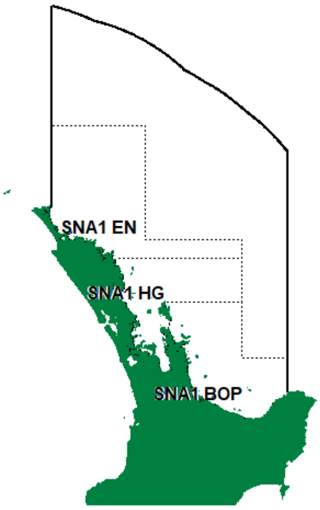
SNAPPER (SNA 1)

(*Chrysophrys auratus*)
Tāmure, 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 1. Landings and TACCs are plotted in Figure 1.

Table 1: Reported landings (t) of snapper from SNA 1 from 1931 to 1982.

Year	SNA 1	Year	SNA 1
1931–32	3 355	1957	5 129
1932–33	3 415	1958	5 007
1933–34	3 909	1959	5 607
1934–35	4 317	1960	5 889
1935–36	5 387	1961	5 887
1936–37	6 369	1962	6 502
1937–38	5 665	1963	6 967
1938–39	6 145	1964	7 269
1939–40	5 918	1965	7 991
1940–41	5 100	1966	8 762
1941–42	4 791	1967	9 244
1942–43	4 096	1968	10 328
1943–44	4 456	1969	11 318
1944	4 909	1970	12 127
1945	4 786	1971	12 709
1946	5 150	1972	11 291
1947	5 561	1973	10 450
1948	6 469	1974	8 769
1949	5 655	1975	6 774
1950	4 945	1976	7 743
1951	4 173	1977	7 674
1952	3 665	1978	9 926
1953	3 581	1979	10 273
1954	4 180	1980	7 274
1955	4 323	1981	7 714
1956	4 615	1982	7 089

Notes:
1. The 1931–1943 years are April–March but from 1944 onwards are calendar years.
2. SNA 1 landings are approximations derived from port landing subtotals, as follows: SNA 1, Mangonui to Whakatane.
3. 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 1 from 1983–84 to present and gazetted and actual TACCs (t) for 1986–87 to present. QMS data from 1986–present.

Fishstock FMAs	SNA 1 1 Landings	TACC	Fishstock FMAs	SNA 1 1 Landings	TACC
1983–84†	6 539	–	2003–04	4 469	4 500
1984–85†	6 898	–	2004–05	4 641	4 500
1985–86†	5 876	–	2005–06	4 539	4 500
1986–87	4 016	4 710	2006–07	4 429	4 500
1987–88	5 038	5 098	2007–08	4 548	4 500
1988–89	5 754	5 614	2008–09	4 543	4 500
1989–90	5 826	5 981	2009–10	4 465	4 500
1990–91	5 273	6 002	2010–11	4 516	4 500
1991–92	6 176	6 010	2011–12	4 614	4 500
1992–93	5 427	4 938	2012–13	4 457	4 500
1993–94	4 847	4 938	2013–14	4 459	4 500
1994–95	4 857	4 938	2014–15	4 479	4 500
1995–96	4 938	4 938	2015–16	4 408	4 500
1996–97	5 047	4 938	2016–17	4 620	4 500
1997–98	4 525	4 500	2017–18	4 567	4 500
1998–99	4 412	4 500	2018–19	4 437	4 500
1999–00	4 509	4 500	2019–20	4 462	4 500
2000–01	4 347	4 500	2020–21	4 579	4 500
2001–02	4 374	4 500	2021–22	4 296	4 500
2002–03	4 487	4 500			

† FSU data.

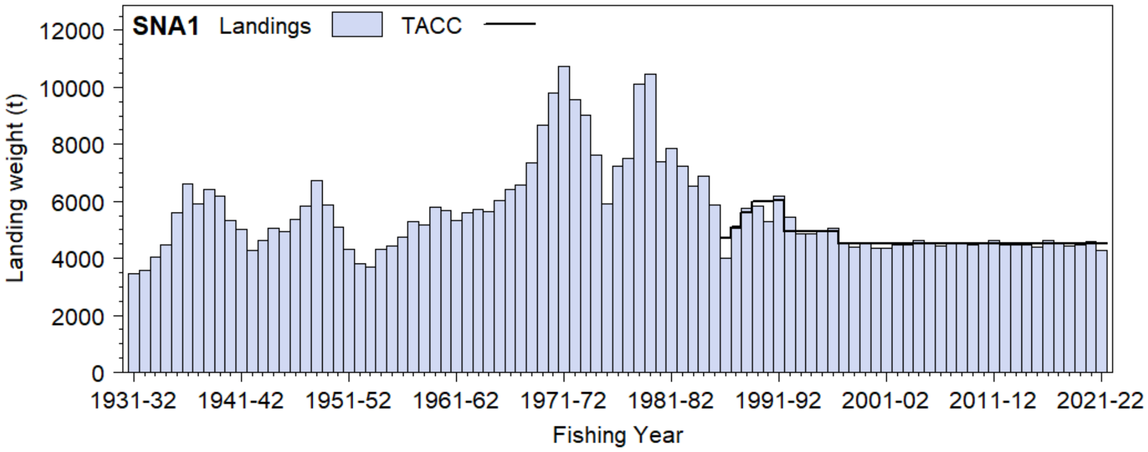


Figure 1: Total reported landings and TACCs for SNA 1.

From 1 October 1997 the TACC for SNA 1 was reduced to 4500 t, within an overall TAC of 7550 t (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 1 from 1 October 2022.

Fishstock	TAC	TACC	Customary allowance	Recreational allowance	Other mortality
SNA 1	8 050	4 500	50	3 050	450

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 and harvest within SNA 1 from 1967 to 1977 by Japanese trawl and longline fisheries.

Year	(a) Trawl	Trawl catch (all species)	Total snapper trawl catch	SNA 1
1967		3092	30	NA
1968		19 721	562	1
1969		25 997	1 289	–
1970		31 789	676	2
1971		42 212	522	5
1972		49 133	1 444	1
1973		45 601	616	–
1974		52 275	472	–
1975		55 288	922	26
1976		133 400	970	NA
1977		214 900	856	NA

Year	(b) Longline		Total Snapper	SNA 1
1975			1 510	761
1976			2 057	930
1977			2 208	1 104

1.2 Recreational fisheries

The snapper fishery is the largest recreational fishery in New Zealand. It is the major target species off 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 1 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 1.

Stock	MLS (cm)	Bag limit (no. fish)	Introduced
SNA 1	25	30	01/01/1985
SNA 1	25	20	30/09/1993
SNA 1	27	15	01/10/1994
SNA 1	27	9	13/10/1995
SNA 1	30	7	01/04/2014

1.2.2 Estimates of recreational harvest

A background to the estimation on recreational harvest of snapper is provided in the Introduction – Snapper chapter.

The recreational catch history for SNA 1 is poorly known. Aerial-access survey harvest estimates are available for the Hauraki Gulf in 2003–04 (Hartill et al 2007b) and for all three regions of SNA 1 in 2004–05 (Hartill et al 2007a), in 2011–12 (Hartill et al 2013) and in 2017–18 (Hartill et al 2019). Recreational harvest estimates for all three regions of SNA 1 are also available from national panel surveys undertaken in 2011–12 and 2017–18 (Wynne-Jones et al 2014, 2019), which were of a broadly similar magnitude to those provided by the concurrent aerial-access survey (Table 6).

1.2.3 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.

Table 6: Recreational catch estimates for SNA 1. 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 boundaries provided in Section 4.1.

Stock	Year	Method	Number of fish (thousands)	Mean weight (g)	Total weight (t)	CV
East Northland	1985	Tag ratio	–	–	370	–
Hauraki Gulf	1985	Tag ratio	–	–	830	–
Bay of Plenty	1984	Tag ratio	–	–	400	–
Total	1985*	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	–†	1 669	–
Hauraki Gulf	2001	Telephone/diary	4 225	–†	3 507	–
Bay of Plenty	2001	Telephone/diary	1 791	–†	1 562	–
Total	2001	Telephone/diary	7 462	–†	**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	718	1 266	909	0.12
Hauraki Gulf	2011–12	Panel survey	2 350	1 022 / 987‡	2 381	0.11
Bay of Plenty	2011–12	Panel survey	714	956 /1 003‡	691	0.12
Total	2011–12	Panel survey	3 884	1 025	**3 981**	**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	587	1 351	793	0.10
Hauraki Gulf	2017–18	Panel survey	1 443	1 162/1 189	1 684	0.10
Bay of Plenty	2017–18	Panel survey	571	1 116/1 205	650	0.12
Total	2017–18	Panel survey	2 601	1 202	**3 127**	**0.07**

* The Bay of Plenty programme was carried out in 1984 but is included in the 1985 total estimate.
† The 2000 mean weights were used in the 2001 estimates.
‡ Separate mean weight estimates were used for summer (1 October 2011 to 30 April 2012) and for winter (1 May to 30 September 2012).

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 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.

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 and scaled to aerial-access estimates for each area in 2004–05 and 2006–07 (Hauraki Gulf only) and 2011–12 and 2017–18 (all areas within SNA 1). Stock boundaries provided in Section 4.1.

Year	East Northland	CV	Hauraki Gulf	CV	Bay of Plenty	CV	Total SNA 1	CV
2004–05	612	0.12	1 196	0.10	646	0.11	2 454	0.07
2006–07	–	–	1 272	0.16	–	–	–	–
2011–12	669	0.10	2 818	0.09	544	0.14	4 031	0.07
2012–13	525	0.11	1 232	0.11	241	0.16	1 099	0.08
2013–14	433	0.11	583	0.16	179	0.18	1 196	0.09
2014–15	414	0.12	448	0.14	182	0.25	1 044	0.09
2015–16	519	0.12	375	0.16	133	0.17	1 027	0.09
2016–17	551	0.11	398	0.15	277	0.19	1 227	0.08
2017–18	703	0.12	1 038	0.16	545	0.15	2 286	0.09
2018–19	774	0.10	1 070	0.14	280	0.13	2 125	0.08
2019–20	466	0.13	551	0.18	191	0.19	1 208	0.10
2020–21	667	0.13	498	0.17	297	0.23	1 462	0.10

The boat ramp interview data provided by this monitoring programme, and other previous boat ramp surveys, was used to model reconstructed regional catch histories for updated SNA 1 stock assessment model in 2023, which extended back as far as 1899–1900.

Analyses in support of the 2023 assessment resulted in a change to the Hauraki Gulf and East Northland boundary (see Section 4.1 below). This change required re-estimating the East Northland and Hauraki Gulf recreational catch histories back to 1900, in additon to deriving catch estimates for all three regions for the 2021–22 fishing year. A zero-inflated negative binomial (ZINB) generalised linear modelling approach (Hartill & Doonan 2022) was used to derive the SNA 1 recreational catch histories; this provides a more comprehensive reconstruction of past recreational catches because it uses data from 2001 onwards that are available from more ramps than those surveyed as part of the web camera/creel survey monitoring programme and can be used to predict the number of snapper landed hourly at each surveyed ramp, including for hours when interviewing did not take place. Environmental covariates (wind speed and tidal state) and temporal factors (fishing year, month, and day type) were offered as explanatory variables to separate regional ZINB models. Hourly catch predictions from the ZINB models were then summed across the ramps surveyed in each region, to derive an index of the number of snapper landed annually at each surveyed access point. Annual mean fish weight estimates were then used to convert these annual estimates of the number of snapper landed at the surveyed ramps, into annual tonnage estimates.

Because only a subset of the access points in each region were surveyed, the resulting annual catch weight indices only provided a relative recreational snapper catch index. Assuming these indices are representative of the region, , each regional catch weight index was scaled up to the geometric mean of the aerial-access estimates of the total harvest landed in each region, in 2004–05, 2011–12, and 2017–18. Annual harvest from 1900 to 1999–2000 was derived by interpolating from the ZINB model derived 1999–2000 point estimates to assumed 1900 catch levels of 50 t for East Northland, 75 t for the Bay of Plenty, and 175 t for the Hauraki Gulf (Figure 2).

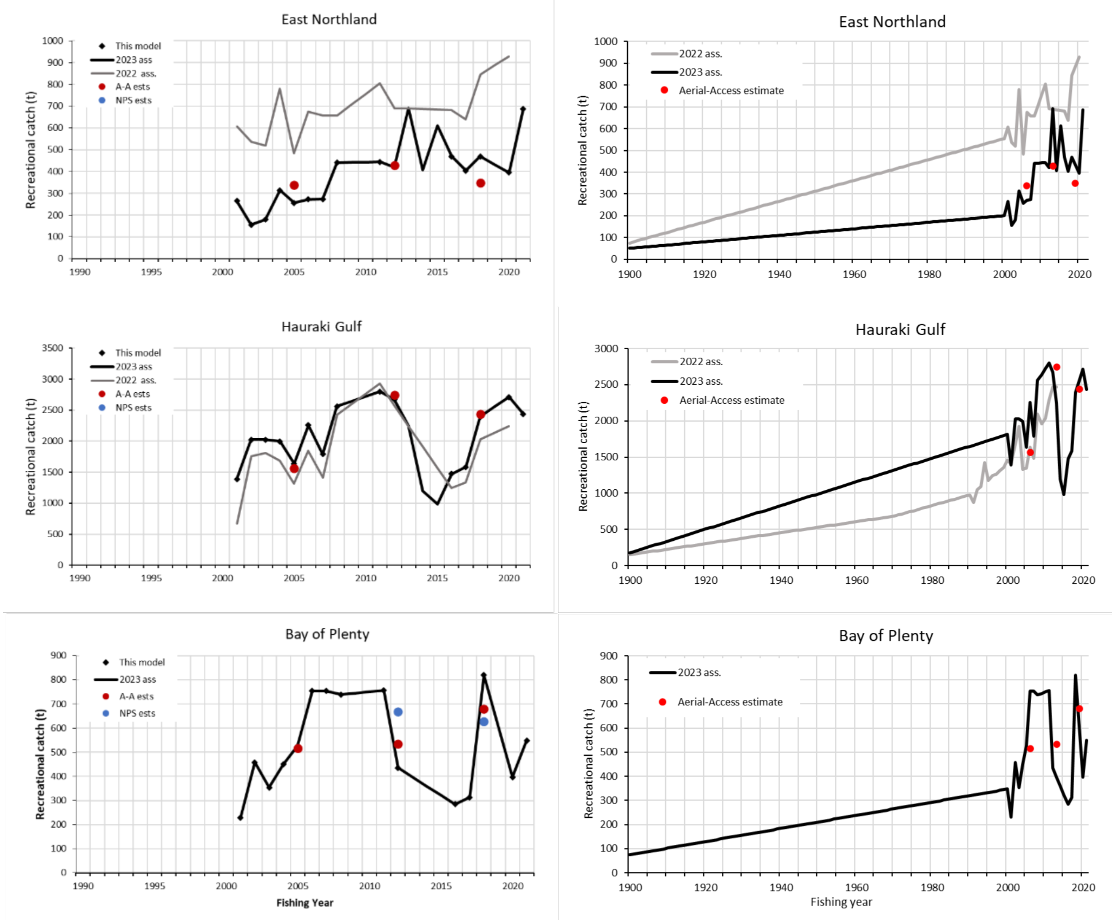


Figure 2: Regional recreational catch histories for SNA 1 by region (defined in Section 4.1) using zero inflated negative binomial modelling of creel survey landings data (snapper landed per complete creel survey hour). The relative harvest indices generated from regional model predictions were scaled up by regional harvest estimates provided by aerial-access surveys of SNA 1 in 2004–05, 2011–12, and 2017–18, to account for the catch landed by all recreational fishers at all access points, including those which had not been surveyed, from 2000–01 (left panels). These regional catch histories were then extended back to assumed recreational catch levels in 1900–01 (right panels).

1.3 Customary non-commercial fisheries

Snapper form important fisheries for customary non-commercial fishers, but the annual catch is not known. The information on Māori customary harvest under the provisions made for customary fishing is limited and it is likely that Māori customary fishers utilise the provisions under recreational fishing regulations.

1.4 Illegal catch

No new information is available to estimate illegal catch. For modelling SNA 1 an assumption was made that non-reporting of catch was 20% of reported domestic commercial catch prior to 1986 and 10% of reported 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 high 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-sized snapper.

1.5 Other sources of mortality

No estimates are available regarding the amount of other sources of mortality on snapper stocks; although 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 (< 5%).

Incidental mortality estimates are available based on catch-at-sea data used in a age-length structured 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 1, recreational fishers release a high proportion of their snapper catch, most of which is usually less than the recreational MLS (Hartill et al 2020). 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.

For SNA 1 estimates of sub-MLS releases (SNX) are available from March 2014. 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 now be returned to the sea. There have been specific efforts to avoid commercial catches of sub-MLS snapper and reported quantities have been small (~40 t in 2020 and 2021 (i.e., < 1% of total annual commercial SNA 1 landed catch weight)), but proportions were higher previously (and varied by method).

2. BIOLOGY

For further information on snapper biology refer to the Introduction – Snapper chapter. A summary of published estimates of biological parameters for SNA 1 is presented 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* = 0.0447	*b* = 2.793		Paul (1976)
East Northland	*a* = 0.0349	*b* = 2.870		
Hauraki Gulf	*a* = 0.0494	*b* = 2.771		Walsh et al (2022)
Bay of Plenty	*a* = 0.0430	*b* = 2.813		
3. von Bertalanffy growth parameters				
	Both sexes combined			
	K	t_0	L_∞	
SNA 1	0.102	-1.11	58.8	Gilbert & Sullivan (1994)
4. Age-at-recruitment (years)				
SNA 1*	4 (39%) 5 (100%)			Gilbert et al (2000)

* 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. Three stocks are 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.

4. STOCK ASSESSMENT

A preliminary stock assessment was carried out in 2022 and was focused primarily on updating the previous 2013 assessment, including maintaining its basic structure and most of the assumptions. These assessments assumed the SNA 1 stock complex comprised three biological regional stocks with interchange between stock regions informed by tagging data. These models were all structured as a single population model for SNA1 comprising three areas with different growth characteristics and movement between the areas estimated within the model.The models used for these assessments attempted to account for the entire SNA 1 catch history back to an assumed unfished equilibrium state in 1900.

The 2022 preliminary assessment outcomes were sensitive to the assumed tagging likelihood weighting governing movement. Consequently, the 2022 Plenary deemed the base model was unsuitable for providing management advice due to unresolved data conflicts and poor model diagnostics. The 2022 Plenary made the following recommendations for improving the assessment.

- Model the East Northland regional stock as separate to the Hauraki Gulf/Bay of Plenty stock complex assuming no movement.
- Fit the models to externally derived tag abundance and movement (Hauraki Gulf/Bay of Plenty) estimates.
- Investigate commencing the assessment models after 1970 to minimise the influence of uncertain catch histories on assessment outcomes.

4.1 SNA 1 Revised spatial stock structure

The boundaries between the three SNA 1 sub-stock regions were re-assessed as part of the 2023 assessment (McKenzie et al in prep). Updated analyses of tagging, age composition, and commercial and survey catch and effort data indicated that the northern Hauraki Gulf boundary should include the majority of Statistical Areas 003 & 004 (the new boundary being just below the Bay of Islands). Incorporating the revised East Northland/Hauraki Gulf boundary definition into the 2023 assessment required reanalysing almost all available East Northland/Hauraki Gulf observation data series (tagging, compositional, CPUE) and revising the commercial and recreational historical catch estimates (note the boundary shift did not affect the Bay of Plenty data series). Although a CPUE series for the East Northland bottom trawl fishery was derived based on these new boundaries, pre-2007 commercial catch data and compositional data could not be subdivided below the statistical area level. As a result, the 2023 East Northland assessment included catches from Statistical Area 002 only, and the Hauraki Gulf assessment included all the catches from Statistical Areas 003 and 004.

4.2 Model structure

The models used for the 2023 assessment were implemented using Casal2 (Casal2 Development Team 2022). Four models were developed for the 2023 assessment:

1. A discrete East Northland model;
2. A Hauraki Gulf/Bay of Plenty movement model;
3. A discrete Hauraki Gulf model;
4. A discrete Bay of Plenty model.

The three discrete area models had only one time step and implemented processes in the following order: age incrementation, recruitment, spawning, natural and fishing mortality.

The Hauraki Gulf/Bay of Plenty model explicitly modelled the movement of fish between areas and assumed a Home Fidelity (HF) movement dynamic which required two time steps to implement (Table 8). Under the HF movement assumption, fish spawn in their home area and some move to other areas at other times of the year where they are subject to fishing. There were two sets of migrations: in time step 1, all fish returned to their home (i.e., spawning) area just before spawning; and in time step 2, some fish moved away from their home area into another area. This second migration was characterised by a 2 × 2 matrix, in which the *ij*th element, p_{ij}, is the proportion of fish from the *i*th area that migrated to the *j*th area.

Movement within SNA 1 (as evidenced by tagging, CPUE, and age composition data) is strongly seasonal (McKenzie et al in prep). As with all previous SNA 1 assessments, it was not feasible to incorporate seasonal dynamics into the 2023 assessment due to the scarcity of observational data at the seasonal level (particularly seasonal tag movement observations). Consequently, only compositional and abundance data from the spring-summer period were used in the SNA 1 2023 assessment, because it was assumed that these data were more representative of the total SNA 1 population than data collected from winter months. Inability to explicitly account for SNA 1 seasonal stock dynamics, although unlikely to invalidate management conclusions, adds an unknown degree of uncertainty to the 2023 assessment predicted outcomes. The overriding assumption is that all fish are back in their home areas when sampled in spring-summer.

All four assessment models modelled population by age (ages 1–30, where the last age was a plus group). As with previous snapper models (e.g., Francis & McKenzie 2015a), the models did not distinguish fish by sex.

All the base models were structured to begin in the 1968 fishing year, in line with the 2022 Plenary recommendation. This required estimating a pre-1968 exploitation rate (F_{init}) parameter. Sensitivities were carried out with the full reconstructed catch history from 1900 (McKenzie et al in prep).

The number of estimated and fixed parameters and covariates in the four models varied. Fixed parameters common across all four models are given in Table 9, and those specific to each model are given in Table 10.

Table 8: Annual model time steps and the processes and observations used in each time step. Note that the home area for a fish is where it spawns (and was recruited). Each year some fish migrate away from their home ground (in step 2) and then return home in step 1 of the following year.

Time step	Model processes (in temporal order)	Observations†
1	age incrementation, migration to home area, recruitment, spawning, tag release	
2	migration from home area, natural and fishing mortality*	biomass, length and age compositions, tag recapture

* Fishing mortality was applied after half the natural mortality.

† The tagging biomass estimate was assumed to occur immediately before the mortality; all other observations occurred halfway through the mortality.

Table 9: Fixed parameters common to all models.

Natural mortality	0.075 y^{-1}
Stock-recruit steepness (Beverton & Holt)	0.85
Proportion mature	0 for ages 1–3, 0.5 for age 4, 1 for ages > 4
Mean length-at-age (stock specific)	provided for years 1990–2022
Coefficients of variation for length-at-age	0.10 at age 1, 0.20 at age 30
Selectivity on initial mortality (F_{init} 1968 models only)	knife-edge length-based at 25cm
Selectivity on tag abundance	knife-edge length-based plateau 25–40 cm

Table 10: Model-specific fixed and estimated parameters (model start year given in brackets). [Continued next 2 pages]

Model: East Northland

Type	Description	Fixed value	No. of parameters	Prior
B_0	Mean unfished spawning biomass	–	1	Casal2 transformation priors
F_{init}	1968 estimated initial fishing mortality	–	1	Casal2 transformation priors
YCS	Year class strengths by year and stock (fixed)	1	15 (1968) 83(1900)	–
YCS	Year class strengths by year and stock (estimated)	–	40 {1975:2014}	Lognormal (u =1, sd = 0.6)
Length-weight	[mean weight (kg) = a (length (cm))^b]	$a = 3.49 \times 10^{-5}$, $b = 2.87$	2	–
q tag abundance	catchability coefficient tag abundance	1	1	–
q CPUE abundance	catchability coefficient BT CPUE	–	1	Uniform-log
Selectivity longline	Logistic selectivity by age	–	2	Uniform
Selectivity bottom trawl	Double normal selectivity by age	$a_1 = 5.15$ y, $\sigma_L = 0.83$ y, $\sigma_R = 17.21$ y	3	See text
Selectivity pair trawl	Double normal selectivity by age	$a_1 = 6$ y, $\sigma_L = 1.5$ y, $\sigma_R = 30$ y	3	–

Table 10 [Continued]:

Type	Description	Fixed value	No. of parameters	Prior
Selectivity recreational line pre 1995	Double normal selectivity by age	–	3	Casal2 transformation priors
Selectivity recreational line post 1995	Double normal selectivity by age	–	3	Casal2 transformation priors
Selectivity recreational line post 2015	Double normal selectivity by age	–	3	Casal2 transformation priors
Model: Bay of Plenty				
B_0	Mean unfished spawning biomass	–	1	Casal2 transformation priors
F_{init}	1968 estimated initial fishing mortality (1968 model only)	–	1	Casal2 transformation priors
YCS	Year class strengths by year and stock (fixed)	1	5 (1968) 73 (1900)	–
YCS	Year class strengths by year and stock (estimated)	–	50 {1972:2021}	Lognormal (u =1, sd = 0.6)
Length-weight	[mean weight (kg) = a (length (cm))^b]	$a = 4.30 \times 10^{-5}$, $b = 2.81$	2	–
q tag abundance	catchability coefficient tag abundance	1	1	–
q CPUE abundance	catchability coefficient BT CPUE	–	1	Uniform-log
q survey abundance	catchability coefficient trawl survey abundance	–	6	Uniform-log
Selectivity longline	Logistic selectivity by age	–	2	Uniform
Selectivity bottom trawl	Double normal selectivity by age	–	3	Casal2 transformation priors
Selectivity MHS	Double normal selectivity by age	$a_1 = 4.3$ y, $\sigma_L = 0.31$ y, $\sigma_R = 18.5$ y	3	–
Selectivity Danish seine	Double normal selectivity by age	–	3	Casal2 transformation priors
Selectivity recreational line pre 1995	Double normal selectivity by age	–	3	Casal2 transformation priors
Selectivity recreational line post 1995	Double normal selectivity by age	–	3	Casal2 transformation priors
Selectivity recreational line post 2015	Double normal selectivity by age	–	3	Casal2 transformation priors
Selectivity Research trawl 6+	Double exponential by age	$x_1 = 4.5$, $x_0=6$, $x_2 = 50$, $y_0 =1$, $y_1= 0.0001$	5	–
Selectivity Research trawl 6+	Double exponential by age	y_2 parameter		uniform
Selectivity Research ages 1–6	Age specific knife–edge	age selectivity = 1	6	–
Model: Hauraki Gulf				
B_0	Mean unfished spawning biomass	–	1	Casal2 transformation priors
F_{init}	1968 estimated initial fishing mortality (1968 model only)	–	1	Casal2 transformation priors
YCS	Year class strengths by year and stock (fixed)	1	1 (1968) 69(1900)	–
YCS	Year class strengths by year and stock (estimated)	–	54 {1968:2021}	Lognormal†
Length-weight	[mean weight (kg) = a (length (cm))^b]	$a = 4.94 \times 10^{-5}$, $b = 2.77$	2	–
q tag abundance	catchability coefficient tag abundance	1	1	–
q CPUE abundance	catchability coefficient BT CPUE	–	1	Uniform-log
q survey abundance	catchability coefficient trawl survey abundance	–	6	Uniform-log
Selectivity longline	Logistic selectivity by age	–	2	Uniform
Selectivity bottom trawl	Double normal selectivity by age	–	3	Casal2 transformation priors
Selectivity MHS	Double normal selectivity by age	a_1=4.3 y, σ_L=0.31 y, σ_R=18.5 y	3	–
Selectivity Danish seine pre 1973	Double normal selectivity by age	–	3	Casal2 transformation priors
Selectivity Danish seine post 1972	Double normal selectivity by age	–	3	Casal2 transformation priors
Selectivity recreational line pre 1995	Double normal selectivity by age	–	3	Casal2 transformation priors

Table 10 [Continued]:

Type	Description	Fixed value	No. of parameters	Prior
Selectivity recreational line post 1995	Double normal selectivity by age	–	3	Casal2 transformation priors
Selectivity recreational line post 2015	Double normal selectivity by age	–	3	Casal2 transformation priors
Selectivity Research trawl 6+	Double exponential by age	x_1=4.5, x_0=6, x_2=50, y_0=1, y_1=0.0001	5	–
Selectivity Research trawl 6+	Double exponential by age	y_2 parameter	1	Uniform
Selectivity Research ages 1–6	Age-specific knife–edge	age selectivity = 1	6	–

Year class strengths were estimated as free parameters but only for years where there was at least one observation of catch-at-age. The YCS estimation period in the model was also the period over which the B_0 parameter was also estimated. YCS estimation conformed to the Haist parameterisation in which the mean of the YCSs is constrained to 1 (Bull et al 2012). For years where the YCS could not be estimated as a free parameter, YCS was set to 1.

Some parameters were fixed, either because they could not be estimated with the available data (notably natural mortality and stock-recruit steepness which were fixed at values determined by the Working Group—see Table 9), or because they were estimated outside the model. As in 2013, mean length-at-age from age 1 to age 30 was specified by annual values (rather than a von Bertalanffy function) from 1990 to 2022 (Table 9) growth appeared to change over time for for the older ages. In each stock, mean lengths-at-age for years before 1990 and for the projections were set to the average values over all years.

Five types of observations were used in the base stock assessment (Table 11). These were the same as in the 2012 assessment (Francis & McKenzie 2015a) except for the addition of data values for each of the CPUE time series and the recreational length compositions. Key changes were use of trawl (rather than longline CPUE indices), survey indices, and fitting the 1994 tagging as externally derived abundance rather than including the data in the model.

Table 11: Details of observations used in the stock assessment model.

Type	Likelihood	Area	Source	Range of years	No. of years
Absolute biomass	Lognormal	BOP	1983 tagging	1983	1
Absolute abundance 25–40 cm	Lognormal	ENLD	1985 tagging	1985	1
		HAGU	1985 tagging	1985	1
		ENLD	1994 tagging	1994	1
		HAGU	1994 tagging	1994	1
		BOP	1994 tagging	1994	1
Relative biomass (CPUE) or survey)	Lognormal	ENLD	single trawl	1996–2021	26
		HAGU	single trawl	1996–2021	26
		HAGU	research survey (ages 1–5, 6+)	1985–2021	11
		BOP	single trawl	1996–2021	26
		BOP	research survey (ages 1–5, 6+)	1990–2021	5
Age composition	Multinomial	ENLD	longline	1994–2020	20
		ENLD	recreational fishing (pre 95)	1994	1
		ENLD	recreational fishing (post 95)	1996–2013	11
		ENLD	recreational fishing (post 2015)	2018-2020	2
		HAGU	Danish seine pre1973	1970–1972	3
		HAGU	Danish seine post 1972	1973-2020	7
		HAGU	longline	1985–2020	25
		HAGU	single trawl	1985–1996	6
		HAGU	recreational fishing (pre 95)	1991–1994	2
		HAGU	recreational fishing (post 95)	1996–2013	11
		HAGU	recreational fishing (post 2015)	2018–2020	2
		HAGU	research survey (ages 6+)	1985–2021	11
Age composition	Multinomial	BOP	Danish seine	1995–2020	2
		BOP	longline	1990–2010	22
		BOP	Modular harvest system (MHS)	2020	1
		BOP	single trawl	1990–2020	6
		BOP	recreational fishing (pre 95)	1991–1994	2
		BOP	recreational fishing (post 95)	1996–2013	11
		BOP	recreational fishing (post 2015)	2018–2020	2
		BOP	research survey (ages 6+)	1990–2021	5

Data weighting

Data weighting followed the methods recommended by Francis (2011). The additional process error CVs on the abundance data sets were defined *a priori* using smoothers to be consistent with the most ‘plausible’ fit the model was expected to achieve to the data (as agreed by the Working Group).

4.3 Catch history

Recreational catch

Refer Section 1.2 above.

Commercial catch

The SNA 1 commercial catch histories from 1989–90 were derived from the catch and effort reporting database (EDW); catches by method and area between 1981–82 and 1989–90 were constructed on the basis of data contained in archived Fisheries New Zealand databases.

Commercial catch histories for the period 1968 to 1982 were determined from two sources.

- 1968–73: Annual Reports on Fisheries, compiled by the Marine Department to 1971 and the Ministry of Agriculture and Fisheries to 1973 as a component of their Annual Reports to Parliament published as Appendices to the Journal of the House of Representatives.
- 1974–82: Ministry of Agriculture and Fisheries, Fisheries Statistics Unit (FSU) calendar year records published by King (1985).

These catch data sources are thought to provide acceptable estimates of SNA 1 annual commercial catch totals prior to 1983 (Francis & Paul 2013). However, information needed to spatially disaggregate the 1968–1982 SNA 1 catch totals at the revised regional sub-stock boundary level were not available. Instead, the pre-1983 SNA 1 regional catch splits were derived by applying the mean observed 1984–1997 regional catch proportions to the pre-1983 annual SNA 1 catch totals (Figure 3).

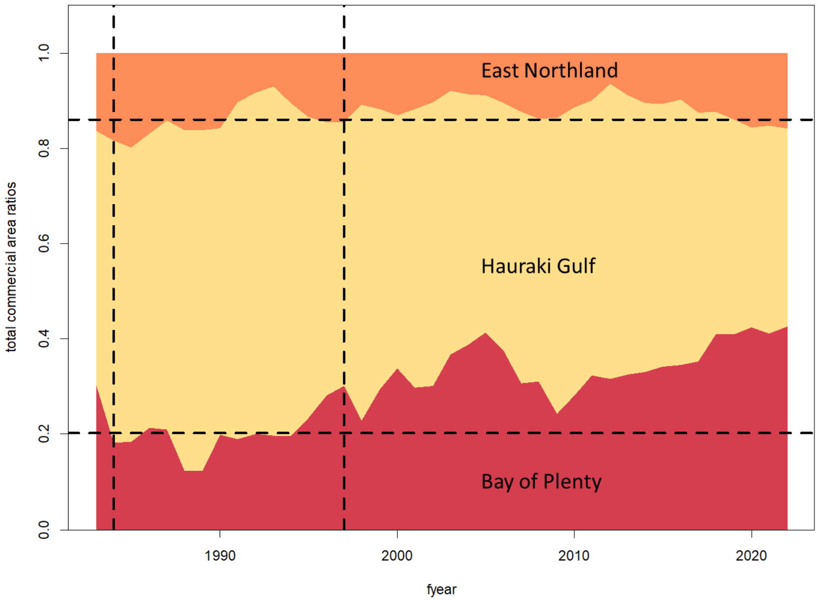


Figure 3: Regional SNA 1 annual commercial catch ratios, 1983–2022. Horizontal lines are the average regional ratios from 1984 to 1997 (vertical lines) used to derive model regional catches from 1968 to 1982.

As was done for the 2012 and 2013 assessments, commercial catch totals prior to the 1986 QMS year were adjusted upwards to account for an assumed 20% level of under-reporting. Catch totals post QMS were scaled assuming 10% under-reporting (Figure 4).

Commercial catch reporting post 1983 also allows the data to be aggregated specific to the main catching methods. For the 2023 SNA 1 assessment, the 1983–2022 commercial catch data were aggregated into six fisheries: longline (BLL), single bottom trawl (BT), pair bottom trawl (BPT), modular harvest system trawl (MHS), Danish seine pre-1973 (DS-pre73), Danish seine post-1972 (DS-post72). Catches from ‘other’ commercial methods (predominantly set net) were not explicitly modelled, but the catch totals were prorated across the fisheries in the same model region. It was not possible to apportion the SNA 1 commercial catch totals by fishery before 1983, so annual fishery catches for all years from 1968 to 1982 were apportioned using the 1983 reported proportions by fishery (Figure 5).

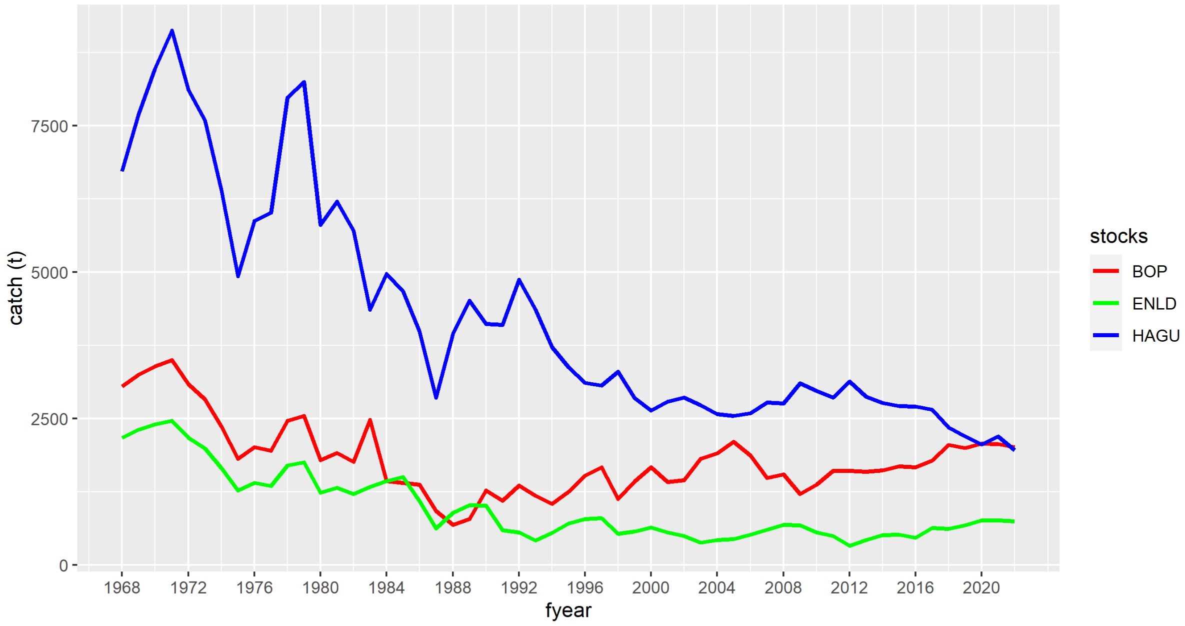


Figure 4: Commercial catch histories by area (adjusted for under-reporting) plus foreign catch used as input to the 2023 SNA 1 assessment model.

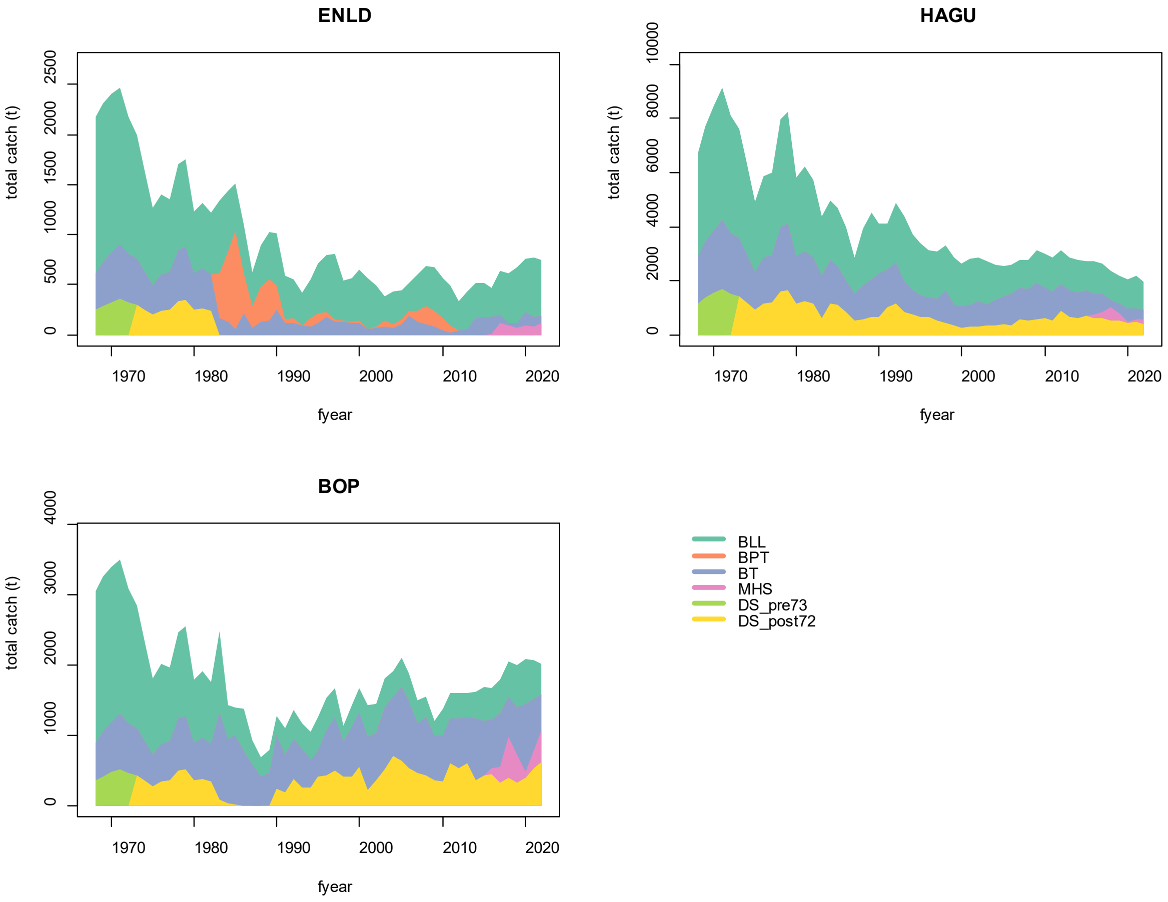


Figure 5: Commercial catch histories by method and area (adjusted for under-reporting) used as input to the 2013 SNA 1 assessment model. Foreign longline inclued in BLL.

Estimation of foreign commercial landings

In the 1997–98 SNA 1 stock assessment (Davies 1999), assumed that the foreign (Japanese longline) catch occurred between 1960 and 1977, with cumulative total removals at three alternative levels: 20 000 t, 30 000 t, and 50 000 t. The assumed pattern of catches increased linearly to a peak in 1968 then declined linearly to 1977; the catch was split evenly between East Northland and the Hauraki Gulf/Bay of Plenty. For the 2023 stock assessment, the base case level of total foreign catch for the period between 1960 and 1977 was assumed to be 30 000 t, and the catch was apportioned among the three sub-stocks in the ratio 30% East Northland, 30% Hauraki Gulf, and 40% Bay of Plenty and added to the domestic longline method totals by year.

4.4 Abundance indices

Trawl surveys

Trawl surveys were carried out in all three areas between the mid-1980s and 2021, but only the Hauraki Gulf and Bay of Plenty survey series were assumed to provide reliable abundance and compositional observations (Table 11), with both surveys providing acceptable abundance estimates of individual age classes 1–5 years old. Consequently, the 2023 assessment models were fitted to separate abundance indices (as numbers) for each of these five age classes independently (Table 11). The models were also fitted to 6+ amalgamated survey abundance (biomass) estimates (Table 11). The assumed precision of the survey abundance indices was estimated from independent analyses of the survey series data (McKenzie et al in prep).

Longline CPUE

Longline CPUE indices were not used in the 2023 assessment models, unlike the 2012 and 2013 stock assessments. This was done because there was evidence that longline CPUE over the recent period of the fishery had been hypostable (not increasing while trawl CPUE and surveys are) because of fishing practices not related to abundance. Analysis of recent longline catch effort data showed that fishers tended to target specific snapper catch sizes and would modify their effort to maintain this optimum (McKenzie et al in prep). This type of behaviour in the longline fleet has been corroborated anecdotally from fisher interviews.

Single trawl CPUE

Single trawl CPUE data were available beginning in fishing years 1989–90 for all three SNA 1 stock regions. However, four different catch effort form types have been in use during this period, partially limiting the temporal continuity of the series. Prior to the 1995–96 fishing year, most SNA 1 trawl fishers used the less detailed daily CELR reporting forms. However, a significant number of SNA 1 trawl fishers (over 70%) began reporting on Trawl Catch Effort Processing Returns (TCEPR) beginning in 1995–96. These forms provided detailed effort information including latitude and longitude information for each tow as well as catch estimates for the top five species catch by weight. Most SNA 1 trawl fishers began using the new Trawl Catch Effort Return (TCER) forms with their introduction in 2007–08. The TCER forms were similar to the TCEPR forms in terms of the information gathered but required estimates of catch for the top eight species, not for five species as required by the TCEPR forms. All SNA 1 trawl fishers were required to report their catch and effort using the new electronic data reporting system (ERS) after 1 October 2019. One notable improvement was that the ERS allowed fishers to report more than the eight top species caught. It was decided not to include the CELR data in the CPUE standardisations and only to include years where a high proportion of TCEPR, TCER, or ERS data were available; specifically, the 1995–96 to 2020–21 fishing years (26-year time series).

Standardised single trawl CPUE abundance indices were derived from the event-based (tow level) spring-summer catch and effort data specific to each sub-stock area using Generalised Linear Modelling (GLM). It was necessary to restrict the classification of positive tows from the full series to the top five species across all reporting form types. This resulted in setting the weight of snapper from tows reported as rank 6 or greater to be set to zero (i.e., the tow was classed as a zero tow). Catch and effort data were restricted to tows catching significant quantities of either snapper or other common co-occurring catch species, i.e., trevally, tarakihi, John Dory, and red gurnard. Data were also restricted to vessels with five or more years involvement in each regional fishery. Further details of the analysis are provided by Langley (in prep).

Due to significant proportions of zero catch tows in the Bay of Plenty and East Northland data series, a delta-lognormal model, which combines indices from lognormal and binomial standardisations, was used to derive the final CPUE indices (McKenzie et al in prep). The proportion of zero-catch tows in the Hauraki Gulf annual catch effort data series was low (< 10%), thus not requiring a delta-lognormal model (Langley 2019).

Categorical variables offered to the GLM models included ‘vessel’ and ‘month’ in addition to fishing year. Continuous variables offered to these models included: log (headline height); depth; log (tow speed); log (tow duration); log (vessel length*depth*breadth). Further details of the CPUE standardisation analysis are provided by Langley (in prep).

The Hauraki Gulf series showed abundance increasing steadily since 1996, while the Bay of Plenty series showed an increasing trend from 2010 (Figure 6). The East Northland series climbed to a 2015 peak followed by a decreasing trend up to the final year in the data set (Figure 6).

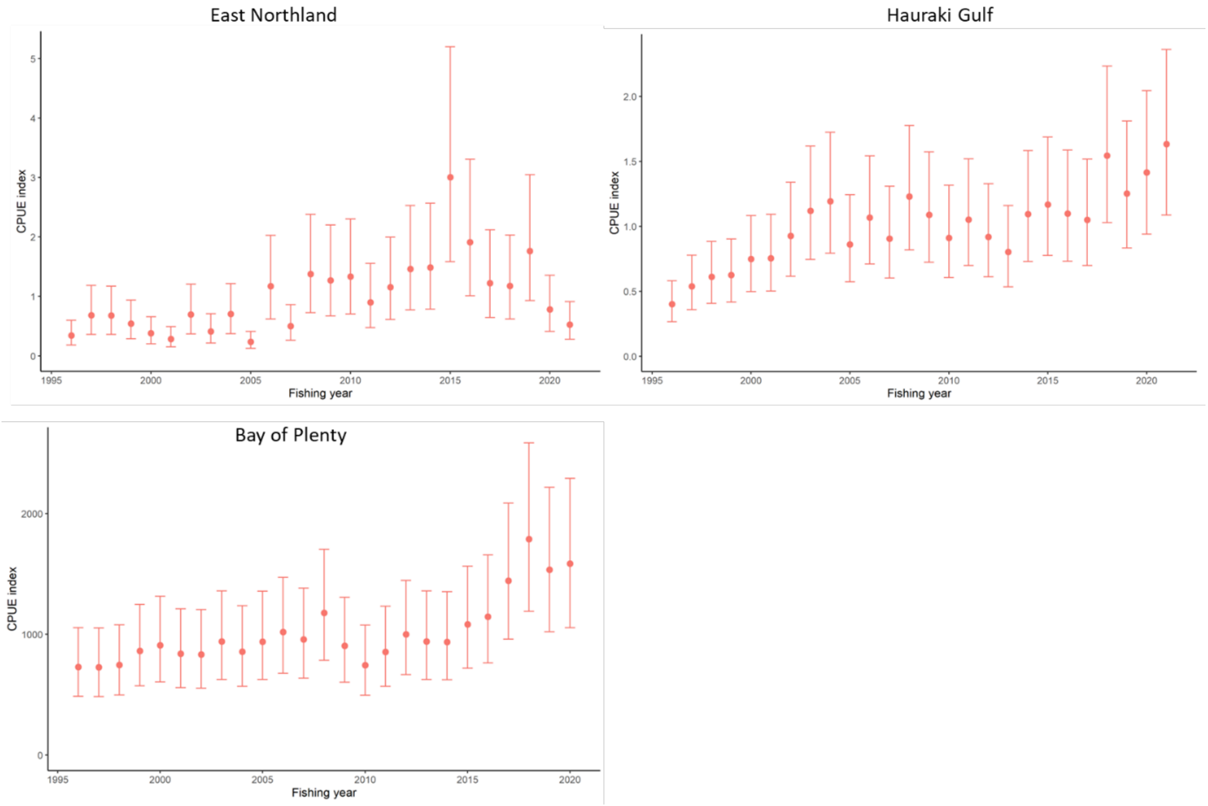


Figure 6: SNA 1 regional single trawl standardised CPUE abundance indices. Error levels on the respective series were agreed to by the Working Group reflecting how tightly the WG considered the models should fit each index (East Northland, Hauraki Gulf, Bay of Plenty: assigned model CVs were 0.31, 0.20, 0.20).

The increase in the Hauraki Gulf trawl CPUE indices is comparable with the magnitude of the increase in the Hauraki Gulf trawl survey biomass indices of recruited (6+ yr) snapper between the 1984–1994, 2000, and 2019–2020 surveys (Figure 7). The strong relative match between Hauraki Gulf survey and CPUE abundance was a significant factor in the Working Group acceptance of single trawl CPUE over longline CPUE in the 2023 SNA 1 assessment.

The East Northland abundance index is based on fewer observations than the other two series and there is variability in both the number of annual records and catch (McKenzie et al in prep). For these reasons, the WG felt this index should be given higher uncertainty than the other two indices in the model fit (Figure 6). Even allowing for increased uncertainty, the East Northland index shows the stock increased in abundance after 2008 to a higher level in the mid-2010s (Figure 6). However, the validity of the decline in East Northland index over the last five years is uncertain (Figure 6).

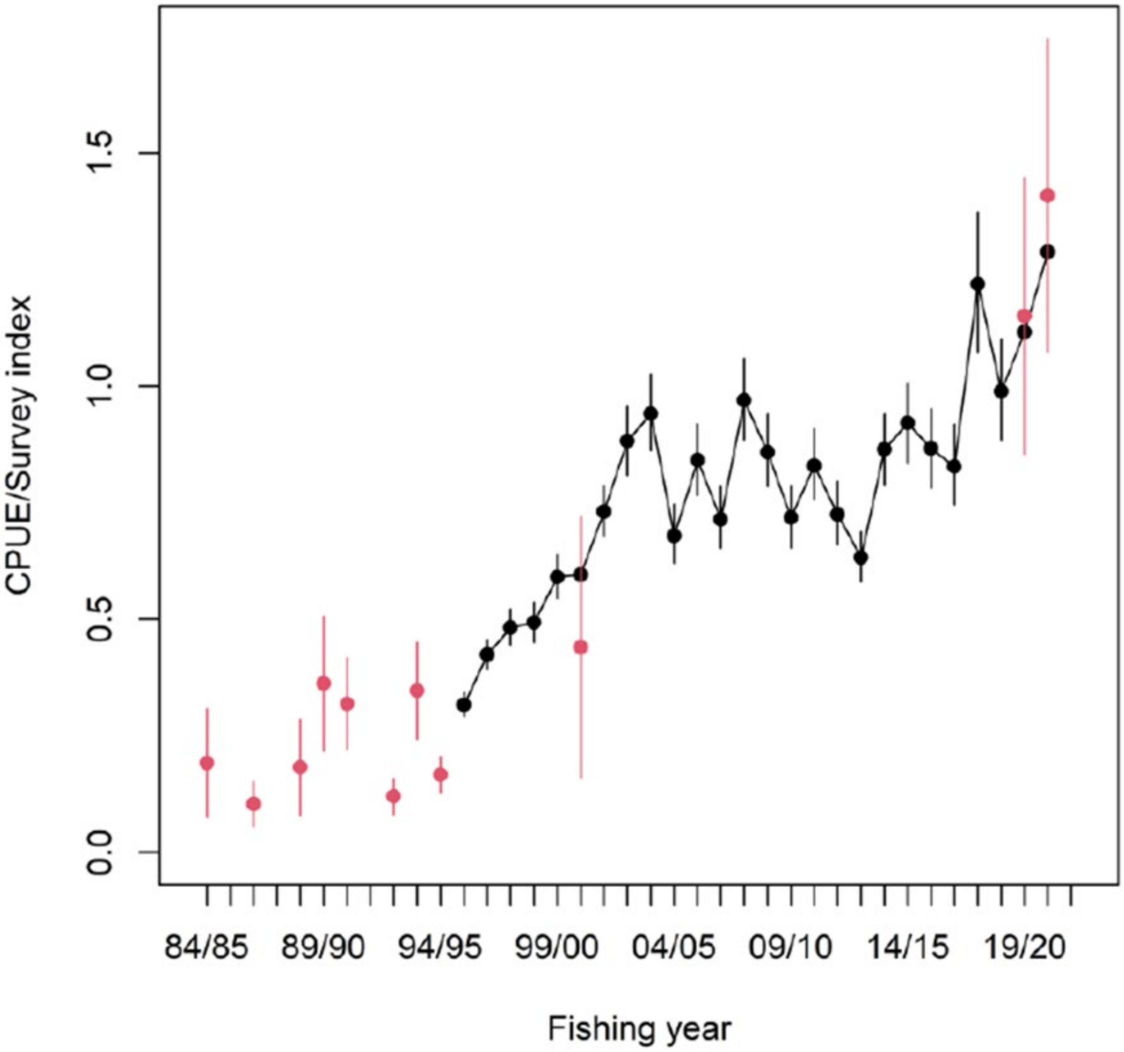


Figure 7: A comparison between the Hauraki Gulf single trawl CPUE indices and the Hauraki Gulf trawl survey biomass indices for recruited snapper (fish aged 6 years and older). The bars represent the 95% confidence intervals.

4.5 Catch-at-age and -length observations

Commercial data

Catch-at-age observations from single trawl, Danish seine, Modular Harvest System (MHS), and longline are available for the three SNA 1 stocks beginning in 1970, but the spatial temporal coverage of methods other than longline is sparse (Table 11).

Catch-at-age sampling since 1985 in East Northland showed a greater accumulation of fish older than 20 years than observed in the Hauraki Gulf or Bay of Plenty sub-stocks (Figures 8–10). The Bay of Plenty longline age composition is similar to that for SNA 8, with the fishery largely comprising 4 to 6 dominant age classes with few relatively fish older than 20 years present in the catch samples (Figure 10).

Recreational data

Observations of recreational catch-at-age are available for most years after 1990 (see Table 11). These data were collected over a period when regulations changing the minimum legal size (MLS) were implemented in 1995 and 2015. To model these regulation changes, different recreational selectivities were estimated for each of these periods.

Research trawl data

Catch-at-age observations from research trawl surveys from the Hauraki Gulf and Bay of Plenty surveys were used in the stock assessment model (see Table 11).

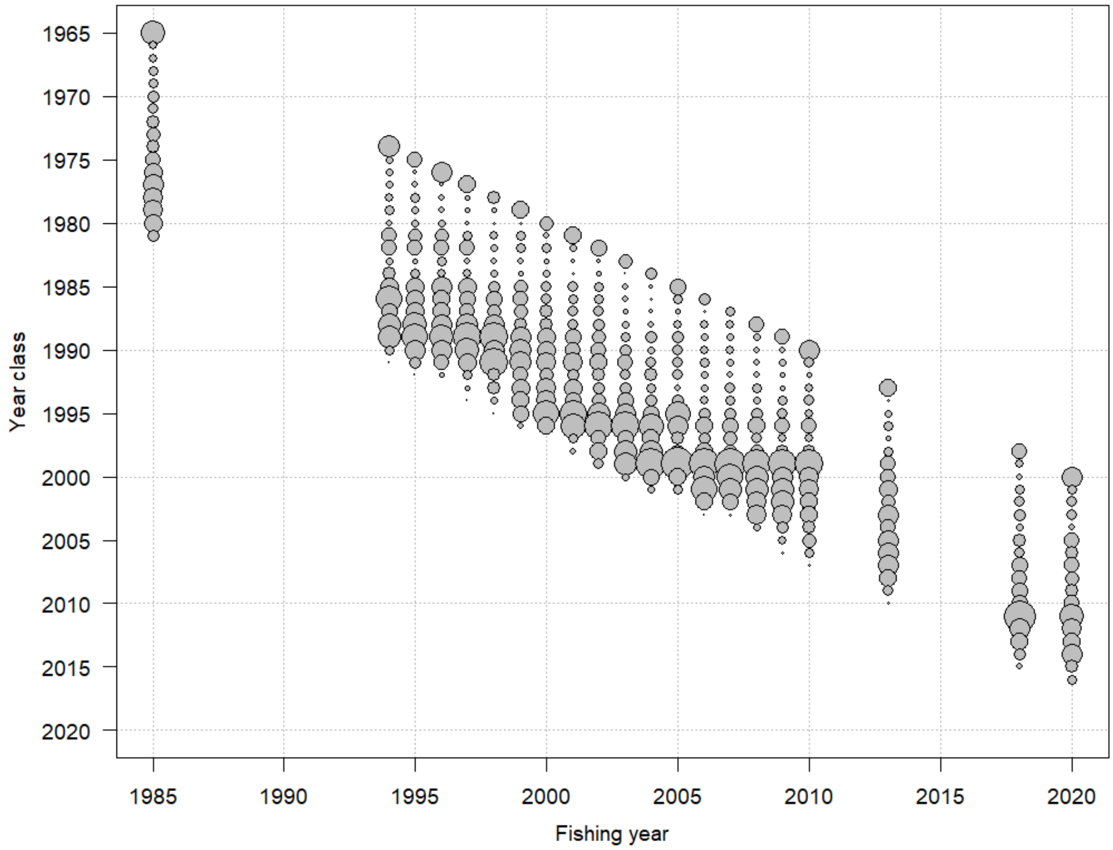


Figure 8: Relative year class strength observed in the East Northland longline fishery 1984–85 to 2019–20. Year on the x-axis refers to the second part of the fishing year. The oldest year class is a 20+ group.

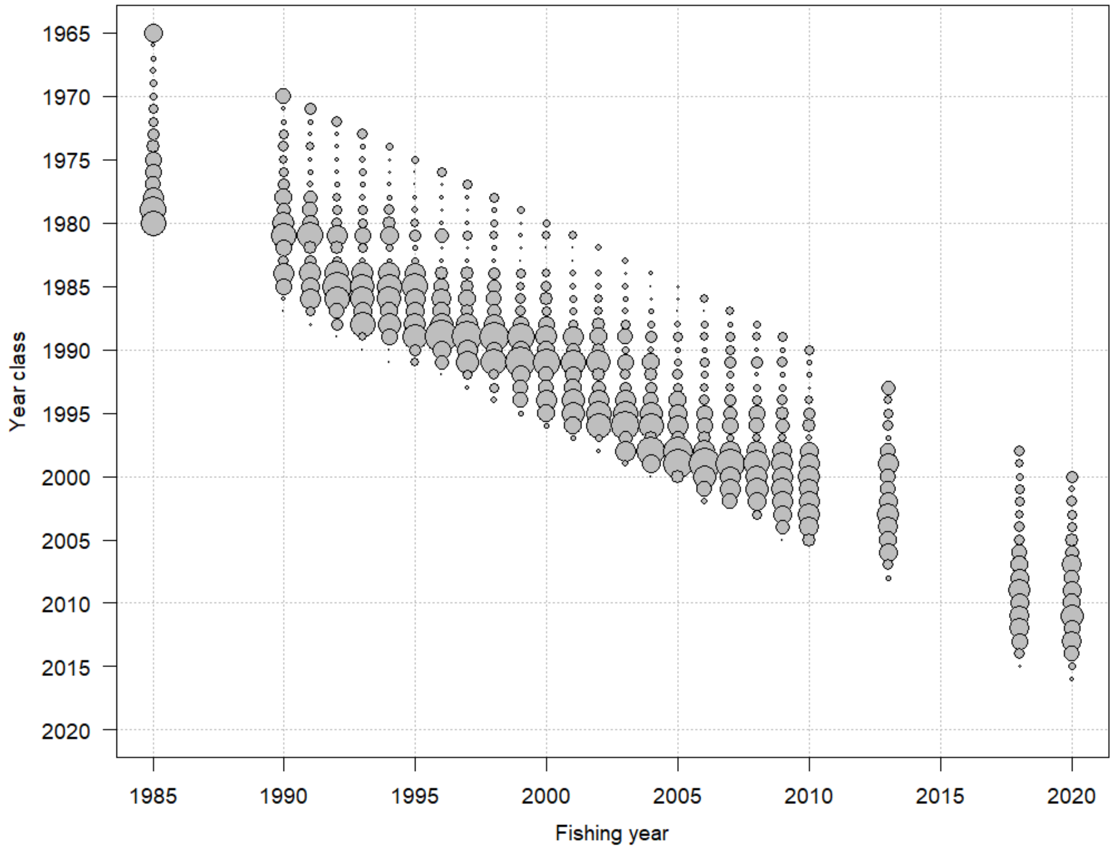


Figure 9: Relative year class strength observed in the Hauraki Gulf longline fishery 1984–85 to 2019–20. Year on the x-axis refers to the second part of the fishing year. The oldest year class is a 20+ group.

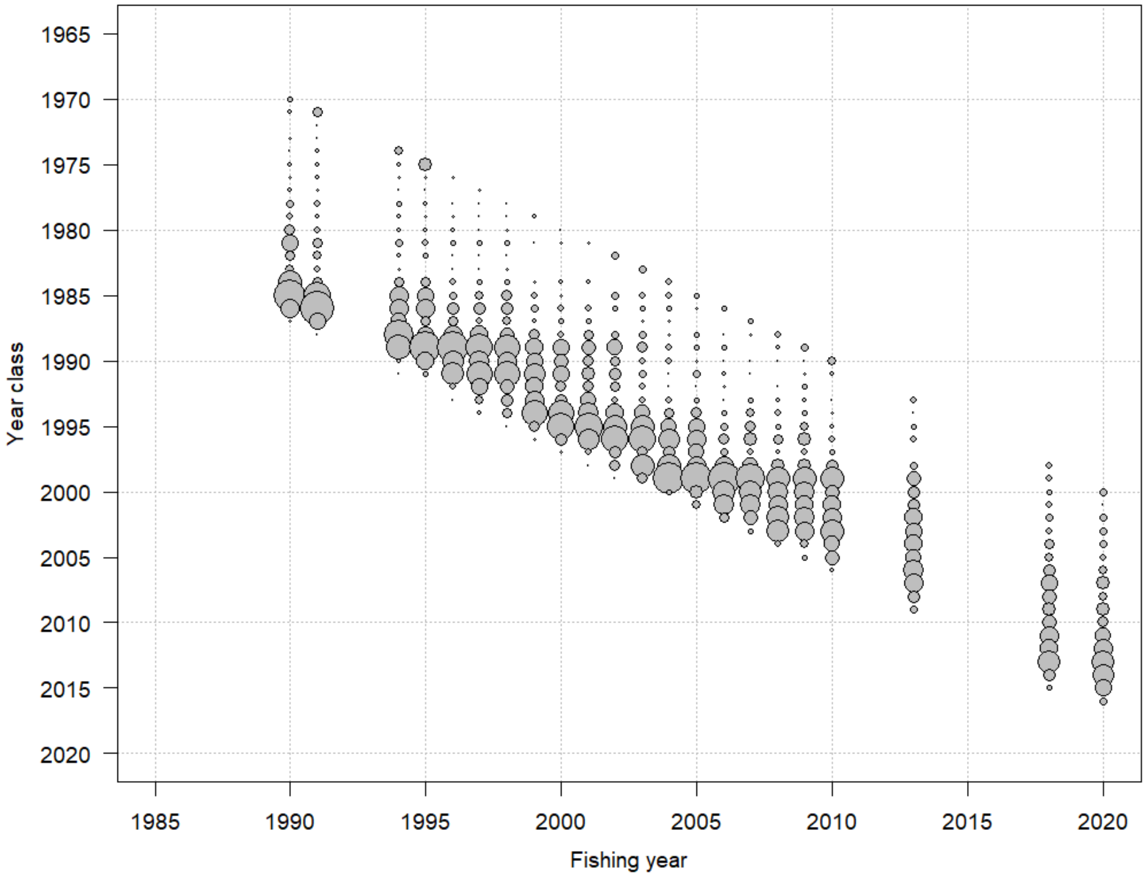


Figure 10: Relative year class strength observed in the Bay of Plenty longline fishery 1990–91 to 2019–20. Year on the x-axis refers to the second part of the fishing year. The oldest year class is a 20+ group.

4.6 Snapper 1983, 1985, and 1994 tagging programmes

Biomass and movement estimates were originally estimated outside of the stock assessment model for the 1983, 1985, and 1994 SNA 1 tagging programmes, using Petersen-type estimators (Sullivan et al 1988, McKenzie & Davies 1996). Before the 2012 and 2013 stock assessments, the Petersen tagging biomass estimates were used in the SNA 1 assessment models as fixed values with assumed CVs (Gilbert et al 2000). However, the 2012 and 2013 SNA 1 stock assessment models used the 1984 and 1994 tagging release and recovery data, which were fitted directly in the assessment model (Francis & McKenzie 2015a, 2015b).

Release and recovery data from the 1983 Bay of Plenty tagging programme were unavailable so the direct fitting of these data could not be implemented. The published biomass estimate (6000 t, Sullivan et al 1988) was fitted in the 2013 assessment as a point estimate but with a high CV (0.4) in recognition of large unknown biases in the data.

Externally derived abundance [and movement] estimates from the 1985 and 1994 tagging programmes were fitted in the 2023 assessments because of concerns about model performance when fitting to the tagging data directly.
The 1985 and 1994 tagging data were reanalysed for the 2023 SNA 1 assessment to accommodate the Hauraki Gulf/East Northland boundary change. Petersen estimators were used for the updated tagging analyses (McKenzie et al in prep).

Bias correction of SNA 1 tagging data

Analysis of past snapper tagging programmes revealed a number of sources of bias that needed to be considered if these data were to be used for assessment purposes.

1. Initial mortality

The release data were adjusted for initial mortality using methods given by Gilbert & McKenzie (1999).

2. Tag loss

The effect of tag loss was only an issue for the 1983 and 1985 tagging programmes where external tags were used. A revised estimate of tag loss was derived from a double-tagging experiment in 1985 (Francis & McKenzie 2015a).

3. Trap avoidance

Gilbert & McKenzie (1999) found evidence of trap avoidance in the 1994 SNA 1 tagging data that suggested fish released by a specific method were less likely to be recaptured by that method. If trap avoidance was a factor in the 1985 and 1994 tagging data, the resulting biomass estimate would be biased high. Subsequent spatial analyses of the 1994 tagging data suggested that avoidance patterns in the tagging data could also be explained by small-scale spatial heterogeneity in the initial tag release data (McKenzie et al in prep). The Working Group felt that the existence of trap avoidance in the SNA 1 tagging data is unproven and recommended not applying the Gilbert & McKenzie (1999) correction factors in the 2023 tag reanalyses.

4. Detection of recaptured tags

Because a fisheries-independent tag recovery process was used in the 1994 programme, a reliable estimate of tag under-detection was obtained. The 1994 tag biomass estimate was adjusted to remove this bias based on this analysis.

The recovery of tags in 1983 and 1984 programmes relied on fishers to voluntarily return tags. Estimates of under-reporting from these programmes are less precisely known but were assumed to be 15% (1988 Snapper Plenary Report).

5. Differential growth of tagged fish

There is evidence that tagged fish may stop growing for about 6 months after tagging (Davies et al 2006). The growth differential between tagged and untagged fish may bias results because the model recovery predictions by length bin were based on the mean growth of untagged snapper. Because it was not possible to incorporate this source of bias in the reanalysis of the tagging data, it was assumed that, given that the majority of tags recovered in both programmes came from the first year after release, growth bias would be minimal.

6. Spatial heterogeneity

A primary objective when tagging fish for biomass estimation is to ensure homogeneous mixing of tags within each spatial stratum so that the probability of recovering a tagged fish is the same in all locations. Spatial heterogeneity interferes with the realisation of this objective. The potential bias caused by spatial heterogeneity may be high or low because it depends largely on the spatial distribution of recapture effort (i.e., fishing) within each spatial stratum. Heterogeneity was observed in both tagging programmes because mark rates varied amongst statistical areas and fishing methods; and this was most apparent in the 1994 Hauraki Gulf Danish seine catches (Gilbert & McKenzie 1999). The results of simulation modelling using Hauraki Gulf data from the 1994 programme showed that, under scenarios where the difference in the spatial mark rates was high (up to 4-fold) and catch examination tonnages were spatially disproportionate, the level of bias (positive or negative) in the biomass estimate could be as high as 35% (Davies et al 1999b). However, for scenarios where fishing was more uniform across strata, the expected level of bias was likely to be about 10%. To further investigate potential bias introduced by heterogeneity in the 1994 tagging programme, fish tagged and released by the Hauraki Gulf Danish seine fishery were excluded from the analysis. This increased the 1995 Hauraki Gulf biomass estimate by 15%, from 30 000 t to 34 000 t (Davies et al 1999a). Evidence for spatial heterogeneity in East Northland and the Bay of Plenty was much weaker than for the Hauraki Gulf (Gilbert & McKenzie 1999). For the

1985 and 1994 tag reanalyses all tag recovery data were used, including Danish seine recoveries from the Hauraki Gulf.

1985 and 1994 Petersen tagging reanalysis results

The revised 1985 and 1994 SNA 1 tagging analyses differed from those described by Gilbert et al (2000), as follows:

- New spatial boundary definitions;
- Analyses restricted to fish of length 25–40 cm at time of release;
- Recovery data not corrected for trap avoidance;
- Abundance expressed as estimated number of fish not biomass;
- Movement estimated as proportional annual movement.

Although it was possible to restructure the 1994 tagging data for the new boundary definitions this was not possible for the 1985 programme. Therefore, the 1985 data were reanalysed pursuant to the 25–40 cm definition to derive a new combined estimate for the HG and EN, and this estimate was then split using the stock abundance ratio derived from the 1994 tag reanalysis.

Table 12 shows the revised tagging abundance estimates and Table 13 the revised Hauraki Gulf/Bay of Plenty movement estimates.

Table 12: Petersen tag abundance estimates (number of 25-40 cm snapper) for 1985 and 1994 fishing years.

	1985		1994	
Stock region	**Numbers**	**CV**	**Numbers**	**CV**
East Northland	4.4 million	0.3	4.8 million	0.2
Hauraki Gulf	29.4 million	0.3	31.5 million	0.2
Bay of Plenty	–	–	12 million	0.2

Table 13: Petersen tag Hauraki Gulf/Bay of Plenty regional annual proportional movement estimates.

		to	
		Hauraki Gulf	Bay of Plenty
from	Hauraki Gulf	0.89	0.11
	Bay of Plenty	0.21	0.79

4.7 Stock assessment results

East Northland model

The base model MPD achieved reasonably good fits to the composition data. MPD fits to the tag abundance observations were both above the 1985 and 1994 estimates but within the model confidence intervals. The MPD fit to the single trawl CPUE index, while capturing the general increase observed after 2008, was unable to fit the decline observed in the final year (2020–21; Figure 11).

Model year class strength estimates, although variable, showed no obvious upward or downward trend over the estimation period (Figure 12). The reduction in year class estimation precision after 2000 is partially due to lower sampling frequency after 2010 (Figure 8; note year classes are not fully recruited to the longline fishery until age 7 or 8). Likelihood profiles showed that predicted strong 1999 year class (Figure 12) was largely informed by the longline compositional data (McKenzie et al in prep).

The model predicted *SSB* posteriors show the median predicted stock biomass in 2022 was 20 000 tonnes (Figure 13). The model biomass trajectory shows a steady decline to 2002, followed by a steep increase (Figure 13). The predicted post-2002 biomass increase is consistent with the strong 1999 year class entering the spawning population.

The model predicted the East Northland stock to be above the soft limit in 2022, with a 33% probability of also being above the target biomass (Figure 13, Table 14).

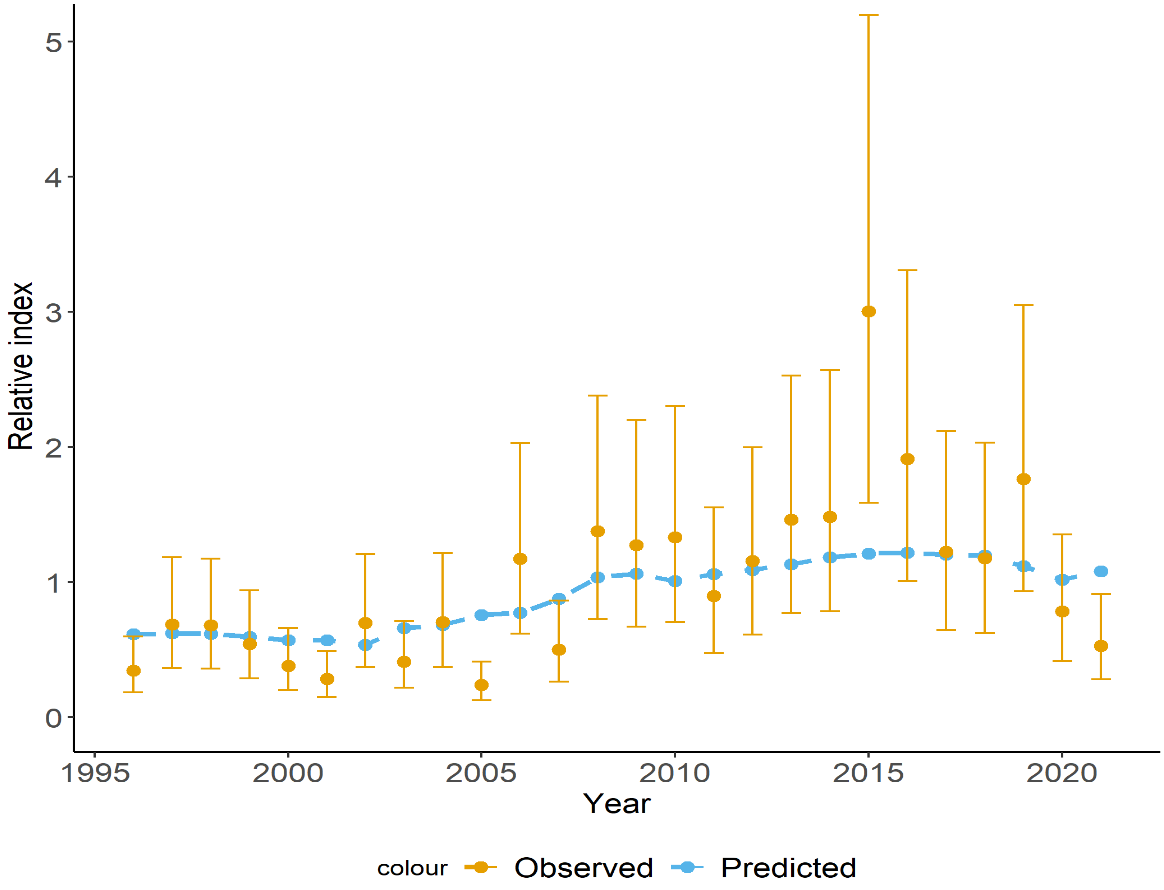


Figure 11: East Northland model MPD fit the the spring-summer single trawl CPUE index.

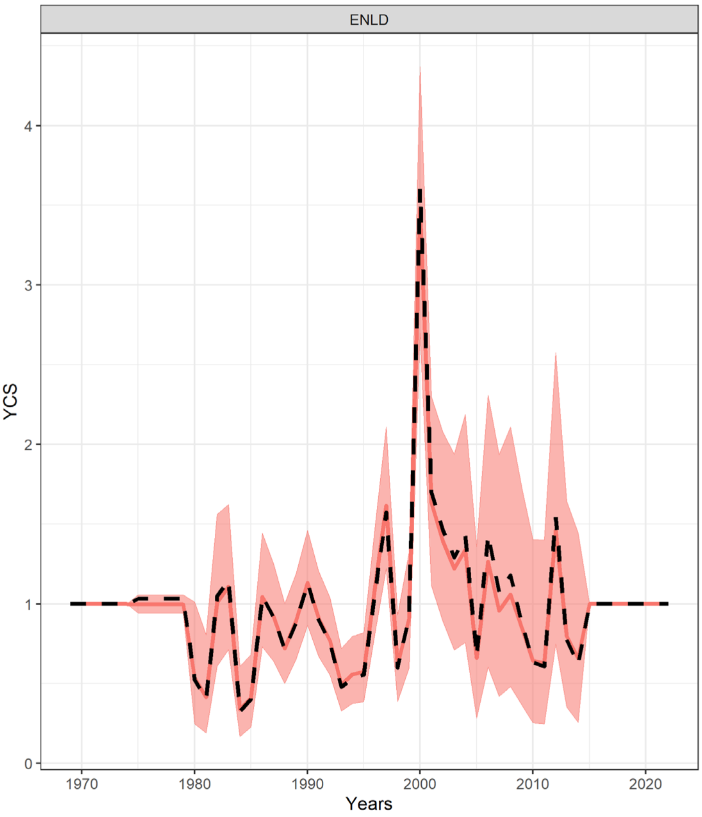


Figure 12: Estimated East Northland year class strengths by year (a value of 1 indicates that the year class has the strength predicted by the stock-recruit relationship). Estimates are: MCMC medians (solid line); 95% confidence intervals (shaded regions); MPD estimates (dashed line).

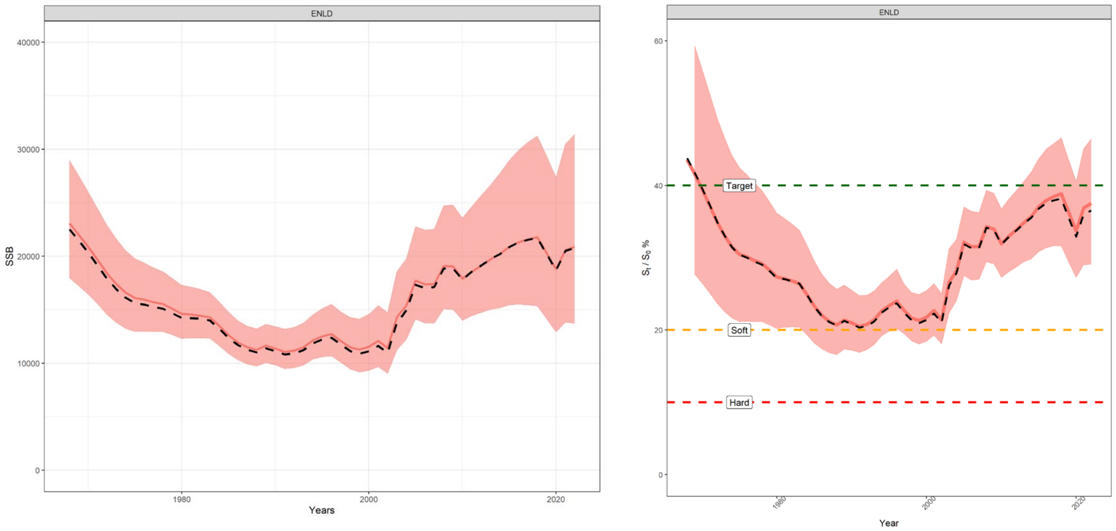


Figure 13: Estimated East Northland Spawning Stock Biomass trajectory (tonnes)(left) and trajectory relative to B_0 (right). Estimates are: MCMC medians (solid line); 95% confidence intervals (shaded regions); MPD estimates (dashed line).

Table 14: Probabilities of the East Northland stock 2022 biomass being at or above the target (40% B_0) and at or below the limit reference points (soft 20% B_0 and hard 10% B_0).

Probability	**%**
At or above target	33.0
Below soft limit	0.0
Below hard limit	0.0
Median B_{2022} % B_0	38.0 (95% CI 29–47)

Sensitivity analyses

Alternative models were constructed and run to determine the sensitivity of the assessment to various model assumptions (McKenzie et al in prep). These included: setting natural mortality (M) to 0.06, assuming growth prior to 1990 was equivalent to 1990 values, inflating pre-1994 commercial catches by 20%, commencing model in 1900. Except for the lower M sensitivity, none of the other sensitivity model runs produced substantially different status or productivity predictions to the base model (McKenzie et al in prep).

Yield estimates and projections

Five-year projections of the base case model were carried out under ‘status quo’ conditions, which were taken to mean constant catches (equal to the 2022 catch). In these projections, simulated year class strengths were re-sampled from the 10 most recent reliably estimated YCSs (deemed to be 2005–2014). The simulated YCSs included both the recent YCSs that were not estimated (due to the lack of recent age composition data) in the MPD (2015–2022) as well as the five ‘future’ YCSs (2023–2027).

Based on the projections, the East Northland stock status is predicted to remain largely at 2022 levels over the following five years (Figure 14). The probability of the stock declining over the projection period was low (Table 15).

Status relative to exploitation: $U_{B40\%}$ reference level

The $U_{B40\%}$ East Northland exploitation ratio was estimated from deterministic projections of the 2023 assessment model with varying levels of constant catch. $U_{B40\%}$ is defined as the annual catch that produced the $SSB_{40\%}$ equilibrium. The East Northland stock $U_{B40\%}$ was estimated to be 0.052 which corresponded to a constant annual projected catch of 1120 tonnes. Exploitation status as derived from MCMC model posteriors are given in Table 16.

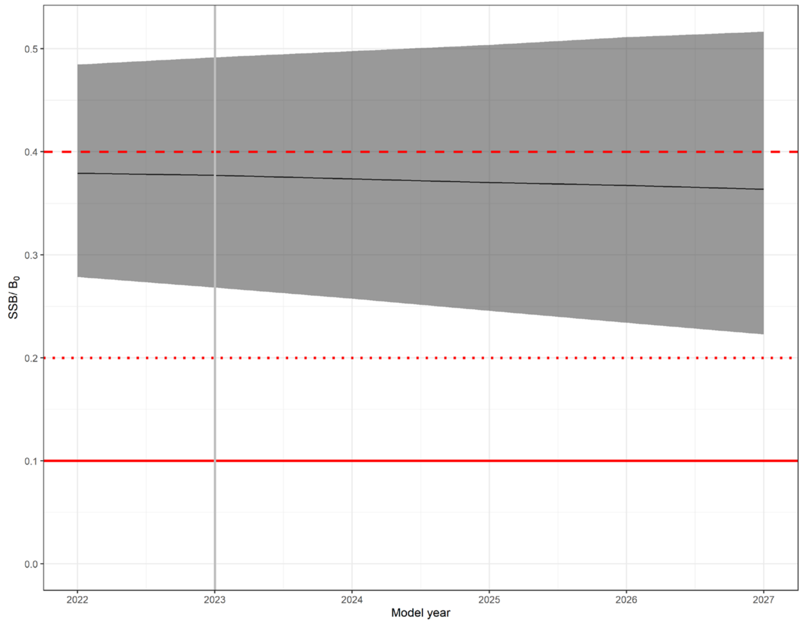


Figure 14: East Northland stock status projections. Estimates are: MCMC medians (solid line); 95% confidence intervals (shaded regions).

Table 15: East Northland projected stock status for fishing years 2023–2027.

	Projection fishing year				
Probability	**2023**	**2024**	**2025**	**2026**	**2027**
< 20% B_0	0.00	0.00	0.00	0.01	0.01
< 40% B_0	0.66	0.67	0.68	0.68	0.69
>= 40% B_0	0.34	0.33	0.32	0.32	0.31

Table 16: East Northland exploition probability status realtive to $U_{B40\%}$.

Probability	**Value**
P[$U_{2022} > U_{B40\%}$]	0.72
P[$U_{2022} <= U_{B40\%}$]	0.28

Hauraki Gulf/Bay of Plenty movement model

It was not possible to achieve MPD convergence with the 1968 commence version of the Hauraki Gulf/Bay of Plenty movement model largely due to high correlation between the B_0 and F_{init} model parameters (McKenzie et al in prep). The 1900 start version of this model was able to achieve convergence. However, the Working Group strongly disfavoured this model on the grounds that model B_0 estimates were largely predetermined by the long period of highly uncertain pre-1970 catch histories going into the model.

MPD convergence was achievable with the Hauraki Gulf/Bay of Plenty commence 1968 model if movement was set to 0, i.e., no movement. The assessment of the Hauraki Gulf/Bay of Plenty stock complex was therefore undertaken using separate regional stock assessment models.

Hauraki Gulf model

The base model MPD achieved reasonably good fits to the composition data except for the pre-1973 Danish seine data (note: the sampling representativeness of these data is unknown hence the lack of fit is less of a concern).

MPD fits to the tag abundance observations were better than in the East Northland model, being closer to the estimated values and well within the assigned confidence intervals. The MPD fit to the single trawl CPUE index was also good, the model capturing the increase seen in this index and fitting within the confidence bounds of all points (Figure 6). MPD fits to the research trawl 1–5 year class indices were also acceptable, with strong and weak cohorts being generally well estimated. The model failed, however, to fit the large biomass increase predicted in the last two years of the survey 6+ biomass series, being below the lower confidence intervals in the last two survey years.

Model year class strength estimates, although variable, show a progressive upward trend over the estimation period (Figure 15). The increasing trend in recruitment strengths is problematic because it implies an underlying shift in Hauraki Gulf stock productivity (i.e., dynamic B_0). If the effective B_0 has been increasing since the 2000s, then the model estimate of B_0 (which is based on an average of all recruitment years), as a relative measure of stock productivity, will likely under-represent the true stock productivity in recent years and over-estimate it in the earlier years.

Likelihood profiles showed that the predicted strong 2015 year class (Figure 15) was largely informed by trawl survey 5-year-old index, which validates this year class as being strong (McKenzie et al in prep). Of concern, however, is the 2015 year class likelihood profiles showing that both single trawl CPUE and survey 6+ biomass likelihoods favour this age class being much stronger than the model maximum likelihood predicted value (McKenzie et al in prep).

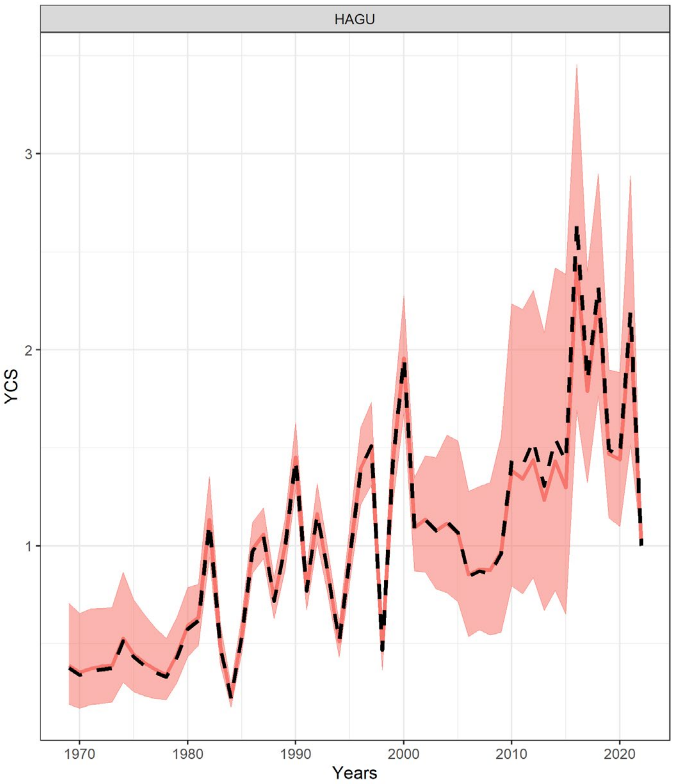


Figure 15: Estimated Hauraki Gulf year class strengths by year (a value of 1 indicates that the year class has the strength predicted by the stock-recruit relationship). Estimates are: MCMC medians (solid line); 95% confidence intervals (shaded regions); MPD estimates (dashed line).

The model predicted *SSB* posteriors show the median predicted stock biomass in 2022 was 143 000 tonnes with the stock predicted to have been reduced to 32 000 tonnes in 1988 (Figure 16). An important point to note is that the mid-1980s to mid-1990s biomass estimates are supported by the 1985 and 1994 tag absolute abundance estimates to which the model fitted acceptably. Because the model was also able to capture the upward trend in the single trawl CPUE series beginning from 1996 (Figure 6), the Plenary felt that the model *SSB* predictions from 1968 to 2022 (Figure 16) should be given a high level of credibility. The Plenary was less confident in the model estimates of B_0 and F_{init} and therefore of the stock sustainability predictions, given the recruitment evidence that mean productivity (B_0) may have changed after 2000 (Figure 15).

Hauraki Gulf model $U_{B40\%}$ reference level

The $U_{B40\%}$ Hauraki Gulf exploitation ratio was estimated from deterministic projections of the 2023 assessment model with varying levels of constant catch. $U_{B40\%}$ is defined as the annual catch that produced the equilibrium $SSB_{40\%}$. The Hauraki Gulf model $U_{B40\%}$ was estimated to be 0.049 which corresponded to a constant annual projected catch of 8800 tonnes.

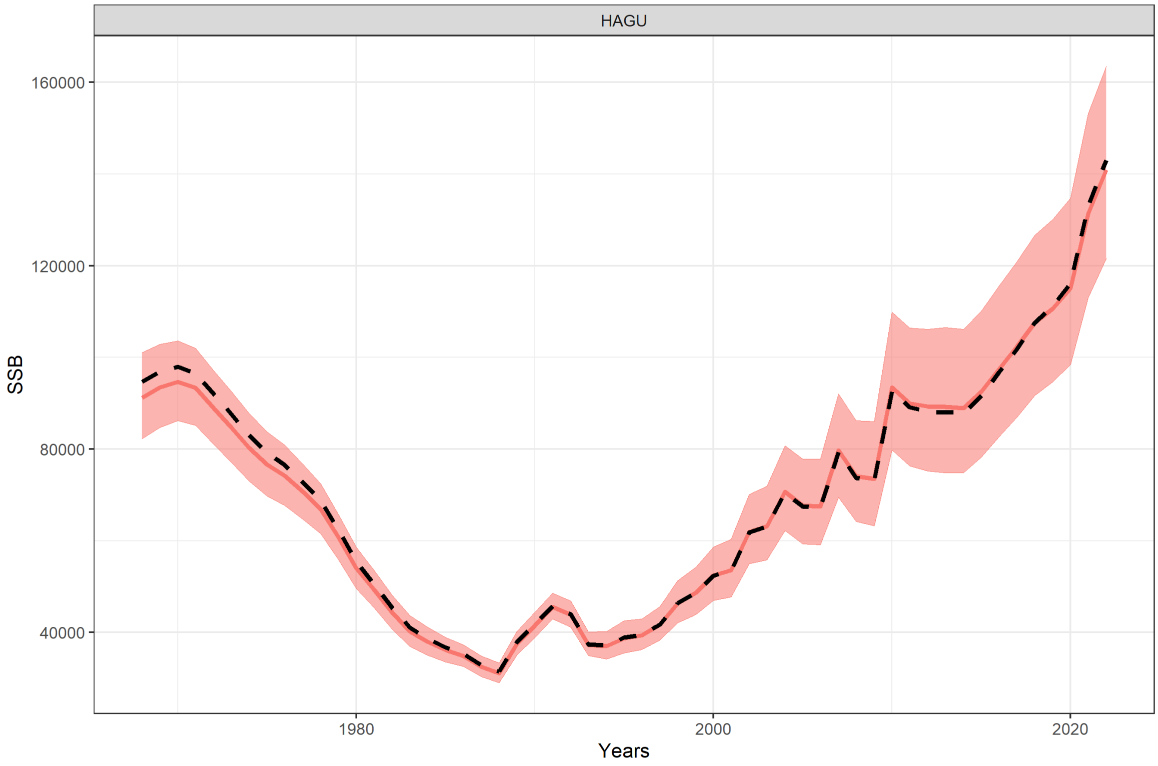


Figure 16: Estimated Hauraki Gulf Spawning Stock Biomass predictions (tonnes). Estimates are: MCMC medians (solid line); 95% confidence intervals (shaded regions); MPD estimates (dashed line).

Bay of Plenty model

The base model MPD achieved reasonably good fits to the composition data. MPD fits to the tag abundance observations were also good, being near the Petersen estimated values. The MPD fit to the single trawl CPUE index predicted a steeper increase in abundance than observed (Figure 6) but the predicted index was within observed index confidence intervals. As with the Hauraki Gulf model the Bay of Plenty model could not match the increase in observed trawl survey 6+ biomass index in the final year (2021).

Model year class strength estimates were again variable, but there is no obvious pattern of increasing trend as seen in the Hauraki Gulf model (Figure 17).

The model predicted *SSB* MCMC posteriors show the median predicted stock biomass in 2022 was 31 000 tonnes with the stock predicted to have been reduced to 4000 tonnes in 1988 (Figure 18). An important point to note is that the mid-1980s to mid-1990s biomass estimates are supported by the 1983 and 1994 tag absolute abundance estimates to which the model fitted acceptably. Because the model was able to capture the general upward trend in the single trawl CPUE (Figure 6), the Plenary felt that the model *SSB* predictions (Figure 18) were credible. As with the Hauraki Gulf model, the Plenary was not confident in the model estimates of B_0 and F_{init} and therefore the stock sustainability predictions because it was unlikely that the stock could have recovered from a predicted 2% B_0 status in 1988 while still being fished.

Bay of Plenty model $U_{B40\%}$ reference level

The $U_{B40\%}$ Bay of Plenty exploitation ratio was estimated from deterministic projections of the 2023 assessment model with varying levels of constant catch. $U_{B40\%}$ is defined as the annual catch that produced the equilibrium $SSB_{40\%}$. The Bay of Plenty model $U_{B40\%}$ was estimated at 0.049 which corresponded to a constant annual projected catch of 3400 tonnes.

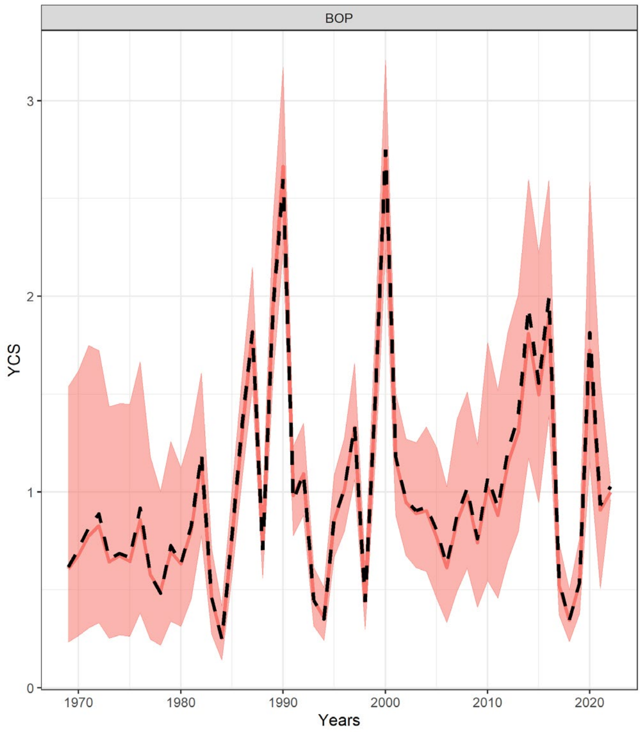


Figure 17: Estimated Bay of Plenty year class strengths by year (a value of 1 indicates that the year class has the strength predicted by the stock-recruit relationship). Estimates are: MCMC medians (solid line); 95% confidence intervals (shaded regions); MPD estimates (dashed line).

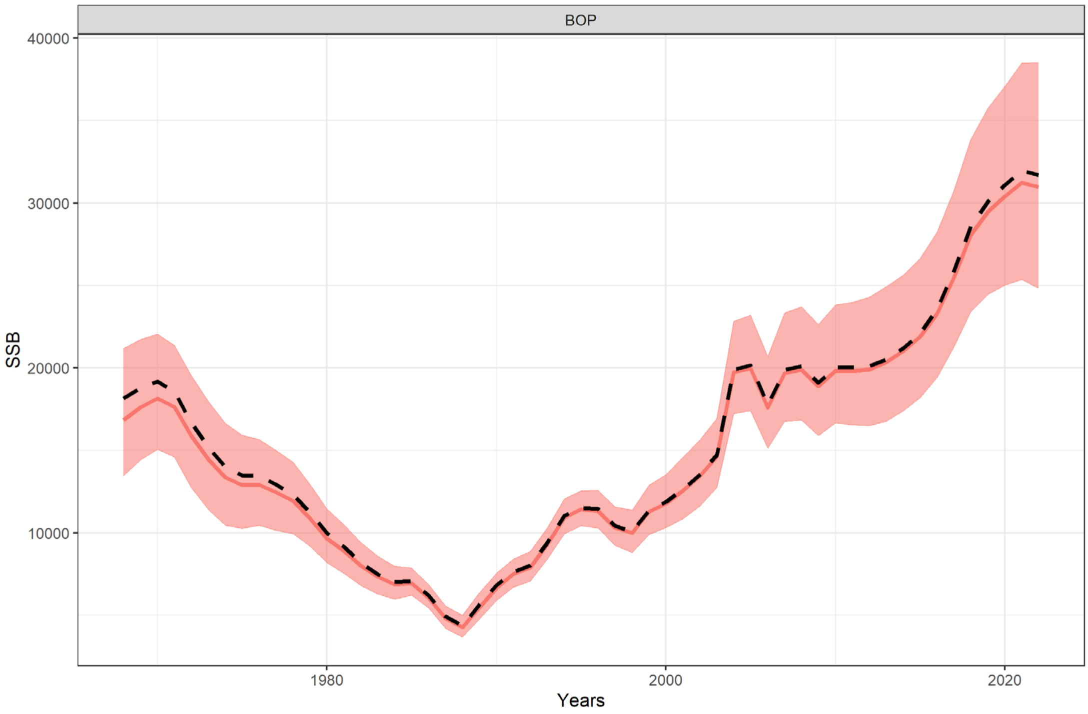


Figure 18: Estimated Bay of Plenty Spawning Stock Biomass predictions (tonnes). Estimates are: MCMC medians (solid line); 95% confidence intervals (shaded regions); MPD estimates (dashed line).

Combined Hauraki Gulf – Bay of Plenty assessment predictions

The separate Hauraki Gulf and Bay of Plenty assessment models do not take account of known rates of movement between the two stock areas, and hence both are likely to be biased. The Plenary recommended combining the results from the two assessment models for the provision of management advice to attempt to reduce the bias. This approach assumes that the movement bias in the two independent models cancel each other out when combined (the combined stock approach was also adopted for the 2013 assessment).

The Plenary felt that validity of reporting the B_0 reference sustainability predictions for the combined model was questionable due to the possibility that a productivity shift occurred in the Hauraki Gulf stock after 2000. In recognition of this, the Plenary recommended using the $U_{B40\%}$ exploitation rate as a $B_{40\%}$ target proxy under the rationale that the *SSB* trajectories from the two models are likely to be well estimated, given the anchoring effect of the two tag biomass estimates and the 2000 and 2001 trawl survey indices.

The model predicted *SSB* posteriors show the median predicted combined stock biomass in 2022 was 170 000 tonnes with the combined stock predicted to have been reduced to 35 000 tonnes in 1988 (Figure 19).

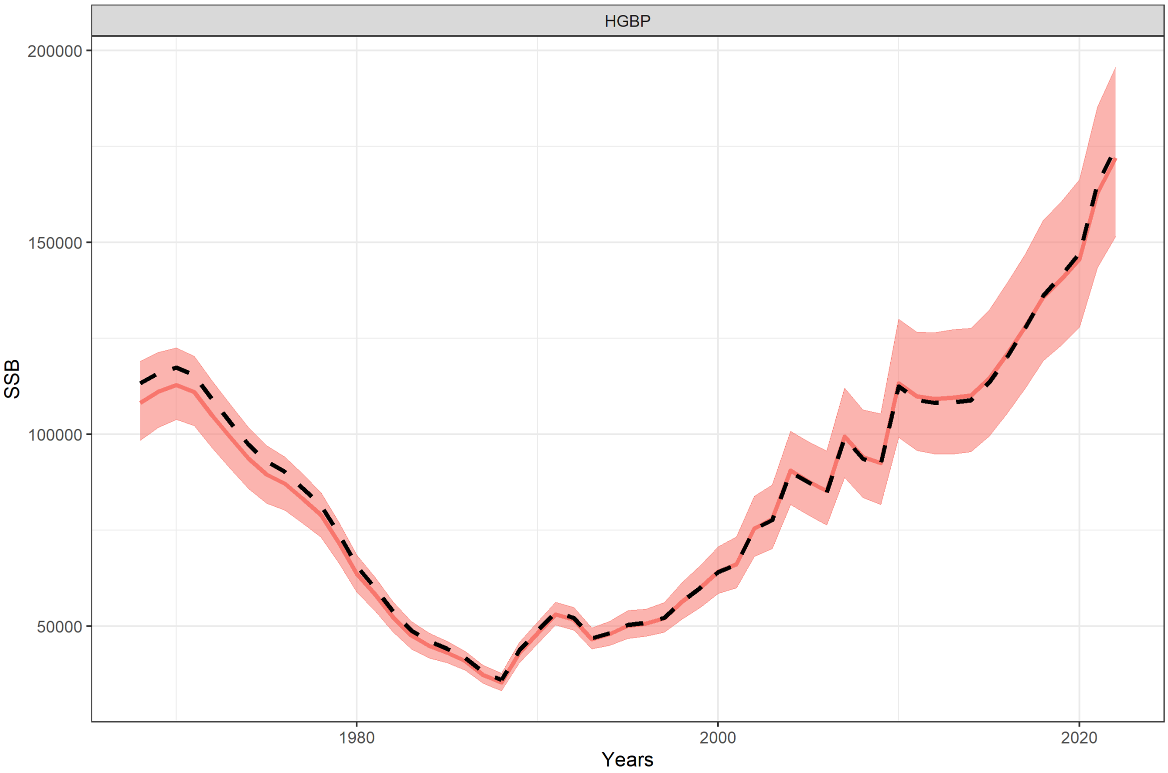


Figure 19: Estimated Huraki Gulf-Bay of Plenty Spawning Stock Biomass predictions (tonnes). Estimates are: MCMC medians (solid line); 95% confidence intervals (shaded regions); MPD estimates (dashed line).

Combined Hauraki Gulf-Bay of Plenty $U_{B40\%}$ reference level

The deterministic $U_{B40\%}$ estimates from the three independent SNA 1 assessment models were similar (0.052, 0.049, 0.049). The Plenary recommended using a value of 0.050 as the Hauraki Gulf-Bay of Plenty stock complex $U_{B40\%}$ target reference point.

The combined model predicted the Hauraki Gulf-Bay of Plenty stock complex to be at or below the $U_{B40\%}$ reference level in 2022 with high probability (nearly 100%, Table 17).

Table 17: Probabilities of Hauraki Gulf – Bay of Plenty stock complex 2022 biomass relative to the U$B_{40\%}$ sustainibility target.

Probability	**%**
At or above target $U_{B40\%}$	0.02
below target $UB_{40\%}$	99.98
Median U_{2022}	0.041 (95% CI 0.036–0.046)

Yield estimates and projections

Five-year projections of the base case model were carried out under 'status quo' conditions, which were taken to mean constant catches (equal to the 2022). In these projections, simulated year class strengths were resampled from the 10 most recent reliably estimated YCSs (deemed to be 2012–2021). The simulated YCSs included both the recent YCSs that were not estimated (due to the lack of recent age composition data) in the MPD (2022) as well as the five 'future' YCSs (2023–2027).

Based on the projections, fishing pressure (U) on the Hauraki Gulf-Bay of Plenty stock complex is predicted to decline further below the $U_{B40\%}$ threshold (Figure 20). The probability of fishing pressure remaining below the $U_{B40\%}$ threshold in each project year is 100% (Table 18).

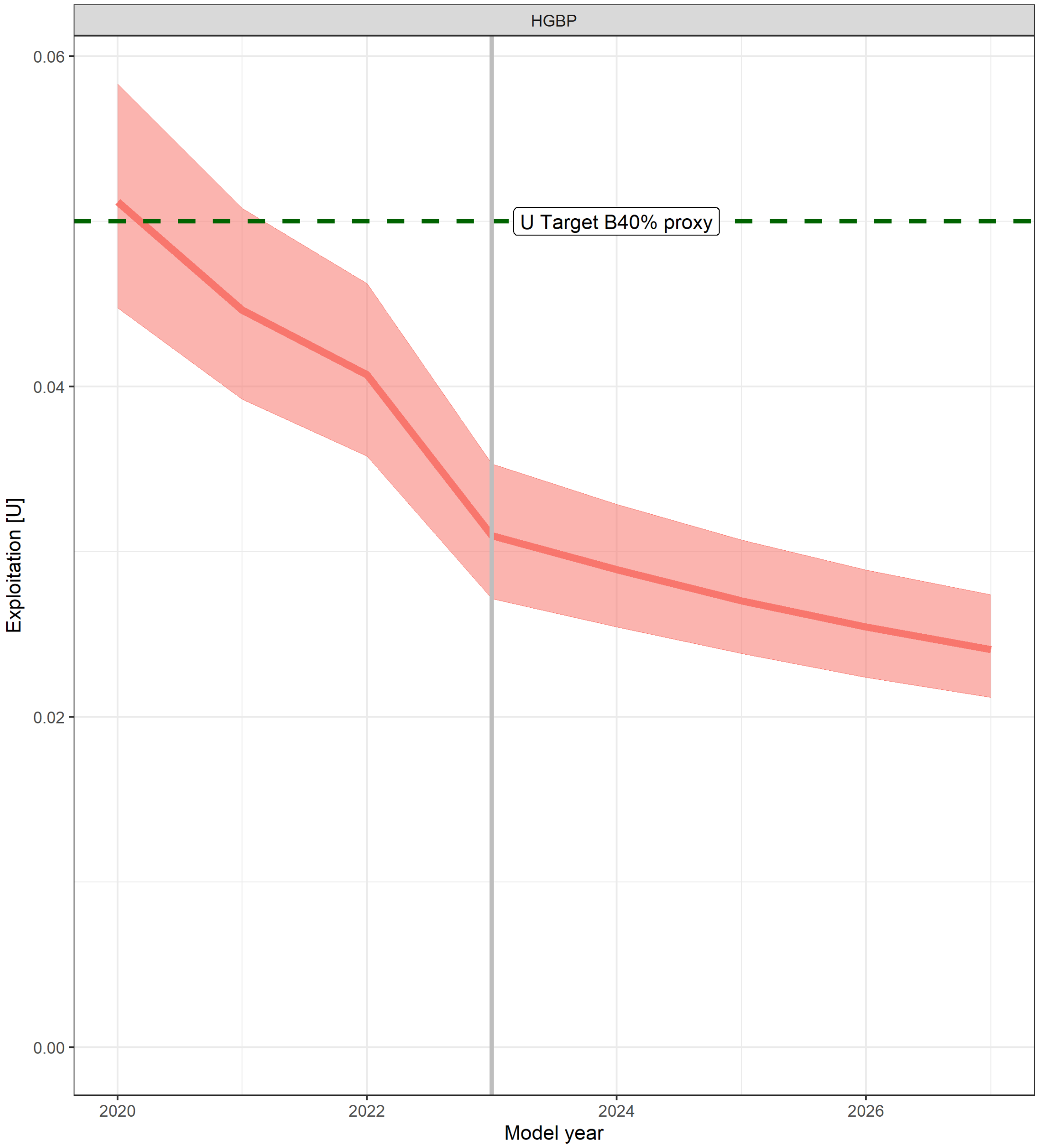


Figure 20: Hauraki Gulf-Bay of Plenty stock complex status ($U_{B40\%}$) projections. Estimates are: MCMC medians (solid line); 95% confidence intervals (shaded regions).

Table 18: Hauraki Gulf-Bay of Plenty stock complex projected stock status for fishing years 2023–2027.

	Projection fishing year				
Probability	**2023**	**2024**	**2025**	**2026**	**2027**
$U < U_{B40\%}$	100%	100%	100%	100%	100%

4.8 Future research considerations

- Undertake a tagging study (including SNA 2N) to estimate biomass, seasonal movement, stock boundaries, and selectivity.
- Investigate options for fisheries-independent abundance estimates, such as a new tagging study or fishery-independent longline surveys in areas not amenable to trawl, e.g., East Northland. This is necessary because there is uncertainty in the relationship between standardised CPUE and abundance.
- Improve the understanding of stock boundaries and movement dynamics in East Northland, Bay of Plenty, the Hauraki Gulf, and SNA 2 to better define stock structure and movement. A new tagging study is likely to be the best option for understanding SNA 1 stock structure and mixing.
- Include bottom trawl catches in the catch-at-age sampling.
- Further develop the recreational catch model, including models with all three areas combined and an area factor and testing the addition of interaction parameters.
- Investigate the feasibility of moving to a seasonal model.
- Evaluate alternative fishery independent abundance monitoring other than trawl surveys.
- Re-examine catch histories. Catch histories from 1968 are based on methods used in 1983. This may overestimate longline catches and underestimate recruitment and so should be re-examined.
- Undertake simulation modelling to:
    - Evaluate the optimal catch-at-age monitoring frequency and spatial-temporal scale necessary to adequately:
        - estimate changes in gear selectivity,
        - estimate recruitment and growth variation,
        - describe and estimate seasonal migration mixing and movement,
        - detect and estimate dynamic productivity changes (e.g., dynamic B_0).
    - Investigate the utility and frequency of fishery independent surveys such as trawl surveys and tagging for monitoring stock spatial abundance and estimating movement.
    - Investigate ways of assessing density dependent growth.
    - Investigate the utility and feasibility of explicitly allowing for incidental mortality (i.e., both surface release and through mesh) in SNA 1 stock assessment.
    - Assess the bias potential of the current SNA 1 assessment models under productivity shifts stemming from of climate change.
    - Evaluate the utility of alternative sustainability measurement criteria under dynamic productivity scenarios (e.g., assess the utility of B_0 now reference points).
    - Assess the efficacy of alternative management and monitoring strategies under dynamic stock productivity scenarios, i.e., undertake model-based Management Strategy Evaluation.
- Undertake meta-analysis of BT CPUE across associated species (ENLD specific) to explore evidence for variable catchability between years.
- Re-examine utility of the ENLD LL CPUE series.

5. STATUS OF THE STOCKS

Stock Structure Assumptions

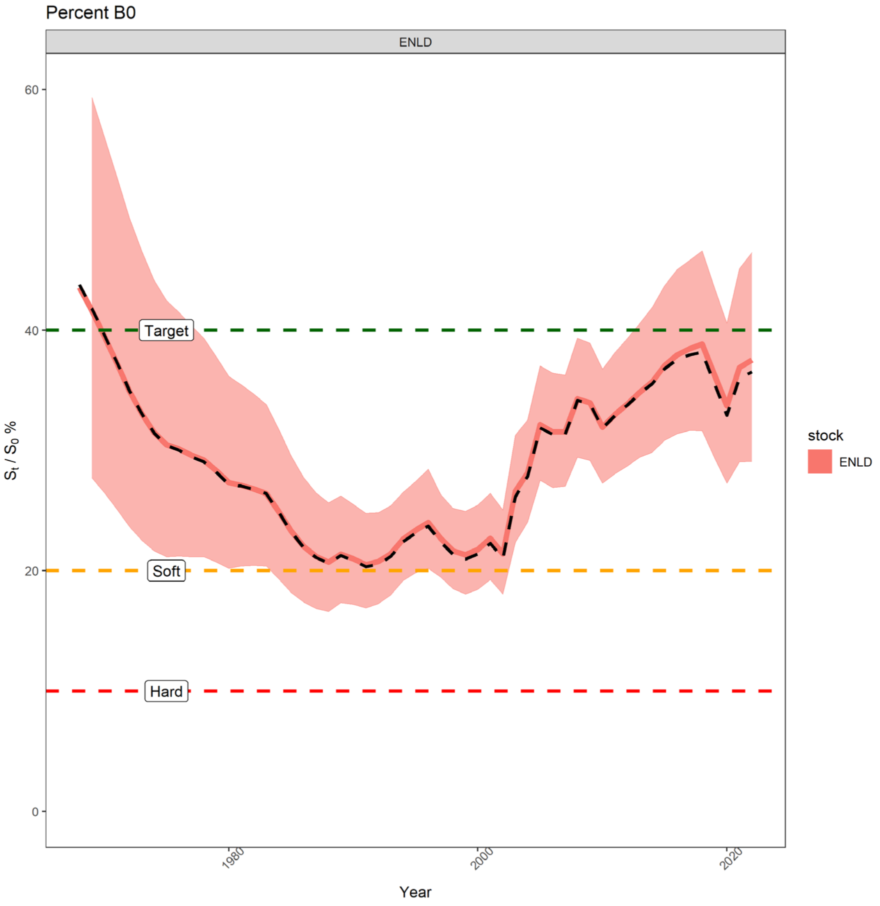
New Zealand snapper are thought to comprise either seven or eight biological stocks based on the location of spawning and nursery grounds, differences in growth rates, age structure, and recruitment strength, and the results of tagging studies. Three stocks are assumed in SNA 1 (East Northland, Hauraki 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 Bay/Golden Bay), 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 1**

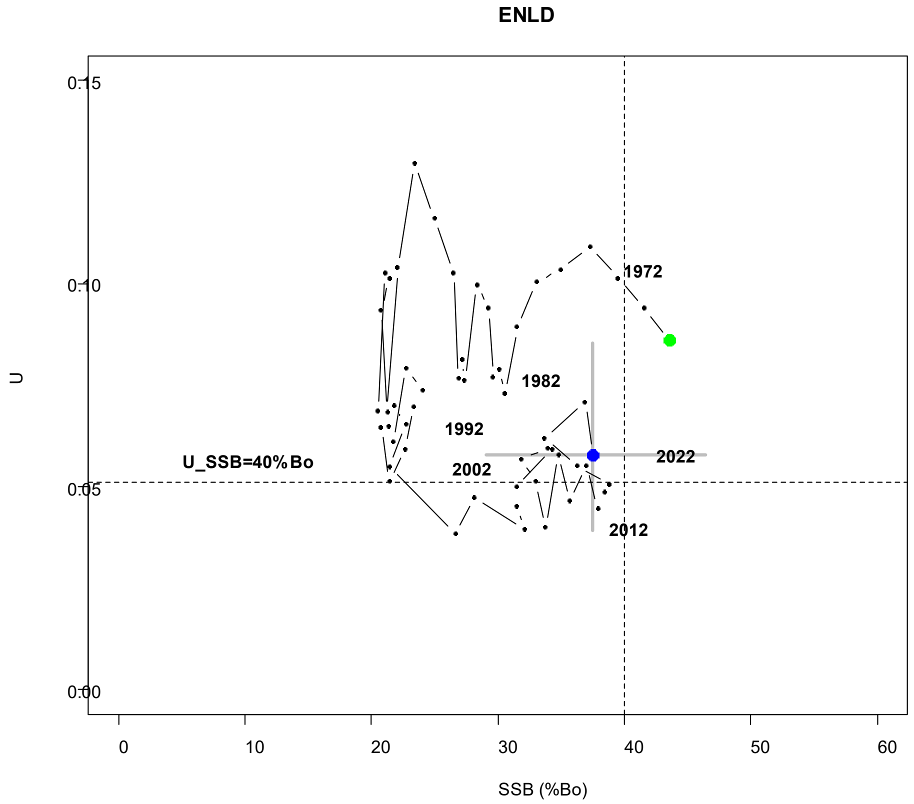
The 2013, 2022, and 2023 assessments were based on three stocks: East Northland, Hauraki Gulf, and Bay of Plenty; however, assessment results for Hauraki Gulf and the Bay of Plenty are combined in the summaries below due to uncertainties about movement of the two stocks between the two areas.

Stock Status East Northland	
Year of Most Recent Assessment	2023
Assessment Runs Presented	Base case model for East Northland
Reference Points	Interim target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: $U_{40\%B0}$
Status in relation to Target	B_{2023} was About as Likely as Not (40–60%) to be at or above the target.
Status in relation to Limits	B_{2023} was Very Unlikely (< 10%) to be below both the soft and hard limits.
Status in relation to Overfishing	2023: Overfishing is About as Likely as Not (40–60%) to be occurring

Historical Stock Status Trajectory and Current Status



MCMC base model *SSB/SSB₀* trajectory, for the period since 1968 (dashed lines indicate soft limit (20% B_0) and hard limit (10% B_0)).

Fisheries and Stock Trends	
Recent Trend in Biomass or Proxy	Stock biomass increased from near the soft limit in 2010 to the target in the final year (2023).
Recent Trend in Fishing Intensity or Proxy	Fishing intensity has fluctuated around the overfishing threshold (exploitation rate target) since the mid 2000s  **Trajectories over time of fishing intensity (*U*) and relative spawning biomass (SSB/SSB_0) for the ENLD stock.**
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis	
Stock Projections or Prognosis	Stock is predicted to remain at current levels over the next five years current levels of catch
Probability of Current Catch or TACC causing Biomass to remain below, or to decline below, Limits (5 years)	Very Unlikely (<10%) for current catch
Probability of Current Catch or TAC causing Overfishing to continue or to commence	About as Likely as not (40-60%) for current catch

Assessment Methodology and Evaluation		
Assessment Type	Level 1 – Full Quantitative Stock Assessment	
Assessment Method	Age-structured, single-sex model undertaken in Casal2	
Assessment Dates	Latest assessment: 2023	Next assessment: 2028
Overall assessment quality rank	1 - High Quality	

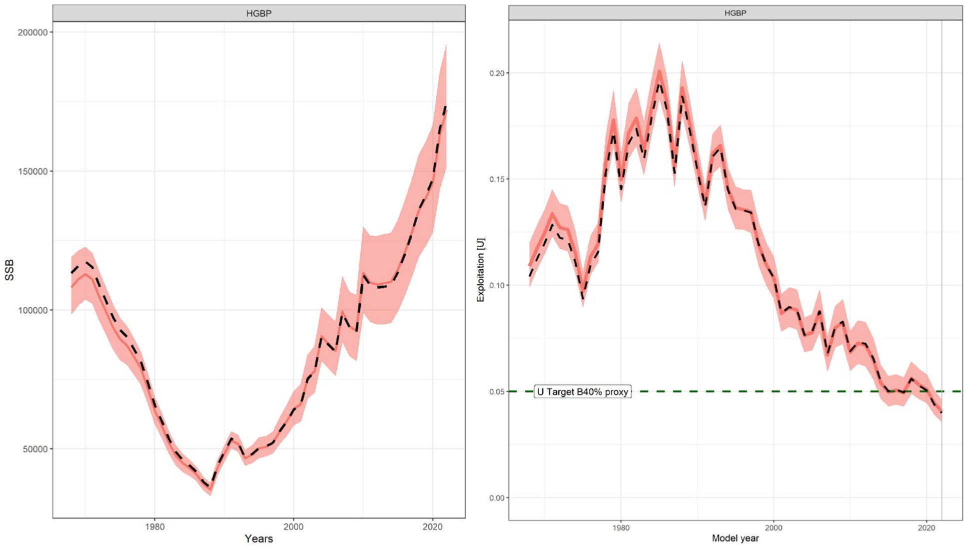
Main data inputs (rank)	- Proportions-at-age from the commercial fisheries - Proportions-at-age from the recreational fishery - Estimates of biological parameters (e.g., growth, age-at-maturity, and length/weight) - Standardised bottom trawl CPUE indices - Estimates of recreational harvest - Commercial catch - Data from tagging experiments in 1985 - Data from tagging in 1994	1 – High Quality 1 – High Quality 1 – High Quality 2 – Medium or Mixed Quality: Potential annual variation in catchability 1 – High Quality 1 – High Quality 1 – High Quality 1 – High Quality
Data not used (rank)	LL CPUE	3 – Low Quality ; thought to be hypostable
Changes to Model Structure and Assumptions	- Single area stock assessment commencing in 1968, with non-equilibrium estimated initial state. - Movement not considered - Dropped LL CPUE in favour of bottom trawl CPUE - Revised stock boundary between HG and EN - Reconstructed recreational and commercial catch history - Tag biomass estimated independently and constrained to fish 25–40 cm.	
Major Sources of Uncertainty	- Stock structure and degree of exchange between EN and HG. - Selectivity based on posterior distribution of HG parameters as there were insufficient bottom trawl age composition data from EN. - Relationship between BT CPUE and abundance is uncertain due to concerns over interannual changes in *q*. - Recruitment since 2015 has not been estimated	

Qualifying Comments
There is strong evidence that the three stocks that make up SNA 1 complex undergo seasonal migrations and are subject to fishing pressure outside their natal regions. For example, indications from tagging suggest that the summer-winter interchange between the Bay of Plenty to Hauraki Gulf regions is in the order of 20%. Whereas the 2013 SNA 1 assessment model, despite being a single season model, was able to account for interchange between the three stocks, the 2023 modelling attempts were unable to estimate movement. In the current assessment, the three SNA 1 stocks were estimated separately ignoring movement. The bottom trawl fleet has changed over time and may have affected selectivity and, by inference, CPUE. The stock boundary between ENLD and HG has been revised, but it is not possible to partition the historical catch and historical sampling data from Statistical Area 003. The recent decline in observed single trawl CPUE was not fitted by the model.

Fisheries Interactions
Main QMS bycatch species are trevally, red gurnard, John dory, and tarakihi. Incidental captures of sea turtles and seabirds occur in the bottom longline fisheries, including black petrel, which are ranked very high risk in the Seabird Risk Assessment (Richard et al 2020).

Stock Status: Hauraki Gulf-Bay of Plenty complex	
Year of Most Recent Assessment	2023
Assessment Runs Presented	Base case models for the Hauraki Gulf Bay and Plenty stock to 2022 combined to produce a joint estimate.
Reference Points	Interim targets: 40% B_0 ; U=5% (current catch/*SSB*) Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: $U_{40\%B0}$
Status in relation to Target	40% B_0 - unknown U=5% - Very likely (>90%) to be below
Status in relation to Limits	Unlikely (< 40%) to be below the soft limit Very Unlikely (< 10%) to be below the hard limit
Status in relation to Overfishing	Very Unlikely (< 10%) to be occurring

Historical Stock Status Trajectory and Current Status



MCMC base model *SSB* and $U_{B40\%}$ status trajectories by stock, for the period since 1968 (dotted line indicates 0.05 target $U_{B40\%}$ exploitation rate)

Fisheries and Stock Trends	
Recent Trend in Biomass or Proxy	<u>Hauraki Gulf+Bay of Plenty</u> Stock biomass has been steadily increasing since the late 1990s.
Recent Trend in Fishing Intensity or Proxy	Fishing intensity has been below the overfishing threshold (exploitation rate target) since 2021.
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis	
Stock Projections or Prognosis	Fishing pressure (*U*) is predicted to continue to decline under current catch
Probability of Current Catch or TACC causing Biomass to remain below, or to decline below, Limits (5 years)	Very Unlikely (< 10%) for current catch
Probability of Current Catch or TAC causing Overfishing to continue or to commence	Very Unlikely (< 10%) for current catch

Assessment Methodology and Evaluation		
Assessment Type	Level 1 – Full Quantitative Stock Assessment	
Assessment Method	Separate age-structured, single-sex model models for HG and BoP undertaken in Casal2	
Assessment Dates	Latest assessment: 2023	Next assessment: 2028
Overall assessment quality rank	1 - High Quality	
Main data inputs (rank)	- Proportions-at-age from the commercial fisheries and fish >=6 y from trawl surveys	1 – High Quality
	- Proportions-at-age from the recreational fishery	1 – High Quality
	- Estimates of biological parameters (e.g., growth, age-at-maturity, and length-weight)	1 – High Quality
	- Standardised single trawl CPUE indices	1 – High Quality
	- Age specific abundance indices (age classes 1–5 y) and >=6 y biomass indices from HG and BoP trawl surveys	1 – High Quality
	- Estimates of recreational harvest	1 – High Quality
	- Commercial catch	1 – High Quality
	- Tag-based biomass estimates (BoP - 1983)	2 – Medium or Mixed Quality: data no longer available
	- Tag-based biomass estimates in 1985 (HG)	1 – High Quality
	- Tag-based biomass estimates from tagging in 1994 (both areas)	1 – High Quality
Data not used (rank)	Recreational CPUE	3 - Low quality: reliable index not available
	Longline CPUE	3 - Low quality: suspected hypostability

Changes to Model Structure and Assumptions	- Single area stock assessments commencing in 1968, with non-equilibrium estimated initial state - Movement not considered - Dropped LL CPUE in favour of bottom trawl CPUE - Revised stock boundary for HG (increased to include Statistical Area 003) - Reconstructed recreational and commercial catch history - Tag biomass estimated independently and constrained to fish 25–40 cm. All except BoP 1983 futted in terms of numbers instead of biomass
Major Sources of Uncertainty	- Stock structure and degree of exchange between BoP and HG. - Possible boundary between western and eastern BoP. - Failure of HG model to fit 6+ y trawl survey index—variable availability to the trawl survey. - Two independent models result in unrealistically low levels of uncertainty for joint results. - Possible increasing productivity and influence on B_0 estimates. F_{init} highly correlated with B_0 and also affected by increasing productivity.

Qualifying Comments
There is strong evidence that the three stocks that make up SNA 1 complex undergo seasonal migrations and are subject to fishing pressure outside their natal regions. For example, indications from tagging suggest that the summer-winter interchange between the Bay of Plenty to Hauraki Gulf regions is in the order of 20%. Whereas the 2013 SNA 1 assessment model, despite being a single season model, was able to account for interchange between the three stocks, the 2023 modelling attempts were unable to estimate movement. In the current assessment, the three SNA 1 stocks were estimated separately ignoring movement. This means that HG biomass may be overestimated and BoP may be underestimated, which is the reason the two are combined. Although the 2023 assessment provides a reasonable estimate of the current biomass and trend since the 1980s for East Northland and the Hauraki Gulf-Bay of Plenty stock complex, estimates of B_0 for Hauraki Gulf-Bay of Plenty are highly uncertain, because of uncertainty of movement dynamics and the apparent increasing productivity in recent years. The bottom trawl fleet has changed over time and may have affected selectivity and, by inference, CPUE. The stock boundary between ENLD and HG has been revised, but it is not possible to partition the historical catch and historical sampling data from Statistical Area 003. SNA 2N may be part of the BoP stock, but is not included in the assessment.

Fisheries Interactions
Main QMS bycatch species are trevally, red gurnard, John dory, and tarakihi. Incidental captures of sea turtles and seabirds occur in the bottom longline fisheries, including black petrel, which are ranked very high risk in the Seabird Risk Assessment (Richard et al 2020).

6. FOR FURTHER INFORMATION

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