regularly about their fishing activities and catch information was collected in computer-assisted standardised phone interviews. The national panel survey was repeated during the 2017–18 and 2022–23 fishing years using very similar methods to produce directly comparable results (Wynne-Jones et al 2019; Heinemann & Gray, in prep). Recreational catch estimates from the three national panel surveys are given in Table 6. Note that national panel survey estimates do not include recreational harvest taken on charter vessel trips or under s111 general approvals.

Monitoring harvest

In addition to estimating absolute harvests, a system to provide relative estimates of harvest over time for key fishstocks has been designed and implemented for some key recreational fisheries. The system uses web cameras to continuously monitor trends in trailer boat traffic at key boat ramps. This monitoring is complemented by creel surveys that provide estimates of the proportion of observed boats that were used for fishing, and of the average harvest of snapper and kahawai per boat trip. These data are combined to provide relative harvest estimates for SNA 1.

Trends inferred from this monitoring programme were initially very similar to that inferred from aerial-access harvest estimates in the Hauraki Gulf in 2004–05, 2006–07, and 2011–12, but the camera/creel snapper harvest estimate for the Hauraki Gulf in 2017–18 is substantially lower than concurrent aerial-access and national panel surveys estimates for the same year (Table 6a cf. Table 6). This difference appears to be due to a recent substantial increase in recreational fishing effort and catch around expanding mussel farms in the Firth of Thames, coinciding with a lesser increase in effort in the north-western Hauraki Gulf. Additional creel survey monitoring has been initiated to monitor changes in the recreational fishery in these areas, which had not been adequately monitored from boat ramps in the Auckland metropolitan area up until 2019–20. These estimates show that the recreational snapper harvest varies substantially more than would be expected if catches were related only to stock abundance; this suggests that changes in localised availability to recreational fishers can also have a marked effect on the recreational harvest. Web camera monitoring is continuing, and the coverage is being progressively extended to other FMAs.

1.2.2.1 SNA 1

Aerial-access surveys were conducted in FMA 1 in 2011–12 and 2017–18 (Hartill et al 2013, 2019) to independently provide harvest estimates for comparison with those generated from concurrent national panel surveys (excluding the Chatham Islands). Both surveys appear to have provided plausible results that corroborate each other and are therefore considered to be broadly reliable. Harvest estimates provided by these surveys are given in Table 6. Regional harvest estimates provided by the 2004–05 and 2011–12 aerial-access surveys were used to inform the 2013 stock assessment for SNA 1. Web camera/creel survey monitoring (see Table 6a) suggests that the recreational harvest of snapper in SNA 1 can vary greatly between years. The overall trend across all three regions of SNA 1 suggests a decline in the recreational harvest in the years following 2011–12, that was mostly driven by declining catch rates in the Hauraki Gulf. This was followed by a period of increasing recreational harvest in recent years, from 2015–16.

Table 6: Recreational catch estimates for snapper stocks. Totals for a stock are given in bold. The telephone/diary surveys ran from December to November but are denoted by the January calendar year. Mean fish weights were obtained from boat ramp surveys (for the telephone/diary and panel survey catch estimates). Numbers and mean weights are not calculated in the tag ratio method. Includes charter boat catch and panel survey estimates of s111 catches. [Continued on next page]

Stock	Year	Method	Number of fish (thousands)	Mean weight (g)	Total weight (t)	CV
SNA 1						
East Northland	1985	Tag ratio	–	–	370	–
Hauraki Gulf	1985	Tag ratio	–	–	830	–
Bay of Plenty	1984	Tag ratio	–	–	400	–
Total	1985[1]	Tag ratio	–	–	**1 600**	–
Total	1994	Telephone/diary	3 804	871	**2 857**	–
East Northland	1996	Telephone/diary	684	1 039	711	–
Hauraki Gulf/BoP	1996	Telephone/diary	1 852	870	1 611	–
Total	1996	Telephone/diary	2 540	915	**2 324**	–
East Northland	2000	Telephone/diary	1 457	1 154	1 681	–
Hauraki Gulf	2000	Telephone/diary	3 173	830	2 632	–
Bay of Plenty	2000	Telephone/diary	2 274	872	1 984	–
Total	2000	Telephone/diary	6 904	904	**6 242**	–
East Northland	2001	Telephone/diary	1 446	–[5]	1 669	–
Hauraki Gulf	2001	Telephone/diary	4 225	–[5]	3 507	–
Bay of Plenty	2001	Telephone/diary	1 791	–[5]	1 562	–
Total	2001	Telephone/diary	7 462	–[5]	**6 738**	–
Hauraki Gulf	2003–04	Aerial-access	–	–	1 334	0.09
East Northland	2004–05	Aerial-access	–	–	557	0.13
Hauraki Gulf	2004–05	Aerial-access	–	–	1 345	0.10
Bay of Plenty	2004–05	Aerial-access	–	–	516	0.10
Total	2004–05	Aerial-access	–	–	**2 419**	**0.06**
East Northland	2011–12	Aerial-access	–	–	718	0.14
Hauraki Gulf	2011–12	Aerial-access	–	–	2490	0.08
Bay of Plenty	2011–12	Aerial-access	–	–	546	0.12
Total	2011–12	Aerial-access	–	–	**3 754**	**0.06**
East Northland	2011–12	Panel survey	686	1 266	869	0.13
Hauraki Gulf	2011–12	Panel survey	2 216	1 022 / 987[6]	2 254	0.12
Bay of Plenty	2011–12	Panel survey	691	956 /1 003[6]	669	0.12
Total	2011–12	Panel survey	3 594	1 025	**3 792**	**0.08**
East Northland	2017–18	Aerial-access	–	–	720	0.10
Hauraki Gulf	2017–18	Aerial-access	–	–	2 068	0.07
Bay of Plenty	2017–18	Aerial-access	–	–	680	0.10
Total	2017–18	Aerial-access	–	–	**3 467**	**0.05**
East Northland	2017–18	Panel survey	563	1 351	761	0.12
Hauraki Gulf	2017–18	Panel survey	1 352	1 162/1 189	1 578	0.11
Bay of Plenty	2017–18	Panel survey	552	1 116/1 205	628	0.12
Total	2017–18	Panel survey	2 467	1 202	**2 967**	**0.07**
East Northland	2022–23	Panel survey	317	1 308	415	0.11
Hauraki Gulf	2022–23	Panel survey	608	1 044/997	629	0.09
Bay of Plenty	2022–23	Panel survey	378	1 243	470	0.13
Total	2022–23	Panel survey	130		**1 514**	**0.60**

1.2.2.2 SNA 2

National Panel Survey harvest estimates are available for SNA 2 from 2011–12 and 2017-18. Web camera/creel survey monitoring has been undertaken within SNA 2 since 2014–15 (monitoring at Napier and Gisborne). These data show a generally increasing trend in snapper harvest, but since the series only overlaps with one National Panel Survey (2017–18), scaled estimates of annual harvest (Table 6b) from the relative boat ramp harvest index should be considered preliminary (B. Hartill, pers. comm.).

Table 6 [Continued]: Recreational catch estimates for snapper stocks. Totals for a stock are given in bold. The telephone/diary surveys ran from December to November but are denoted by the January calendar year. Mean fish weights were obtained from boat ramp surveys (for the telephone/diary and panel survey catch estimates). Numbers and mean weights are not calculated in the tag ratio method. Includes charter boat catch and panel survey estimates of s111 catches.

Stock	Year	Method	Number of fish (thousands)	Mean weight (g)	Total weight (t)	CV
SNA 2						
Total	1993	Telephone/diary	28	1 282	**36**	–
Total	1996	Telephone/diary	31	1 282[2]	**40**	–
Total	2000	Telephone/diary	268	1 200[4]	**322**	–
Total	2001	Telephone/diary	144	–[5]	**173**	–
Total	2011–12	Panel survey	55	1 027	**57**	**0.25**
Total	2017–18	Panel survey	82	1 117	**91**	**0.24**
Total	2022–23	Panel survey	88	1 282/1 610	**116**	**0.25**
SNA 7						
Tasman Bay /Golden Bay	1987	Tag ratio	–	–	**15**	–
Total	1993	Telephone/diary	77	2 398[3]	**184**	–
Total	1996	Telephone/diary	74	2 398	**177**	–
Total	2000	Telephone/diary	63	2 148	**134**	–
Total	2001	Telephone/diary	58	–[5]	**125**	–
Total	2005–06	Aerial-access	–	–	**43**	**0.17**
Total	2011–12	Panel survey	110	799	**88**	**0.17**
Total	2015–16	Aerial-access	–	–	**83**	**0.18**
Total	2017–18	Panel survey	95	1 505	**144**	**0.16**
Total	2022–23	Panel survey	88	1 446/1 836	**130**	**0.14**
SNA 8						
Total	1991	Tag ratio	–	–	**250**	–
Total	1994	Telephone/diary	361	658	**238**	–
Total	1996	Telephone/diary	271	871	**236**	–
Total	2000	Telephone/diary	648	1 020	**661**	–
Total	2001	Telephone/diary	1 111	–	**1 133**	–
Total	2007	Aerial-access	–	–	**260**	**0.10**
Total	2011–12	Panel survey	557	770 /1 255 / 1 160[7]	**630**	**0.16**
Total	2017–18	Panel survey	654	–	**830**	**0.13**
Total	2022–23	Panel survey	355	1 500/1 359	**543**	**0.12**

[1] The Bay of Plenty programme was carried out in 1984 but is included in the 1985 total estimate.
[2] Mean weight obtained from 1992–93 boat ramp sampling.
[3] Mean weight obtained from 1995–96 boat ramp sampling.
[4] Mean weight obtained from 1999–2000 commercial landed catch sampling.
[5] The 2000 mean weights were used in the 2001 estimates.
[6] Separate mean weight estimates were used for summer (1 October 2011 to 30 April 2012) and for winter (1 May to 30 September 2012).
[7] Separate mean weight estimates were used for harbours (Kaipara and Manukau)/North coast (open coast fishery north of Tirua Point)/ South coast (open coast fishery south of Tirua Point).

Table 6a: Recreational catch estimates (t) for snapper in different parts of the SNA 1 stock area calculated from web camera and creel monitoring at key ramps combined with aerial-access estimates for each area in 2004–05 and 2006–07 (Hauraki Gulf only) and 2011–12 and 2018–19 (all areas within SNA 1).

Year	East Northland	CV	Hauraki Gulf	CV	Bay of Plenty	CV	Total SNA 1	CV
2004–05	730	0.14	1 216	0.13	605	0.15	2 551	0.08
2006–07	–	–	1 224	0.16	–	–	–	–
2011–12	689	0.13	2 772	0.09	596	0.18	4 057	0.07
2012–13	679	0.15	1 718	0.09	273	0.21	2 671	0.07
2013–14	540	0.12	876	0.13	216	0.19	1 632	0.08
2014–15	511	0.14	735	0.11	223	0.25	1 469	0.08
2015–16	647	0.13	657	0.15	171	0.19	1 475	0.09
2016–17	649	0.13	649	0.12	385	0.19	1 683	0.08
2017–18	751	0.13	1 037	0.11	623	0.16	2 410	0.08
2018–19	1 030	0.09	1 312	0.09	376	0.13	2 718	0.06

1.2.2.3 SNA 7

Plausible estimates for recreational catches from SNA 7 are available from the 1987 tagging programme, the aerial access surveys (in 2005–06 and 2015–16) and the national panel surveys (2011–12 and 2017–18). The estimates of recreational catch increased considerably from 2005–06 to 2017–18.

Table 6b: Preliminary recreational catch estimates for SNA 2, split by SNA 2N and SNA 2S, on basis of National Panel Survey and web camera/creel survey monitoring.

Year	SNA 2N	SNA 2S	SNA 2	source
2011–12	29.5	26.3	55.8	NPS
2012–13				
2013–14				
2014–15	10.9	25.8	36.7	Scaled creel survey
2015–16	18.4	33.6	52.0	Scaled creel survey
2016–17	13.9	36.5	50.4	Scaled creel survey
2017–18	35.2	57.9	93.1	NPS
2018–19	41.8	87.8	129.7	Scaled creel survey
2019–20	34.6	43.8	78.4	Scaled creel survey
2020–21	53.1	60.5	113.6	Scaled creel survey

Most of the recreational catch has been recorded from Tasman Bay and Golden Bay. The catch is predominantly taken by rod-and-line, although a significant proportion of the catch was taken by longline during the mid 2010s. A small proportion of the total SNA 7 recreational catch was recorded from the Marlborough Sounds.

1.2.2.4 SNA 8

In 2005, the Snapper Working Group and Plenary considered recreational catches from SNA 8. Two alternative levels were assumed for the recreational catch from 1990 to 2004, either 300 t or 600 t. The Plenary considered these values were likely to bracket the true average level of catch in this period. The estimate from the 2006–07 aerial overflight survey of the SNA 8 fishery (260 t) suggests that the assumed value of 300 t may have been the more plausible. There are potential sources of bias associated with the aerial-access estimate, both negative (a potential underestimation of the shore-based harvest, especially to the south) and positive (over-reporting of harvests by charter boat operators in a log book survey which are included in the estimate). The 2011–12 and 2017–18 national panel surveys provided plausible results and are considered to be broadly reliable and suggest that catch is increasing. Web camera/ creel survey monitoring in SNA 8 started in late 2011 and has found no general trend in fishing effort, but a gradual fluctuating increase in catch rates and hence harvest, since that time. No estimates of absolute catch have yet been developed from these data.

1.3 Customary non-commercial fisheries

Snapper form important fisheries for customary non-commercial, but the annual catch is not known. The information on Māori customary harvest under the provisions made for customary fishing is limited (Table 6c). It is likely that Māori customary fishers utilise the provisions under recreational fishing regulations. Customary reporting varies within SNA 8. Large areas of SNA 8 are gazetted under the

Fisheries (Kaimoana Customary Fishing) Regulations 1998 which require reporting on authorisations. In the areas not gazetted, customary fishing authorisations issued would be under the Fisheries (Amateur Fishing) Regulations 2013, where there is no requirement to report. The numbers reported in Table 6b may be underestimated.

Table 6c: Customary approvals and reported harvest in SNA 8 from 2005–06 to present.

Year	Quantity approved (kg)	Reported actual quantity harvested (kg)	Number of authorisations issued
2005–06	250		4
2006–07	120	40	2
2007–08	130	30	2
2008–09	330	151	5
2009–10	4 747	3 046	14
2010–11	5 130	3 089	14
2011–12	3 800	2 633	16
2012–13	4 367	2 439	17
2013–14	12 825	4 514	30
2014–15	17 730	5 887	20
2015–16	14 388	6 553	31
2016–17	3 693	1 669	17
2017–18	770	534	11
2018–19	7 090	1 344	32
2019–20	15 500	2 422	34
2020–21	9 770	270	24
2021–22	2 460		7
2022–23	29 225		74

There are no estimates of customary catch available for SNA 7. Current levels of customary catch in SNA 7 are considered to be small and are assumed to be included into recreational catch estimates.

1.4 Illegal catch

No new analyses are available that provide estimates of illegal catch. For modelling SNA 1, SNA 7, and SNA 8, an assumption was made that non-reporting of catch was 20% of reported domestic commercial catch prior to 1986 and 10% of reported domestic commercial catch since the QMS was introduced. This was to account for all forms of under-reporting. These proportions were estimated in 1996, taking account of information on the black-market trade in snapper and higher levels of under-reporting (to avoid tax) that existed prior to the introduction of the QMS. The 10% under-reporting post-QMS accounts for the practice of under-recording of landed weights and the discarding of legal-size snapper. From 2016–2018 all snapper 1 trawl vessels participated in a video observation programme (Middleton & Guard 2021); the focus of that project was verification of the quantity of undersized fish returned to the sea, but significant discarding of legal-sized snapper by these vessels was unlikely during this period.

1.5 Other sources of mortality

No estimates are available regarding the amount of other sources of mortality on snapper stocks; although high-grading of longline fish and discarding of under-sized fish by all methods occurs. An at-sea study of SNA 1 commercial longline fisheries in 1997 (McKenzie 2000) found that 6–10% of snapper caught by number were under 25 cm (MLS). Results from a holding net study indicate that mortality levels amongst lip-hooked snapper caught shallower than 35 m were low.

Estimates for incidental mortality were based on other catch-at-sea data using an age-length structure model for longline, trawl, seine, and recreational fisheries. In SNA 1, estimates of incidental mortality for the year 2000 from longlines were less than 3% and for trawl, seine, and recreational fisheries between 7% and 11% (Millar et al 2001). In SNA 8, estimates of trawl and recreational incidental mortality were lower, mainly because of low numbers of 2- and 3-year old fish estimated in 2000.

With the introduction of Electronic Reporting in 2019, commercial fishers must provide comprehensive reporting of all discards and returns. All fish under the minimum legal size ("sub-MLS fish”) must be returned to the sea.

In SNA 1, recreational fishers release a high proportion of their snapper catch, most of which was less than 30 cm (recreational MLS). An at-sea study in 2006–07 recorded snapper release rates of 54.2% of the catch by trailer boat fishers and 60.1% of the catch on charter boats (Holdsworth & Boyd 2008). Incidental mortality estimated from condition at release was 2.7% to 8.2% of total catch by weight depending on assumptions used.

2. BIOLOGY

Snapper are demersal fish found down to depths of about 200 m, but are most abundant in 15–60 m. They are the dominant fish in northern inshore communities and occupy a wide range of habitats, including rocky reefs and areas of sand and mud bottom. They are widely distributed in the warmer waters of New Zealand, being most abundant in the Hauraki Gulf.

Although all snapper undergo a female phase as juveniles, after maturity each individual functions as one sex (either male or female) during the rest of its life. Sexual maturity occurs at an age of 3–4 years and a length of 20–28 cm; and the sex ratio of the adult population is approximately 50:50. Snapper are serial spawners, releasing many batches of eggs over an extended season during spring and summer. The larvae have a relatively short planktonic phase which results in the spawning grounds corresponding fairly closely with the nursery grounds of young snapper. Juvenile snapper (0+) are known to reach high abundances in shallow west and east coast harbours and estuaries around the northern half of the North Island and have also been observed in catches from trawl surveys conducted in shallow coastal waters around northern New Zealand, East Cape, Hawke Bay and Tasman Bay and Golden Bay. Despite observations of spawning condition adults along the Wairarapa and Kapiti coasts, 0+ snapper have yet to be found in these areas. Young snapper disperse more widely into less sheltered coastal areas as they grow older. Large schools of snapper congregate before spawning and move on to the spawning grounds, usually in November–December. The spawning season may extend to January–March in some areas and years before the fish disperse, often inshore to feeding grounds. The winter grounds are thought to be in deeper waters where the fish are more widespread.

Water temperature appears to play an important part in the success of recruitment. Generally strong year classes in the population correspond to warm years, weak year classes correspond to cold years (Francis 1993).

Growth rate varies geographically and from year to year. Snapper from SNA 2, Tasman Bay/Golden Bay and off the west coast of the North Island grow faster and reach a larger average size than elsewhere. Snapper have a strong seasonal growth pattern, with rapid growth from November to May, and then a slowing down or cessation of growth from June to September. They may live up to 60 years or more and have very low rates of natural mortality. An estimate of $M = 0.06\ yr^{-1}$ was made from catch curves of commercial catches from the west coast North Island pair trawl fishery in the mid-1970s. These data were re-analysed in 1997 and the resulting estimate of $0.075\ yr^{-1}$ has been used in the base case assessments for SNA 1, 2, 7, and 8.

Regular sampling has provided evidence that growth rates of snapper in SNA 1, SNA 7 and SNA 8 have also varied over time. For SNA 8, growth rates were considerably higher during the 1980s and 1990s compared with the 1970s and more recent period (from mid-2000s). The SNA 7 and SNA 8 growth parameters in Table 7 were derived from age-length observations from the early 1990s and, hence, represent the period of higher growth rates. The temporal variation in growth may indicate density-dependence in the growth rates of snapper, at least in SNA 1, SNA 7 and SNA 8, given the historical exploitation patterns of those stocks. Estimates of biological parameters relevant to stock assessment are shown in Table 7.

Table 7: Estimates of biological parameters.

Fishstock	Estimate			Source
1. Instantaneous rate of natural mortality (*M*)				
SNA 1, 2, 7, & 8	0.075			Hilborn & Starr (unpub. analysis)
2. Weight = *a*(length)^b (Weight in g, length in cm fork length)				
All	*a* = 0.04467	*b* = 2.793		Paul (1976)
3. von Bertalanffy growth parameters				
	Both sexes combined			
	K	t_0	L_∞	
SNA 1	0.102	-1.11	58.8	Gilbert & Sullivan (1994)
SNA 2	0.061	-5.42	68.9	NIWA (unpub. analysis)
SNA 7 (1990s)	0.122	-0.71	69.6	MPI (unpub. data)
SNA 8 (1990s)	0.16	-0.11	66.7	Gilbert & Sullivan (1994)
4. Age at recruitment (years)				
SNA 1*	4 (39%) 5 (100%)			Gilbert et al (2000)
SNA 7	3			MPI (unpub. data)
SNA 8	3			Gilbert & Sullivan (1994)

* For years when not estimated.

3. STOCKS AND AREAS

New Zealand snapper are thought to comprise either seven or eight biological stocks based on: the location of spawning and nursery grounds; differences in growth rates, age structure, and recruitment strength; and the results of tagging studies. These stocks are assumed to comprise three in SNA 1 (East Northland, Hauraki Gulf, and Bay of Plenty (BoP)), two in SNA 2 (one of which may be associated with the BoP stock), two in SNA 7 (Marlborough Sounds and Tasman Bay/Golden Bay) and one in SNA 8. Tagging studies reveal that limited mixing occurs between the three SNA 1 biological stocks, with greatest exchange between BoP and Hauraki Gulf.

Tagging studies in SNA 8 have shown considerable movements of fish between South Taranaki Bight and the area north of Cape Egmont. However, recent *Kaharoa* WCNI trawl surveys indicate some differences in the age structure of snapper between the two areas which may suggest a degree of spatial stratification of the SNA 8 stock.

Tagging studies in SNA 7 (1986/87) and SNA 8 (1990) revealed reciprocal movements of snapper between Tasman Bay/Golden Bay and South Taranaki Bight, although the scale of the movement was relatively low during that period.

Location-based snapper catch data from the trawl fisheries in SNA 7 and southern SNA8 has revealed an overlap of the distribution of snapper catches in western approaches to Cook Strait between Durville Island and Kapiti Island, particularly since 2014/15. Snapper age compositions are available from recent (2018-2020) *Kaharoa* trawl surveys of the South Taranaki Bight and the Tasman Bay/Golden Bay area of the WCSI trawl survey. There are strong differences in the relative strength of individual year classes from the 2019 South Taranaki Bight age composition compared to the 2018 and 2020 surveys, while the 2019 STB age composition was very similar to the age structures from the 2019 Tasman Bay/Golden Bay trawl survey and the commercial fishery in the TBGB area. These observations indicate a degree of mixing of the snapper populations between SNA 7 and the STB area (SNA8), although the extent of mixing may vary between years, potentially related to variation in the timing of the main spawning period in each area.

4. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

This section was last updated from the 2022 Fisheries Assessment Plenary. An issue-by-issue analysis 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

Snapper are one of the most abundant demersal generalist predators found in the inshore waters of northern New Zealand (Morrison & Stevenson 2001, Kendrick & Francis 2002), and as such are likely to be an important part of the coastal marine ecosystem (Salomon et al 2008). Localised depletion of snapper probably occurs within the key parts of the fisheries (Parsons et al 2009), and this has unknown consequences for ecosystem functioning in those areas.

4.1.1 Trophic interactions

Snapper are generalists, occupying nearly every coastal marine habitat less than 200 m deep. Because of this generalist nature there is a large potential for a variety of trophic interactions to involve snapper. The diet of snapper is diverse and opportunistic and largely includes crustaceans, polychaetes, echinoderms, molluscs, and other fish (Godfriaux 1969, Godfriaux 1974). As snapper increase in size, harder bodied and larger diet items increase in importance (e.g., fish, echinoids, hermit crabs, molluscs, and brachyuran crabs) (Godfriaux 1969, Usmar 2012). There is some evidence to suggest a seasonal component to snapper diet, with high proportions of pelagic items (e.g., salps and pelagic fish such as pilchards) observed during spring in one study (Powell 1937).

There is some evidence to suggest that snapper can influence the environment that they occupy in some situations. On some rocky reefs, recovery of predators inside marine reserves (including snapper and rock lobster, *Jasus edwardsii*) has led to the recovery of algal beds through predation exerted on herbivorous urchins (Babcock et al 1999, Shears & Babcock 2002). Snapper competes with other species; overlap in diet is likely with a number of other demersal predators (e.g., tarakihi, red gurnard, trevally, rig, and eagle ray). The wide range of prey consumed by these species and differences in diet preference and habitat occupied, however, is likely to reduce the amount of competition overall (Godfriaux 1970, 1974). The importance of snapper as a food source for other predators is poorly understood.

4.1.2 Ecosystem Indicators

Tuck et al (2009) used data from the Hauraki Gulf trawl survey series (up to 2000) to derive fish-based ecosystem indicators using diversity, fish size, and trophic level. This trawl survey series covers a key component of the distribution of snapper. Tuck et al (2009) showed decreasing trends in the proportion of species with low resilience (from FishBase, Froese & Pauly 2000) and the proportion of demersal fish species in waters shallower than 50 m in the Hauraki Gulf. Several indices of fish diversity showed significant declines in muddy waters shallower than 50 m, especially in the Firth of Thames. Tuck et al (2009) did not find size-based indicators as useful as they have been overseas, but there was some indication that the maximum size of fish has decreased in the Hauraki Gulf survey area, especially over sandy bottoms. Since 2008, routine measurement of all fish species in New Zealand trawl surveys has been undertaken and this may increase the utility of size-based indicators in the future.

4.2 Bycatch (fish and invertebrates)

Snapper in SNA 1 is the declared target species, but tends to be more of a bycatch species in SNA 2, SNA 7 and SNA 8, particularly in inshore trawl fisheries. No summaries of observed fish and invertebrate bycatch in snapper target fisheries are currently available, although there is extensive information on commercial bycatch, which is documented in stock characterisations routinely undertaken.

4.3 Incidental capture of protected species (mammals, seabirds, turtles, 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 or caught on a hook but not brought onboard the vessel, Middleton & Abraham 2007, Brothers et al 2010).

4.3.1 Marine mammal captures

There were two observed captures of New Zealand fur seals in trawls targeting snapper between 2002–03 and 2019–20, but historically low observer coverage of inshore trawlers (average 6.98% in FMAs 1 and 9 between 2002–03 and 2017–18, but averaging 20.51% between 2013–14 and 2017–18) (https://psc.dragonfly.co.nz/2019v1/released/new-zealand-fur-seal/inshore-trawl/all-vessels/eez/2002-03-2017-18/) means that the frequency of captures is highly uncertain. In the same time period, there were no observed marine mammal captures in snapper longline fisheries, when coverage has averaged 2.18% of hooks set (2.5 and 7.3% in the two most recent years) (Protected species bycatch (protectedspeciescaptures.nz)).

Observers recorded two dolphin deaths during snapper trawling in 2016–17: one common dolphin from off the North Island east coast and one bottlenose dolphin from the Northland-Hauraki Gulf area (Abraham et al 2021).

4.3.2 Seabird interactions and captures

There have been thirteen observed captures of seabirds (3 flesh-footed shearwater, 3 black petrel, 2 shearwaters that were not identified further, and 2 common diving petrel, 2 New Zealand white-faced storm petrel and an unidentified small seabird) and 26 observed deck strikes (10 common diving petrels, 10 grey-faced petrel, 2 Buller's shearwater, 1 flesh-footed shearwater, 1 cape petrel, 1 black petrel, and 1 Cook's petrel) in trawls targeting snapper between 2002–03 and 2019–20, but historically low observer coverage of inshore trawlers (average 6.98% in FMAs 1 and 9 between 2002–03 and 2017–18, but averaging 20.51% between 2013–14 and 2017–18) means that the frequency of interactions is highly uncertain. (Protected species bycatch (protectedspeciescaptures.nz))

The estimated number of total incidental captures of all seabirds in the snapper bottom longline fishery declined from 3436 in 2000–01 to 247–644 in 2003–04 (depending on the model used, Table 8, estimates from MacKenzie & Fletcher 2006, Baird & Smith 2007, 2008, Abraham & Thompson 2011a). The estimated number of captures between 2003–04 and 2006–07 appears to have been relatively stable at about 400–600 birds each year.

Table 8: Model based estimates of seabird captures in the SNA 1 bottom longline fishery from 1998–99 to 2006–07 (from MacKenzie & Fletcher 2006 (for vessels under 28 m), Baird & Smith 2007, 2008, Abraham & Thompson 2011a). Numbers in parentheses are 95% confidence limits or estimated CVs.

Fishing year	MacKenzie & Fletcher		Baird & Smith		Abraham & Thompson	
1998–99	1 464	(271–9 392)	–	–	–	–
1999–00	2 578	(513–13 549)	–	–	–	–
2000–01	3 436	(697–17 907)	–	–	–	–
2001–02	1 856	(353–11 260)	–	–	–	–
2002–03	1 583	(299–9 980)	–	–	739	(332–1 997)
2003–04	247	(51–1 685)	546	(CV = 34%)	644	(301–1 585)
2004–05	–	–	587	(CV = 42%)	501	(245–1 233)
2005–06	–	–	–	–	469	(222–1 234)
2006–07	–	–	–	–	457	(195–1 257)

Between 2002–03 and 2017–18, there were 156 observed captures of birds in snapper bottom longline fisheries (Table 9). Estimates of the mean total seabird captures from 2002–03 to 2017–18 vary from 713 to 325 based on a consistent capture rate. The rate of capture varied between 0.0 and 0.1 birds per 1000 hooks observed, fluctuating without obvious trend. Seabirds observed captured in snapper longline fisheries were mostly flesh-footed shearwater (53%) and black (Parkinson's) petrel (24%), and the majority were taken in the Northland-Hauraki area (88%) (Table 10). These numbers should be regarded as only a general guide on the composition of captures because the observer coverage is low, is not uniform across the area, and may not be representative.

Table 9: Number of tows by fishing year, observed, and estimated seabird captures in the snapper bottom longline fishery, 2002–03 to 2019–20. No. obs, number of observed hooks; % obs, percentage of hooks observed; Rate, number of captures per 1000 observed hooks. Estimates are based on methods described by Abraham et al (2016) and Abraham & Richard (2017, 2018) and are available via [Protected species bycatch (protectedspeciescaptures.nz)](protectedspeciescaptures.nz). Observed and estimated protected species captures in this table derive from the PSC database version PSCV6.

		Fishing effort		Observed captures		Estimated captures		
	All hooks	No. obs	% obs	Number	Rate	Mean	95% c.i.	% included
2002–03	13 728 672	0	0.0	0	–	713	522-942	93.2
2003–04	12 266 197	187 282	1.5	10	0.05	636	471-850	100.0
2004–05	11 542 491	244 692	2.1	13	0.05	573	421-766	100.0
2005–06	11 695 613	116 288	1.0	12	0.10	454	324-622	93.1
2006–07	10 348 741	62 360	0.6	0	0.00	438	319-599	93.4
2007–08	9 047 522	0	0.0	0	–	426	302-583	100.0
2008–09	8 981 466	318 274	3.5	27	0.08	441	322-594	100.0
2009–10	11 041 405	634 145	5.7	32	0.05	471	343-633	100.0
2010–11	11 343 582	0	0.0	0	–	497	356-676	100.0
2011–12	11 037 136	0	0.0	0	–	446	318-613	100.0
2012–13	10 501 460	366 120	3.5	2	0.01	418	301-567	100.0
2013–14	11 122 634	747 597	6.7	47	0.06	426	315-573	100.0
2014–15	10 845 182	0	0.0	0	–	356	250-492	100.0
2015–16	10 611 551	337 125	3.2	7	0.02	336	238-463	100.0
2016–17	10 757 586	486 700	4.5	5	0.01	338	235-469	100.0
2017–18	10 427 687	327 091	3.1	14	0.04	325	228-447	100.0
2018–19	10 811 176	269 659	2.5	3	0.01	354	245-485	100.0
2019–20	11 067 703	806 795	7.3	14	0.02	363	260-495	100.0

The snapper target bottom longline fishery contributes to the total risk posed by New Zealand commercial fishing to seabirds (Table 11). The two species to which the fishery poses the most risk are black petrel and flesh-footed shearwater, with this target fishery posing 0.4421 and 0.2166 of PST, respectively (Table 11). The black petrel is assessed at very high risk from commercial fishing in New Zealand waters, and the flesh-footed shearwater is assessed at high risk from commercial fishing in New Zealand waters (Richard et al 2020).

Table 10: Number of observed seabird captures in the snapper longline fishery, 2002–03 to 2018–19, by species or species group. The risk category is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Population Sustainability Threshold, PST (from Richard et al 2017, where full details of the risk assessment approach can be found). Observed and estimated protected species captures in this table derive from the PSC database version PSCV4, www.data.dragonfly.co.nz/psc.

Taxa	Risk category	Northland and Hauraki	Bay of Plenty	West Coast North Island	Taranaki
Black petrel	Very high	40	0	0	0
Flesh-footed shearwater	High	76	11	0	7
Northern giant petrel	Medium	1	0	0	0
Pied shag	Negligible	2	0	0	0
Fluttering shearwater	Negligible	6	0	0	0
Sooty shearwater	Negligible	2	0	0	0
Australasian gannet	Negligible	2	0	0	0
Buller's shearwater	Negligible	13	0	1	0
Southern black-backed gull	Negligible	5	0	0	0
Petrels	–	3	1	0	1
Total birds	–	163	14	1	8

Table 11: Risk ratio of seabirds predicted by the risk assessment for the snapper target bottom longline fishery and all fisheries included in the risk assessment, 2006–07 to 2016–17, showing seabird species with a risk ratio of Very High or High; estimates at a fishery-specific level were not available for other species. The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Population Sustainability Threshold, PST (from Richard et al 2017, where full details of the risk assessment approach can be found). The DOC threat classifications are given by (Robertson et al 2017 at http://www.doc.govt.nz/documents/science-and-technical/nztcs19entire.pdf).

		Risk ratio			
Species name	PST (mean)	SNA target bottom longline	Total	Risk category	DOC Threat Classification
Black petrel	447	0.4421	1.23	Very high	Threatened: Nationally Vulnerable
Flesh-footed shearwater	1 450	0.2166	0.49	High	Threatened: Nationally Vulnerable

4.3.3 Sea turtle captures

Between 2002–03 and 2019–20 there was one observed capture of a green turtle in the snapper bottom longline fishery occurring in the Northland and Hauraki fishing area. Observer records documented the green turtle as captured and released alive (Fisheries New Zealand unpublished data). In the same period, there were no captures of turtles in the snapper trawl fishery.

4.3.4 Protected fish captures

White pointer sharks (*Carcharodon carcharias*, also known as great white shark) were protected in New Zealand waters in 2007 under the Wildlife Act 1953, but they are incidentally caught in commercial and recreational fisheries (Francis & Lyon 2012). Fishers have reported catching a total of 24 white pointer shark individuals in snapper trawls since 2009, 4 of which were dead upon capture, 5 were released alive but injured, and the remainder were released alive. Little is known about the survival of released individuals, but it is assumed to be low.

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 for all trawl fisheries combined (Baird & Mules 2021). This most recent analysis provides an assessment of the inshore trawl footprint was for the period 2007–08 to 2020-21 (MacGibbon & Mules 2023).

A total of almost 49 700 bottom contacting tows have targeted snapper between 2007–08 and 2020–21. Annual numbers fluctuated around 4000 tows per year up to 2012–13 but have declined to around 2400 since 2015–16 (MacGibbon & Mules 2023). The total aggregate area fished between 2007–08 and 2020-21 was 55 629 km^2. This has mostly (67%) been within SNA 1, where annual aggregate area fished declined from around 3000 km^2 (2007–08 to 2012–13) to 2100 km^2 (2016–17), before increasing to around 3000 km^2 (2017–18 and 2020–21). Annual area fished within SNA 2 and SNA 7 has fluctuated around 350 km^2; whereas in SNA 8, the annual area fished declined from 1300 km^2 in 2007–08 to 480 km^2 by 2010–11 and has fluctuated around this level since this time (MacGibbon & Mules 2023).

A proportion of the commercial catch of snapper is taken using bottom trawls in Benthic Optimised Marine Environment Classification (BOMEC, Leathwick et al 2012) classes A, C (northern shelf), and H (shelf break and upper-slope) (Baird & Wood 2012), and at least 90% of trawls occur shallower than 100 m depth (Baird et al 2011, tabulating data from TCEPR forms). Trawling for snapper, like trawling for other demersal species, is likely to have effects on benthic community structure and function (e.g., Thrush et al 1998, Rice 2006) 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

4.5.1 Spawning disruption

Fishing within aggregations of spawning fish may have the potential to disrupt spawning behaviour and, for some fishing methods or species, may lead to reduced spawning success. No research has been conducted on disruption of snapper spawning, but aggregations of spawning snapper often receive high commercial and recreational fishing effort (Fisheries New Zealand unpublished data). Areas likely to be important for snapper spawning include the Hauraki Gulf (Cradock Channel, Coromandel Harbour to the Firth of Thames, and between the Noises, Tiritiri Matangi, and Kawau Islands (Zeldis & Francis 1998)), Rangaunu and Doubtless Bay, the Bay of Islands, eastern Bay of Plenty, and the coastal areas adjacent to the harbour mouths on the west coast such as Manukau Harbour and Kaipara Harbour (Hurst et al 2000).

4.5.2 Genetic effects
Fishing, environmental changes, including those caused by climate change or pollution, could alter the genetic composition or diversity of a species. Bernal-Ramírez et al (2003) estimated genetic diversity and confidence limits for snapper in Tasman Bay and the Hauraki Gulf. They showed a significant decline of both mean heterozygosity and mean number of alleles in Tasman Bay, but only random fluctuations in the Hauraki Gulf. In Tasman Bay, there was a decrease in genetic diversity at six of seven loci examined, compared with only one in the Hauraki Gulf. Bernal-Ramírez et al (2003) associated this decline with overfishing of the SNA 7 stock and estimated the effective population size in Tasman Bay declined to a low level between 1950 and 1998.

4.5.3 Habitat of particular significance to fisheries management
Habitat of particular significance for fisheries management (HPSFM) does not have a policy definition (Ministry for Primary Industries 2013). For juvenile snapper, it is likely that certain habitats, or locations, are critical to successful recruitment of snapper. Post settlement juvenile snapper (10–70 mm fork length) associate strongly with three-dimensional structured habitats in estuaries, harbours, and sheltered coastal areas (such as beds of seagrass and horse mussels, Thrush et al 2002, Morrison et al 2009, 2014a, b). The reason for this association is currently unclear, but the provision of food and shelter are likely explanations. Some potential nursery habitats appear to contribute disproportionately to their area. For example, the Kaipara Harbour in northern New Zealand contributed to more than 75% of the recruits to the SNA 8 fishery in 2003 (Morrison, NIWA, unpublished data, Morrison et al 2009) and a similar situation exists for snapper from Port Phillip Bay in Australia (Hamer et al 2011). These habitats are subject to land-based stressors (Morrison et al 2009, Lowe et al 2015) that may affect the survival of juvenile snapper and hence recruitment to the SNA 8 fishery. It should, however, be noted that recruitment over the last decade has been exceptionally good, suggesting that environmental factors affecting egg and larval survival in the ocean have had greater influence on the number of fertilised eggs surviving to adulthood.

5. RECRUITMENT, ENVIRONMENTAL VARIABILITY, AND CLIMATE CHANGE

This section was last updated in May 2021.

Recruitment dynamics are challenging to assess or predict because of the many underlying drivers that vary over time and space. Stock size, demographic and trait composition, condition and distribution of spawning fish, and the spatio-temporal dynamics of trophic and environmental interactions all influence recruitment processes. Annual variations in snapper recruitment have considerable impact on this fishery and improved understanding of the influence of environmental variables on recruitment patterns would be very useful for the future projection of stock size under different climate change scenarios and different environmental conditions.

New Zealand waters are becoming warmer and more acidic due to the emission of anthropogenic carbon dioxide (Law et al 2018a, 2018b). Recruitment success of New Zealand snapper has been highly correlated with warmer conditions (Francis 1993, Harley & Gilbert 2000, Zeldis et al 2005, Dunn et al 2009, Langley 2015, Garg 2020). Snapper recruitment fluctuations may significantly influence biomass where: 1) a series of weak or strong year classes occur in adjacent years, 2) a population is heavily fished and thus more easily dominated by younger year classes, or 3) a population is near the geographic limit of its range and is dominated by a few year classes due to irregular recruitment; each of which has occurred in at least one snapper stock in New Zealand (Francis 1993).

Recruitment in SNA 7 and SNA 8 has been above average in recent years (Langley 2020a, 2020b). Some spatial differences in year class strength (YCS) patterns are evident across different stocks, but appear to be reasonably well correlated, which may be a result of each stock showing similar responses to broad climatic phenomena, such as the Southern Oscillation Index (SOI) (Francis & Mackenzie 2015). Stock assessments have estimated high levels of recruitment in SNA 7 and SNA 8 between 2006 and 2019 (Langley 2015, 2020a, 2020b), which may possibly be linked to increasing water temperatures. It should nevertheless be noted that the relationship between recruitment and water temperature is unlikely to be linear, with growth and recruitment decreasing after reaching an optimum thermal maxima for Australian snapper populations (Fowler & Jennings 2003, Murphy 2013). It is unclear what the thermal maxima will be for snapper in New Zealand.

In SNA 7, recruitment has been shown to be positively correlated with air temperature (Harley & Gilbert 2000). Strong year classes have also been linked to positive SOI conditions, whereas weak year classes have been linked to negative SOI conditions (Langley 2015). More recently, Garg (2020) examined environment-recruitment relationships for SNA 1 (1970–2007) and SNA 7 (1982–2012) using generalised linear models based on annual recruitment estimates from stock assessment models that incorporated age data from otolith samples. The most variation in YCS was explained by the mean autumn (April–June) SST in SNA 1 and by mean annual SOI in SNA 7, and the Interdecadal Pacific Oscillation accounted for the second greatest amount of variation in both SNA 1 and SNA 7. These findings were consistent with Francis (1993), who concluded that water temperature appears to play an important part in the success of recruitment, with strong year classes in the population generally corresponding to warm years, and weak year classes to cold years. As well as finding a positive correlation between YCS and SST, Dunn et al (2009) also found a positive correlation between YCS and SOI for SNA 1.

A recent study found that fishing and environmental factors initially promote individual fish growth of snapper, but regional-scale wind and temperature may also increase the sensitivity of stocks to environmental change (Morrongiello et al 2021).

Temperature-recruitment relationships are typically non-linear, and studies on snapper in South Australia have shown a reduction in recruitment after temperatures rose above 25 °C (Fowler & Jennings 2003). In Western Australia, snapper growth is greatest at mid latitudes with more moderate temperatures, and lowest at the northern limit of the geographical range for snapper, where temperatures are at their highest (Wakefield et al 2017). In South Australia, biochronology work has found an optimal temperature maximum of 18–20 °C for growth in snapper, and temperatures greater than this result in slower growth rates (Martino et al 2019), which was also in support of optimum growth conditions for juvenile snapper ascertained from aquaculture experimental studies (Fielder et al 2005). The Hauraki Gulf is currently experiencing temperatures near 20 °C, but the optimal temperature range for snapper stocks in New Zealand is unknown (Parsons et al 2020). Recent Hauraki and Bay of Plenty trawl surveys which monitored snapper recruitment and compared it to SST show that the estimated year class strength of 1+ and 2+ snapper in the Hauraki Gulf 2019 survey was well above the long-term average, whereas in the Bay of Plenty, YCSs were well above average (1+) and about average (2+) (see Parsons & Bian in prep).

Several causal mechanisms may result in the increased production of prey and a faster larval growth rate of snapper (Murphy 2013). Zeldis et al (2005) found that wind-driven upwelling caused increased flux of shelf water into the Hauraki Gulf, resulting in greater primary productivity, prey abundance, and higher larval snapper survival.

Ocean acidification (OA) has been shown to have a variable influence on snapper larvae. Although higher temperature and carbon dioxide levels may positively impact growth and survival of snapper larvae, this effect may be countered by the negative effects of elevated carbon dioxide on metabolic rates and swimming performance (McMahon et al 2020a, 2020b). Modelling the overall effect from both OA and warming on snapper populations estimated a 29% reduction to a 44% increase in fishery yield and therefore remains highly uncertain (Parsons et al 2020).

Cummings et al (2021) assessed the vulnerability of New Zealand's snapper fishery to projected environmental change as 'moderate' and outlined the following potential outcomes of increased sea temperatures: 1) southward range expansion, 2) change in distribution of predators, competitors, parasites, and disease, and 3) toxicity and decreased dissolved oxygen due to harmful algal blooms. In recent years, snapper populations appear to have been increasing, in some areas substantially, suggesting that environmental conditions are currently favourable for snapper recruitment and survival.

6. FOR FURTHER INFORMATION

Abraham, E R; Berkenbusch, K; Richard, Y; Thompson, F (2016) Summary of the capture of seabirds, mammals, and turtles in New Zealand commercial fisheries, 2002–03 to 2012–13. *New Zealand Aquatic Environment and Biodiversity Report No. 169*. 205 p.

Abraham, E R; Richard, Y (2017) Summary of the capture of seabirds in New Zealand commercial fisheries, 2002–03 to 2013–14. *New Zealand Aquatic Environment and Biodiversity Report No. 184*. 88 p.

Abraham, E R; Richard, Y (2018) Estimated capture of seabirds in New Zealand trawl and longline fisheries, 2002–03 to 2014–15. *New Zealand Aquatic Environment and Biodiversity Report No. 197*. 97 p.

Abraham, E R; Thompson, F N (2011a) Estimated capture of seabirds in New Zealand trawl and longline fisheries, 2002–03 to 2008–09. *New Zealand Aquatic Environment and Biodiversity Report No. 79*.

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

Abraham, E R; Thompson, F N; Oliver, M D (2010) Summary of the capture of seabirds, mammals, and turtles in New Zealand commercial fisheries, 1998–99 to 2007–08. *New Zealand Aquatic Environment and Biodiversity Report No. 45*. 149 p.

Abraham, E R; Tremblay-Boyer, L; Berkenbusch, K (2021) Estimated captures of New Zealand fur seal, common dolphin, and turtles in New Zealand commercial fisheries, to 2017–18. *New Zealand Aquatic Environment and Biodiversity Report No. 258*. 94 p.

Babcock, R C; Kelly, S; Shears, N T; Walker, J W; Willis, T J (1999) Changes in community structure in temperate marine reserves. *Marine Ecology Progress Series 189*: 125–134.

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

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

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

Baird, S J (2005) Incidental capture of seabird species in commercial fisheries in New Zealand waters, 2002–03. *New Zealand Fisheries Assessment Report 2005/2*.50 p.

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

Baird, S.J; Smith, M.H. (2008) Incidental capture of seabird species in commercial fisheries in New Zealand waters, 2005–06. *New Zealand Aquatic Environment and Biodiversity Report No. 18*. 124 p.

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

Baird, S J; Wood, B A; Bagley, N W (2011) Nature and extent of commercial fishing effort on or near the seafloor within the New Zealand 200 n. mile Exclusive Economic Zone, 1989–90 to 2004–05. *New Zealand Aquatic Environment and Biodiversity Report No. 73*. 143 p.

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

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

Bernal-Ramírez, J H; Adcock, G J; Hauser, L; Carvalho, G R; Smith, P J (2003) Temporal stability of genetic population structure in the New Zealand snapper, *Pagrus auratus*, and relationship to coastal currents. *Marine Biology 142(3)*: 567–574.

Boyd, R O; Gowing, L; Reilly, J L (2004) 2000–2001 national marine recreational fishing survey: diary results and harvest estimates. . Final Research Report for Ministry of Fisheries. (Unpublished report held by Fisheries New Zealand, Wellington.) 93 p.

Boyd, R O; Reilly, J L (2002) 1999/2000 National marine recreational fishing survey: harvest estimates. Final Research Report for Ministry of Fisheries Research Project REC9803. (Unpublished report held by Fisheries New Zealand, Wellington.)

Bradford, E (1998) Harvest estimates from the 1996 national marine fishing surveys. New Zealand Fisheries Assessment Research Document 1998/16. 27 p. (Unpublished document held by NIWA library, Wellington.)

Brothers, N; Duckworth, A R; Safina, C; Gilman, E L (2010) Seabird bycatch in pelagic longline fisheries is grossly underestimated when using only haul data. *PloS ONE 5*: e12491. doi: 10.1371/journal.pone.001249

Cummings, V J; Lundquist, C J; Dunn, M R; Francis, M; Horn, P; Law, C; Pinkerton, M H; Sutton, P; Tracey, D; Hansen, L; Mielbrecht, E (2021) Assessment of potential effects of climate-related changes in coastal and offshore waters on New Zealand's seafood sector. *New Zealand Aquatic Environment and Biodiversity Report No. 261*. 153 p.

Dunn, M R; Hurst, R J; Renwick J; Francis, R I C C; Devine, J; McKenzie, A (2009) Fish abundance and climate trends in New Zealand. *New Zealand Aquatic Environment and Biodiversity Report No. 31*. 73 p.

Fielder, D S; Bardsley, W J; Allan, G L; Pankhurst, P M (2005) The effects of salinity and temperature on growth and survival of Australian snapper, *Pagrus auratus* larvae. *Aquaculture 250(1–2)*: 201–214.

Fisheries New Zealand (2021) Aquatic Environment and Biodiversity Annual Review 2021. Compiled by the Aquatic Environment Team, Fisheries Science and Information, Fisheries New Zealand, Wellington, New Zealand. 779 p.

Fowler, A J; Jennings, P R (2003) Dynamics in 0+ recruitment and early life history for snapper (*Pagrus auratus*, Sparidae) in South Australia. *Marine and Freshwater Research 54(8)*: 941–956.

Francis, M P (1993) Does water temperature determine year class strength in New Zealand snapper (*Pagrus auratus*, Sparidae)? *Fisheries Oceanography* 2(2): 65–72.

Francis, M P (1994) Growth of juvenile snapper, *Pagrus auratus*. *New Zealand Journal of Marine and Freshwater Research 28(2)*: 201–218.

Francis, M P; Evans, J (1992) Immigration of subtropical and tropical animals into north-eastern New Zealand. Paper presented at the Proceedings of the Second International Temperate Reef Symposium.

Francis, M P; Langley, A; Gilbert, D (1997) Prediction of snapper (*Pagrus auratus*) recruitment from sea surface temperature. *In*: Hancock, D A; Smith, D C; Grant, A; Beumer J P (Eds) *Developing and sustaining world fisheries resources: the state of science and management*, pp. 67–71. 2nd World Fisheries Congress 28 Jul–2 Aug 1996, Brisbane, Australia. CSIRO Publishing.

Francis, M P; Langley, A D; Gilbert, D J (1995) Snapper recruitment in the Hauraki Gulf. New Zealand Fisheries Assessment Research Document 1995/17. 26 p. (Unpublished document held by NIWA library, Wellington.)

Francis, M P; Lyon, W S (2012) Review of commercial fishery interactions and population information for eight New Zealand protected fish species. (Unpublished NIWA client report WLG2012-64 prepared for the Department of Conservation, Wellington.) 67 p. Available at https://www.doc.govt.nz/Documents/conservation/marine-and-coastal/marine-conservation-services/pop2011-03-protected-fish-review.pdf

Francis, M P; Paul, L J (2013) New Zealand inshore finfish and shellfish commercial landings, 1931–82. *New Zealand Fisheries Assessment Report 2013/55.* 136 p.

Froese, R; Pauly, D (2000) FishBase 2000: concepts, design and data sources. ICLARM, Los Banos, Laguna, Philippines. 344 p.

Garg, R (2020) Environment-Recruitment Relationships and Catch Data Based Analysis of Movement Patterns in New Zealand Snapper (*Chrysophrys auratus*). Unpublished master's thesis. University of Auckland, New Zealand.

Gilbert, D J (1994) A total catch history model for SNA 1. New Zealand Fisheries Assessment Research Document 1994/24. 16 p. (Unpublished document held by NIWA library, Wellington.)

Gilbert, D J; Taylor, P R (2001) The relationships between snapper (*Pagrus auratus*) year class strength and temperature for SNA 2 and SNA 7. *New Zealand Fisheries Assessment Report 2001/64*. 33 p.

Godfriaux, B L (1969) Food of predatory demersal fish in Hauraki Gulf. 1. Food and Feeding habitats of snapper. *New Zealand Journal of Marine and Freshwater Research 3*: 518–544.

Godfriaux, B L (1970) Food of predatory demersal fish in Hauraki Gulf. 3. Feeding relationships. *New Zealand Journal of Marine and Freshwater Research 4*: 325–336.

Godfriaux, B L (1974) Feeding relationships between terakihi and snapper in western Bay of Plenty, New Zealand. *New Zealand Journal of Marine and Freshwater Research 8*: 589–609.

Hamer, P A; Acevedo, S; Jenkins, G P; Newman, A (2011) Connectivity of a large embayment and coastal fishery: spawning aggregations in one bay source local and broadscale fishery replenishment. *Journal of Fish Biology 78*: 1090–1109.

Hartill, B; Bian, R; Armiger, H; Vaughan, M; Rush, N (2007) Recreational marine harvest estimates of snapper, kahawai, and kingfish in QMA 1 in 2004–05. *New Zealand Fisheries Assessment Report 2007/26*. 44 p.

Hartill, B; Bian, R; Rush, N; Armiger, H (2013) Aerial-access recreational harvest estimates for snapper, kahawai, red gurnard, tarakihi and trevally in FMA 1 in 2011–12. *New Zealand Fisheries Assessment Report 2013/70*. 49 p.

Hartill, B; Bian, R; Rush, N; Armiger, H (2019) Aerial-access recreational harvest estimates for snapper, kahawai, red gurnard, tarakihi and trevally in FMA 1 in 2017–18. *New Zealand Fisheries Assessment Report 2019/23*. 39 p.

Hartill, B; Sutton, C (2011) Characterisation and catch per unit effort indices for the SNA 7 fishery. *New Zealand Fisheries Assessment Report 2011/53*. 55 p.

Hartill, B; Watson, T; Cryer, M; Armiger, H (2007) Recreational marine harvest estimates of snapper and kahawai in the Hauraki Gulf in 2003–04. *New Zealand Fisheries Assessment Report 2007/25*. 55 p.

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

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

Holdsworth, J C; Boyd, R O (2008) Size, condition and estimated release mortality of snapper (*Pagrus auratus*) caught in the SNA 1 recreational fishery, 2006–07. *New Zealand Fisheries Assessment Report 2008/53*. 37 p.

Hurst, R J; Stevenson, M L; Bagley, N W; Griggs, L H; Morrison, M A; Francis, M P (2000) Areas of importance for spawning, pupping or egg-laying, and juveniles of New Zealand coastal fish. Final Research Report to the Ministry of Fisheries Research Project ENV1999-03. 271 p. (Unpublished draft NIWA Technical Report available at https://fs.fish.govt.nz/Doc/22534/ENV1999-03%20Coastal%20Fish%20NZ%20Objective%201%20Final.pdf.ashx.)

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

Jones, E; Morrison, M; Parsons, D M; Paterson, C; Usmar, N; Bagley, N (2010) Fish communities (Chapter 13). Oceans 2020 Bay of Islands Survey report to LINZ prepared by NIWA. 98 p.

King, M R (1985) Fish and shellfish landings by domestic fishermen, 1974–82. *Fisheries Research Division Occasional Publication: Data Series 20*. 96 p.

King, M R (1986) Catch statistics for foreign and domestic commercial fishing in New Zealand waters, January–December, 1983. *Fisheries Research Division Occasional Publication: Data series 21*. 140 p.

King, M R; Jones, D M; Fisher, K A; Sanders, B M (1987) Catch statistics for foreign and domestic commercial fishing in New Zealand waters, January – December 1984. *New Zealand Fisheries Data Report No. 30*. 150 p.

Law, C S; Bell, J J; Bostock, H C; Cornwall, C E; Cummings, V J; Currie, K; ... & Tracey, D M (2018a) Ocean acidification in New Zealand waters: trends and impacts. *New Zealand Journal of Marine and Freshwater Research 52(2)*: 155–195.

Law, C S; Rickard, G J; Mikaloff-Fletcher, S E; Pinkerton, M H; Behrens, E; Chiswell, S M; Currie, K (2018b) Climate change projections for the surface ocean around New Zealand. *New Zealand Journal of Marine and Freshwater Research 52(3)*: 309–335.

Leathwick, J R; Rowden, A; Nodder, S; Gorman, R; Bardsley, S; Pinkerton, M; Baird, S J; Hadfield, M; Currie, K; Goh, A (2012) A benthic-optimised marine environment classification for New Zealand waters. *New Zealand Aquatic Environment and Biodiversity Report No. 88*. 54 p.

Lowe, M L; Morrison, M A; Taylor, R B (2015) Harmful effects of sediment-induced turbidity on juvenile fish in estuaries. *Marine Ecology Progress Series 539*: 241–254.

MacGibbon, D J; Mules, R (2023) Extent and intensity of bottom contact by commercial trawling and shellfish dredging in New Zealand waters, 1990–2021. *New Zealand Aquatic Environment and Biodiversity Report No. 316*. 174 p.

MacKenzie, D; Fletcher, D (2006) Characterisation of seabird captures in NZ fisheries. Final Research Report prepared for the Ministry of Fisheries, Proteus Wildlife Consultants. 99 p. (Unpublished report held by Fisheries New Zealand, Wellington.)

Maggs, J Q; Hartill, B W; Evans, O E; Holdsworth, J C; Lumley, T; Stevens, T (2024) Mortality rates of snapper released by recreational fishers. *New Zealand Fisheries Assessment Report 2024/17*. 31 p.

Martino, J C; Fowler, A; Doubleday, Z A; Grammer, G L; Gillanders, B M (2019) Using otolith chronologies to understand long-term trends and extrinsic drivers of growth in fisheries. *Ecosphere 10(1)*: e02553.

Maunder, M N; Starr, P J (1995) Validating the Hauraki Gulf snapper pre-recruit trawl surveys and temperature recruitment relationship using catch at age analysis with auxiliary information. New Zealand Fisheries Assessment Research Document 1998/15. (Unpublished document held by NIWA library, Wellington.)

McKenzie, J R (2000) Factors Affecting Mortality of small Snapper (*Pagrus auratus*) caught and released by the SNA 1 Longline Fishery. (Draft Fisheries Assessment Report held by NIWA Library, Wellington).

McMahon, S J; Parsons, D M; Donelson, J M; Pether, S M; Munday, P L (2020a) Elevated CO 2 and heatwave conditions affect the aerobic and swimming performance of juvenile Australasian snapper. *Marine Biology 167(1)*: 1–12.

McMahon, S J; Parsons, D M; Donelson, J M; Pether, S M; Munday, P L (2020b) Elevated temperature and CO_2 have positive effects on the growth and survival of larval Australasian snapper. *Marine Environmental Research 161*: 105054.

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

Middleton, D A J; Guard, D (2021) Summary and evaluation of the electronic monitoring programmes in the SNA 1 trawl and bottom longline fisheries. *New Zealand Fisheries Assessment Report 2021/37*. 69 p

Ministry for Primary Industries (2013) Aquatic Environment and Biodiversity Annual Review 2013. Compiled by the Fisheries Management Science Team, Ministry for Primary Industries, Wellington, New Zealand. 538 p.

Ministry of Fisheries (2008) Harvest Strategy Standard for New Zealand Fisheries. 25 p. Available online at: https://fs.fish.govt.nz/Doc/16543/harveststrategyfinal.pdf.ashx

Morrison, M A; Jones, E G; Consalvey, M; Berkenbusch, K (2014a) Linking marine fisheries species to biogenic habitats in New Zealand: a review and synthesis of knowledge. *New Zealand Aquatic Environment and Biodiversity Report No. 130*. 156 p.

Morrison, M A; Lowe, M L; Parsons, D M; Usmar, N R; McLeod, I M (2009) A review of land-based effects on coastal fisheries and supporting biodiversity in New Zealand. *New Zealand Aquatic Environment and Biodiversity Report No. 37*. 100 p.

Morrison, M A; Lowe, M L; Grant, C M; Smith, P J; Carbines, G; Reed, J; Bury, S J; Brown, J (2014b) Seagrass meadows as biodiversity and productivity hotspots. *New Zealand Aquatic Environment and Biodiversity Report No. 137*. 147 p.

Morrongiello, J. R., Horn, P. L., Ó Maolagáin, C., & Sutton, P. J. (2021) Synergistic effects of harvest and climate drive synchronous somatic growth within key New Zealand fisheries. *Global Change Biology 27(7)*: 1470–1484.

Murphy, H M; Jenkins, G P; Hamer, P A; Swearer, S E (2013) Interannual variation in larval abundance and growth in snapper *Chrysophrys auratus* (Sparidae) is related to prey availability and temperature. *Marine Ecology Progress Series 487*: 151–162.

Parsons, D M; Bian, R (in prep) Trawl surveys of the Hauraki Gulf and Bay of Plenty in 2019, 2020, and 2021 to estimate the abundance of juvenile snapper. Draft New Zealand Fisheries Assessment Report.

Parsons, D M; Bian, R; McKenzie, J R; McMahon, S J; Pether, S; Munday, P L (2020) An uncertain future: Effects of ocean acidification and elevated temperature on a New Zealand snapper (*Chrysophrys auratus*) population. *Marine Environmental Research 161*: 105089.

Parsons, D M; Morrison, M A; MacDiarmid, A B; Stirling, B; Cleaver, P; Smith, I W G; Butcher, M (2009) Risks of shifting baselines highlighted by anecdotal accounts of New Zealand's snapper (*Pagrus auratus*) fishery. *New Zealand Journal of Marine and Freshwater Research 43*: 965–983.

Paul, L J (1976) A study on age, growth and population structure of the snapper, *Chrysophrys auratus* in Hauraki Gulf. *New Zealand Fisheries Research Bulletin No. 13*. 63 p.

Paul, L J (1977) The commercial fishery for snapper *Chrysophrys (Pagrus) auratus* in the Auckland region, New Zealand, from 1900 to 1971. *Fisheries Research Division Bulletin No 15*. 84 p.

Powell, A W B (1937) Animal Communities of the Sea-bottom in Auckland and Manukau Harbours. *Transactions and Proceedings of the Royal Society of New Zealand 66*: 354–401.

Reiss, H; Greenstreet, S P; Sieben, K; Ehrich, S; Piet, G J; Quirijns, F; Robinson, L; Wolff, W J; Kröncke, I (2009) Effects of fishing disturbance on benthic communities and secondary production within an intensively fished area. *Marine Ecology Progress Series 394*: 201–213.

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

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

Richard, Y; Abraham, E R (2015) Assessment of the risk of commercial fisheries to New Zealand seabirds, 2006–07 to 2012–13. *New Zealand Aquatic Environment and Biodiversity Report No. 162*. 85 p.

Richard, Y; Abraham, E R; Berkenbusch, K (2017) Assessment of the risk of commercial fisheries to New Zealand seabirds, 2006–07 to 2014–15. *New Zealand Aquatic Environment and Biodiversity Report No. 191*. 133 p.

Richard, Y; Abraham, E R; Berkenbusch, K (2020) Assessment of the risk of commercial fisheries to New Zealand seabirds, 2006–07 to 2016–17. *New Zealand Aquatic Environment and Biodiversity Report No. 237*. 57 p

Ritchie, L; Saul, P; O'Sullivan, K. (1975) The wetfish report 1941–1970. *New Zealand Ministry of Agriculture and Fisheries Fisheries Technical Report 137*. 370 p.

Robertson, H A; Baird, K; Dowding J E; Elliott, G P; Hitchmough, R A; Miskelly, C M; McArthur, N; O'Donnell, C F J; Sagar, P M; Scofield, R P; Taylor, G A (2017) Conservation status of New Zealand birds, 2016. *New Zealand Threat Classification Series 19*. Department of Conservation, Wellington. 23 p.

Rowe, S (2009) Level 1 Risk Assessment Methodology for incidental seabird mortality associated with New Zealand fisheries in the NZ EEZ. (Unpublished report to the Seabird Stakeholder Advisory 138 Group (SSAG09.49) held by the Department of Conservation, Wellington.)

Salomon, A K; Shears, N T; Langlois, T J; Babcock, R C (2008) Cascading effects of fishing can alter carbon flow through a temperate coastal ecosystem. *Ecological Applications 18*:1874–1887.

Shears, N T; Babcock, R C (2002) Marine reserves demonstrate top-down control of community structure on temperate reefs. *Oecologia 132*: 131–142.

Stevenson, M L; MacGibbon, D J (2018) Inshore trawl survey of the west coast South Island and Tasman and Golden Bays, March-April 2017 (KAH1703) *New Zealand Fisheries Assessment Report 2018/18*. 92 p.

Sullivan, K J (1985) Snapper. *In:* Colman, J A; McKoy, J L; Baird, G G (Comps. and Eds.) (1985) Background papers for the 1985 Total Allowable Catch recommendations, pp. 187–214. (Unpublished report, held in NIWA library, Wellington.)

Sullivan, K J; Hore, A J; Wilkinson, V H (1988) Snapper. *In:* Baird, G G; McKoy, J L Papers from the workshop to review fish stock assessments for the 1987–88 New Zealand fishing year, pp. 251–275. (Unpublished report, held in NIWA library, Wellington.)

Sylvester, T (1995) Initial results of the Northern boat ramp survey. *Seafood New Zealand*, February 1995. pp. 11–13.

Teirney, L D; Kilner, A R; Millar, R B; Bradford, E; Bell, J D (1997) Estimation of recreational harvests from 1991–92 to 1993–94. New Zealand Fisheries Assessment Research Document 1997/15. 43 p. (Unpublished document held by NIWA library, Wellington.)

Thompson, N F; Berkenbusch, K; Abraham, E R (2016) Incidental Capture of Marine mammals in New Zealand trawl fisheries, 1995–96 to 2011–12. *New Zealand Aquatic Environment and Biodiversity Report No. 167*. 78 p.

Thrush, S F; Hewitt, J E; Cummings, V J; Dayton, P K; Cryer, M; Turner, S J; Funnell, G A; Budd, R G; Milburn, C J; Wilkinson M R (1998) Disturbance of the marine benthic habitat by commercial fishing: impacts at the scale of the fishery. *Ecological Applications 8*: 866–879.

Thrush, S F; Schultz, D; Hewitt, J E; Talley, D (2002) Habitat structure in soft-sediment environments and abundance of juvenile snapper *Pagrus auratus*. *Marine Ecology Progress Series 245*: 273–280.

Tuck, I; Cole, R; Devine, J (2009) Ecosystem indicators for New Zealand fisheries. *New Zealand Aquatic Environment and Biodiversity Report No. 42*. 188 p.

Usmar, N R (2012) Ontogenetic diet shifts in snapper (*Pagrus auratus*: Sparidae) within a New Zealand estuary. *New Zealand Journal of Marine and Freshwater Research 46*: 31–46.

Wakefield, C B; Potter, I C; Hall, N G; Lenanton, R C; Hesp, S A (2017) Timing of growth zone formations in otoliths of the snapper, *Chrysophrys auratus*, in subtropical and temperate waters differ and growth follows a parabolic relationship with latitude. *ICES Journal of Marine Science 74(1)*; 180–192.

Wright, P; McClary, D; Boyd, R O (2004) 2000/2001 National Marine Recreational Fishing Survey: direct questioning of fishers compared with reported diary data. Final Research Report for Ministry of Fisheries Project REC2000-01: Objective 2. (Unpublished report held by Fisheries New Zealand, Wellington.)

Wynne-Jones, J; Gray, A; Heinemann, A; Hill, L; Walton, L (2019) National Panel Survey of Marine Recreational Fishers 2017–2018. *New Zealand Fisheries Assessment Report 2019/24*. 104 p.

Wynne-Jones, J; Gray, A; Hill, L; Heinemann, A (2014) National Panel Survey of Marine Recreational Fishers 2011–12: Harvest Estimates. *New Zealand Fisheries Assessment Report 2014/67*. 139 p.

Zeldis, J R; Oldman, J; Ballara, S L; Richards, L A (2005) Physical fluxes, pelagic ecosystem structure, and larval fish survival in Hauraki Gulf, New Zealand. *Canadian Journal of Fisheries and Aquatic Sciences 62(3)*: 593–610.

Zeldis, J R; Francis, R I C C (1998) A daily egg production method estimate of snapper biomass in Hauraki Gulf, New Zealand. *ICES Journal of Marine Science 55*: 522–534.

SNAPPER (SNA 8)

(*Chrysophrys auratus*)
Tamure, Kouarea

1. FISHERIES SUMMARY

1.1 Commercial fisheries

Table 1 and Table 2 provide a summary by fishing year of the reported commercial catches, TACCs, and TACs for SNA 8. Landings and TACC are plotted in Figure 1.

Table 1: Reported landings (t) of snapper from SNA 8 from 1931 to 1990.

Year	SNA 8	Year	SNA 8
1931–32	140	1961	1 178
1932–33	159	1962	1 352
1933–34	213	1963	1 456
1934–35	190	1964	1 276
1935–36	108	1965	1 182
1936–37	103	1966	1 831
1937–38	85	1967	1 477
1938–39	89	1968	1 491
1939–40	71	1969	1 344
1940–41	76	1970	1 588
1941–42	62	1971	1 852
1942–43	57	1972	1 961
1943–44	75	1973	3 038
1944	69	1974	4 340
1945	124	1975	4 217
1946	244	1976	5 326
1947	251	1977	3 941
1948	215	1978	4 340
1949	277	1979	3 464
1950	318	1980	3 309
1951	364	1981	3 153
1952	361	1982	2 636
1953	1 124	1983	1 814
1954	1 093	1984	1 536
1955	1 202	1985	1 866
1956	1 163	1986	959
1957	1 472	1987	1 072
1958	1 128	1988	1 565
1959	1 114	1989	1 571
1960	1 202	1990	1 551

Notes:
1. The 1931–1943 years are April–March but from 1944 onwards are calendar years.
2. The ‘QMA totals’ are approximations derived from port landing subtotals, as follows: SNA 8 Paraparaumu to Hokianga.
3. Before 1946 the ‘QMA’ subtotals sum to less than the New Zealand total because data from the complete set of ports are not available.
4. Data up to 1985 are from fishing returns: data from 1986 to 1990 are from Quota Management Reports.
5. Data for the period 1931 to 1982 are based on reported landings by harbour and are likely to be underestimated as a result of under-reporting and discarding practices. Data include both foreign and domestic landings.

Table 2: Reported landings (t) of snapper from SNA 8 from 1983–84 to present and gazetted and actual TACCs (t) for 1986–87 to present. QMS data from 1986–present.

Fishstock	SNA 8	
FMAs	8, 9	
	Landings	TACC
1983–84†	1 725	–
1984–85†	1 546	–
1985–86†	1 828	–
1986–87	893	1 331
1987–88	1 401	1 383
1988–89	1 527	1 508
1989–90	1 551	1 594
1990–91	1 659	1 594
1991–92	1 459	1 594
1992–93	1 543	1 500
1993–94	1 542	1 500
1994–95	1 436	1 500
1995–96	1 558	1 500
1996–97	1 613	1 500
1997–98	1 589	1 500
1998–99	1 636	1 500
1999–00	1 604	1 500
2000–01	1 631	1 500
2001–02	1 577	1 500
2002–03	1 558	1 500
2003–04	1 667	1 500
2004–05	1 663	1 500
2005–06	1 434	1 300
2006–07	1 327	1 300
2007–08	1 304	1 300
2008–09	1 345	1 300
2009–10	1 280	1 300
2010–11	1 313	1 300
2011–12	1 360	1 300
2012–13	1 331	1 300
2013–14	1 275	1 300
2014–15	1 272	1 300
2015–16	1 328	1 300
2016–17	1 334	1 300
2017–18	1 288	1 300
2018–19	1 293	1 300
2019–20	1 347	1 300
2020–21	1 295	1 300
2021–22	1 720	1 600
2022–23	1 728	1 600

† FSU data. SNA 8 = Statistical Areas 037, 039–048.

In 1 October 2005 the TACC for SNA 8 was reduced to 1300 t within a TAC of 1785 t to ensure a faster rebuild of the stock. From 1 October 2021, the TACC for SNA 8 was increased to 1600 t with allowances for customary and recreational sectors and other sources of mortality (Table 3).

All commercial fisheries have a minimum legal size (MLS) for snapper of 25 cm.

Table 3: TACs, TACCs, and allowances (t) for SNA 8 as of 1 October 2023.

Fishstock	TAC	TACC	Customary allowance	Recreational allowance	Other mortality
SNA 8	3 065	1 600	100	1 205	160

Foreign fishing

Japanese catch records and observations made by New Zealand naval vessels indicate that significant quantities of snapper were taken from New Zealand waters by Japanese vessels from the late 1950s until 1977. There are insufficient data to quantify historical Japanese catch tonnages for the respective snapper stocks. However, trawl catches have been reported by area from 1967 to 1977, and longline catches from 1975 to 1977 (Table 4). These data were supplied to the Fisheries Research Division of MAF in the late 1970s; however, the data series is incomplete, particularly for longline catches.

Table 4: Reported landings (t) of snapper from 1967 to 1977 by Japanese trawl and longline fisheries.

Year	(a) Trawl	Trawl catch (all species)	Total snapper trawl catch	SNA 8
1967		3092	30	NA
1968		19 721	562	309
1969		25 997	1 289	929
1970		31 789	676	543
1971		42 212	522	403
1972		49 133	1 444	1 217
1973		45 601	616	466
1974		52 275	472	363
1975		55 288	922	735
1976		133 400	970	676
1977		214 900	856	708
Year	**(b) Longline**		**Total Snapper**	**SNA 8**
1975			1 510	749
1976			2 057	1 127
1977			2 208	1 104

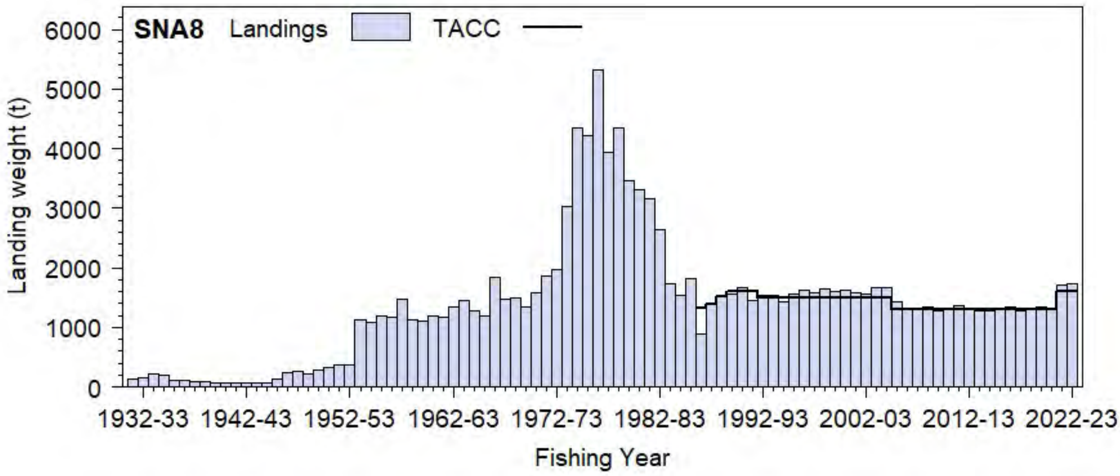


Figure 1: Total reported landings and TACC for SNA 8.

1.2 Recreational fisheries

The snapper fishery is the largest recreational fishery in New Zealand. It is the major target species on the northeast and northwest coasts of the North Island and is targeted seasonally around the rest of the North Island and the top of the South Island. The current allowance within the SNA 8 TAC is shown in Table 3.

1.2.1 Management controls

The two main methods used to manage recreational harvests of snapper are minimum legal size limits (MLS) and daily bag limits. Both have changed over time (Table 5). The number of hooks permitted on a recreational longline was reduced from 50 to 25 in 1995.

Table 5: Changes to minimum legal size limits (MLS) and daily bag limits used to manage recreational harvesting levels in SNA 8.

Stock	MLS	Bag limit	Introduced
SNA 8	25	30	1/01/1985
SNA 8 (FMA 9 only)	25	20	30/09/1993
SNA 8 (FMA 9 only)	27	15	1/10/1994
SNA 8	27	10	1/10/2005

1.2.2 Estimates of recreational harvest

A background to the estimation on recreational harvest of snapper is provided in the Introduction – Snapper chapter. Recreational harvest estimates for SNA 8 are provided in Table 6.

In 2005, the Snapper Working Group and Plenary considered recreational catches from SNA 8. Two alternative levels were assumed for the recreational catch from 1990 to 2004, either 300 t or 600 t. The Plenary considered that these values were likely to bracket the true average level of catch in this period. The estimate from the 2006–07 aerial overflight survey of the SNA 8 fishery (260 t) suggests that the assumed value of 300 t may have been the more plausible. There are potential sources of bias associated with the aerial-access estimate, both negative (a potential underestimation of the shore-based harvest, especially to the south) and positive (over-reporting of harvests by charter boat operators in a log book survey which are included in the estimate). The 2011–12, 2017–18 and 2022–23 national panel surveys provided plausible results and are considered to be broadly reliable. Web camera/ creel survey boat ramp monitoring in SNA 8 started in late 2011 and has found no general trend in fishing effort, but a gradual fluctuating increase in catch rates and hence harvest, since that time (up to 2021–22), consistent with the National Panel Survey. Preliminary examination of the 2022–23 data suggest a decline in that year, consistent with the reduced National Panel Survey estimate. No estimates of absolute catch have yet been developed from these ramp monitoring data.

Table 6: Recreational catch estimates for snapper stocks. Totals for a stock are given in bold. The telephone/diary surveys ran from December to November but are denoted by the January calendar year. Mean fish weights were obtained from boat ramp surveys (for the telephone/diary and panel survey catch estimates). Numbers and mean weights are not calculated in the tag ratio method. Amateur charter vessel (ACV) and recreational take from commercial vessels under s111 general approvals as reported, with Total the sum of NPS, ACV and s111. ACVs have only been required to report harvest for SNA since 2020–21.

			Harvest survey			ACV	s111	Total
Stock	**Year**	**Method**	**Number of fish (000s)**	**Harvest estimate (t)**	**CV**	**(t)**	**(t)**	**(t)**
SNA 8								
Total	1991	Tag ratio	–	**250**	–			
Total	1994	Telephone/diary	361	**238**	–			
Total	1996	Telephone/diary	271	**236**	–			
Total	2000	Telephone/diary	648	**661**	–			
Total	2001	Telephone/diary	1 111	**1 133**	–			
Total	2007	Aerial-access	–	**260**	**0.10**			
Total	2011–12	Panel survey	557	**630**	**0.16**	**3**	**9**	**641**
Total	2017–18	Panel survey	654	**830**	**0.13**	**16**	**6**	**853**
Total	2022–23	Panel survey	354	**543**	**0.12**	**157**	**2**	**702**

1.3 Customary non-commercial fisheries

Snapper form important fisheries for customary non-commercial, but the annual catch is not known. The information on Māori customary harvest under the provisions made for customary fishing is limited (Table 7). It is likely that Māori customary fishers utilise the provisions under recreational fishing regulations. Customary reporting varies within SNA 8. Large areas of SNA 8 are gazetted under the Fisheries (Kaimoana Customary Fishing) Regulations 1998 which require reporting on authorisations. In the areas not gazetted, customary fishing authorisations issued would be under the Fisheries (Amateur Fishing) Regulations 2013, where there is no requirement to report. The numbers reported in Table 7 may be underestimated.

Table 7: Customary approvals and reported harvest in SNA 8 from 2005–06 to present.

Year	Quantity approved (kg)	Reported actual quantity harvested (kg)	Number of authorisations issued
2005–06	250		4
2006–07	120	40	2
2007–08	130	30	2
2008–09	330	151	5
2009–10	4 747	3 046	14
2010–11	5 130	3 089	14
2011–12	3 800	2 633	16
2012–13	4 367	2 439	17
2013–14	12 825	4 514	30
2014–15	17 730	5 887	20
2015–16	14 388	6 553	31
2016–17	3 693	1 669	17
2017–18	770	534	11
2018–19	7 090	1 344	32
2019–20	15 500	2 422	34
2020–21	9 770	270	24
2021–22	2 460		7
2022–23	29 225		74

1.4 Illegal catch

No new information is available to estimate illegal catch. For modelling SNA 8 an assumption was made that non-reporting of catch was 20% of reported domestic commercial catch prior to 1986 and 10% of reported domestic commercial catch since the QMS was introduced. This was to account for all forms of under-reporting. These proportions were based on the black-market trade in snapper and higher levels of under-reporting (to avoid tax) that existed prior to the introduction of the QMS. The 10% under-reporting post-QMS accounts for the practice of ‘weighing light’ and the discarding of legal-size snapper.

1.5 Other sources of mortality

No estimates are available regarding the amount of other sources of mortality on snapper stocks; although high-grading of longline fish and discarding of under-sized fish by all methods occurs. An at-sea study of SNA 1 commercial longline fisheries in 1997 (McKenzie 2000) found that 6–10% of snapper caught by number were under 25 cm (MLS). Results from a holding net study indicate that mortality levels amongst lip-hooked snapper caught shallower than 35 m were low.

Estimates for incidental mortality were based on other catch-at-sea data using an age-length structure model for longline, trawl, seine, and recreational fisheries. In SNA 1, estimates of incidental mortality for the year 2000 from longlines were less than 3% and for trawl, seine, and recreational fisheries between 7% and 11% (Millar et al 2001). In SNA 8, estimates of trawl and recreational incidental mortality were lower, mainly because of low numbers of 2- and 3-year old fish estimated in 2000.

In SNA 1, recreational fishers release a high proportion of their snapper catch, most of which was less than 27 cm (recreational MLS). An at-sea study in 2006–07 recorded snapper release rates of 54.2% of the catch by trailer boat fishers and 60.1% of the catch on charter boats (Holdsworth & Boyd 2008). Incidental mortality estimated from condition at release was 2.7% to 8.2% of total catch by weight depending on assumptions used.

2. BIOLOGY

For further information on snapper biology refer to the Introduction – Snapper chapter. A summary of published estimates of biological parameters for SNA 8 is presented in Table 8.

Table 8: Estimates of biological parameters.

Fishstock	Estimate			Source
1. Instantaneous rate of natural mortality (*M*)				
SNA 1, 2, 7, & 8	0.075			Hilborn & Starr (in Langley 2020)
2. Weight = a(length)^b (Weight in g, length in cm fork length)				
All	a = 0.04467	b = 2.793		Paul (1976)
3. von Bertalanffy growth parameters				
	Both sexes combined			
	K	t_0	L_∞	
SNA 8 (1990s)	0.16	-0.11	66.7	Gilbert & Sullivan (1994)

3. STOCKS AND AREAS

New Zealand snapper are thought to comprise either seven or eight biological stocks based on: the location of spawning and nursery grounds; differences in growth rates, age structure, and recruitment strength; and the results of tagging studies. These stocks comprise three in SNA 1 (East Northland, Hauraki Gulf, and Bay of Plenty (BoP)), two in SNA 2 (one of which may be associated with the BoP stock), two in SNA 7 (Marlborough Sounds and Tasman Bay/Golden Bay) and one in SNA 8. Tagging studies reveal that limited mixing occurs between the three SNA 1 biological stocks, with greatest exchange between BoP and Hauraki Gulf.

Tagging studies in SNA 8 have shown considerable movements of fish between South Taranaki Bight and the area north of Cape Egmont. However, recent *Kaharoa* WCNI trawl surveys indicate some differences in the age structure of snapper between the two areas which may suggest a degree of spatial stratification of the SNA 8 stock.

Tagging studies in SNA 7 (1986/87) and SNA 8 (1990) revealed reciprocal movements of snapper between Tasman Bay/Golden Bay and South Taranaki Bight, although the scale of the movement was relatively low during that period.

Location-based snapper catch data from the trawl fisheries in SNA 7 and southern SNA 8 has revealed an overlap of the distribution of snapper catches in western approaches to Cook Strait between D'Urville Island and Kapiti Island, particularly since 2014–15. Snapper age compositions are available from recent (2018–2020 and 2022) *Kaharoa* trawl surveys of the South Taranaki Bight and the Tasman Bay/Golden Bay area of the WCSI trawl survey. There are strong differences in the relative strength of individual year classes from the 2019 South Taranaki Bight age composition compared to the 2018 and 2020 surveys, while the 2019 STB age composition was very similar to the age structures from the 2019 Tasman Bay/Golden Bay trawl survey and the commercial fishery in the TBGB area. These observations indicate a degree of mixing of the snapper populations between SNA 7 and the STB area (SNA 8), although the extent of mixing may vary between years, potentially related to variation in the timing of the main spawning period in each area.

The 2022 South Taranaki Bight (STB) trawl survey age composition was dominated by a very strong age 5 cohort , representing the 2017 year class. The 2017 year class was not present as a strong age 3 cohort in the previous (2020) survey, suggesting an immigration of snapper into the STB region. The 2017 year class appeared to be moderately strong in the age compositions from 2018, 2019 and 2020 surveys in the northern area of SNA 8 (at ages 1, 2 and 3 yr, respectively) but was not particularly strong in the 2022 survey age composition. The 2017 year class was observed to be very strong in

Tasman Bay and Golden Bay when surveyed in 2019, 2021 and 2023. This year class also represented the dominant age class in the 2022–23 age composition from the SNA 7 commercial fishery

The SNA 8 trawl fishery was sampled in 2022–23, partitioned between the areas north and south of Cape Egmont. The age composition of the commercial fishery in STB was similar to the age composition from the 2022 WCNI trawl survey, dominated by the 2017 year class at age 5. For all three fisheries (north of Egmont, STB and Tasman Bay/Golden Bay, there were broad similarities in the relative proportion of fish in the older (greater than 9 years) age classes. A comparison of the average length at age from the three areas revealed that initial growth rates were faster for fish sampled from Tasman Bay and Golden Bay, while growth rates were similar between STB and northern SNA 8 up to age 5 years. For older age classes, the average length at age diverged between STB and northern SNA 8, with average length at age for STB approximating Tasman Bay and Golden Bay from about 7 years of age.

4. STOCK ASSESSMENT

An assessment for SNA 8 was conducted in 2020 and finalised in 2021. The assessment was refined and updated in 2024.

4.1. Stock assessment model

The 2024 stock assessment of SNA 8 was conducted using an age-structured population model implemented in Stock Synthesis. There were two main changes to the assessement from the previous (2021) assessment: a) the model was initialised in 1975 under exploited conditions and b) recruitment deviates were not constrained to an average of zero (simple deviates rather than dev_vector). Initialising the model in 1975 reduced the influence of the catch from the pre QMS period when the annual catches are considered to be more uncertain. The initial (1975) population age structure was informed by the age composition data available from the trawl fisheries from the mid-late 1970s. The entire catch history (from 1931) was retained for a model sensitivity. A simulation study based on SNA 8 had shown that the parameterisation of annual recruitment via constrained deviates biased estimates of spawning biomass (current and reference) under conditions of increasing recruitments, as evident in SNA 8 (Marsh et al 2024). Recruitment parameterisation based on simple deviates provided unbiased estimates of spawning biomass.

The model incorporated data to the 2023–24 fishing year (2024 model year) including:

- Commercial catches by method, 1931–2024;
- Recreational catches, 1931–2024;
- Tag biomass estimates and population length compositions 1990, 2002;
- Estimates of numbers at age 2, 3, 4, and 5 year from *Kaharoa* inshore trawl surveys;
- Single trawl CPUE indices 1997–2023;
- Pair trawl CPUE indices 1974–1991;
- Single trawl catch age compositions (27 observations) 1975–2023;
- Pair trawl catch age compositions (18 observations) 1975–2006;
- Recreational catch length compositions; and
- Average length-at-age derived from otolith samples.

Commercial catches

Reported commercial catches from 1931–1990 were compiled by Gilbert & Sullivan (1994). These catches include estimates of reported foreign catches for 1968 to 1979 (Gilbert & Sullivan 1994). Annual commercial catches from 1986–87 to 2022–23 fishing years were available from catch reporting under the Quota Management System (Figure 2). The 2023–24 catch was assumed to be at the level of the TACC (with an additional allowance for unreported catch).

Previous snapper assessments have included an additional component of catch to account for unreported commercial catches (Davies et al 2006). Annual unreported catches were assumed to represent an additional 20% of the reported catch in the period prior to the introduction of the QMS and 10% of the reported catch in the subsequent years.

The commercial catch was dominated by two main fishing methods: single trawl and pair trawl. The pair trawl fishery developed in the mid-1970s and was the dominant method during 1976–1989 accounting for an average of 75% of the annual catch. The proportion of the catch taken by each trawl method during 1989–90 to 2023–24 was determined from the catch and effort data from the fisheries.

The compiled commercial catch history included estimates of foreign catch; i.e., trawl catches from 1967 to 1977 and longline catch from 1975 to 1977 were included at the reported levels (Davies 1999). However, catch reports from the Japanese longline fleet were not available for 1965–1974 (Davies et al 2006). Following previous assessments (e.g., Davies et al 2006), an additional catch of 2000 t per annum was assumed for the Japanese fleet for that period.

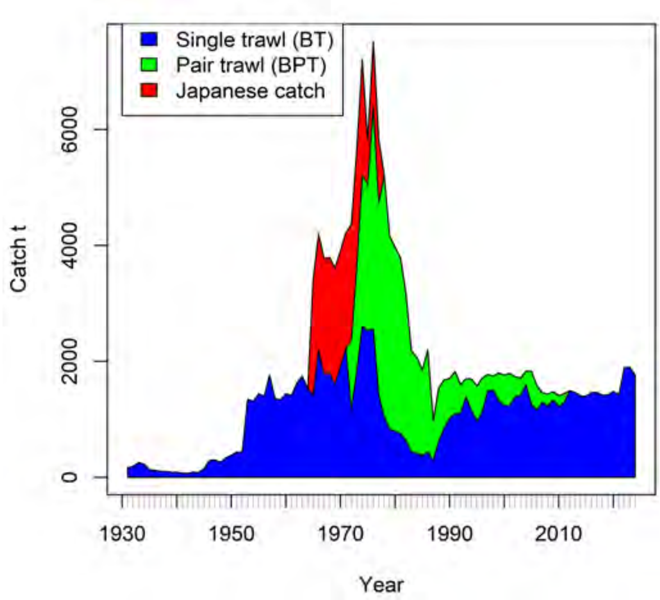


Figure 2: Annual commercial catches included in the SNA 8 assessment, assuming unreported Japanese longline catches of 2000 t. The base model was initialised in 1975 (i.e., excluded earlier catches).

Recreational catches

A time series of recreational catch for 1931–2024 was configured, informed by recreational catch estimates available from 1990 (Figure 3). There was no information available regarding earlier (pre-1990) levels of recreational catch. Previous assessments formulated annual catches for this period based on an assumed initial (1931) level of recreational catch of 60 t and a linear increase in catch over subsequent years to the level of the 1990 recreational catch estimate (239 t). Annual catches were assumed to remain at the same level during 1990–1996.

Recreational catches in 2007, 2012, 2018 and 2023 were assumed to be equivalent to the point estimates from the respective recreational surveys, assumed known without error. The scaled boat ramp survey estimates of recreational catch provided annual catch estimates for the years 2013 to 2022 (except 2018).

A preliminary catch history was configured that assumed that recreational catches increased linearly between each successive survey. The resultant catch history was incorporated in a preliminary configuration of the assessment model to generate a biomass trajectory that provided estimates of the exploitation rate for the recreational fishery corresponding to each survey estimate. The resultant estimates of exploitation rate were then used to iteratively regenerate the recreational catches in the years between the survey estimates (for 1997 to 2011). Exploitation rates were assumed to change linearly between successive surveys and the interpolated exploitation rate was applied to the annual biomass estimates to determine the recreational catches for the intervening years.

The recreational catch estimate for 2023 was considered to be an anomolously low value, presumably due to unfavourable weather conditions during 2022–23. Two alternative scenarios were assumed for the recreational catch in 2024 and for the projection period: a) based on the exploitation rate corresponding to the recreational catch estimate from 2018 (*RecF*) or b) a constant recreational catch of 1000 t, representing an intermediate level of catch between the *RecF* option and the 2023 recreational catch estimate.

Length composition data from the SNA 8 recreational fishery revealed that smaller fish were typically caught inside the west coast harbours (Hokianga, Kaipara, Manukau, Raglan, Kawhia) rather than the coastal area outside the harbours. On that basis, the annual recreational catches were partitioned into two fisheries based on these definitions, apportioned based on the recent distribution of catch (approximately 25% within harbours).

Customary Catch

There were no reliable estimates of annual customary catches from SNA 8 available for inclusion in the assessment model, although recent information indicated that the level of customary catch was relatively low (less than 6 t per annum, Table 7). A component of the customary catch was probably included within the time series of recreational catch estimates and no additional estimate for customary catch was included in the assessment model.

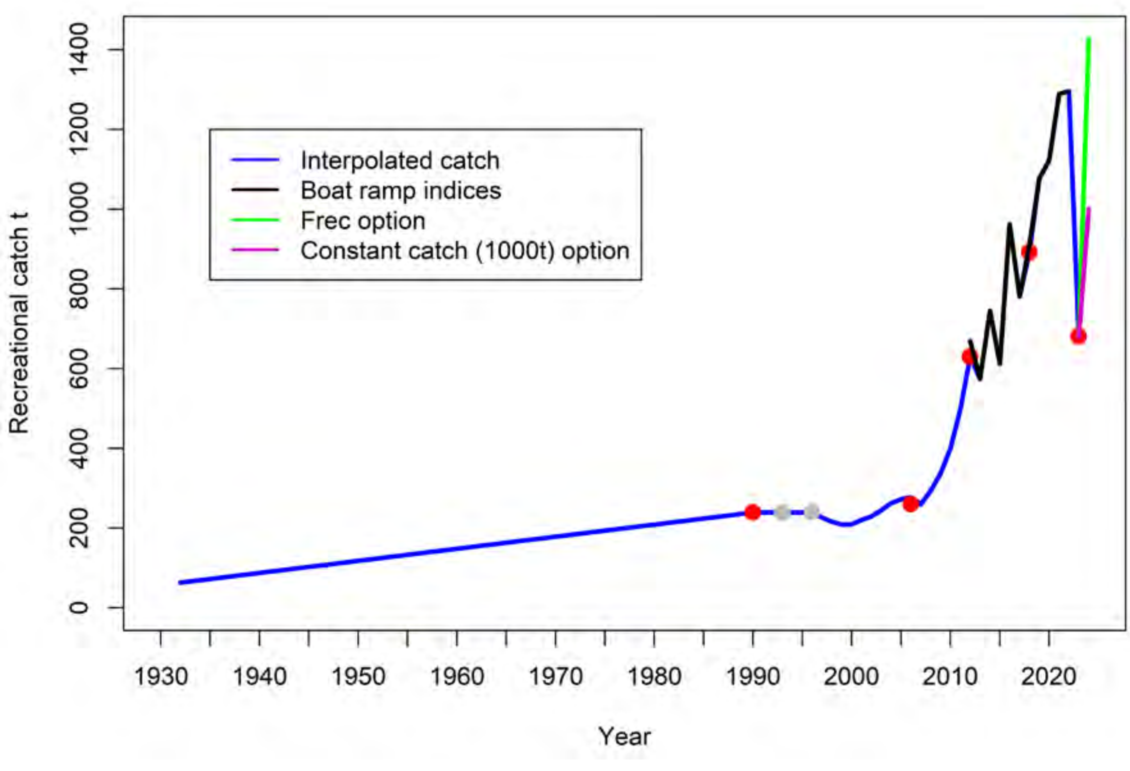


Figure 3: Recreational catch estimates from SNA 8 (red points) and boat ramp indices (black line) used in the derivation of the recreational catch history (blue line). Two alternative levels of catch were assumed for 2024: the green line represents the catch predicted assuming the recreational harvest rate from 2018, the purple line assumes a recreational catch of 1000 t. The grey points are additional recreational catch estimates from the 1993–94 and 1995–96 telephone diary surveys (presented for comparison only).

Tagging biomass

Two estimates of absolute biomass are available from tagging programmes conducted in 1990 and 2002. The current assessment used the equivalent biomass estimates included in a previous assessment; i.e., 1990, 9505 t (CV = 0.18) and 2002, 10 442 t (CV = 0.12) (Davies et al 2013). The biomass estimates were derived to represent all fish in the population 3 years and older, corresponding to fish above 25 cm fork length (FL).

The two tagging programmes also provided estimates of the population length composition for fish above 25 cm FL. The current assessment used the population proportions-at-length included in the previous assessment (Davies et al 2013). These length compositions represented fish aged 3 years and older and, accordingly, were truncated at a lower bound of 25 cm which approximates the lower length range of 3-year old fish.

Trawl survey indices

Trawl surveys of inshore finfish species, including snapper, off the west coast of the North Island were first conducted by RV *Kaharoa* in October–November 1986 and 1987. The spatial extent of these initial surveys was relatively limited and did not encompass the broader distribution of snapper. The survey area was extended for the subsequent series of trawl surveys that were conducted in 1989, 1991, 1994, 1996, and 1999 (Morrison and Stevenson 2001). The *Kaharoa* trawl surveys were reinstated in 2018 and additional surveys were conducted in 2019, 2020 and 2022 (Jones et al 2022; 2023; 2024).

Since 1989, all surveys have encompassed a core area (from Ninety Mile Beach to North Taranaki Bight extending to the 100 m depth contour) and applied a similar spatial stratification. The spatial domain of the core area was refined to account for the removal of the Māui dolphin trawl exclusion area which was not sampled by the 2018–2022 trawl surveys (Jones et al 2023).

The core area was applied to derive a comparable time series of survey biomass indices and scaled length compositions. The length compositions were converted to age compositions using an age-length key derived from otoliths collected from the core area of the survey.

The surveys were conducted at the beginning of the fishing year (October–November) and have been assigned to the corresponding model year following the calendar year of the survey. For example, the trawl survey in November 2018 was assigned to the 2019 model year (and denoted the 2018–19 survey). Correspondingly, the ages of the sampled fish were incremented to the age at 1 January following the survey (e.g., fish aged 1+ at the time of the survey were assigned an age of 2 years).

The five biomass indices from the earlier surveys were substantially lower than the biomass estimates from the three recent surveys, although there was also a considerable difference in the magnitude of these three recent indices (Figure 4). The corresponding age compositions from the surveys revealed that the earlier surveys were dominated by 2- to 5-year old fish. For the recent surveys, the age compositions comprised a higher proportion of fish older than 6 years, particularly for the 2019–20 and 2020–21 surveys.

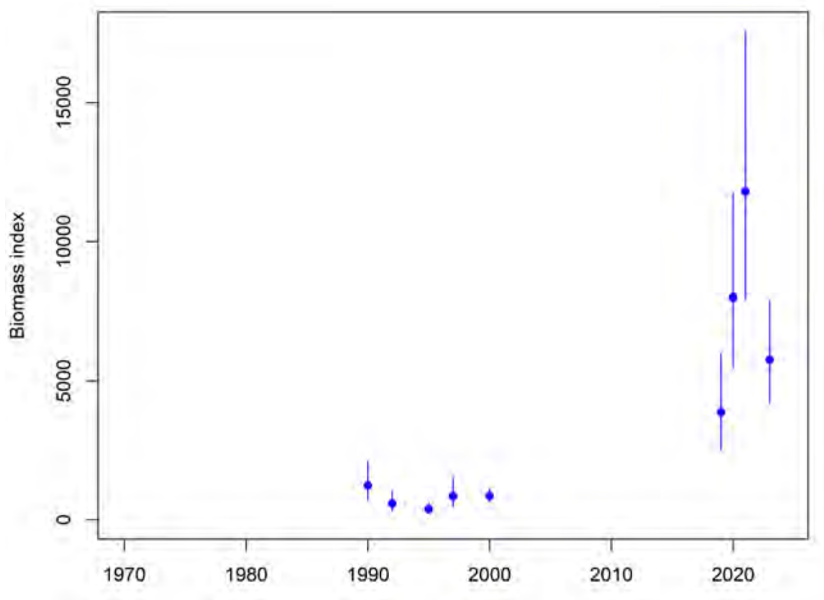


Figure 4: Snapper total biomass indices (and 95% confidence intervals) from the core area of the WCNI trawl survey area.

Most of the large increase in the biomass indices between the 2018–19 and 2019–20 trawl surveys was attributable to an increase in the abundance of fish surveyed in the 8- to 12-year old age range fish. The comparison of successive estimates of the individual year classes indicated that the catchability of these older fish was greater for the 2019–20 survey than for the 2018–19 survey. There was some concern regarding the timing of the 2018–19 trawl survey which was later than the other surveys in the series. The distribution of snapper catches and the gonadal maturation data suggested that the 2018–19 survey may have coincided with the main spawning period (Jones et al 2023). Consequently, a significant proportion of the adult biomass may have been concentrated in areas not adequately sampled by the survey, in particular the shallower areas in the vicinity of harbour entrances.

Similarly, there was a considerable increase in the snapper biomass indices between the 2019–20 and 2020–21 trawl surveys (Figure 4), including an increase in the abundance of older fish (> 10 years). Most of the increase in biomass was in the 50–100 m depth range in the vicinity of Kaipara Harbour and Manukau Harbour. This may indicate an expansion of the distribution of mature snapper, from the shallower areas not fully sampled by the current trawl survey, thereby increasing the overall availability of snapper to the trawl survey. The lower biomass estimate from the 2022–23 trawl survey was attributable to a considerably lower abundance of the fish in the year classes sampled in the two previous surveys at ages greater than 5 y (i.e., fish older than 7 y in 2020–2023). This indicated that the availability of mature fish to the 2022–23 trawl survey was considerably lower than for the 2019–20 and 2020–21 trawl surveys.

The survey age compositions were partitioned to derive estimates of numbers of fish in each age class. Survey estimates of 1-year old fish (0+) were relatively imprecise compared with estimates of numbers of fish in the older age classes. There were a limited number of year classes for which successive estimates of relative abundance (numbers of fish) were available from across a range of age classes from successive surveys. However, estimates of the numbers of 1-year old fish were generally substantially lower than subsequent estimates of the same year class at older ages and the individual estimates were poorly correlated. This indicated that the survey estimates of 1-year old fish probably did not provide a reliable index of the relative abundance of an individual year class. This was probably because a large proportion resided in shallow water and harbours, which were not surveyed.

In contrast, there was a reasonable correspondence between successive trawl survey estimates of the number of fish in a specific year class over the 2- to 5-year age classes (Figure 5). For example, the estimates of abundance of the 2016 year class from the three successive trawl surveys (at ages 3, 4, and 5 years) indicated that the year class was one of the strongest indices from the respective series. This suggested that the trawl surveys were consistently sampling fish within those age classes.

Commercial age compositions

There is a considerable time series of age compositions available from the single trawl (27 years) and pair trawl fisheries (18 years), including samples from the mid-late 1970s. These samples are characterised by a high proportion of fish in the oldest, aggregated age group (30+ ‘plus group’). Fish older than 30 years represented a trivial proportion of the sampled catch from 1990 onwards. The more recent age compositions tended to be dominated by relatively strong year classes that are evident in successive samples.

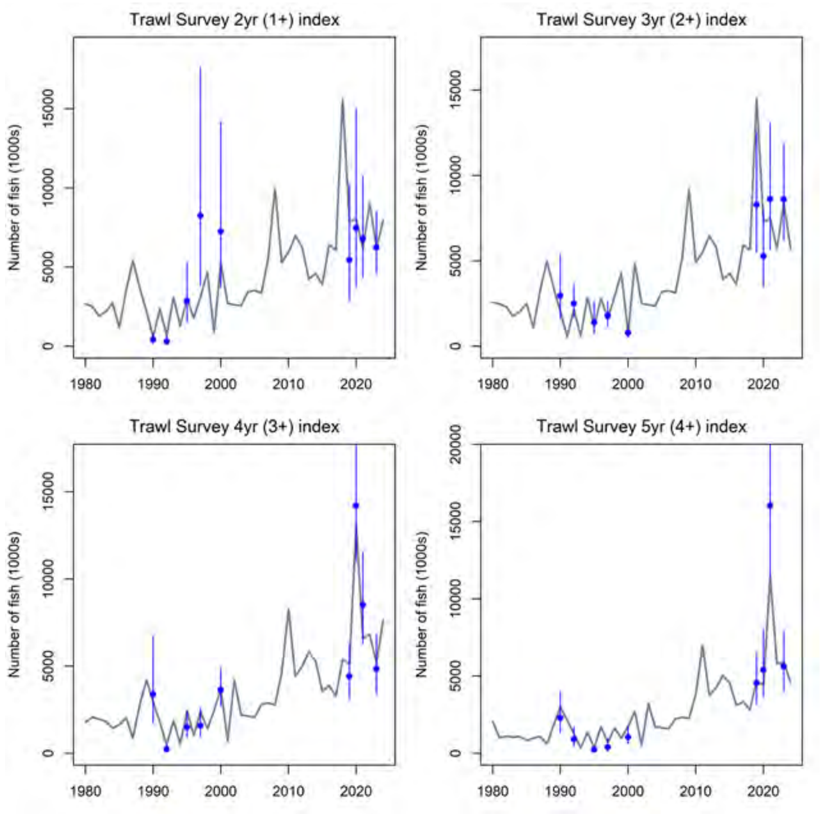


Figure 5: The four sets of age-specific trawl survey abundance indices (blue points and associated 95% confidence intervals) and the model fit to each set of indices (grey lines).

CPUE indices

Vignaux (1993) derived CPUE indices for the pair trawl fishery for 1974–1991 and these CPUE indices have been incorporated in the stock assessments of SNA 8 conducted since Gilbert & Sullivan (1994). The CPUE indices declined considerably during 1974–1986 and then recovered somewhat over the subsequent years (Figure 6). The CPUE indices have an associated CV of 0.13–0.30 (Vignaux 1993) and Davies et al (2013) assumed an additional process error of 0.20.

A standardised CPUE analysis of the SNA 8 single trawl fishery catch and effort data was updated, including data from 1996–97 to 2022–23 (following Langley 2017). The data set comprised individual trawl records (fishing event-based data) from trawls targeting snapper, trevally, and red gurnard during January–April. The annual CPUE indices were relatively constant during 1996–97 to 2006–07. The indices increased considerably over the subsequent years; the indices from 2018–19 to 2022–23 were 438% of the initial decade, although the recent indices were highly variable (Figure 6). In recent years, there had been a limited number of vessels operating in the inshore trawl fishery and the operation of the vessels had changed in response to the increase in the abundance of snapper (increased avoidance). It was considered that the standardised CPUE analysis had not adequately accounted for the changes in fleet configuration and fishing operation.

The trawl CPUE indices updated for this assessment had an associated CV of 0.12–0.18. From the results of preliminary modelling, the CPUE indices were assigned a process error of 0.1.

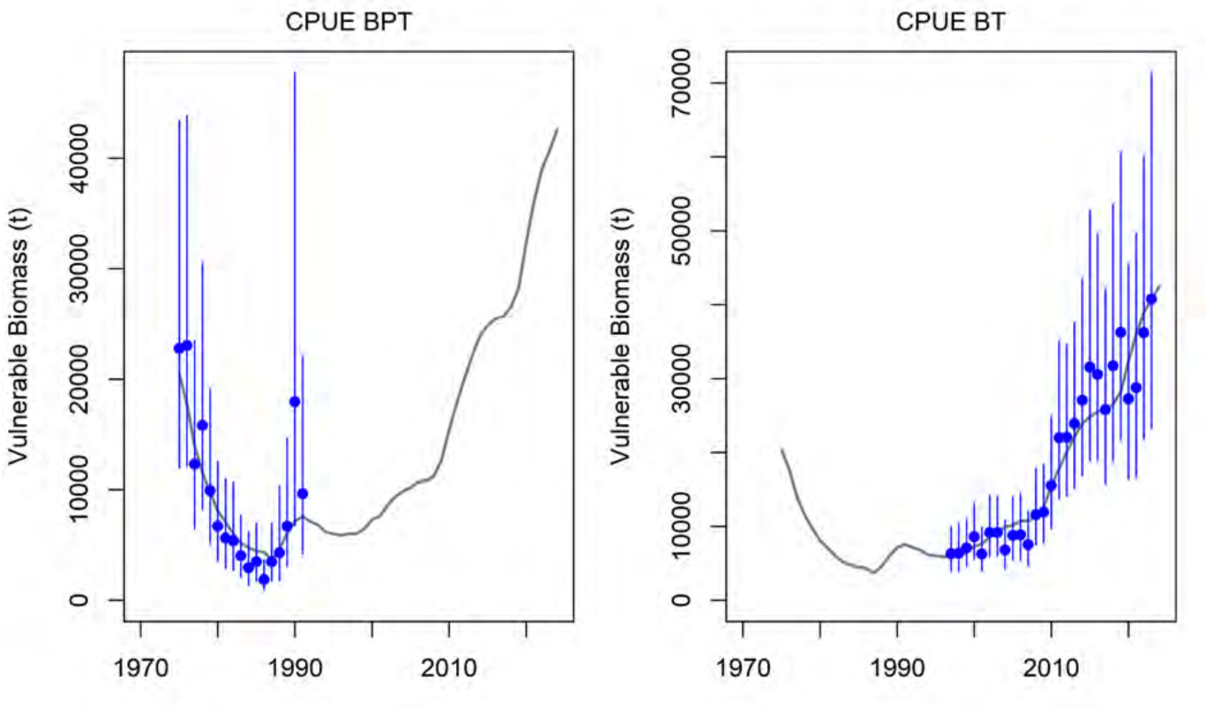


Figure 6: BPT CPUE indices (left) and BT CPUE indices (right). The grey line represents the model fit to the indices.

Model structure

The base assessment model initialised the population in 1975 under exploited conditions. The population structure included 30 age classes (both sexes combined), the oldest age class representing an aggregated 'plus' group (30 years and older). The model data period extended to the 2024 year (2023–24 fishing year). The initial age structure was derived by estimating an equilibrium fishing mortality rate and recruitment deviations for the initial age structure (1950–1974 year classes). An alternative model option (*start1931*) incorporated the entire SNA 8 catch history (from 1931) and assumed that the initial population age structure was in an equilibrium, unexploited state.

The key biological parameters for the SNA 8 stock assessment are presented in Table 9. Natural mortality (*M*) was specified as a constant value of 0.075 based on the analysis of Hilborn & Starr (given in Langley 2020).

There is no evidence of sexual dimorphism in snapper growth and the growth parameters have been determined for both sexes combined. There is a large data set of age-length observations from snapper sampled from the mid-1970s to recent years. These data indicated that the growth of snapper had varied over time characterised by three periods: slower growth rates of fish sampled during the 1970s, higher growth rates during the 1980s, 1990s, and early 2000s, and slower growth rates since the mid-2000s. Separate growth parameters (*k* and *Linf*) of the von Bertalanffy function were estimated for these three time blocks (1931–1979, 1980–2005, and 2006–2024) during the preliminary modelling phase. The model was informed by the time series of age-length data aggregated as annual mean length-at-age observations. The resultant growth parameters were fixed in the final set of model options (and the mean length-at-age observations were not included in the input data sets). The estimated growth parameters were very similar for the early and recent periods, and the growth parameters for the intervening period were comparable with the published growth parameters derived from the same period.

The parameterisation of growth in Stock Synthesis constrains annual growth increments to be greater than or equal to zero. Thus, the decline in growth rates between 2005 and 2006 resulted in a transition in the growth of individual cohorts with the length of the older cohorts remaining constant for several years.

Maturity was assumed to be length based and was informed by gonad staging data from the WCNI trawl surveys (1994, 1996, 1999, 2018 and 2019)[1]. The maturity ogive was parameterised with a logistic function with 50% maturity at 35 cm (5% at 26 cm, 95% at 44 cm). This corresponded to onset of maturity from about 3 years and full maturity at about 7 years.

Table 9: Biological parameters and priors for the interim base case model.

Component	Parameters	Value, Priors	
Biology	*M*	0.075	Fixed
	VB Growth	*Len1* = 13.1 cm	Fixed
	1931–1979	*k* = 0.146, *Linf* = 54.5 cm	Fixed
	1980–2005	*k* = 0.112, *Linf* = 69.6 cm	Fixed
	2006–2021	*k* = 0.150, *Linf* = 54.4 cm	Fixed
	CV length-at-age	0.08	Fixed
	Length-wt	*a* = 4.467e-5, *b* = 2.793	Fixed
	Maturity at length (logistic)	L50% = 35 cm, L5% 26 cm, L95% 44 cm	Fixed
Recruitment	LnR_0		Estimated (1)
	B-H SRR steepness *h*	0.95	Fixed
	SigmaR σR	0.6	Fixed
	Recruitment deviates	Initialising period (1950–1974)	Estimated (25)
		Main period (1975–2021)	Estimated (47)

The model was structured with an annual time step comprising two seasons (October–January and February–September). The seasonal structure partitioned the main spawning period and commercial catch (season 1). Spawning was assumed to occur instantaneously at the start of the year and recruitment was a function of the spawning biomass at the start of the year. A Beverton-Holt spawning stock-recruitment relationship (SRR) was assumed with a fixed value of steepness (*h*). The main recruitment deviates (1975–2021) from the SRR were estimated assuming a standard deviation of the natural logarithm of recruitment (σ_R) of 0.6. There was no averaging constraint applied to the recruitment deviates (i.e. estimated as simple independent deviates). Additional recruitment deviates (1950–1974) were estimated to initialise the age structure in 1975.

The base model assumed a high value of steepness (0.95). Initially, the high value was adopted to ensure stability in the MCMC sampling; a lower value of steepness (0.85) resulted in a significant proportion of samples crashing during the 2000s due to very low recruitments predicted from the low stock biomass and the assumed SRR. This issue was resolved when recruitments were estimated as simple independent deviates. However, there was no information to support the lower value of steepness; the very high recruitments occurred in the mid 2000s when the stock was at a very low level (aproximately 10% SB_0). Nonetheless, the lower value of steepness (0.85) was retained for a model sensitivity.

The model was configured to encompass three commercial fisheries: single trawl (BT), pair trawl (BPT), and Japanese longline. In addition, there were two recreational fisheries (inside and outside harbours). Age composition data are available from the single trawl fishery (27 observations) and the pair trawl fishery (18 observations). For all age compositions, no error was assumed to be associated with the age determination.

A comparison between the age compositions from the single and pair trawl fisheries revealed no appreciable difference in the age structure of the catch from the two methods. A common age-specific selectivity function was assumed for the two fisheries, and the associated sets of CPUE indices parameterised using a flexible, double normal selectivity function enabling the estimation of the age

[1] The 2020 WCNI survey was not included because its timing potentially excluded part of the population which was spawning in unsurveyed area; the 2022 WCNI survey data were not available when this analysis was conducted.

of peak selectivity, the widths of the ascending and descending limbs, and the selectivity of the terminal (oldest) age class.

There were no data from the Japanese longline fishery and the level of catch was assumed. The selectivity function for the fishery was defined to approximate the selectivity of a generalised snapper longline fishery with a knife-edge selectivity at age 5 years and full selection of the older age classes.

The two recreational fisheries were characterised by differences in length composition. The length composition data were included in a preliminary model option and the selectivity of each fishery was estimated using a length-based, double normal selectivity function. The resultant estimate of selectivity for the harbour fishery was tightly constrained around a mode of 28–32 cm, whereas the recreational fishery outside the harbours was estimated to have a broader selectivity for larger fish. The selectivity parameters were fixed in the final model options and the recreational fishery length frequency observations were excluded from the estimation procedure.

The tagging biomass estimates and associated population length observations were derived for all fish aged 3 years and older (Davies et al 2006). Accordingly, an age-specific, knife-edged selectivity function was assumed with an associated catchability of 1.0.

The WCNI trawl survey data were reconfigured to determine estimates of the relative abundance of the individual age classes which appear to be consistently sampled by the trawl survey; i.e., fish aged 2 (1+), 3 (2+), 4 (3+), and 5 (4+) years. Thus, four separate sets of indices were derived from the trawl survey data, expressed as the number of fish at age from each survey (with an associated coefficient of variation). The indices were incorporated in the model with a corresponding age-specific selectivity and separate catchability coefficients. The abundance indices and age compositions used in the model are summarised in Table 10. Estimated parameters and structural assumptions are summarised in Table 11.

The initialising equilibrium fishing mortality was estimated assuming an age-based selectivity equivalent to the BPT and BT selectivity function. Fishing mortality was modelled using a hybrid method that calculates the harvest rate using Pope’s approximation and then converted to an approximation of the corresponding fishery specific *F*. The timing of the fisheries and CPUE indices within the year were specified so that annual catches were taken instantaneously halfway through the first season (October–January). This was generally consistent with the period of the main commercial catch.

Table 10: Summary of input data sets for the Base Case assessment model. The relative weighting includes the Effective Sample Size (ESS) of age/size composition data and the coefficient of variation (CV) associated with the abundance data.

Data set	Model years	Nobs	Error structure	Observation error/ESS	Process error
			Lognormal		
Tag biomass	1990, 2002	2	Lognormal	0.18, 0.12	–
BT CPUE indices	1997–2023	26	Lognormal	0.12–0.18	0.1
BPT CPUE indices	1974–1991	18	Lognormal	0.12–0.30	0.2
Trawl survey age 2yr	1990, 1992, 1995, 1997, 2000, 2019, 2020, 2021, 2023	8	Lognormal	0.16–0.39	–
Trawl survey age 3yr	1990, 1992, 1995, 1997, 2000, 2019, 2020, 2021, 2023	8	Lognormal	0.16–0.32	–
Trawl survey age 4yr	1990, 1992, 1995, 1997, 2000, 2019, 2020, 2021, 2023	8	Lognormal	0.12–0.38	–
Trawl survey age 5yr	1990, 1992, 1995, 1997, 2000, 2019, 2020, 2021, 2023	8	Lognormal	0.18–0.45	–
BT age comp	1975, 1976, 1990–2010, 2013, 2016, 2019, 2023	29	Multinomial	ESS 6–35	
BPT age comp	1975, 1976, 1978–1980, 1986, 1987, 1989–1992, 2000–2006	18	Multinomial	ESS 10–36	
Tag length comp	1990, 2002	2	Multinomial	ESS 10	

Table 11: Estimated parameters and structural assumptions for the interim base model.

Parameter	Number of parameters	Parameterisation, priors, constraints
LnR_0	1	Uniform, uninformative
Main Rec devs (1975–2021)	47	SigmaR 0.6, simple deviates
Initial Rec devs (1950–1974)	25	SigmaR 0.6
Initial equilibrium *F*	1	Uniform, uninformative
Selectivity BPT and BT commercial	4	Double normal
Selectivity JP	–	Knife edged 5 yr
Selectivity trawl survey age indices	–	Fixed, age specific (4)
Catchability trawl survey age indices	4	Uniform, uninformative
Selectivity tag	–	Knife edged 3 yr
Selectivity Recreational (2)	–	Fixed
CPUE *q*	2	Uniform, uninformative

The main data inputs were assigned relative weightings based on the approach of Francis (2011). The two sets of trawl CPUE indices (BPT and BT) were assumed to have a lognormal distribution with observation error specified as the standard error of the individual CPUE indices. Based on initial model fits the indices were assigned an additional process error of 0.1 for the BT CPUE indices and 0.2 for the BPT CPUE indices. The tagging biomass indices and age-specific trawl survey indices were assigned the native coefficient of variation from each index with no additional process error. For the two sets of fisheries age compositions, the individual age compositions were each assigned an Effective Sample Size approximating the value derived from Method TA1.8 of Francis (2011).

Model uncertainty was determined using Markov chain Monte Carlo (MCMC) implemented using the Metropolis-Hastings algorithm. For each model option, 1000 MCMC samples were drawn at 1000 intervals from a chain of 1.1 million following an initial burn-in of 100 000. The performance of the MCMC sample was evaluated using a range of diagnostics.

Previous assessments determined stock status relative to the equilibrium, unexploited spawning (mature) biomass of female fish (SB_0) with current biomass defined as the biomass in the terminal year of the model ($SB_{CURRENT}$ or SB_{2024}).

However, recruitment to the SNA 8 stock was estimated to have been substantially higher during 2005–2021 compared to the preceding period (1975–2004). Consequently, estimates of SB_0 (derived from long term average recruitment) were not considered to represent a reliable measure of the overall productivity of the stock under recent levels of recruitment. Estimates of current stock biomass were considered to be more reliable in absolute terms (rather than relative to SB_0), indicating that a fishing mortality based management target would be appropriate. Current levels of fishing mortality were reported relative to the level of fishing mortality that resulted in $SB_{40\%}$ under equilibrium conditions (i.e., $F_{SB40\%}$). The reference level of age specific fishing mortality was determined from the composite age-specific fishing mortality from the last year of the model data period (2023–24). Estimates of equilibrium yield were determined from the level of fishing mortality that produced the target biomass level ($F_{SB40\%}$), which was equivalent to an exploitation rate of 4.8%.

Results

The model provided a coherent fit to all the main datasets. The trend in stock biomass was consistent with previous stock assessments (Davies et al 2013, Langley 2020, Langley 2021); i.e., the stock was estimated to have been heavily exploited in the early model years due to the high catches in the 1960s and early 1970s. Fishing mortality rates remained high during the late 1970s and early 1980s and the stock biomass reached a nadir in 1987 at about 7% of the current (2023–24) biomass level. The spawning biomass increased slightly in the late 1980s, following the recruitment of the strong 1985 and 1986 year classes, and then remained at a relatively low level throughout the 1990s. The more recent data sets, specifically the recent CPUE indices and age compositions, provided a coherent signal that stock abundance had increased considerably since 2010, primarily due to an increase in recruitment from the mid-2000s.

Annual recruitments were generally below average during the 1970s, 1980s and 1990s (Figure 7). Relatively large recruitments were estimated during the mid-2000s when the stock biomass was still at a low level. Recruitment was well above average during 2005–2021, with exceptionally high recruitments estimated for 2006, 2016–2018 and 2020. These estimates of recent recruitment were informed by the age-specific trawl survey indices.

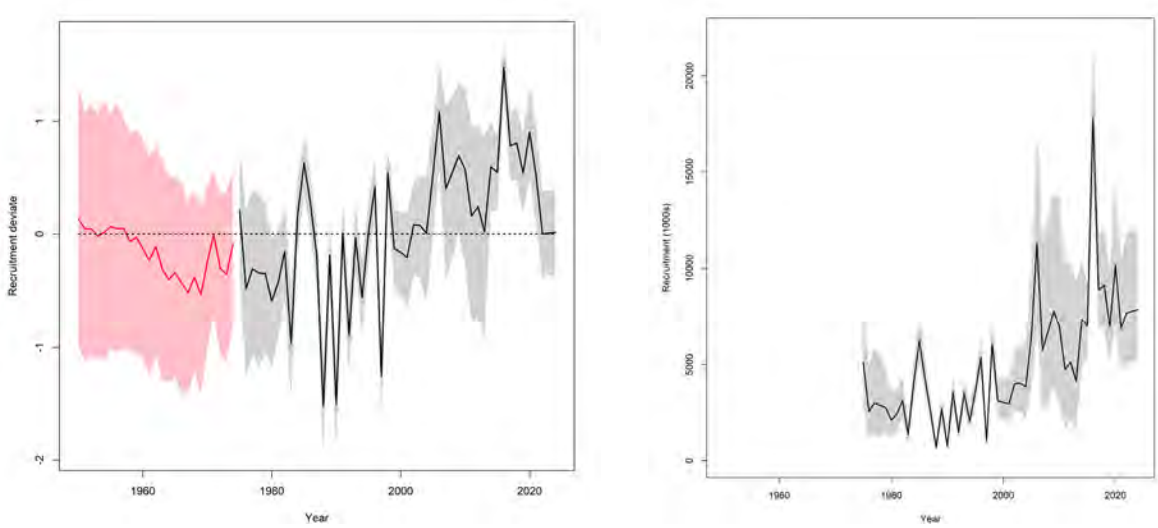


Figure 7: Estimates of annual recruitment deviates (left) and recruitment (numbers of fish, thousands) (right) from the Base Case model (MCMCs). The black line represents the median of the MCMC estimates and the shaded area represents the 95% credibility interval. Recruitment deviates for the initialisation period (1950-1974) are presented in red.

Spawning biomass increased by about 400% from 2009–10 to 2023–24 There was a corresponding decline in fishing mortality over the last 15 years and current (2024) fishing mortality was estimated to approximate the rate that equates to the target biomass level (under equilibrium conditions i.e., $F_{SB40\%}$ or U = 4.8%) (Table 12). The current level of spawning biomass was approximately 50% higher than the biomass in 1975 (the period of peak catch from the fishery).

Sensitivities

A number of key assumptions of the model were investigated as (single change) sensitivities to the Base Case model (Table 12).

The sensitivities investigated the influence of key stock productivity parameters, specifically a lower value of natural mortality of 0.06 (*LowM*), a higher variability (sigmaR 1.1) in the deviations of recruitment deviations (*SigmaR11*), recruitment deviations constrained to zero (*RecruitDev*) and a lower value of steepness (0.85) of the SRR (*Steep085*). The influence of key data sets was also investigated. The trawl CPUE indices from the last five years (2019–2023) were excluded due to concerns regarding the reliability of the indices (*CPUEex5yr*). The selectivity of the commercial fisheries was alternatively configured to fully select the older age classes (*BPTBTlogistic*). The sensitivity of the stock affinity of snapper in the southern portion of SNA 8 was examined by excluding the FMA 8 (STB) commercial catch (*FMA8exclude*). In addition, the base case model was compared to a full catch history model (*start1931*) with simple recruitment deviates estimated from 1950 and a steepness parameter of 0.95.

The model sensitivities yielded estimates of current biomass that are similar to the Base Case, although current (2024) biomass was estimated to be higher for the *SigmaR11* model and lower for the *BTBPTselect* option. The reference fishing mortality rate ($F_{SB40\%}$) was very similar for all model options, with the exception that $F_{SB40\%}$ was slightly lower for the *LowM* and *Steepness85* options. Current levels of fishing mortality approximated the reference level and potential current yields (at $F_{SB40\%}$) were estimated at 3000–4500 t (for 2023–24).

Table 12: Estimates of current (2024 = FY 2023–24) spawning biomass (t) (median and the 95% confidence interval from the MCMCs) and probability of fishing mortality being below the level of fishing mortality associated with the interim target biomass level. The potential yield in 2024 was derived by applying the $F_{SB40\%}$ fishing mortality rate to the current (2024) biomass.

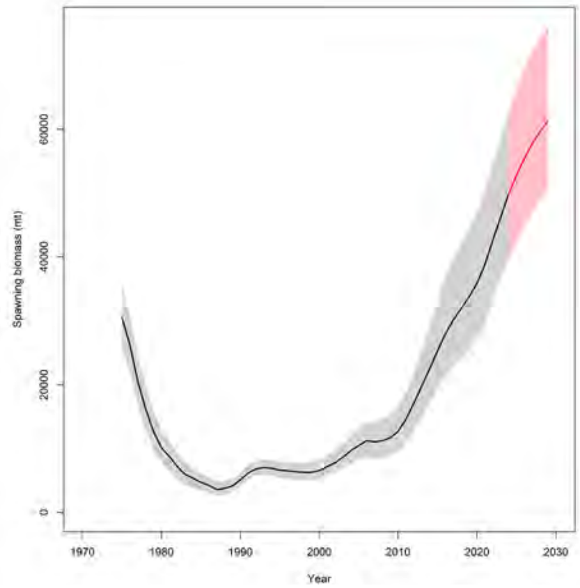
Model	*SB2024*	Ftarget	F2024/Ftarget	Pr(F2024 < Ftarget)	CurrentYieldF40%
Base	49 830	0.0494	0.999	0.508	3 667
	(39 807–62 665)		(0.814–1.204)		(3 043–4 444)
BTBPTselect	40 719	0.0535	1.091	0.190	3 149
	(32 688–50 953)		(0.897–1.317)		(2 614–3 847)
CPUEex5yr	50 818	0.0495	0.98	0.560	3 746
	(38 720–64 827)		(0.800–1.246)		(2 996–4 496)
FMA8exclude	48 932	0.0493	0.99	0.538	3 578
	(38 653–62 240)		(0.805–1.222)		(2 949–4 389)
LowM	53 222	0.0413	1.142	0.119	3 383
	(41 179–68 136)		(0.918–1.435)		(2 705–4 117)
RecDevVector	50 270	0.0494	0.992	0.525	3 688
	(37 002–64 943)		(0.797–1.279)		(2 920–4 521)
SigmaR11	55 184	0.0492	0.911	0.784	4 015
	(41 835–72 683)		(0.717–1.153)		(3 242–5 001)
Steepness85	52 802	0.0461	1.006	0.471	3 674
	(41 374–67 945)		(0.805–1.253)		(2 967–4 505)
start1931	49 491	0.0496	1.008	0.464	3 625
	(38 202–62 104)		(0.824–1.252)		(2 964–4 413)

Projections

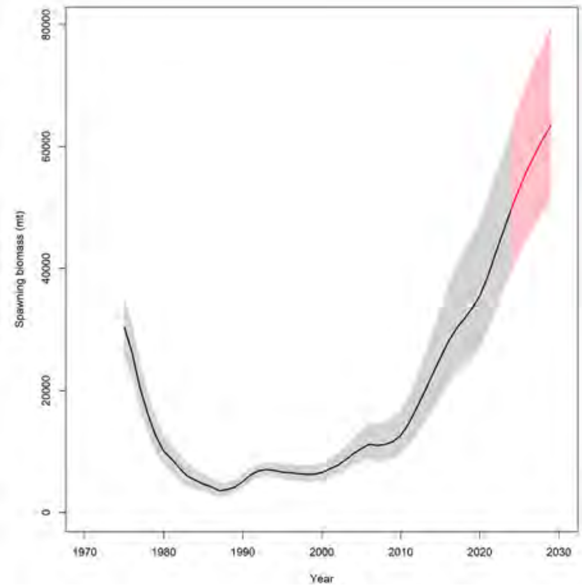
Five-year stock projections (to the 2028–29 fishing year) were conducted using the Base Case model assuming a status quo commercial catch; i.e., the current TACC of 1600 t and an allowance of 10% for unreported catches (total 1760 t). Three options were assumed for the recreational catch consistent with the assumptions regarding recreational catch in 2024: recreational fishery mortality rate at the average from 2014–2023 (*RecF*) or a constant catch of 1000 t/y (*RecCatch*), and also a constant catch set at the level of the recreational allowance of 1205 t/y (*RecAllow*).

Annual recruitment deviates for the 5-year projection period were resampled from the recent (2011–2020) average level with the standard deviation equivalent in sigmaR (0.6). The average level of estimated recruitment in the recent period was considerably higher (~87% higher) than the long-term average level of recruitment. Note that recruitment for the first 3 years of the 5 year projection period was informed by the trawl survey estimates of abundance for 1–4 year old fish.

The projections indicated that the stock biomass was expected to increase, and fishing mortality would decrease, during the 5-year projection period due, in part, to the contribution of the recent high recruitment from the 2016 to 2021 year classes. At current levels of catch, the biomass at the end of the period (2028–2029) was projected to be 23% or 27% higher than current (2023–24) biomass respectively under the two recreational catch scenarios (Figure 8, Table 13).



Project *Frec*



Project *RecCatch*

Figure 8: Annual spawning biomass estimated from the Base Case model (black) and the five-year projection (red) assuming two options for the 2024 recreational catch and the recreational catch in the projection period: the *RecF* model assumes current commercial catch and a constant harvest rate for the recreational fishery and the *RecCatch* option assumes a constant catch of 1000 t. The solid line represents the median of the MCMCs and the shaded area represents the 95% confidence interval. The horizontal dashed line represents the default target biomass level.

Table 13: Projected spawning biomass relative to current biomass (and 95% confidence interval) and the probability of the fishing mortality being below the interim target level ($F_{SB40\%}$.) in 2029 (fishing year 2028–29) for the base case based on three assumptions for recreational catch: the *RecF* model assumes current commercial catch and a constant harvest rate for the recreational fishery, the *RecAllow* model assumes a constant catch of 1205 t, and the *RecCatch* option assumes a constant catch of 1000 t.

Model	**Catch (t)**	**SB_{2029}/SB_{2024}**	**Pr ($F_{2029} < FSB40\%$)**
RecF	1 760 + Rec (Rec ~ 1 465)	1.23 (1.14–1.34)	0.99
RecAllow	2 965 (1 760 + 1 205)	1.24 (1.15–1.36)	0.99
RecCatch	2760 (1760+1 000)	1.27 (1.18–1.39)	1.00

Qualifying comments

For the current assessment, recent trends in stock abundance were strongly informed by the recent CPUE indices from the trawl fishery. The overall trend in these indices was generally consistent with other recent observations from the fisheries. However, it was apparent that the operation of the commercial fisheries has changed considerably in response to the increase in the abundance of snapper over the last decade. These changes were unlikely to have been fully accounted for in the derivation of the standardised CPUE indices. Since these changes in the commercial fishery have been largely directed at reducing the bycatch of snapper while targeting other commercial species due to quota scarcity, this may have led to a CPUE series that was biased low.

Since 1989–90, the area north of Cape Egmont has accounted for 90–95% of the SNA 8 commercial catch. Most observational data included in the model were also derived from the northern area of the fisheries including the CPUE indices, trawl survey indices, and the commercial age composition data. Consequently, the dynamics of the assessment model will be strongly influenced by the data from the northern area of the fisheries.

Prior to the mid-1980s, the southern area of the fisheries accounted for approximately 30% of the commercial catch. The 2002 tagging programme estimated that 21% of the SNA 8 biomass resided in the southern area (Gilbert et al 2005) and while most movements of tagged fish were relatively limited, there were northward movements of tagged fish from the South Taranaki Bight and reciprocal movements of fish from the areas north of Cape Egmont.

Previously, similar patterns in the age structure of snapper from South Taranaki Bight and northern areas of the SNA 8 fisheries were apparent from commercial catch-at-age data (Walsh et al 2006b). However, the results of the recent *Kaharoa* trawl surveys and catch sampling have identified some differences in the age structure of the snapper population between the two areas, including differences in the relative strength of individual year classes. There are some similiarities in the age compositions of snapper recently sampled from the South Taranaki Bight and Tasman Bay/Golden Bay from both *Kaharoa* trawl surveys and the commercial fishery. Snapper from the South Taranaki Bight also grow significantly faster than those found further north, but not as fast as those from SNA 7. This may indicate some degree of spatial structure in the SNA 8 population and possible linkages between the southern area of SNA 8 and the SNA 7 (Tasman Bay/Golden Bay) stock.

Productivity of the SNA 8 stock appeared to have varied considerably over the history of the fisheries, with variable levels of recruitment and variation in growth rates (that appeared to be related to stock abundance). Recent recruitment was estimated to be at an historically high level, suggesting that the stock was currently in a phase of higher productivity and that there was a degree of non-stationarity in the assumed nature of the relationship between spawning biomass and recruitment that violated the assumption of equilibrium conditions. Further consideration is required to develop stock status indicators that accounted for variation in the productivity of the SNA 8 stock.

The higher potential yields estimated for the stock are attributable to the higher recruitment estimated for the recent period (10–15 years). These recruitments have the potential to support higher catches over the short term (5 years), although future catch levels would need to be determined based on ongoing monitoring and assessment.

Derivation of Reference Points

Substantial increases in annual recruitment suggested an increase in productivity, and possibly a regime shift, for SNA 8. Owing to the complexities associated with estimating SB_0 under these circumstances, the Inshore Working Group made the decision to base the target reference point on exploitation rate instead of biomass as a proportion of SB_0. Consistent with international best practice the hard and soft limits were based on absolute biomass.

The default target accepted for SNA 8 was the exploition rate that, if applied perfectly over the long term and assuming equilibrium recruitment, would produce a spawning biomass of 40% of that in the absence of fishing ($F_{SB40\%}$; U=4.8%).

The hard limit was selected as the average spawning biomass estimated for the period 1992 to 2000. This was a relatively stable period that was close to the default Harvest Strategy Standard hard limit of 10% SB_0 when estimated in previous assessments, particularly the 2005 assessment (Davies et al 2013), which did not include the period of increased productivity. This period was preceeded by a period of very high catch from which it took the stock a long time to rebuild, possibly due to impaired recruitment. The soft limit was assumed to be twice the biomass of the hard limit.

Future research considerations

Abundance indices

Trawl surveys: The variability in the catchability of adult snapper in the recent west coast North Island (WCNI) trawl surveys has limited the utility of the trawl surveys to monitor the overall magnitude of the increase in the abundance of snapper. The limitations of the trawl survey are partly attributable to variability in the timing of the survey relative to the main spawning period and the restriction from sampling within the Māui dolphin trawl exclusion zone. Further, the distribution of snapper appears to have expanded (into deeper water) as the abundance of snapper has increased over recent years. A longer time series of trawl surveys may enable a more thorough evaluation of the factors influencing the variability in catchability of adults (> 5 y) and, thereby, increase the utility of the trawl surveys to monitor stock abundance. In the interim, subsequent trawl surveys would continue to provide additional estimates of the abundance of recent year classes (surveyed as 2- to 5-year old fish).

A change should be considered in the timing of the survey to coincide with the survey off the WCSI and jointly monitor snapper in both SNA 7 and SNA 8 during the summer period when the availability of snapper may be less variable. The South Taranaki Bight area could be included with the WCSI trawl survey.

Investigate alternative methods for sampling abundance of fish within the dolphin areas.

CPUE indices: The trawl CPUE indices represent an important index of abundance within the current assessment model. However, there have been considerable recent changes in the operation of the inshore trawl fishery to minimise snapper catches. These changes in fishing operation are not fully accounted for in the standardised CPUE analysis and, consequently, the CPUE indices are likely to underestimate the extent of the increase in snapper abundance, especially in recent (5–10) years. This limits the utility of the CPUE indices to monitor current and future trends in stock abundance. Investigate splitting the vessels with long time series into two or more pseudo vessels.

Changes in fishing behaviour: A project to document past and ongoing changes in gear and fishing behaviour should also be undertaken to help interpret CPUE data. This should be considered as two phases: (i) developing ongoing relationships with fishers, and (ii) working together to ensure relevant information is identified and provided. Note that this is generic across snapper and other fisheries.

Given the possible breakdown of the bottom trawl CPUE series in recent years, and difficulties encountered with including the estimates of adult biomass from the trawl survey in the stock assessment, a review of future monitoring of SNA 8 biomass is recommended.

Other methods for developing abundance indices: Such a review should also consider other potential methods for monitoring abundance such as another traditional mark-recapture experiment (in association with SNA 7) or a genetics-based estimate of stock size.

Stock structure and biological parameters

Stock structure: Age compositions from recent inshore trawl surveys should be examined to further investigate stock relationships between SNA 8 and SNA 7 and the spatial structure of the snapper population within sub areas of SNA 8.

Extend whole genome sequencing analysis by including additional samples to resolve stock relationships between SNA 1 and SNA 8, and SNA 8 and SNA 7.

Biological parameters: Further refinement to the maturity ogive should be made, incorporating the entire time series of trawl surveys in the analysis, and weighting according to biomass in each stratum. Estimates of several other biological parameters also rely on old analyses and should also be revisited and revised if necessary. In particular, estimates of growth by eras should be evaluated.

Catch and age

Catch sampling: The current assessment highlights the utility of regular (currently two years in five) sampling of the age composition of the commercial catch, particularly to provide information regarding the relative strength of recruited year classes. The current assessment estimates an exceptionally strong 2016 year class based on observations of the year class from the three recent trawl surveys (at ages 3, 4, and 5 years). This year class is likely to have recruited to the commercial fisheries over the last few years and age composition data from the fisheries will refine model estimates of the relative strength of the year class. The next catch sampling programme for SNA 8 is scheduled for 2025–26. Sampling should be conducted year round because of the extension of the snapper fishery into the autumn and winter months. This sampling should adopt a random age frequency approach as the age-length key approach currently used is not appropriate over such a long period.

Recreational fisheries

The increase in the catch from the recreational fishery highlights the importance of this component of the fishery, which currently accounts for approximately 30–40% of the total catch. Consequently, it is important to routinely monitor the level of recreational catch to determine total removals from the stock. The next national panel survey to estimate recreational catch is scheduled for 2027–28, depending on budgets and priorities. Indices of recreational fishing activity developed from web cam observations at key boat ramps within SNA 8 have also been incorporated in the current assessment. The 2022–23 survey harvest estimate appears to be anomolously low and should be further evaluated via data collected from the monitoring of recreational fishing activity at selected boat ramps.

Other

Environmental considerations: Recruitment variation is undoubtedly linked to variation in the prevailing environmental conditions (including sea temperature) associated with the spawning period and/or larval phase. Further investigation should be conducted to identify correlations between snapper recruitment estimates and key environmental variables to improve understanding of snapper recruitment dynamics. Consideration should be given to examining SNA 7 and SNA 8 together with a view to understanding the drivers of productivity changes.

Density-dependent processes: Projections indicate a continued increase in population biomass at current catch levels. The potential for density-dependent processes to curb such large increases should be considered and possibly modelled.

Other sources of fishing-related mortality: The default assumption is that Other Sources of Fishing Related Mortality added 20% to catches prior to the introduction of snapper into the QMS in 1986 and 10% thereafter. The basis for this assumption should be revisited, particularly for the latter period. In particular, it is important to identify whether there are any regulations or changes in fishing behaviour that could have resulted in step changes.

Harvest Control Rule: Develop a harvest control rule that requires the exploition rate to decline below the target as the spawning biomass approaches the soft limit, e.g., akin to the Harvest Strategy Standard default.

Overfishing Threshold: Develop an overfishing threshold that is higher than the exploitation rate target or consider changing the nomenclature to refer to a fishing target rather than an overfishing threshold.

Model Structure: Develop one or more spatially structured models that include SNA 7 and relevant parts of SNA 8. Explore sensitivities to dome shaped selectivity and report non-vulnerable biomass.

6. STATUS OF THE STOCKS

Stock Structure Assumptions

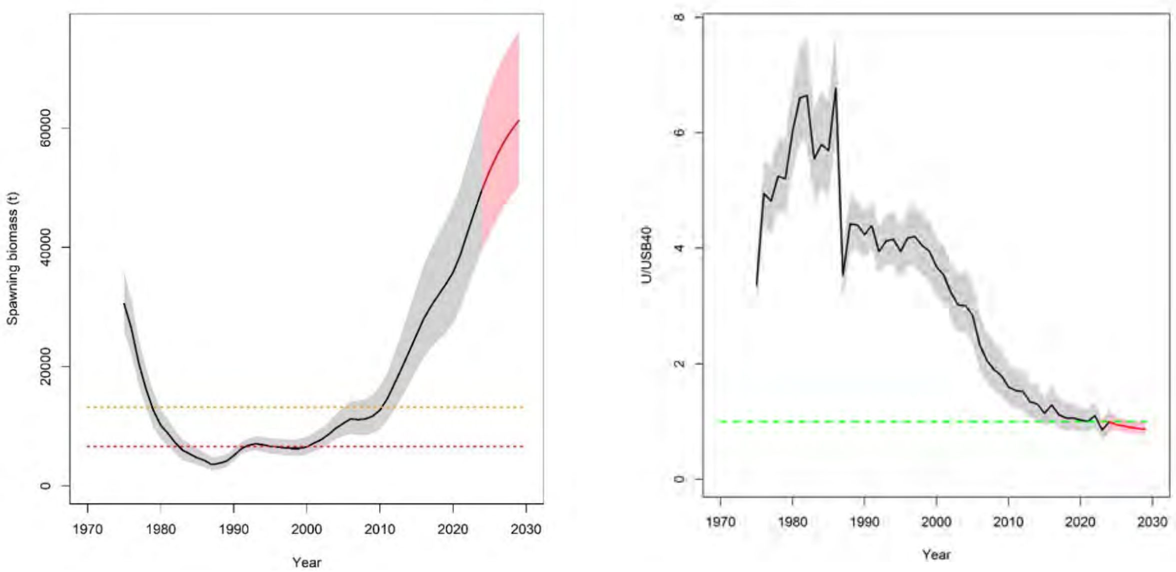
New Zealand snapper are thought to comprise either seven or eight biological stocks based on the location of spawning and nursery grounds, differences in growth rates, age structure, recruitment strengths, and the results of tagging studies. These stocks are assumed to comprise three in SNA 1 (East Northland, Hauraki Gulf, and Bay of Plenty), two in SNA 2 (one of which may be associated with the Bay of Plenty stock), two in SNA 7 (Marlborough Sounds and Tasman/Golden Bay/west coast South Island), and one in SNA 8. Tagging studies reveal that limited mixing occurs between the three SNA 1 biological stocks, with the greatest exchange between the Bay of Plenty and Hauraki Gulf.

- **SNA 8**

Tagging, genetic, and morphological studies have revealed that snapper off the northern west coast of the North Island (i.e., FMA 9) are likely to comprise a separate biological unit. Snapper within FMA 8 (southern SNA 8) may be composed of an increasing proportion of snapper from the SNA 7 biological stock. There is increasing evidence to support the hypothesis that the area of SNA 8 south of Cape Egmont (FMA 8) represents an area of mixed snapper from SNA 7 and SNA 8.

Stock Status		
Most Recent Assessment Plenary Publication Year	2024	
Catch in most recent year of assessment	Year: 2023–24	Catch: 2 965 t (TACC 1 600 t, additional mortality 160 t, recreational allowance 1 205 t)
Assessment Runs Presented	Base Case model	
Reference Points	Interim target: $U_{SB40\%}$= 4.8% Soft Limit: twice the biomass of the hard limit Hard Limit: average spawning biomass between 1992 and 2000 Overfishing threshold: $U_{SB40\%}$	
Status in relation to Target	About as Likely as Not (40–60%) to be at or below	
Status in relation to Limits	Soft Limit: Very Unlikely (< 10%) to be below. Hard Limit: Exceptionally Unlikely (< 1%) to be below	
Status in relation to Overfishing	$U_{2023–24}$ was estimated to be near $U_{SB40\%}$. Overfishing is About as Likely as Not (40–60%) to be occurring	

Historical Stock Status Trajectory and Current Status



Base model *SSB* (left) and $U_{SB40\%}$ status (right) trajectories for the period since 1975 (green dotted line indicates target $U_{SB40\%}$ fishing mortality rate). Projections are in red. The line represents the median and the shaded area represents the 95% credible interval. The red and orange dashed lines represent the hard and soft limits, respectively.

Fisheries and Stock Trends	
Recent Trend in Biomass or	Spawning biomass was estimated to have increased gradually during

Proxy	the 2000s followed by a more rapid increase in biomass from 2009 (in response to above average recruitment since the mid 2000s).
Recent Trend in Fishing Mortality or Proxy	Fishing mortality is estimated to have declined by around 75% since 2000.
Other Abundance Indices	The increase in the trawl survey adult (> 6 y) biomass indices between 1989–1999 and 2018–2022 corroborates the recent increase in biomass.
Trends in Other Relevant Indicators or Variables	Estimates of recreational catch have increased 3-fold since 2006. The increase in catch is likely to be related to an increase in stock abundance.

Projections and Prognosis	
Stock Projections or Prognosis	Abundance is Very Likely (> 90%) to increase over the next five years at projected levels of catch (3187 t compared to a TAC of 3065 t) and is Likely (> 60%) to increase at higher levels of catch corresponding to $U_{SB40\%}$ (in 2024 = 3667 t). Exploitation rate is Likely to decline over the next five years at projected catch levels (including plausable levels of recreational harvest).
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	Unlikely (< 40%)

Assessment Methodology		
Assessment Type	Level 1 – Full Quantitative Stock Assessment	
Assessment Method	Age-structured Bayesian stock assessment implemented with Stock Synthesis software and uncertainty estimated by MCMC	
Assessment Dates	Latest assessment Plenary publication year: 2024	Next assessment: 2029
Overall assessment quality rank	1 – High Quality	
Main data inputs	- Proportions at age data from the commercial fisheries - Estimates of biological parameters (e.g., growth, age-at-maturity and length/ weight), including temporal variation in growth - Standardised single trawl CPUE index of abundance - Estimates of recreational harvest (recent levels) - Estimates of recreational harvest (pre-1990) - Commercial catch (from 1983 onwards) - Commercial catch (prior to 1983) - Two tag-based biomass estimates - Trawl survey age specific	1 – High Quality 1 – High Quality 1 – High Quality (less reliable CPUE indices for the last 5–8 years) 1 – High Quality 2 – Medium or Mixed Quality: level of catch is assumed 1 – High Quality 2 – Medium or Mixed Quality: less reliable reporting of catches prior to 1983 1 – High Quality (second estimate)

	indices	1 – High Quality
Data not used (rank)	- Trawl survey total biomass indices	2 – Medium or Mixed Quality: variable catchability of older age classes for the three most recent trawl surveys
Changes to Model Structure and Assumptions	Relative to the 2021 assessment: - Initialise stock in 1975 under exploited conditions; estimation of initialising *F* and recruitments (1950–1974). - BH SRR with an assumed value of steepness and recruitment deviates estimated (from 1975) as simple deviates (i.e. not constrained to an average of one). - Updated recreational catch history incorporating recent recreational catch estimate (2022/23) and boat ramp indices of fishing activity. Alternative assumptions for future recreational catches. - Revised maturity ogive.	

Major Sources of Uncertainty	- There have been considerable changes in the operation of the trawl fisheries during the assessment period related to the extent of targeting/avoidance of snapper. The CPUE analysis has endeavoured to account for some of these changes; however, the CPUE indices are considered to under-estimate the increase in abundance during the more recent years. - The shift in the overall level of recruitment is likely to be related to environmental conditions. Non-stationarity of the relationship between spawning biomass and recruitment is not represented by the stock-recruitment relationship and the assumed value of steepness. - The trawl survey has been excluded from key inshore areas in recent years.

Qualifying Comments
The stock structure relationship between the northern and southern areas of SNA 8 is unclear. The current assessment is primarily based on data from the northern area of the fisheries and the population dynamics may differ in the southern area. Domed selectivity for bottom trawl and bottom pair trawl results in cryptic biomass.

Fisheries Interactions
The primary species caught in association with snapper in bottom trawl fisheries are trevally, red gurnard, John dory, and tarakihi. Since 2010–11, most (> 80%) of the commercial catch of snapper has been taken as a bycatch of trawls targeting trevally and red gurnard.

7. FOR FURTHER INFORMATION

Annala, J H; Sullivan, K J (Comps.) (1997) Report from the Fishery Assessment Plenary, May 1997: stock assessments and yield estimates. 381 p. (Unpublished report held by NIWA library, Wellington.).

Bian, R; McKenzie, J R; Davies, N M (2009) Determination of optimum frequency for SNA 8 snapper market sampling based on retrospective analysis. *New Zealand Fisheries Assessment Report 2009/50*. 15 p.

Boyd, R O; Gowing, L; Reilly, J L (2004) 2000–2001 national marine recreational fishing survey: diary results and harvest estimates. Final Research Report for Ministry of Fisheries. (Unpublished report held by Fisheries New Zealand, Wellington.) 93 p.

Boyd, R O; Reilly, J L (2002) 1999/2000 National marine recreational fishing survey: harvest estimates. Final Research Report for Ministry of Fisheries Research Project REC9803. (Unpublished report held by Fisheries New Zealand, Wellington.)

Bradford, E (1998) Harvest estimates from the 1996 national marine fishing surveys. New Zealand Fisheries Assessment Research Document 1998/16. 27 p. (Unpublished document held by NIWA library, Wellington.)

Bull, B; Francis, R I C C; Dunn, A; Gilbert, D J; Bian, R; Fu, D (2012) CASAL (C++ algorithmic stock assessment laboratory): CASAL User Manual v2.30.2012/03/21. *NIWA Technical Report 135*. 280 p.

Bull, B; Francis, R I C C; Dunn, A; McKenzie, A; Gilbert, D J; Smith, M H (2004) CASAL (C++ algorithmic stock assessment laboratory): CASAL User Manual v2.06-2004/09/26. *NIWA Technical Report 126*. 261 p.

Davies, N M (1997) Assessment of the west coast snapper (*Pagrus auratus*) stock (SNA 8) for the 1996–97 fishing year. New Zealand Fisheries Assessment Research Document 1997/12. 47 p. (Unpublished document held by NIWA library, Wellington.)

Davies, N M (1999) Assessment of the SNA 1 and 8 stocks for the 1997–98 fishing year. New Zealand Fisheries Assessment Research Document 1999/19. 87 p. (Unpublished document held by NIWA library, Wellington.)

Davies, N M; Gilbert, D J; McKenzie, J R (1999a) Assessment of the SNA 1 and 8 stocks for the 1998–99 fishing year. New Zealand Fisheries Assessment Research Document 1999/28. 82 p. (Unpublished document held by NIWA library, Wellington.)

Davies, N M; McKenzie, J R; Gilbert, D J (1999b) Monte Carlo estimation of bias in Petersen mark-recapture estimates for snapper (*Pagrus auratus*). New Zealand Fisheries Assessment Research Document 1999/20. 52 p. (Unpublished document held by NIWA library, Wellington.)

Davies, N M; McKenzie, J R; Gilbert, D J (2006) Assessment of the SNA 8 stock for the 2003–04 fishing year. *New Zealand Fisheries Assessment Report 2006/9.* 32 p.

Davies, N M; McKenzie, J R; Gilbert, D J (2013) Assessment of the SNA 8 stock for the 2004–05 fishing year. *New Zealand Fisheries Assessment Report 2013/28.* 73 p.

Francis, M P; Paul, L J (2013) New Zealand inshore finfish and shellfish commercial landings, 1931–82. *New Zealand Fisheries Assessment Report 2013/55.* 136 p.

Francis, R I C C (2011) Data weighting in statistical fisheries stock assessment models *Canadian Journal of Fisheries and Aquatic Sciences.* 68: 1124–1138.

Francis, R I C C; McKenzie, J R (2015a) Assessment of the SNA 1 stocks in 2012. *New Zealand Fisheries Assessment Report 2015/75.*

Francis, R I C C; McKenzie, J R (2015b) Assessment of the SNA 1 stocks in 2013. *New Zealand Fisheries Assessment Report 2015/76.*

Froese, R; Pauly, D (2000) FishBase 2000: concepts, design and data sources. ICLARM, Los Banos, Laguna, Philippines. 344 p.

Gilbert, D J; Sullivan, K J (1994) Stock assessment of snapper for the 1992–93 fishing year. New Zealand Fisheries Assessment Research Document 1994/3. 37 p. (Unpublished document held by NIWA library, Wellington.)

Gilbert, D J; McKenzie, J R; Watson, T G; Davies, N M (2005) Etag-est, a tag-recapture abundance estimator, applied to west coast North Island New Zealand snapper (*Pagrus auratus*).Final Research Report for Ministry of Fisheries Research Project SNA2000/03, Objective 10.3. (Unpublished report held by Fisheries New Zealand).

Heinemann A; Gray, A. (in prep.) National Panel Survey of Recreational Marine Fishers 2022-23.

Holdsworth, J C; Boyd, R O (2008) Size, condition and estimated release mortality of snapper (*Pagrus auratus*) caught in the SNA 1 recreational fishery, 2006–07. *New Zealand Fisheries Assessment Report 2008/53*. 37 p.

Jones, E G; Bian, R; MacGibbon, D J; McKenzie, J R; Escobar-Flores, P C; Stevens, D W; Walsh, C; O'Driscoll, R L (2022) Inshore trawl surveys off the west coast North Island, October–November 2018, 2019, and 2020. *New Zealand Fisheries Assessment Report 2022/63*. 156 p.

Jones, E G; Ballara, S; Bian, R; Langley, A; McKenzie, J; O'Driscoll, R L (2023) Review of inshore trawl surveys off the west coast North Island. *New Zealand Fisheries Assessment Report 2023/10.* 243 p.

Jones, E G; Underwood, M J; Bian, R; Walsh, C; O'Driscoll, R L (2024) Inshore trawl survey of the west coast North Island, October 2022 (KAH2205). *New Zealand Fisheries Assessment Report 2024/18*. 129 p

Kendrick, T H; Bentley, N (2010) Fishery characterisation and catch-per-unit-effort indices for snapper in SNA 8, 1989–90 to 2007–08. *New Zealand Fisheries Assessment Report 2010/42.*

King, M R (1985) Fish and shellfish landings by domestic fishermen, 1974–82. *Fisheries Research Division Occasional Publication: Data Series 20*. 96 p.

King, M R (1986) Catch statistics for foreign and domestic commercial fishing in New Zealand waters, January–December, 1983. *Fisheries Research Division Occasional Publication: Data series 21*. 140 p.

King, M R; Jones, D M; Fisher, K A; Sanders, B M (1987) Catch statistics for foreign and domestic commercial fishing in New Zealand waters, January – December 1984. *New Zealand Fisheries Data Report No. 30*. 150 p.

Langley, A D (1995b) Trawl survey of snapper and associated species off the west coast of the North Island, October 1994 (KAH9410). *New Zealand Fisheries Data Report No. 65*. 35 p.

Langley, A D (2017) Catch-Per-Unit-Effort indices for snapper in SNA 8. *New Zealand Fisheries Assessment Report 2017/45*. 40 p.

Langley, A D (2020) Stock assessment of snapper in SNA 8 for 2020. *New Zealand Fisheries Assessment Report 2020/20.* 87 p

Langley, A D (2021) Stock assessment of snapper in SNA 8 for 2021. *New Zealand Fisheries Assessment Report 2021/38.* 86 p

McKenzie, J R (2000) Factors Affecting Mortality of small Snapper (*Pagrus auratus*) caught and released by the SNA 1 Longline Fishery. (Draft Fisheries Assessment Report held by NIWA Library, Wellington).

McKenzie, J R; Diggles, B; Tubbs, L; Poortenaar, C; Parkinson, D; Webster, K; Miller, N (2006) An evaluation of a new type of plastic-coated PIT tag for tagging snapper (*Pagrus auratus*). *New Zealand Fisheries Assessment Report 2006/8*. 40 p.

Marsh, C; McKenzie, J.R., Langley, A. D. (2024). Simulation testing recruitment productivity shifts based on the 2021 SNA 8 stock assessment.*New Zealand Fisheries Assessment Report 2024/24*. 27 p

Methot, R D (1990) Synthesis model: an adaptable framework for analysis of diverse stock assessment data. *International North Pacific Fisheries Commission Bulletin 50*: 259–275.

Methot, R D (2005) Technical description of the Stock Synthesis II assessment program. NOAA Technical Memorandum SEDAR 16-AW-04.

Methot, R D (2009) User manual for Stock Synthesis, model version 3.02C.

Methot, R D; Wetzell, C R (2013) Stock Synthesis: A biological and statistical framework for fish stock assessment and fishery management. *Fisheries Research 142*: 86–99.

Millar, R B; Akroyd, J M; Walshe, K A R (2001) Incidental mortality of snapper in SNA 1 and SNA 8. *New Zealand Fisheries Assessment Report 2001/78*. 36 p.

Ministry of Fisheries (2008). Harvest Strategy Standard for New Zealand Fisheries. 25 p. Available online at: https://fs.fish.govt.nz/Doc/16543/harveststrategyfinal.pdf.ashx

Morrison, M A (1998) Trawl survey of snapper and associated species off the west coast of the North Island, November 1996 (KAH9615). *NIWA Technical Report 33*. 48 p.

Morrison, M A; Parkinson, D M (2001) Trawl survey of snapper and associated species off the west coast of the North Island, November 1999 (KAH9915). *NIWA Technical Report 100*. 51 p.

Morrison, M A; Stevenson, M L (2001) Review of west coast North Island trawl survey time series, 1986–96. *NIWA Technical Report 107*. 55 p.

Paul, L J (1976) A study on age, growth and population structure of the snapper, *Chrysophrys auratus* in Hauraki Gulf. *New Zealand Fisheries Research Bulletin No. 13*. 63 p.

Paul, L J (1977) The commercial fishery for snapper *Chrysophrys (Pagrus) auratus* in the Auckland region, New Zealand, from 1900 to 1971. *Fisheries Research Division Bulletin No 15*. 84 p.

Ritchie, L; Saul, P; O'Sullivan, K. (1975) The wetfish report 1941–1970. *New Zealand Ministry of Agriculture and Fisheries Fisheries Technical Report 137*. 370 p.

Sullivan, K J (1985) Snapper. *In:* Colman, J A; McKoy, J L; Baird, G G (Comps. and Eds.) (1985) Background papers for the 1985 Total Allowable Catch recommendations, pp. 187–214. (Unpublished report, held in NIWA library, Wellington.)

Sullivan, K J; Hore, A J; Wilkinson, V H (1988) Snapper. *In:* Baird, G G; McKoy, J L Papers from the workshop to review fish stock assessments for the 1987–88 New Zealand fishing year, pp. 251–275. (Unpublished report, held in NIWA library, Wellington.)

Sylvester, T (1995) Initial results of the Northern boat ramp survey. *Seafood New Zealand*, February 1995. pp. 11–13.

Teirney, L D; Kilner, A R; Millar, R B; Bradford, E; Bell, J D (1997) Estimation of recreational harvests from 1991–92 to 1993–94. New Zealand Fisheries Assessment Research Document 1997/15. 43 p. (Unpublished document held by NIWA library, Wellington.)

Vignaux, M (1993) Catch per unit of effort (CPUE) analysis of the SNA 8 snapper fishery. New Zealand Fisheries Assessment Research Document 1993/2. 12 p. (Unpublished document held by NIWA library, Wellington.)

Walsh, C; Armiger, H; Bian, R; Buckthought, D; McKenzie, J (2017) Length and age composition of commercial snapper landings in SNA 8, 2015–16. *New Zealand Fisheries Assessment Report 2017/02.* 40 p.

Walsh, C; Davies, N M (2004) Length and age composition of commercial landings in SNA 8, 2003–04. *New Zealand Fisheries Assessment Report 2004/56*. 18 p.

Walsh, C; Davies, N M; Buckthought, D (2006a) Length and age composition of commercial snapper landings in SNA 8, 2005–06. *New Zealand Fisheries Assessment Report 2006/54*. 21 p.

Walsh, C; McKenzie, J; Arminger, H (2006b) Spatial and temporal patterns in snapper length and age composition and movement, west coast North Island, New Zealand. *New Zealand Fisheries Assessment Report 2006/6*. 59 p.

Wright, P; McClary, D; Boyd, R O (2004) 2000/2001 National Marine Recreational Fishing Survey: direct questioning of fishers compared with reported diary data. Final Research Report for Ministry of Fisheries Project REC2000-01: Objective 2. (Unpublished report held by Fisheries New Zealand, Wellington.)

Wynne-Jones, J; Gray, A; Heinemann, A; Hill, L; Walton, L (2019). National Panel Survey of Marine Recreational Fishers 2017–2018. *New Zealand Fisheries Assessment Report 2019/24*. 104 p.

Wynne-Jones, J; Gray, A; Hill, L; Heinemann, A (2014) National Panel Survey of Marine Recreational Fishers 2011–12: Harvest Estimates. *New Zealand Fisheries Assessment Report 2014/67*. 139 p.