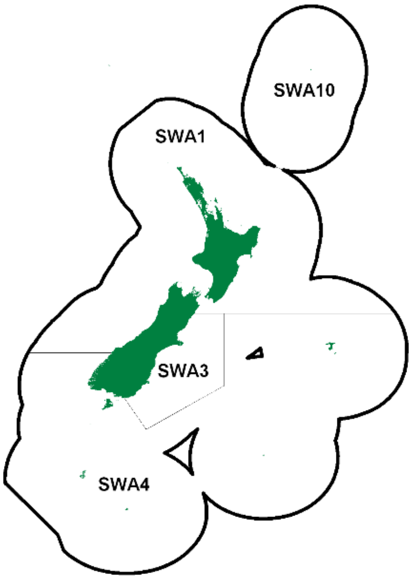
SILVER WAREHOU (SWA)

(*Seriolella punctata*)
Warehou



1. FISHERY SUMMARY

1.1 Commercial fisheries

Silver warehou entered the Quota Management System (QMS) on 1 October 1986. Silver warehou are common around the South Island and on the Chatham Rise in depths of 200–800 m. The majority of the commercial catch is taken from the Chatham Rise, Canterbury Bight, southeast of Stewart Island, and off the west coast of the South Island. Reported landings by nation from 1974 to 1987–88 are shown in Table 1.

Table 1: Reported landings (t) by nation from 1974 to 1987–88. Source: 1974–1978 (Paul 1980); 1978 to 1987–88 (FSU).

Fishing Year	New Zealand				Foreign Licensed			Grand Total
	Domestic	Chartered	Total	Japan	Korea	USSR	Total	
1974*								7 412
1975*								6 869
1976*	estimated as 70% of total warehou landings							13 142
1977*								12 966
1978*								12 581
1978–79**	?	629	629	3 868	122	212	4 203	4 832
1979–80**	?	3 466	3 466	4 431	217	196	4 843	8 309
1980–81**	?	2 397	2 397	1 246	–	13	1 259	3 656
1981–81**	?	2 184	2 184	1 174	186	3	1 363	3 547
1982–83**	?	3 363	3 363	1 162	265	189	1 616	4 979
1983†	?	1 556	1 556	510	98	3	611	2 167
1983–84§#	303	3 249	3 552	418	194	3	615	4 167
1984–85§#	203	4 754	4 957	1 348	387	15	1 749	6 706
1985–86§#	276	5 132	5 408	1 424	217	5	1 646	7 054
1986–87§#	261	4 565	4 826	1 169	29	100	1 299	6 125
1987–88§#	499	7 008	7 507	431	111	39	581	8 088

* Calendar year.
**1 April to 31 March.
†1 April to 30 September.
§1 October to 30 September.
Totals do not match those in Table 2. Data were collected independently and there was known under-reporting to the FSU in 1987–88. This needs to be resolved.

Commercial fishing for silver warehou developed in the late 1960s and early 1970s. Before the establishment of the Exclusive Economic Zone (EEZ), silver warehou, common or blue warehou, and white warehou were all lumped under the category of "warehous". Estimated total annual catches of silver warehou based on area of capture were about 13 000 t in 1976, 1977, and 1978 (Paul 1980, Livingston 1988; Table 1). Concern about overfishing on the eastern Stewart-Snares shelf led to closure of this area to trawlers between October 1977 and January 1978. Initially, effort shifted to the Chatham Rise and total estimated catch did not change. The catches did drop significantly after the establishment of the EEZ, and the reported landings fluctuated between 3000 t and 8000 t from 1978–79 to 1986–87 (Livingston 1988; Table 1 and Table 2).

Some target fishing for silver warehou does still occur, predominantly on the Chatham Rise and along the Stewart-Snares shelf. Recent reported landings are shown in Table 2, and Figure 1 shows the historical landings and TACC values for the main SWA stocks.

Table 2: Reported landings (t) of silver warehou by Fishstock from 1983–84 to present and TACCs (t) from 1986–87 to present. QMS data from 1986–present.

Fishstock	SWA 1		SWA 3		SWA 4		SWA 10			
FMA (s)	1, 2, 7, 8 & 9		3		4, 5 & 6		10		Total	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1983–84*	541	–	725	–	1 829	–	0	–	3 095§	–
1984–85*	587	–	1 557	–	4 563	–	0	–	6 707§	–
1985–86*	806	–	2 284	–	3 966	–	0	–	7 056§	–
1986–87	1 337	1 800	1 931	2 600	2 779	3 600	0	10	6 047§	8 010
1987–88	2 947	1 815	3 810	2 601	2 600	3 600	0	10	9 357§	8 026
1988–89	1 605	1 821	1 476	2 640	2 789	3 745	0	10	5 870	8 216
1989–90	2 316	2 128	2 713	3 140	3 596	3 855	0	10	8 625	9 133
1990–91	2 121	2 128	1 889	3 144	3 176	3 855	0	10	7 186	9 137
1991–92	1 388	2 500	2 661	3 144	3 018	3 855	0	10	7 066	9 509
1992–93	1 231	2 504	2 432	3 145	3 137	3 855	0	10	6 800	9 514
1993–94	2 960	2 504	2 724	3 145	2 993	3 855	0	10	8 677	9 514
1994–95	2 281	2 504	2 336	3 280	2 638	4 090	0	10	7 255	9 884
1995–96	2 884	2 504	2 939	3 280	3 581	4 090	0	10	9 404	9 884
1996–97	3 636	2 504	4 063	3 280	5 336	4 090	0	10	13 035	9 884
1997–98	3 380	2 132	3 721	3 280	3 944	4 090	0	10	11 045	9 512
1998–99	1 980	2 132	2 796	3 280	4 021	4 090	0	10	8 797	9 512
1999–00	2 525	2 132	4 129	3 280	4 606	4 090	0	10	11 260	9 512
2000–01	3 025	2 132	3 664	3 280	4 650	4 090	0	10	11 339	9 512
2001–02	1 004	2 132	2 899	3 280	4 648	4 090	0	10	8 551	9 512
2002–03	1 029	3 000	3 772	3 280	4 746	4 090	0	10	9 547	10 380
2003–04	1 595	3 000	3 606	3 280	5 529	4 090	0	10	10 730	10 380
2004–05	1 467	3 000	3 797	3 280	4 279	4 090	0	10	9 543	10 380
2005–06	1 023	3 000	4 524	3 280	5 591	4 090	0	10	11 138	10 380
2006–07	2 093	3 000	6 059	3 280	6 022	4 090	0	10	14 174	10 380
2007–08	1 679	3 000	2 918	3 280	3 510	4 090	0	10	8 107	10 380
2008–09	1 366	3 000	3 264	3 280	4 213	4 090	0	10	8 843	10 380
2009–10	712	3 000	2 937	3 280	3 429	4 090	0	10	7 078	10 380
2010–11	938	3 000	3 559	3 280	3 507	4 090	0	10	8 004	10 380
2011–12	1 029	3 000	3 318	3 280	2 783	4 090	0	10	7 130	10 380
2012–13	748	3 000	3 788	3 280	4 128	4 090	0	10	8 664	10 380
2013-14	903	3 000	3 201	3 280	3 885	4 090	0	10	7 989	10.380
2014–15	878	3 000	3 820	3 280	4 355	4 090	0	10	9 053	10 380
2015–16	1 225	3 000	2 734	3 280	3 555	4 090	0	10	7 515	10 380
2016–17	696	3 000	3 667	3 280	4 307	4 090	0	10	8 670	10 380
2017–18	543	3 000	3 396	3 280	4 714	4 090	0	10	8 653	10 380
2018–19	463	3 000	3 270	3 280	4 879	4 090	0	10	8 612	10 380
2019–20	460	3 000	3 356	3 280	3 954	4 090	0	10	7 769	10 380
2020–21	216	3 000	4 076	3 610	4 193	4 500	0	10	8 486	11 120
2021–22	321	3 000	3 987	3 610	4 275	4 500	0	10	8 580	11 120
2022–23	235	3 000	4 402	3 601	4 857	4 500	0	10	9 494	11 120

§Totals do not match those in Table 1 because the data were collected independently and there was known under-reporting to the FSU in 1987–88. This needs to be resolved.

SWA 1

In recent years, most of the silver warehou catch has been taken as a bycatch of the hoki, squid, barracouta, and jack mackerel trawl fisheries. Landings from SWA 1 increased substantially after 1985–86 following the development of the west coast South Island hoki fishery. Overruns of the TAC (mid 1980s to about 2000) probably partly reflected the hoki fleet fishing in relatively shallow water (northern grounds) in the later part of the season, but they could also have reflected changes in abundance.

The TACC in SWA 1 was increased in 1991–92 under the Adaptive Management Programme (AMP). A review of this Fishstock at the completion of 5 years in the AMP concluded that it was not known if the current TACC would be sustainable and an appropriate monitoring programme was not in place. Under the criteria developed for the AMP the Minister therefore removed this Fishstock from the AMP in October 1997 and set the TACC at 2132 t. A new AMP proposal in 2002 resulted in the TACC being increased to 3000 t from 1 October 2002, with 1 t customary and 2 t recreational allowances within a TAC of 3003 t. Landings have not approached the new TACC level since 2001–02 because reductions in the hoki quota have resulted in much less effort off the WCSI in winter; under 550 t were landed annually from 2017–18 to 2019–20. Catches then dropped further and were 235 t in 2022–23.

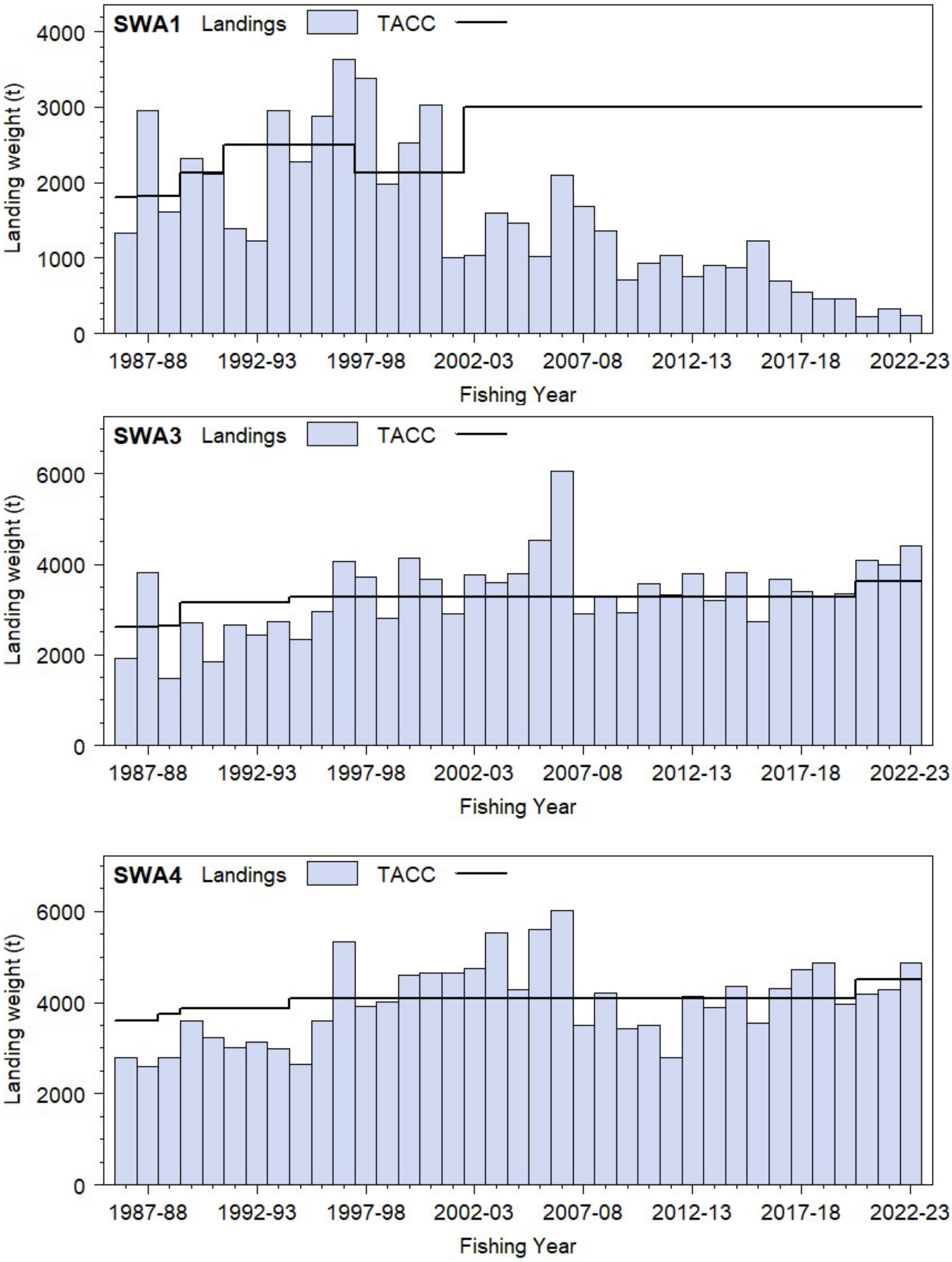


Figure 1: Reported commercial landings and TACCs for the three main SWA stocks. From top to bottom: SWA 1 (Auckland East), SWA 3 (South East Coast), and SWA 4 (South East Chatham Rise). Note that these figures do not show data prior to entry into the QMS.

SWA 3 and 4

In most years from 2000–01 to 2006–07, landings in SWA 3 and SWA 4 were well above the TACCs because fishers landed catches well in excess of ACE holdings and paid deemed values for the overcatch. From 1 October 2007 the deemed values were increased to $1.22 per kg for all SWA stocks and two differential rates were also introduced. The second differential rate applies to all catch over 130% of ACE holding at which point the deemed value rate increased to $3 per kg. The effect of these measures was seen immediately in 2007–08 as fishing without ACE was reduced and catch fell below the TACCs in both SWA 3 and SWA 4. Landings again exceeded the TACC in SWA 3 from 2019–20, 2022–23. SWA 4 landings consistently exceeded the TACC during the fishing years 2016–17 to 2018–19, but were just below the TACC after 2019–20, until 2022–23. Statements here on catches relative to TACC do not make allowance for any carryover of ACE.

1.2 Recreational fisheries

There are no current recreational fisheries for silver warehou.

1.3 Customary non-commercial fisheries

Quantitative information on the current level of customary non-commercial take is not available.

1.4 Illegal catch

Silver warehou have been misreported as white and blue warehou in the past. The extent of this practice is unknown and could lead to under-reporting of silver warehou catches.

1.5 Other sources of mortality

Other sources of mortality are unknown.

2. BIOLOGY

Initial growth is rapid and fish reach sexual maturity at around 45 cm fork length in 4 years. Based on a study of ageing methodology and growth parameters (Horn & Sutton 1995), maximum age observed was 23 years for females and 19 years for males. An estimate of instantaneous natural mortality (*M*) was derived by using the equation $M = \log_e 100/A_{MAX}$, where A_{MAX} is the age reached by 1% of the virgin population. From their study, A_{MAX} of 19 years for female silver warehou and 17 years for males produced estimates of *M* of 0.24 and 0.27, respectively. Horn & Sutton (1995) qualified this result because the samples used in their study were not from virgin populations and the sampling method did not comprehensively sample the whole population. Based on these results *M* is likely to fall within the range 0.2–0.3.

Horn & Sutton (1995) also calculated von Bertalanffy growth curve parameters from their sample of fish from off the south and southeast coasts of the South Island (Table 3). Other biological parameters relevant to the stock assessment are shown in Table 3. Length-weight regressions were calculated from two series of research trawl surveys using *Tangaroa*. One series was conducted on the Chatham Rise in January 1992–97 and the other in Southland during February–March 1993–96.

Silver warehou is a schooling species, aggregating to both feed and spawn. During spring-summer, both adult and juvenile silver warehou migrate to feed along the continental slope off the east and southeast coast of the South Island. Late-stage silver warehou eggs and larvae have been identified in plankton samples, and the early life history of silver warehou appears typical of many teleosts. Juvenile silver warehou inhabit shallow water at depths of 150–200 m and remain apart from sexually mature fish. Few immature fish are consequently taken by trawlers targeting silver warehou. Juveniles have been caught in Tasman Bay, off the east coast of the South Island, and around the Chatham Islands. Once sexually mature, fish move out to deeper water along the shelf edge, such that mature fish dominate catches at depths greater than about 300 m.

Table 3: Estimates of biological parameters of silver warehou.

Fishstock					Estimate	Source
1. Weight = *a*(length)^b (Weight in g, length in cm, total length).						
				Both sexes		
				a	*b*	*Tangaroa* Survey:
Chatham Rise				0.00848	3.214	January 1992–97
Southland				0.00473	3.380	February–March 1993–96

2. von Bertalanffy growth parameters	Female			Males			
	L_∞	k	t_0	L_∞	k	t_0	
All areas	54.5	0.33	-1.04	51.8	0.41	-0.71	Horn & Sutton (1995)

3. STOCKS AND AREAS

The stock structure is not well known.

Horn et al (2001) suggest four distinct spawning areas: off west coast South Island, southern South Island, eastern North Island, and on the Chatham Rise, with possible sub-areas of spawning within these. For example, Livingston (1988) inferred from voyage reports the time of spawning on the Chatham Islands was later (spring-summer) than that at the Mernoo Bank (winter-spring). The peak timing for spawning appears to be earliest on the WCSI (winter), then proceeding in a southeast direction, at the Mernoo Bank (winter-spring), Stewart-Snares shelf, and around the Chatham Islands (spring-summer). It is uncertain whether the same stock migrates from one area to another, spawning whenever conditions are appropriate, or if there are several separate stocks. The current management areas bear little relation to known spawning areas and silver warehou distribution. Horn et al (2001) investigated growth rates, gonad staging information, and age structure with regard to stock structure, but found no evidence from these characteristics for separate reproductive units.

4. STOCK ASSESSMENT

The following biological stocks have been considered for the purpose of stock assessment:

- West coast South Island (WCSI, part of SWA 1).
- East coast South Island (ECSI): the northern part of SWA 3 and Chatham Rise west of 180° (part of SWA 4).
- East Chatham Rise (ECR): the Chatham Rise east of 180° (part of SWA 4).
- Southland: the southern part of SWA 3 and SWA 4 excluding the Chatham Rise.
- Chatham Rise and Southland (SWA 3 and SWA 4 combined).

An assessment of the East Coast South Island silver warehou stock was attempted in 2018 (McGregor 2019a, b). Although the assessment was not accepted by the Deepwater Working Group, biomass information derived from the assessment was considered adequate to provide sustainability advice on this stock. This assessment was based on the following biological stock structure assumption: there was a break in the spatial distribution of catches between the fishery on Chatham Rise and East coast South Island down to roughly 45.4° S, and the Stewart-Snares shelf comprising the northwestern side of QMA 4 and the northern part of QMA 3, and known timing and location of spawning.

Further work was completed in 2019–20 to describe the distribution of fish and fishing within the East Coast South Island biological stock area and to examine the hypothesis that changes in CPUE may have resulted from operational changes in the fishery (Dutilloy & Dunn 2020). These analyses concluded that the inshore and offshore fisheries within the stock area should have different fishery selectivities, that the trend in revised CPUE analyses was broadly similar to that reported by McGregor (2019a), and that a peak in CPUE around 2006–07 was most likely a consequence of increased abundance.

An assessment of a stock including all of Chatham Rise and Southland (SWA 3 and SWA 4) was then attempted in 2023. The available catch and effort data, observer length and female maturity data, and age sample data could not reject a single stock hypothesis. The combined SWA 3 and SWA 4 stock hypothesis was an alternative to the previous western Chatham Rise and east coast South Island stock assessment (rejected) (Figure 2). The 2023 assessment was also not accepted by the Deepwater Working Group.

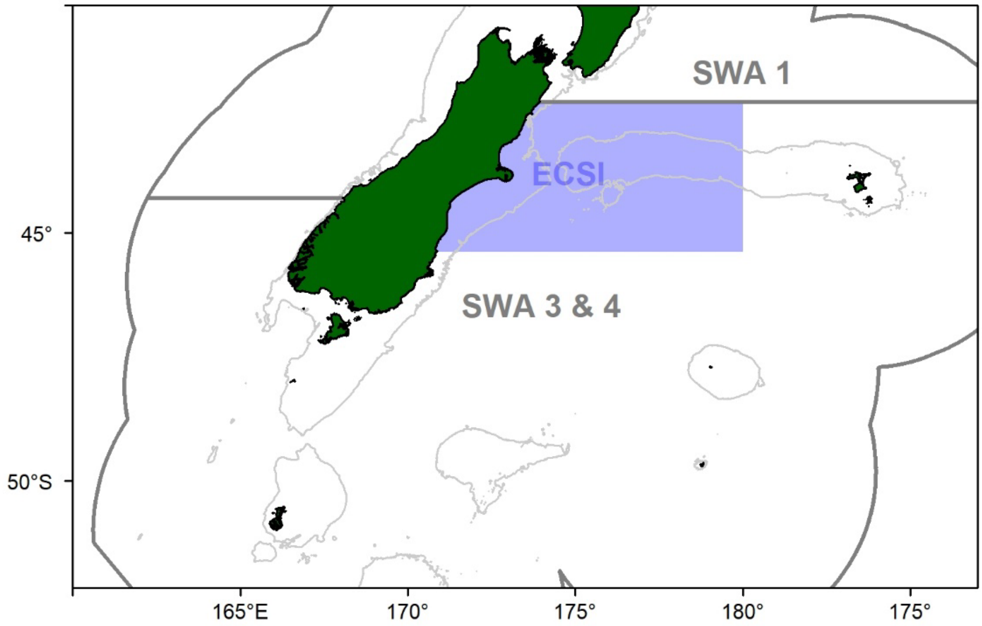


Figure 2: Map showing: shaded blue area, the east coast South Island stock assumed by McGregor (2019b); in dark grey, the SWA 3 & 4 boundaries; light grey, the 500 m isobath.

4.1 Estimates of fishery parameters and abundance

Bottom trawl surveys have been conducted since the early 1990s using either the *Tangaroa* (Chatham Rise survey, Sub-Antarctic survey, and WCSI) or the *Kaharoa* (inshore east and wast coasts of the South Island). These surveys all encounter silver warehou, and the station allocation for the *Tangaroa* surveys off the WCSI have taken into account SWA from 2012 (Table 4). However, for the other surveys the average CVs are high, and they have not been considered suitable for stock assessment or as good monitoring tools for these stocks. They may, nonetheless, be useful in interpreting CPUE analyses.

Relative biomass indices based on CPUE have been derived using a wide-variety of assumptions, using merged (stratified) and unmerged (tow-level) commercial and Ministry observer datasets (McGregor 2019a, Dutilloy & Dunn 2020, Dunn & McGregor 2023). McGregor (2019a) estimated CPUE for the target and bycatch trawl fisheries, including the recorded target species as a covariate in the analyses. Dutilloy & Dunn (2020) concluded that the target fishery in the ECSI stock was not well defined and estimated CPUE for silver warehou caught as bycatch in the domestic vessel offshore bottom trawl fishery (targeting hoki) and inshore bottom trawl fishery (often targeting barracouta). Dunn & McGregor (2023) used only Ministry observer catch and effort data, with a delta-lognormal generalised linear or spatio-temporal model using sdmTMB (Anderson et al 2022).

Length and age data have been collected during the course of trawl surveys and by Ministry observers from commercial fishing vessels. A feature of these time series, especially with Chatham Rise and ECSI surveys, is that the size distributions are extremely variable among years. The Chatham Rise survey sometimes completely lacks the typical 50 cm size class, and often lacks the 25 cm or 35 cm modes even though the appropriate mode is present in the subsequent year. The variability is highest in the ECSI survey, which shows up to four distinct size modes, but usually only one or two simultaneously. Beentjes et al (2004) noted that variability in adult size classes captured in the ECSI survey had been a common feature and considered it to be a result of either environmental influences on fish distribution, fish schooling by size, or the result of problems with gear performance (Beentjes et al 2004). Dunn et al (2020) noted that the relatively high catches of silver warehou in the ECSI survey were only taken close to the deep boundary (400 m) of the survey region.

Table 4: Biomass indices (t) and estimated coefficients of variation (CV) for core survey areas.

Fishstock	Area	Vessel	Trip code	Date	Biomass	CV (%)
SWA 3&4	Chatham Rise	*Tangaroa*	TAN9106	Jan–Feb 1992	4 489	54
			TAN9212	Jan–Feb 1993	2 694	51
			TAN9401	Jan 1994	11 640	49
			TAN9501	Jan 1995	3 737	28
			TAN9601	Jan 1996	1 707	28
			TAN9701	Jan 1997	2 101	32
			TAN9801	Jan 1998	4 708	48
			TAN9901	Jan 1999	6 760	34
			TAN0001	Jan 2000	5 425	46
			TAN0101	Jan 2001	2 728	22
			TAN0201	Jan 2002	6 410	81
			TAN0301	Jan 2003	7 815	74
			TAN0401	Jan 2004	20 548	40
			TAN0501	Jan 2005	6 671	22
			TAN0601	Jan 2006	7 704	48
			TAN0701	Jan 2007	14 646	32
			TAN0801	Jan 2008	15 546	36
			TAN0901	Jan 2009	15 061	34
			TAN1001	Jan 2010	80 469	58
			TAN1101	Jan 2011	82 075	62
			TAN1201	Jan 2012	16 055	52
			TAN1301	Jan 2013	6 945	29
			TAN1401	Jan 2014	2 658	61
			TAN1601	Jan 2016	14 983	25
			TAN1801	Jan 2018	12 953	44
			TAN2001	Jan 2020	9 659	53
			TAN2201	Jan 2022	49 888	53
SWA 3	ECSI	*Kaharoa*	KAH9105	May–Jun 1991	29	21
			KAH9205	May–Jun 1992	32	22
			KAH9306	May–Jun 1993	256	44
			KAH9406	May–Jun 1994	35	28
			KAH9606	May–Jun 1996	231	32
			KAH0705	May–Jun 2007	445	44
			KAH0806	May–Jun 2008	319	32
			KAH0905	May–Jun 2009	446	42
			KAH1207	Apr–Jun 2012	438	46
			KAH1402	Apr–Jun 2014	626	83
			KAH1605	Apr–Jun 2016	428	53
			KAH1803	Apr–Jun 2018	191	42
			KAH2104	Apr-Jun 2021	790	88
SWA 1	WCSI	*Tangaroa*	TAN0007	Aug 2000	1 507	25
			TAN1210	Aug 2012	617	32
			TAN1308	Aug 2013	313	23
			TAN1609	Aug 2016	271	37
			TAN1807	Aug 2018	91	21
			TAN2107	July-Aug 2021	176	39
SWA4	Subantarctic	*Tangaroa*	TAN9105	Nov–Dec 1991	1 113	47
			TAN9211	Nov–Dec 1992	225	64
			TAN9310	Nov–Dec 1993	164	63
			TAN0012	Nov–Dec 2000	21	65
			TAN0118	Nov–Dec 2001	1 069	59
			TAN0219	Nov–Dec 2002	141	62
			TAN0317	Nov–Dec 2003	22	72
			TAN0414	Nov–Dec 2004	171	34
			TAN0515	Nov–Dec 2005	1 198	99
			TAN0617	Nov–Dec 2006	71	56
			TAN0714	Nov–Dec 2007	514	38
			TAN0813	Nov–Dec 2008	4 122	55
			TAN0911	Nov–Dec 2009	3 620	98
			TAN1117	Nov–Dec 2011	136	61
			TAN1215	Nov–Dec 2012	13	75
			TAN1412	Nov–Dec 2014	29	72
			TAN1614	Nov–Dec 2016	85	115
			TAN1811	Nov–Dec 2018	2 694	41
			TAN2014	Nov–Dec 2020	2 642	92
			TAN2215	Nov–Dec 2020	231	68

Chatham Rise and Southland (SWA 3 and SWA 4)

Trawl surveys and CPUE indices

The most recent update of CPUE indices was by Dunn & McGregor (2023), using data to the end of the 2020–21 fishing year. The various CPUE indices developed since 2018, covering different periods and parts of SWA 3 and SWA 4, were all relatively low during the late 1990s, then increased to a peak in the period 2003–04 to 2006–07, and then declined but remained relatively high (Figure 3).

The Chatham Rise trawl survey index also suggested an overall upward biomass trend in the early 2000s (Figure 3), although the 2010, 2011, and 2021 years had very large CIs.

The GLM and spatio-temporal models developed by Dunn & McGregor (2023), both using the same observer data set to 2020–21, had a similar trend. The spatio-temporal model was under development and was used as a sensitivity in 2023 (Figure 3).

The Sub-Antarctic trawl survey index (Table 4) has been generally flat, with intermittent peaks, the highest being in 2008 and 2009. The CVs are generally large, and the survey is not currently considered a reliable index for silver warehou.

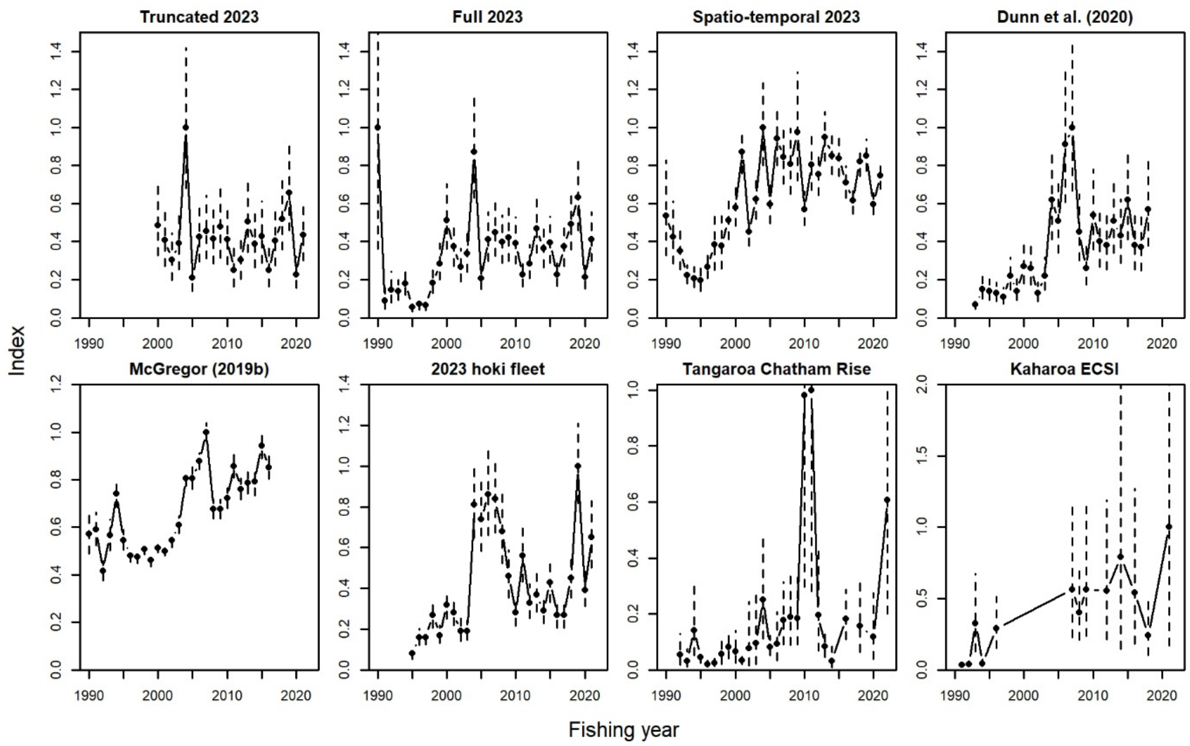


Figure 3: SWA 3 and SWA 4 CPUE indices. The 2023 indices are from Dunn & McGregor (2023), and are the delta-lognormal CPUE index using observer data starting in 1999–2000 ('Truncated') or 1989–90 ('Full'); the spatio-temporal index using the same data; and a CPUE series using commercial data from selected hoki-target factory trawlers ('Hoki fleet'). Other indices are: Dunn et al (2020), a standardised CPUE series using commercial data to 2017–18 from west Chatham Rise; McGregor (2019b), a CPUE series derived from commercial data accepted and used in the 2018 (rejected) assessment; the *Tangaroa* Chatham Rise trawl survey core strata biomass index, and *Kaharoa* east coast South Island trawl survey series biomass index. Vertical broken lines indicate the 95% CI of the indices, but the y-axis does not extend to the upper CI of some trawl survey estimates.

The ECSI trawl survey showed a similar broad upward biomass trend, with a peak in 2014, followed by a decline to 2018, then a historical high in 2021 (Figure 3). Biomass in the core strata (30–400 m) for the years since 2007 was higher overall than in the 1990s by about two-fold.

Because of the influence of large occasional catches of silver warehou, the Chatham Rise and ECSI trawl surveys have large uncertainty; however, they do corroborate the general biomass increase seen in the CPUE series.

Length and age data

The *Kaharoa* ECSI trawl survey monitors pre-recruited cohorts, but not fish in the recruited size range. Time series plots of length frequency distributions consistently show the presence of the pre-recruited cohorts on nearly all surveys, with indications that these could be tracked through time (modal progression).

The *Tangaroa* Chatham Rise survey monitors both the pre-recruit (from about 20 cm) and recruited size range. Plots of time series show strong cohorts that often can be tracked through time, but also appearance and/or disappearance of some length modes between adjacent survey years. The survey sometimes largely or almost completely lacks the mode at 40–50 cm, which is usually the dominant size class.

The *Tangaroa* SubAntarctic survey monitors predominantly the recruited size range of 40–55 cm. Modal progression of cohorts cannot be seen in the time series of length frequency plots.

Length data from Ministry observers show some tracking of length modes is possible, suggesting the passage of strong and weak year classes (McGregor 2019a).

Otoliths collected by the Ministry observers were aged for Chatham Rise and east coast South Island fishing years 2000–01, 2004–05, 2006-07, 2009–10, 2010–11, 2012–13, 2013–14, and 2015–16 and Southland and northern SubAntarctic 1992–93, 1993–94, 1994–95, 1995–96, 2011–12, and 2013–14, with around 300 otoliths read for each region in each year (Horn et al 2012, Horn & McGregor 2018). The Chatham Rise and east coast South Island age compositions suggest strong year classes in spawned fish around 2000 and 2004–2006, and, in the Southland and SubAntarctic, age compositions show strong year classes around 1990–91, 2003–04, and 2011 (Figure 4).

Stock assessment modelling

Stock assessment modelling was attempted for the western Chatham Rise and part of the east coast South Island by McGregor (2019b) and for an alternative stock structure of combined Chatham Rise and Southland in 2023 (Dunn & McGregor 2023). Both assessments were rejected by the Working Group. The rationale for rejecting the 2023 assessment was primarily based on the use of CPUE:

- The Working Group considered that the longer CPUE series derived from observer catch and effort data (see Figure 3) were not preferred because data before 1999–2000 were likely not representative of the fishery. It was, however, noted that the overall CPUE increase they exhibited was consistent with other analyses and data sets.
- A truncated CPUE series, starting in 1999–2000, was accepted by the Working Group. However, in the stock assessment model the shorter index provided little contrast in CPUE in relation to catch, and estimates of the upper bound of the biomass using this index were poorly defined, and stock status estimates consequently unreliable.
- There were no alternative biomass indices. Trawl survey indices of abundance were not considered reliable due to sporadic high catches.

In addition to concerns about the use of CPUE:

- The age data were noisy, and in some years were inconsistent, such that model fits were not good. Spatial stratification of the age data into inshore and offshore strata did not improve consistency in the age frequency distributions.
- Selectivity was estimated to be much older than maturity, and implausibly high, with maturity assumed at about age 3–4 and full selectivity estimated at about age 13–14.
- Year class strength estimates were found to be fitting primarily to the biomass index (CPUE) and were only weakly influenced by the age data. The year class strength estimates were also suspected to be confounded with the selectivity parameters.
- Model estimates were sensititive to the assumed natural mortality rate (*M*), which remains poorly known.
- Whilst analyses by Dutilloy & Dunn (2020) and Dunn & McGregor (2023) supported a spatial fishery stratification in the assessment model (i.e., adult fish predominantly offshore), the 2023 assessment model was simplified to have a single fishery after problems were encountered with weakly informative data.

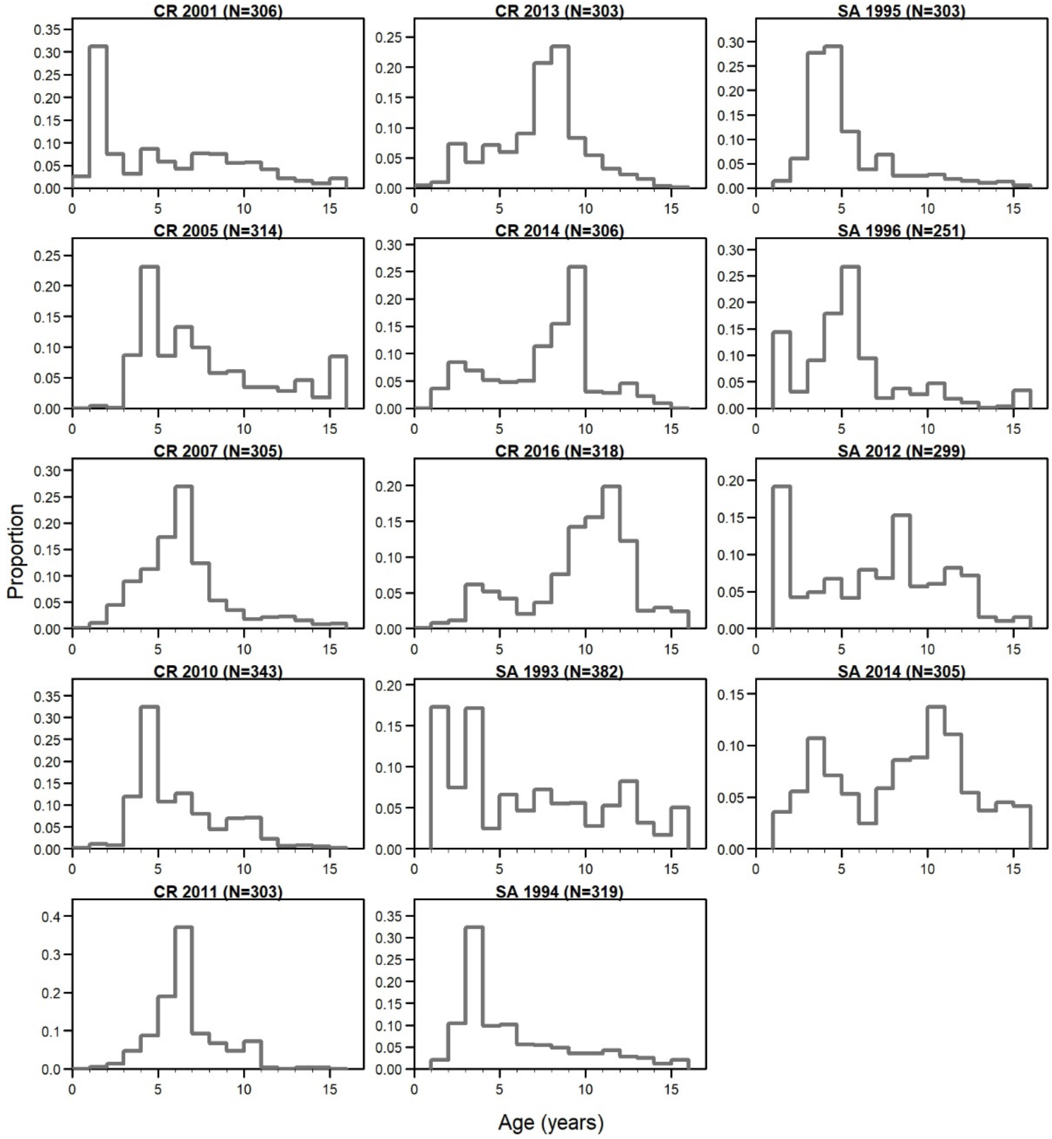


Figure 4: Scaled commercial catch-at-age distributions for the trawl catch of silver warehou sampled from the Chatham Rise and east coast South Island (CR), and Southland and Subantarcic (SA), by sample fishing year (labelled by year ending); N, number of otoliths.

Although the 2023 assessment model was not accepted, the Plenary concluded there was no sustainability issue for Chatham Rise & Southland. This was because (1) all CPUE and trawl survey indices increased to about the year 2000 and have remained stable since, and concurrently (2) age frequency data indicated recruitment of several large year classes, which persisted into the spawning stock; although age data only extend to 2016, they showed no reduction in the occurrence of older fish.

West Coast South Island (part of SWA 1)

Trawl survey and CPUE indices

CPUE analyses for the WCSI were most recently updated by McGregor (2016), using data to end of the 2010–11 fishing year (Figure 5). McGregor (2016) suggested that the west coast South Island CPUE time series was promising as an index of abundance, and that Observer length data may help interpret patterns in the CPUE. The inshore *Kaharoa* trawl surveys were not considered a good monitoring tool or useful for stock assessment for this area.

The WCSI *Kaharoa* survey includes the TBGB (Tasman Bay and Golden Bay) area, which is a shallow area and dominated by juvenile SWA. When separated out, the TBGB index showed a downward trend while the WCSI index with TBGB omitted was fairly flat, with highly variable CIs.

The WCSI *Tangaroa* survey biomass estimate indicates a substantial biomass decline (Table 4).

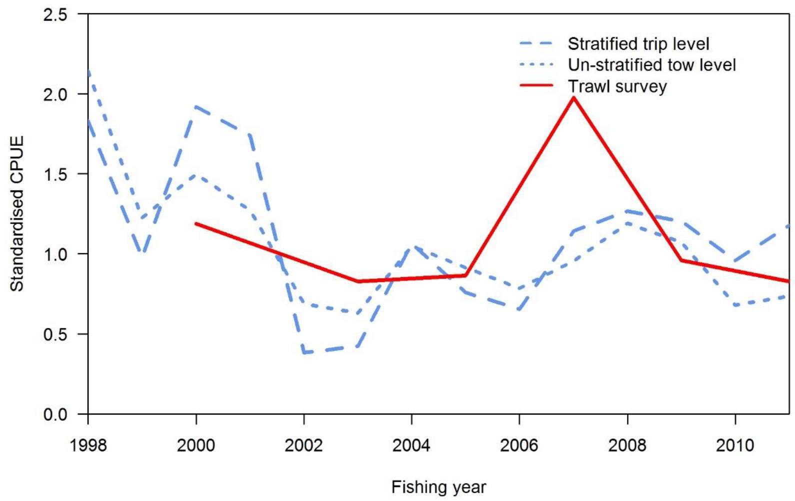


Figure 5: West coast South Island standardised CPUE (1997–98 to 2010–11) for merged (stratified, trip level) and unmerged (un-stratified, tow level) data; and biomass estimates from Tasman Bay-Golden Bay *Kaharoa* trawl surveys 1998–2011.

A CPUE analysis for this stock, covering years before 1997–98, was also conducted in 2009 (Cordue 2009) using selected observer catch and effort data for a core fleet of vessels for positive bottom and midwater trawl SWA catches in area FMA 7 for winter fishing within a WCSI box (40.2° S–43.3° S). The resulting index (Figure 6) is noisy but shows a general trend of slow CPUE decline from 1986 to 1992, a steep increase from 1992 to 1996 and high levels through to 2000, followed by a steep decline back to low levels by 2002 and a stable trend at slightly above historically lowest levels through to 2008. This CPUE index was possibly consistent with strong year classes in 1993–94 and in 1997 (evident in the length frequency data) and the resulting increased abundance over the ensuing few years.

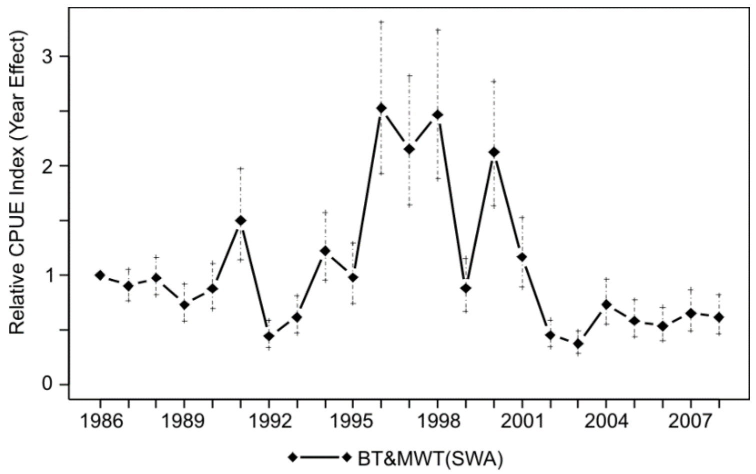


Figure 6: Standardised CPUE index (year effects) for SWA 1 from an analysis of Scientific Observer Programme trawl records (Cordue 2009).

Length and age data

The WCSI inshore trawl series typically has a dominant 20 cm mode and a smaller mode around 35 cm. Age frequency distributions from otoliths collected by the Scientific Observer Programme from the west coast South Island hoki fishery indicate that a wide range of year classes were present in the catch for all seasons 1992–96. Catch curve analysis based on the age structure of annual catches made from 1992–2005 suggested that fishing mortality was lower than natural mortality (SeaFIC 2007). Observer length data may help interpret patterns in CPUE.

The Working Group noted that this fishstock sustained catches which averaged 2800 t y^{-1} from 1993–94 to 2000–01 without resulting in high estimates of total mortality, Z, but that this occurred over a period when CPUE indices indicate abundance of more than double current levels. A stock assessment is considered to be a more appropriate methodology to assess this Fishstock than relying on catch curve analyses (Middleton 2009).

5. FUTURE RESEARCH CONSIDERATIONS

- The stock structure for silver warehou remains poorly known. A holistic approach using all available information for all areas of New Zealand should be used to identify the most likely biological stocks. The analyses by Dutilloy & Dunn (2020) and Dunn & McGregor (2023) examined only SWA 3 and SWA 4.

SWA 3 and SWA 4

- The Chatham Rise trawl survey estimates should be re-evaluated. Research by Dunn et al (2020) indicated large catches of silver warehou occurred in areas outside the commercial trawl fishing footprint and in relatively shallow and warm water, although not in a consistent area. Biomass estimated from the trawl surveys excluding these areas might provide credible estimates and a usable trend. Alternatively, an analysis method that better accounts for spatial and temporal variability should be applied (e.g., VAST; Thorson & Barnett 2017).
- Ageing of otoliths from years after 2015–16, and also adjacent to existing samples, should increase year class strength information in the assessment model and may reduce confounding between year class strength and selectivity. The assumptions and methods used to estimate age frequency should be reviewed to check their appropriateness.
- Alternative CPUE models should be explored, including inclusion of hypothesis driven interaction terms, alternative data sources (e.g., daily processing), and the consideration of sub-fleets and spatial approaches.
- Spatial analysis of trawl survey data may be helpful for explorations of stock structure.

SWA 1

- Reassess the WCSI *Tangaroa* and *Kahaora* trawl surveys in light of the spatial and depth understanding developed for the surveys in SWA 3 and 4.
- Consider updating the CPUE for the WCSI. The WCSI commercial CPUE has not been updated since 2011; the *Tangaroa* trawl survey has indicated a large biomass decline. Given the substantial amount of catch-at-age data for this stock (on average 428 otoliths per year for 1991–92 to 2002–03), a stock assessment could now be conducted to investigate the coherence between catch-at-age data and the abundance indices

6. STATUS OF THE STOCKS

- **WCSI (part of SWA 1)**

Stock Status		
Most Recent Assessment Plenary Publication Year	2018	
Catch in most recent year of assessment	Year: 2016–17	Catch: -
Reference Points	Management Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: $F_{40\% B0}$	
Status in relation to Target	Unknown	
Status in relation to Limits	Unknown	
Status in relation to Overfishing	Unknown	

Historical Stock Status Trajectory and Current Status
-

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	The *Tangaroa* trawl survey indicates a substantial decline in biomass between 2000 and 2021.
Recent Trend in Fishing Intensity or Proxy	-
Other Abundance Indices	CPUE indices were relatively high between 1996 and 2001 but have not been updated since 2011.
Trends in Other Relevant Indicators or Variables	Age frequency estimates for the period 1992–2003 indicated fishing mortality rate was lower than the assumed natural mortality rate. This has not been updated since.

Projections and Prognosis	
Stock Projections or Prognosis	Unknown
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Soft Limit: Unknown Hard Limit: Unknown
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Unknown

Assessment Methodology and Evaluation		
Assessment Type	Level 3 - Qualitative Evaluation	
Assessment Method	-	
Assessment Dates	Latest assessment Plenary publication year: 2018	Next assessment: Unknown
Overall assessment quality rank	-	
Main data inputs (rank)	- *Tangaroa* trawl survey index	2 – Medium or Mixed Quality: only 5 data points and may not be appropriate for monitoring SWA
	- CPUE	2 – Medium or Mixed Quality: needs to be updated
	- age frequency (up to 2005)	2 – Medium or Mixed Quality: needs to be updated
	- *Kaharoa* WCSI inshore survey	2 – Medium or Mixed Quality: needs further evaluation
Data not used (rank)		
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	There is currently no reliable way of tracking abundance due to the characteristics and behaviour of the fish and the fishing fleet.	

Qualifying Comments
-

Fishery Interactions
-

- **Chatham Rise and Southland (SWA 3 and SWA 4)**

Stock Status		
Most Recent Assessment Plenary Publication Year	2023	
Catch in most recent year of assessment	Year: 2021–22	Catch: 8 262 t
Reference Points	Management Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: $F_{40\% B0}$	
Status in relation to Target	Unknown	
Status in relation to Limits	Soft limit: Unlikely (<40%) to be below Hard Limit: Very Unlikely (< 10%) to be below	
Status in relation to Overfishing	Unknown	

Historical Stock Status Trajectory and Current Status
-

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	CPUE and biomass indices have been variable but relatively stable since 2000.
Recent Trend in Fishing Intensity or Proxy	Fishing intensity is likely to have been stable, because the CPUE series and catches have been relatively stable since 2000.
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	Age composition data suggest the increase in catch rates and catches was consistent with the recruitment of some relatively large year classes.

Projections and Prognosis	
Stock Projections or Prognosis	Unknown
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Soft Limit: Unknown Hard Limit: Unknown
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Unknown

Assessment Methodology and Evaluation		
Assessment Type	Level 3 - Qualitative Evalutaion.	
Assessment Method	Examination of relative abundance indices	
Assessment Dates	Latest assessment Plenary publication year: 2023	Next assessment: Unknown
Overall assessment quality rank	2 – Medium or Mixed Quality	
Main data inputs (rank)	- *Tangaroa* Chatham Rise trawl survey index	2 – Medium or Mixed Quality: high CVs
	- CPUE	2 – Medium or Mixed Quality: mixture of verified and unverified data; high variability
	- Age frequencies	

	- *Kaharoa* ECSI inshore survey	2 – Medium or Mixed Quality: some samples inconsistent 2 – Medium or Mixed Quality: survey doesn't cover full depth range
Data not used (rank)	- Length frequencies	2 – Medium or Mixed Quality: some samples inconsistent
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	There is currently no single reliable series for tracking abundance due to the characteristics and behaviour of the fish and the fishing fleet.	

Qualifying Comments
- Silver warehou specialise in feeding on salps. The biomass of other species feeding on salps also increased in Chatham Rise surveys during the late 1990s and early 2000s (white warehou, sea perch, spiny dogfish), which suggests of an increase in food availability.

Fishery Interactions
-

- **SWA 10**

No information is available for SWA 10.

7. FOR FURTHER INFORMATION

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