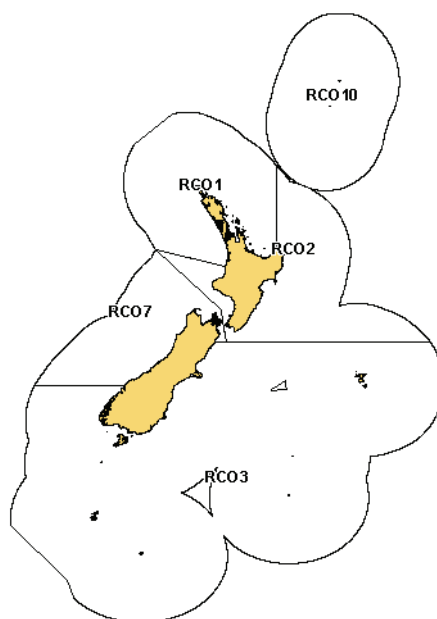


RED COD (RCO)

(Pseudophycis bachus)

Hoka



1. FISHERY SUMMARY

1.1 Commercial fisheries

Red cod are targeted primarily by domestic trawlers in the depth range between 30 and 200 m and are also a bycatch of deepwater fisheries off the southeast and southwest coasts of the South Island. The domestic red cod fishery is seasonal, usually beginning in November and continuing to May or June, with peak catches around January and May. During spring and summer, red cod are caught inshore before moving into deeper water during winter.

Reported annual catches by nation from 1970 to 1986–87 are given in Table 1. With the introduction of the EEZ and subsequently the QMS, foreign vessel catches declined and were negligible by 1987–88.

Table 1: Reported annual catch (t) of red cod by nation from 1970 to 1986–87.

Fishing year	New Zealand		Foreign licensed				Combined Total
	Domestic	Chartered	Japan	Korea	USSR	Total	
1970*	760	–	995	–	–	995	1 755
1971*	393	–	2 140	–	–	2 140	2 533
1972*	301	–	2 082	–	< 100	2 182	2 483
1973*	736	–	2 747	–	< 100	2 847	3 583
1974*	1 876	–	2 950	–	< 100	3 050	4 926
1975*	721	–	2 131	–	< 100	2 231	2 952
1976*	948	–	4 001	–	600	4 601	5 549
1977*	2 690	–	8 001	1 358	§2 200	11 559	14 249
1978–79*	5 343	124	2 560	151	51	2 762	8 229
1979–80*	5 638	883	537	259	116	912	7 433
1981–82*	3 210	387	474	70	102	646	4 243
1982–83*	4 342	406	764	675	52	1 493	6 241
1983–83†	3 751	390	149	401	3	553	4 694
1983–84†	10 189	1 764	1 364	480	49	1 893	13 846
1984–85†	14 097	2 381	978	829	7	1 814	18 292
1985–86†	9 035	1 014	739	147	5	891	10 940
1986–87‡	2 620	1 089	197	4	59	261	3 969

1970–1977 = calendar years; 1978–79 to 1982–83 = 1 April–31 March; 1980–1981=no fishing returns processed this year; 1983–1983 – 1 April–30 September; 1983–84 to 1986–87 – 1 October–30 September; * MAF data; † FSU data; ‡ QMS data § mainly ribaldo and red cod.

Recent reported landings and TACCs of red cod by Fishstock are shown in Table 2, while Figure 1 depicts historical landings and TACC values for the three main RCO stocks.

Table 2: Reported landings (t) of red cod by Fishstock from 1983–84 to 2007–08, and actual TACCs (t) for 1986–87 to 2007–08. QMS data from 1986–present.

Fishstock FMA (s)	RCO 1 1 & 9		RCO 2 2 & 8		RCO 3 3, 4, 5 & 6		RCO 7 7		RCO 10 10	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1983–84*	12	–	197	–	9 357	–	3051	–	0	–
1984–85*	9	–	126	–	14 751	–	1 442	–	0	–
1985–86*	6	–	48	–	9 346	–	408	–	0	–
1986–87	5	30	46	350	3 300	11 960	619	2 940	0	10
1987–88	8	40	81	357	2 878	12 182	1 605	2 982	0	10
1988–89	9	40	85	359	7 732	12 362	1 345	3 057	0	10
1989–90	8	42	105	362	6 589	13 018	800	3 105	0	10
1990–91	12	42	68	364	4 630	12 299	839	3 125	0	10
1991–92	26	42	358	364	6 500	12 299	2 220	3 125	0	10
1992–93	46	42	441	364	9 633	12 389	4 083	3 125	0	10
1993–94	44	42	477	364	7 977	12 389	2 992	3 125	0	10
1994–95	63	42	762	364	12 603	12 389	3 569	3 125	0	10
1995–96	28	42	584	500	11 038	12 389	3 728	3 125	0	10
1996–97	42	42	396	500	10 056	12 389	3 710	3 125	0	10
1997–98	22	42	192	500	9 972	12 389	2 700	3 125	0	10
1998–99	10	42	282	500	13 926	12 389	2 055	3 125	0	10
1999–00	3	42	130	500	4 824	12 389	633	3 125	0	10
2000–01	5	42	112	500	2 776	12 389	1 538	3 125	0	10
2001–02	6	42	150	500	2 862	12 389	1 409	3 126	0	10
2002–03	8	42	144	500	5 107	12 389	1 657	3 126	0	10
2003–04	11	42	225	500	7 724	12 389	2 358	3 126	0	10
2004–05	21	42	423	500	4 212	12 389	3 052	3 126	0	10
2005–06	24	42	372	500	3 222	12 389	3 061	3 126	0	10
2006–07	25	42	256	500	1 877	12 389	3 393	3 126	0	10
2007–08	12	42	225	500	3 236	4 600	2 984	3 126	0	10

Fishstock FMA (s)	Total	
	Landings§	TACC
1983–84*	13 848	–
1984–85*	18 292	–
1985–86*	10 940	–
1986–87	3 970	15 290
1987–88	4 506	15 571
1988–89	9 171	15 828
1989–90	7 502	16 537
1990–91	5 549	15 840
1991–92	9 104	15 840
1992–93	14 203	15 930
1993–94	11 491	15 930
1994–95	16 997	15 930
1995–96	15 350	16 066
1996–97	14 204	16 066
1997–98	12 886	16 066
1998–99	16 273	16 066
1999–00	5 590	16 066
2000–01	4 432	16 066
2001–02	4 427	16 067
2002–03	6 916	16 067
2003–04	10 318	16 067
2004–05	7 708	16 067
2005–06	6 679	16 067
2006–07	5 551	16 067
2007–08	6 457	8 278

*FSU data.

§ Includes landings from unknown areas before 1986–87.

Historically the bulk of the reported landings were taken from RCO 3, in particular the Canterbury Bight and Banks Peninsula areas, but since 2003–04 the RCO 3 fishery has been in decline and the RCO 7 2006–07 landings exceeded the RCO 3 landings for the first time. The red cod fishery is characterised by large variations in catches between years. Research indicates that this interannual variation in catch is due to varied recruitment causing biomass fluctuations rather than a change in

RED COD (RCO)

catchability. Annual landings have been substantially lower than the TACCs in all QMAs since 1999–00 and, with the exception of the 2003–04 fishing year, total catches have been below 10 000 t. Total landings are at their lowest levels since 2002–03, as a result of substantial declines in catches in RCO 3. The RCO 3 TACC was reduced by 63% from the 1st October 2007 to 4600 t, with the TAC being set at 4930t (customary, recreational and other sources of mortality were allocated 5, 95 and 230 t respectively).

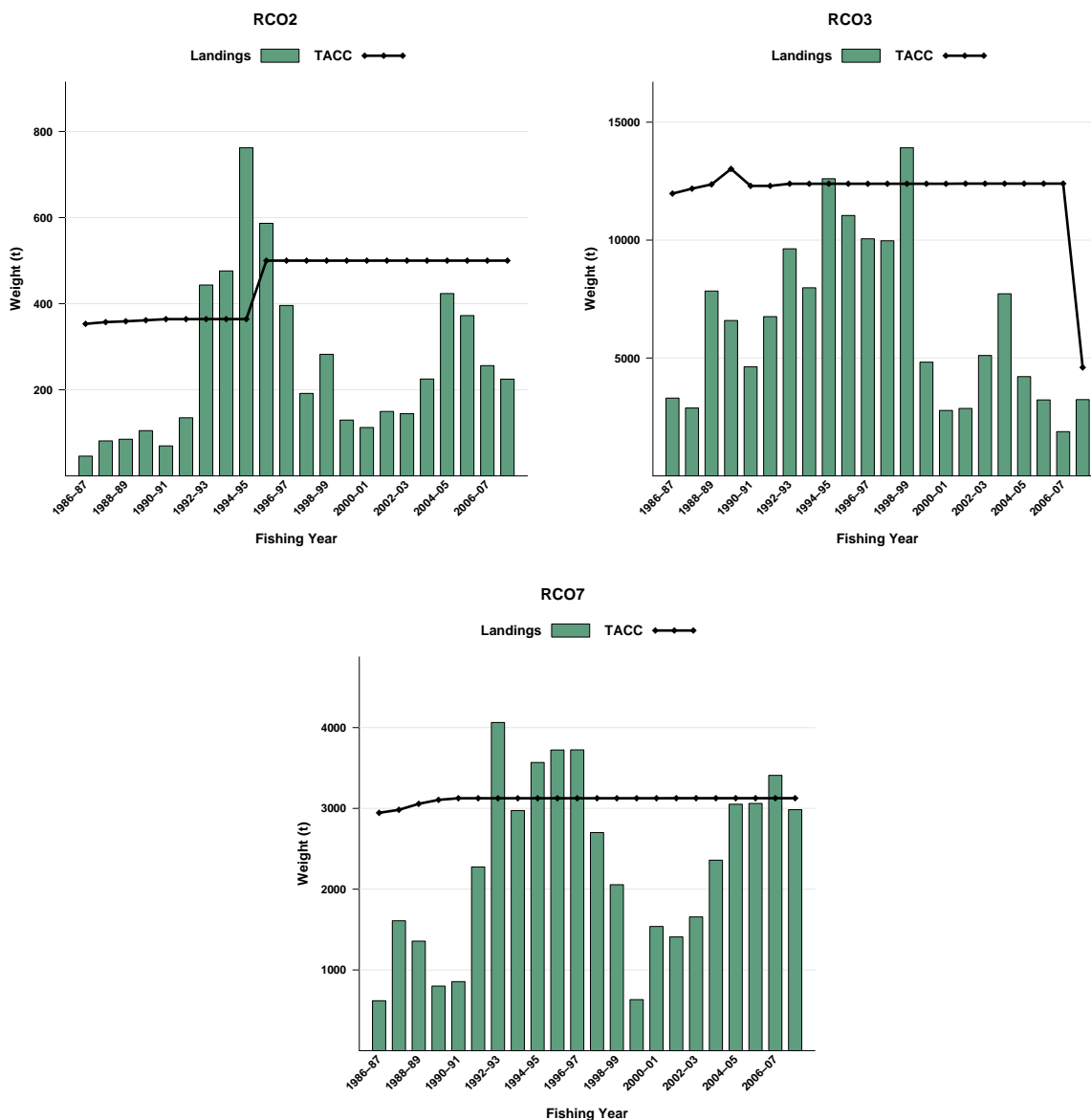


Figure 1: Historical landings and TACC for the three main RCO stocks. From top left: RCO2 (Central East), RCO3 (South East Coast), and RCO 7 (Challenger). Note that these figures do not show data prior to entry into the QMS.

1.2 Recreational fisheries

Recreational fishers take red cod, particularly on the east coast of the South Island. Results of five separate recreational fishing surveys are shown in Table 3.

Table 3: Estimated number and weight of red cod harvested by recreational fishers, by Fishstock and survey. Surveys were carried out in different years in the Ministry of Fisheries regions: South in 1991–92, Central in 1992–93, North in 1993–94 (Teirney *et al.* 1997) and nationally in 1996 (Bradford 1998) and 1999–00 (Boyd & Reilly 2002). Survey harvest is presented as a range to reflect the uncertainty in the estimates.

Fishstock	Survey	Number	CV %	Estimated harvest range (t)	Estimated point estimate (t)
1991–92					
RCO 3	South	104 000	16	90–120	-
RCO 7	South	1 000	-	0–5	-
1992–93					
RCO 2	Central	151 000	19	105–155	-
RCO 7	Central	1 100	34	5–15	-
1993–94					
RCO 1	North	9000	34	5–15	-
1996					
RCO 1	National	11 000	18	5–15	11
RCO 2	National	88 000	11	80–105	92
RCO 3	National	99 000	10	90–115	103
RCO 7	National	38 000	15	30–50	40
1999–00					
RCO 1	National	21 000	36	5–11	8
RCO 2	National	39 000	25	8–14	11
RCO 3	National	207 000	25	210–349	280
RCO 7	National	23 000	50	5–14	9

A key component of the estimating recreational harvest from diary surveys is determining the proportion of the population that fish. The Recreational Technical Working Group concluded that the harvest estimates from the diary surveys should be used only with the following qualifications: a) they may be very inaccurate; b) the 1996 and earlier surveys contain a methodological error; and, c) the 2000 and 2001 estimates are implausibly high for many important fisheries. The 1999–00 harvest estimates for each Fishstock should be evaluated with reference to the coefficient of variation.

1.3 Customary non-commercial fisheries

Quantitative estimates of the current level of customary non-commercial catch are not available.

1.4 Illegal catch

Quantitative estimates of the level of illegal catch are not available.

1.5 Other sources of mortality

Processing limits on red cod are sometimes imposed to discourage fishers from landing red cod when the species cannot be processed or when markets are poor. This practice has encouraged dumping. Processing limits are currently less of a problem than in earlier years.

2. BIOLOGY

Red cod are a fast-growing, short-lived species with few fish in the commercial fishery older than six years. Red cod grow to about 25 cm total length (TL) in the first year, followed by annual growth increments of around 15, 10 and 5 cm. Growth of sexes is similar for the first two years, after which females tend to grow faster than males and reach a larger overall length. Sexual maturity ranges from 45 to 55 cm TL with a mean value of 52 cm TL for both sexes at an age of 2–3 years. *M* has been estimated to equal 0.76 for both sexes. In 1995, ageing of red cod was validated using marginal zone analysis.

In the 1989–90 to 1992–93 fishing years, 80% of the landings in RCO 3 were 2⁺ and 3⁺ fish (50–57 cm TL). The sex ratio of the commercial catch during this period was skewed towards females during November (F:M ratio of 3.4:1) with the ratio tending to even out by May. Schools are generally comprised of single age cohorts rather than a mix of age classes.

Spawning in red cod varies with latitude, with spawning occurring later at higher latitudes. In the

RED COD (RCO)

Canterbury Bight, spawning occurs from August to October. No definite spawning grounds have been identified on the southeast coast, but there is some evidence that red cod spawn in deeper water (> 300-750 m). Running ripe fish were caught on the Puysegur Bank in 600 m during the Southland trawl survey in February 1994. Juvenile red cod are found in offshore waters after the spawning period; however, no nursery grounds are known for this species.

Red cod are seasonally abundant, with schools appearing in the Canterbury Bight and Banks Peninsula area around November. These schools are feeding aggregations and are not found in these waters after about June. Catch data indicates that they move into deeper water after this time. Recruitment is highly variable resulting in large variations in catches between years.

Biological parameters relevant to the stock assessment are shown in Table 4.

Table 4: Estimates of biological parameters for red cod.

Fishstock	Estimate				Source		
1. Natural mortality (M)							
RCO 3	0.76				Beentjes (1992)		
2. Weight = $a(\text{length})^b$ (Weight in g, length in cm fork length).							
	Females		Males				
	a	b	a	b			
RCO 3	0.00074	3.059	0.0145	2.892	Beentjes (1992)		
3. von Bertalanffy growth parameters							
	Females			Males			
	L_{∞}	k	t_0	L_{∞}	k	t_0	
RCO 3	76.5	0.41	-0.03	68.5	0.47	0.06	Horn (1995)
RCO 7	79.6	0.49	0.20	68.2	0.53	0.22	Beentjes (2000)

3. STOCKS AND AREAS

The number of red cod stocks is unknown. There are no new data which would alter the stock boundaries given in previous assessment documents.

4. STOCK ASSESSMENT

No recent stock assessments have been carried out on any red cod stocks. Previous assessments were undertaken, however, these are outdated but details appear in previous versions of the Plenary report.

Trawl survey biomass estimates are available from one *Tangaroa* and four *Kaharoa* time series (Table 5, Figures 2, 3 and 4). In 2001, the Inshore FAWG recommended that the summer east coast South Island trawl survey be discontinued due to the extreme variability in the catchability of the target species. The winter series was re-instated in 2007 and will be run initially for 3 consecutive years. The East and West Coast South Island trawl surveys track both biomass and population length structure.

Table 5: Biomass indices (t) and coefficients of variation (CV). (– no data). Vertical and areal availability and vulnerability were assumed to equal 1.0. Pre-recruit biomass are red cod < 41 cm.

Fishstock	Area	Trip code	Date	Biomass	% CV	Pre-recruit biomass	
							% CV
RCO 2	East coast	KAH 9304	Feb-Mar 1993	913	52	197	31
		KAH 9402	Feb-Mar 1994	1 298	50	547	52
	North Island	KAH 9502	Feb-Mar 1995	469	36	47	34
RCO 3	East coast	KAH 9105	May-Jun 1991	3 545	33	1 787	44
	South Island	KAH 9205	May-Jun 1992	4 527	40	2 277	50

Table 5 continued:

Fishstock	Area	Trip code	Date	Biomass	% CV	Pre-recruit biomass	
							% CV
RCO 3	(Winter)	KAH 9306	May-Jun 1993	5 601	29	1 252	50
		KAH 9406	May-Jun 1994	5 803	31	3 625	37
		KAH 9606	May-Jun 1996	4 567	30	664	31
		KAH0705	May-Jun 2007	1 486	25	190	33
		KAH0806	May-Jun 2008	1812	50	1695	50
RCO 3	Southland	TAN 9301	Feb-Mar 1993	100	68	–	–
		TAN 9402	Feb-Mar 1994	707	68	–	–
		TAN 9502	Feb-Mar 1995	2 554	49	182	66
		TAN 9604	Feb-Mar 1996	33 390	94	736	99
RCO 7	West coast	KAH 9204	Mar-Apr 1992	2 719	13	1 167	17
		South Island	KAH 9404	Mar-Apr 1994	3 169	18	888
	South Island	KAH 9504	Mar-Apr 1995	3 123	15	1 007	18
		KAH 9701	Mar-Apr 1997	2 546	23	1 353	28
		KAH 0004	Mar-Apr 2000	414	26	–	–
		KAH 0304	Mar-Apr 2003	906	24	290	31
		KAH0503	Mar-Apr 2005	2610	18	501	
		KAH0704	Mar-Apr 2007	1638	19	842	
RCO 3	East coast	KAH 9618	Dec-Jan 1996–97	10 634	23	4 101	23
	South Island (Summer)	KAH 9704	Dec-Jan 1997–98	7 536	23	4 426	24
		KAH 9809	Dec-Jan 1998–99	12 823	17	3 770	15
		KAH 9917	Dec-Jan 1999–00	6 690	30	2 728	41
		KAH 0014	Dec-Jan 2000–01	1 402	82	1 283	89

RED COD (RCO)

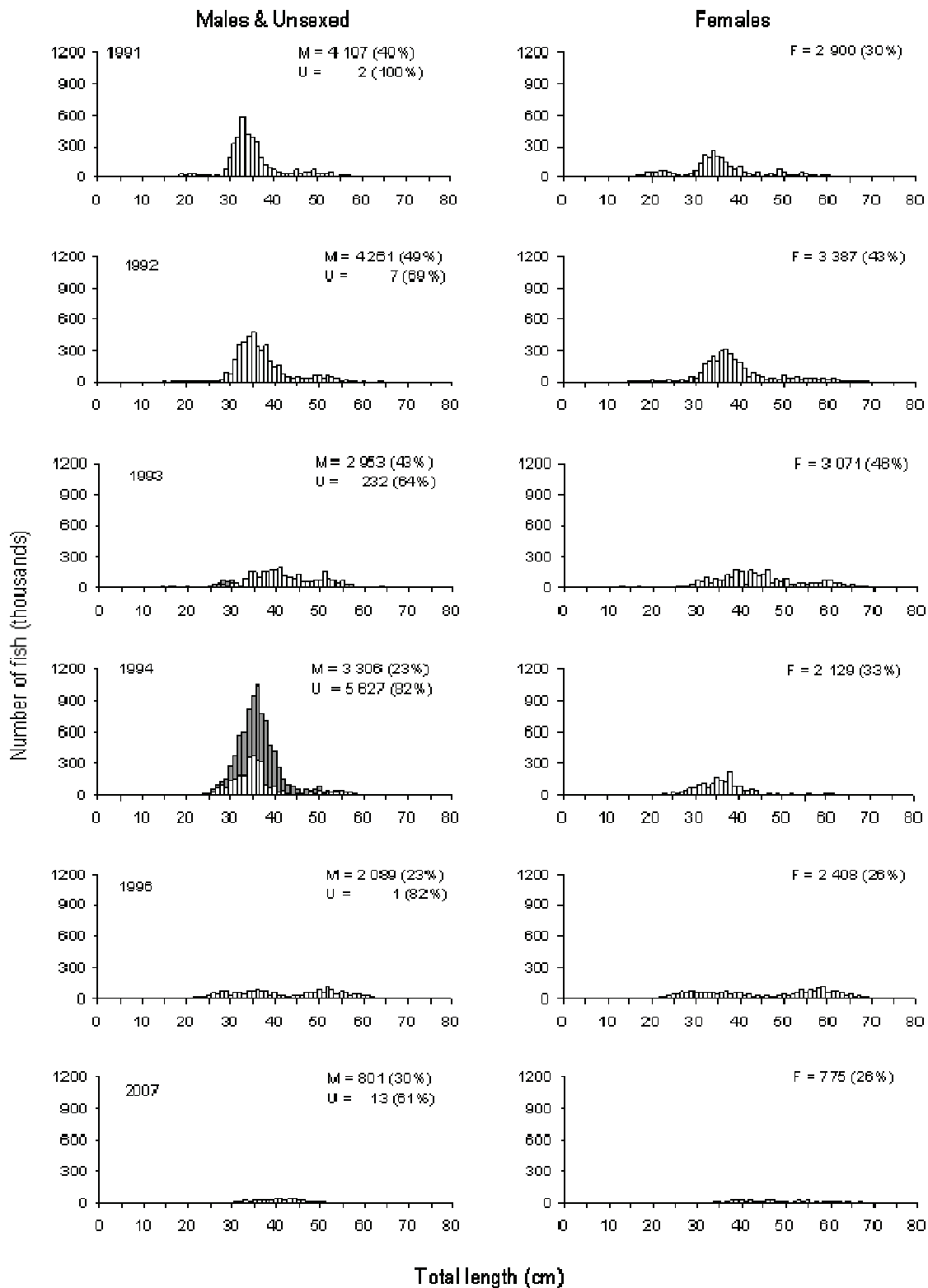


Figure 2: Scaled length frequency distributions for red cod in 30–400 m, for all six winter ECSI surveys. M, males; F, females; (), CV.

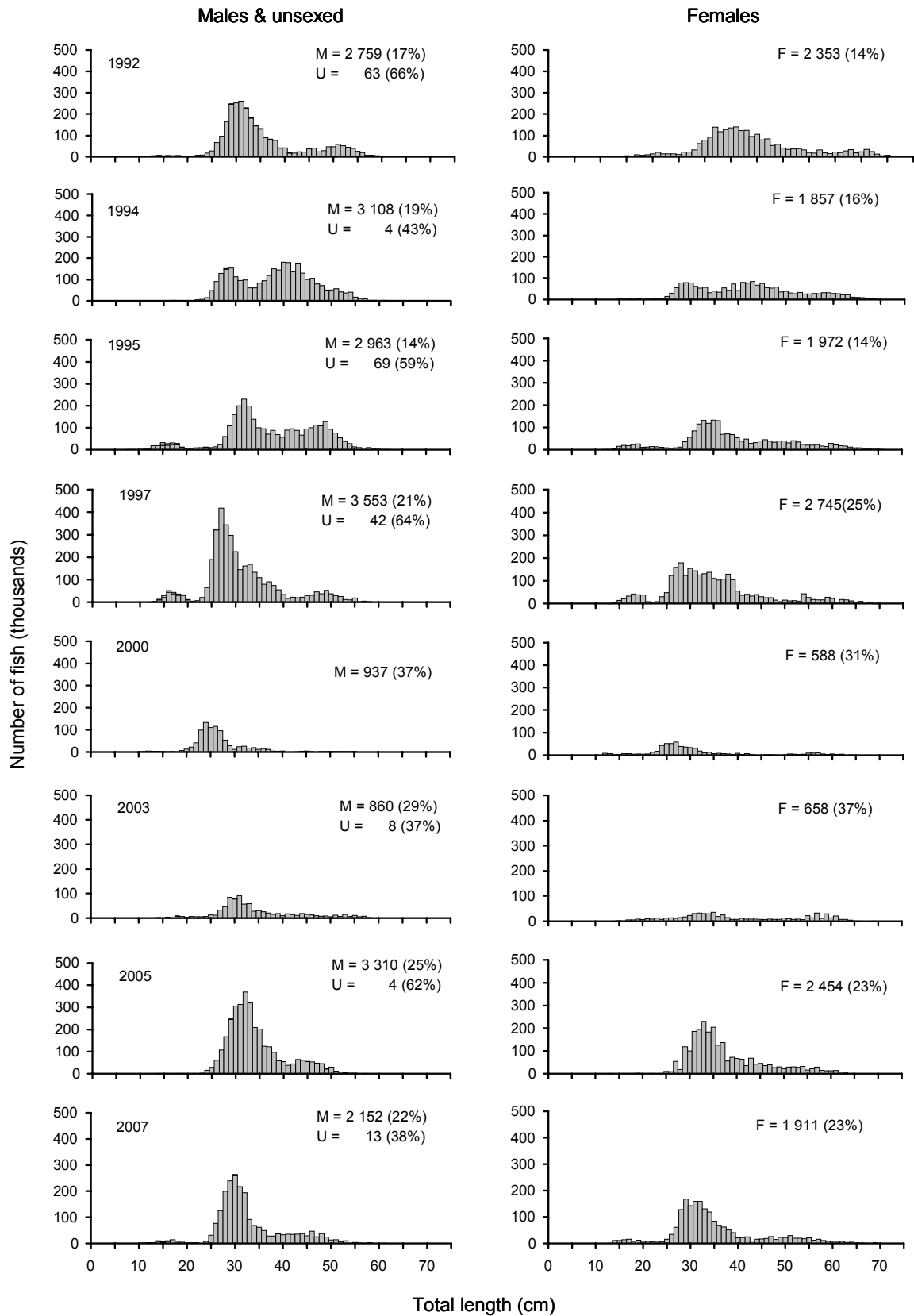


Figure 3: Scaled length frequency distributions for red cod in 30–400 m, for all WCSI surveys. M, males; F, females; U, unsexed; CV, (Stevenson 2007).

RED COD (RCO)

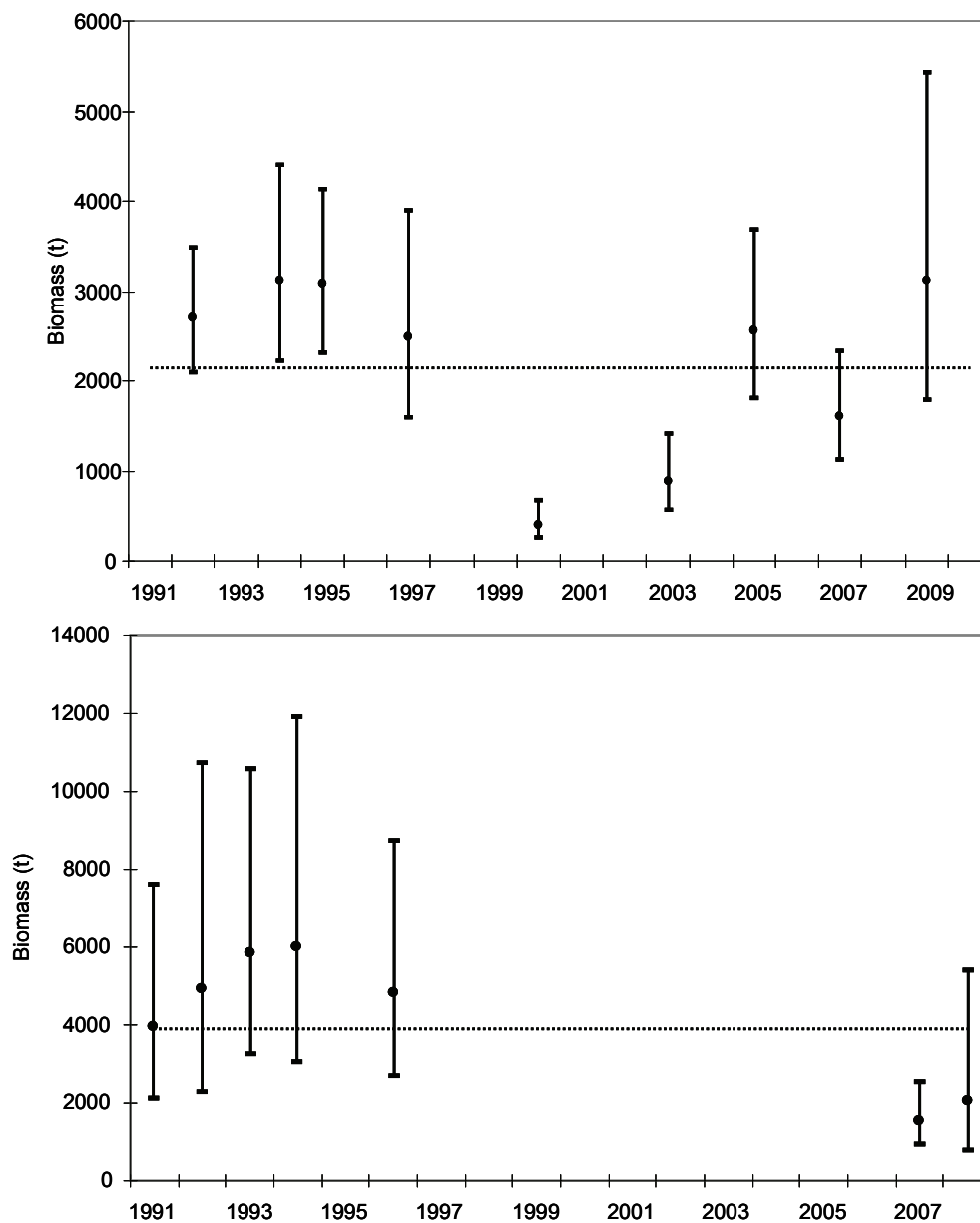


Figure 4: Biomass trends $\pm 95\%$ CI (estimated from survey CV's assuming a lognormal distribution) and the time series mean (dotted line) from the West (top) and East (bottom) Coast South Island trawl surveys.

4.5 Other factors

There have been large fluctuations in red cod abundance and landings, particularly on the east and west coast of the South Island. This causes problems for the fishers who rely on red cod, and creates additional pressure on the ACE system. Changes in catch rates of red cod, combined with the recovery of other quota species since the introduction of the QMS, has resulted in a catch mix for which some fishers do not have the appropriate quota holdings. Bycatch species while targeting red cod are stargazer, red gurnard, elephant fish, rig, school shark, blue cod, groper and tarakihi. As a result, effort into targeting red cod may be reduced to alleviate bycatch problems, despite the availability of red cod quota.

5. STATUS OF THE STOCKS

Yearly fluctuations in red cod catch (t) reflect changes in recruitment. Trawl surveys and catch sampling of red cod have shown that the fishery is based almost exclusively on two and three year old fish and is highly dependent on recruitment success.

The disparity between the TACC and reported landings indicates that the TACC is not generally attainable. The rationale for introducing and retaining a TACC of this magnitude was to provide the fishing industry with the flexibility to capitalise on years when red cod are plentiful. TACCs were exceeded in 1994–95 and 1998–99, when total catches were the highest since the introduction of the QMS. However, since then total landings have declined and recent catches in the major Fishstocks have been lower than the Y_{AV} and MIAEL method MCY estimates.

RCO 1 & RCO 2

For RCO 1 and RCO 2 it is not known if the current TACCs and recent catch levels are sustainable or if they are at levels that will allow the stocks to move towards a size that will support the MSY.

RCO 3

An analysis of recruitment–environment relationship showed that in RCO 3 there is a strong correlation between recruitment and environmental variables with a periodic 14 month time lag. The stock assessment model was sensitive to inclusion of the environment abundance index which predicts a sharp decline in recruitment in recent years. However, the predictive power of the environment–abundance model in RCO 3 proved to be poor for the most recent years (i.e., YCS estimates low and landings high).

For RCO 3 a constant catch at the level of the current TACC is unlikely to be attainable or sustainable in most years.

Catches and the winter East Coast South Island survey biomass index in 2006–07 were at their lowest recorded levels. These low catch and biomass estimates are likely a function of a depressed population, rather than from recruitment failure. This conclusion is based on the similarity of the size distribution of red cod in the recent winter survey compared to that of previous surveys (Figure 2).

RCO 7

Stock Structure Assumptions

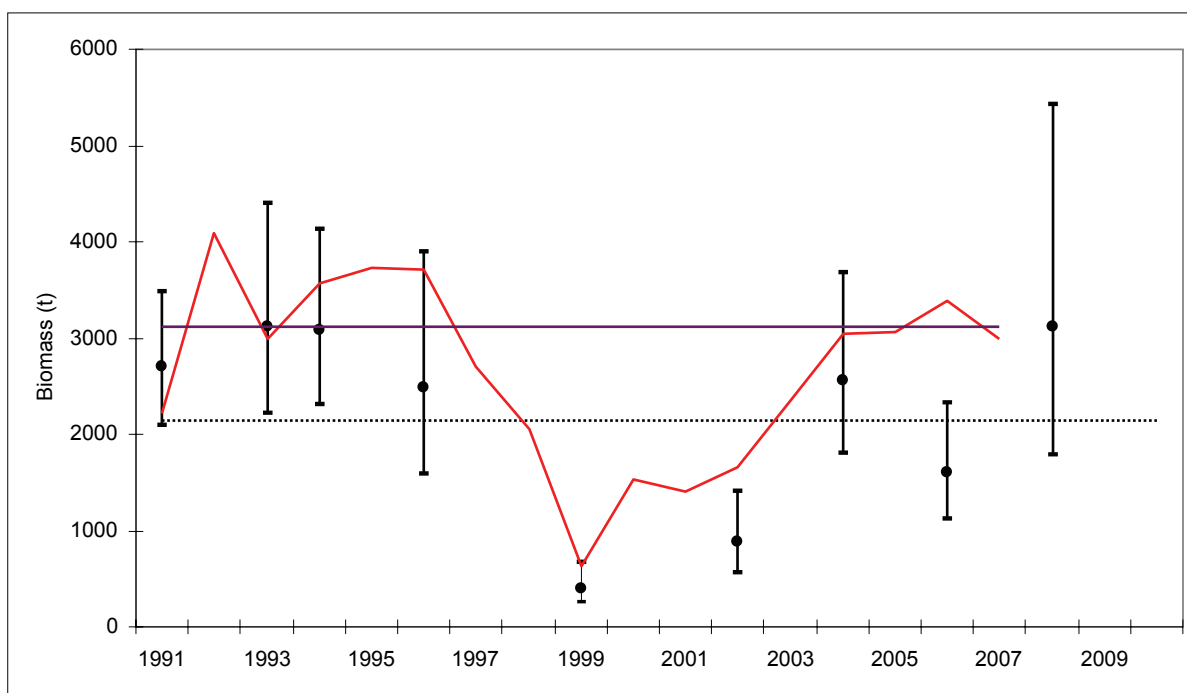
Stock boundaries are unknown, but for the purpose of this summary RCO 7 is considered to be a single management unit.

Stock Status	
Year of Most Recent Assessment	2009 West Coast South Island trawl survey
Reference Points	Target: Not established Soft Limit: Not established Hard Limit: Not established
Status in relation to Target	Unknown
Status in relation to Limits	Unknown

Fishery and Stock Trends	
Trend in Biomass or Proxy	Red cod is a target species for the WCSI trawl survey series. Survey biomass trends were relatively consistent throughout the 1990's but dropped to a very low level in 2000 from which it recovered to near the long-term mean in 2005 and 2007. The most recent point estimate (provisional 2009) was the highest in the series.
Trend in Fishing Mortality or Proxy	

RED COD (RCO)

Historical survey biomass, Catch and TACC Trajectories



West Coast South Island survey biomass (points) commercial catch (red line) and TACC (purple line) for the period 1990 to 2007. Horizontal line dashed is the mean biomass index, 1992–2007.

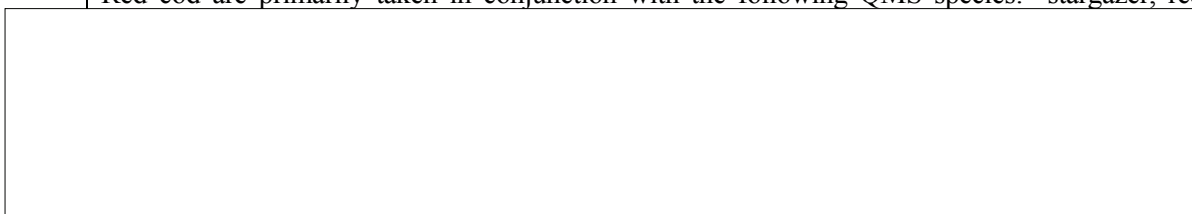
Other Abundance Indices	-
Trends in Other Relevant Indicator or Variables	Levels of recent recruitment are unknown, but length frequency analysis from the West Coast South Island trawl survey showed that there were substantial numbers of 25—30 cm fish in 2005 and fewer pre-recruits in 2007. Pre-recruits did not appear in substantial numbers in 2000 or 2003.

Projections and Prognosis	
Stock Projections or Prognosis	Recent quantitative stock projections are unavailable, and the previous assessment is too outdated to be informative for such a short lived species.
Probability of Current Catch / TACC causing decline below Limits	Soft Limit: Unknown Hard Limit: Unknown

Assessment Methodology	
Assessment Type	Level 2: Agreed abundance index
Assessment Method	Evaluation of survey biomass trends and length frequencies.
Main data inputs	- West Coast South Island Survey biomass - Length frequency.
Period of Assessment	Latest assessment: 2009 Next assessment: 2011
Changes to Model Structure and Assumptions	N/A
Major Sources of Uncertainty	The 2009 survey biomass estimate is the highest in the series but it also has the highest CV.

Qualifying Comments

Fishery Interactions
Red cod are primarily taken in conjunction with the following QMS species: stargazer, red gurnard,



Yield estimates, TACCs and reported landings for the 2007–08 fishing year are summarised in Table 6.

Table 6: Summary of yield estimates (t), TACCs (t) and reported landings (t) of red cod for the most recent fishing year. MCY(1) from cY_{AV} method, MCY(2) from MIAEL method (range only given).

Fishstock	FMA		MCY(1)	MCY(2)	2007–08 Actual TACC	2007–08 Reported landings
RCO 1	Auckland (East) (West)	1 & 9	60		42	12
RCO 2	Central (East) (West)	2 & 8		500	500	225
RCO 3	South–East, Southland and Sub-Antarctic	3, 4, 5, & 6	4 400	2 418–13 330	4 600	3 236
RCO 7	Challenger	7	800	2 568–3 452	3 125	2 984
RCO 10	Kermadec	10	–		10	0
Total			5 260		8 277	6 457

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