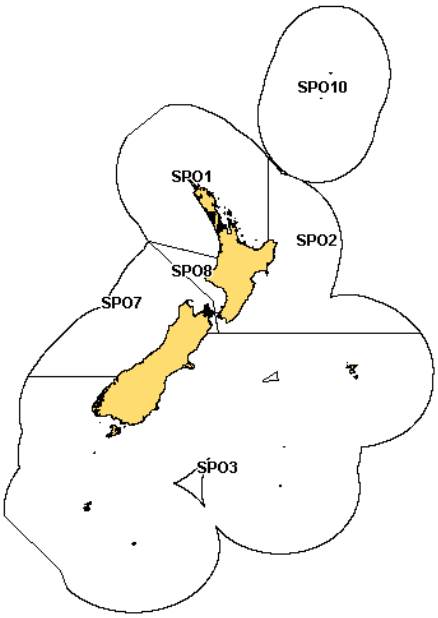
RIG (SPO)

(Mustelus lenticulatus)
Pioke, Makoo



1. FISHERIES SUMMARY

1.1 Commercial fisheries

Rig are caught in coastal waters throughout New Zealand. Most of the catch is taken in water less than 50 m deep during spring and summer, when rig aggregate inshore. Before the introduction of the QMS in 1986, 80% of the commercial catch was taken by bottom setnet and most of the remainder by trawl. Total reported landings of rig increased rapidly during the 1970s, and averaged about 3200 t per year during the late 1970s and early 1980s (Table 1). Since then, a larger proportion has been taken by trawlers as bycatch, but the exact split by method is unknown (because method data were available only for a portion of the rig catch in the CELR database). The most important bottom setnet fisheries are at 90-Mile Beach, Kaipara Harbour, Manukau Harbour, South Taranaki Bight – Tasman/Golden Bay, Canterbury Bight, Kaikoura and Hauraki Gulf. Due to a decline in CPUE the TACC for SPO 7 was decreased to 221 t on the 1st October 2006.

Table 1: Reported total New Zealand landings (t) of rig for the calendar years 1965 to 1985. Sources: MAF and FSU data.

Year	Landings	Year	Landings	Year	Landings	Year	Landings
1965	723	1971	1 120	1977	3 281	1983	3 826
1966	850	1972	1 011	1978	3 300	1984	3 562
1967	737	1973	–	1979	2 701	1985	3 222
1968	677	1974	2 040	1980	3 000		
1969	690	1975	1 841	1981	3 006		
1970	930	1976	2 610	1982	3 425		

Following the introduction of the QMS, landings declined to less than half those of the previous decade. Since 1986–87, landings have generally increased in response to TAC increases (Table 2). TACCs for all Fishstocks except SPO 10 were increased by 20% for the 1991–92 fishing year under the Adaptive Management Programme (AMP). Another TACC increase (from 454 t to 600 t) was implemented in SPO 3 for the 2000–01 fishing year. The TACCs for SPO 1, SPO 2 and SPO 8 reverted to the pre-AMP levels for the 1997–98 fishing year, when these Fishstocks were removed from the AMP in July 1997. The TACC for SPO 2 was increased from 72 t to 86 t from 1 October 2004 under the low knowledge bycatch framework.

In October 1992, the conversion factors for headed and gutted, and dressed, rig were reduced from 2.00 to 1.75. Since most rig are landed in these states, this reduction produced a maximum increase in removals of about 14% for the same nominal TACC. Landings prior to 1992–93 have not been adjusted for the change in the conversion factor. The combined effect of adaptive management and conversion factor changes was a 37% increase in allowable commercial removals from all main stocks between 1991 and 1993.

SPO 7 is managed under a stakeholder lead fisheries plan. This draft fisheries plan was developed by the Challenger Finfisheries Management Company Limited on behalf of quota owners and includes details of rebuild goals and objectives for the rig fishery in quota management area 7 (SPO 7). It represents part of the commitment made by 93% of the rig quota owners towards improving the value of their property rights and ensuring the future utilisation of the fishery for future generations. This plan was submitted to the Minister of Fisheries for approval pursuant to Section 11(a) of the Fisheries Act 1996. The plan seeks to improve the productivity of the SPO 7 fishstock through implementing area closures and catch reductions.

Table 2: Reported landings (t) of rig by Fishstock from 1985–86 to 2006–07 and actual TACs (t) from 1986–87 to 2006–07.

Fishstock	SPO 1		SPO 2		SPO 3		SPO 7		SPO 8	
FMA (s)	1 & 9		2		3,4,5, & 6		7		8	
	Landings	TAC	Landings	TAC	Landings	TAC	Landings	TAC	Landings	TAC
1985–86*	845	–	96	–	921	–	367	–	465	–
1986–87†	366	540	55	60	312	330	233	240	125	240
1987–88†	525	614	66	68	355	347	262	269	187	261
1988–89†	687	653	68	70	307	352	239	284	212	295
1989–90†	689	687	61	70	292	359	266	291	206	310
1990–91†	656	688	63	71	284	364	268	294	196	310
1991–92†	878	825	105	85	352	430	290	350	145	370
1992–93†	719	825	90	86	278	432	324	350	239	370
1993–94†	631	829	96	86	327	452	310	350	255	370
1994–95†	666	829	88	86	402	454	341	350	273	370
1995–96†	603	829	107	86	408	454	400	350	330	370
1996–97†	681	829	99	86	434	454	397	350	277	370
1997–98†	621	692	85	72	442	454	325	350	287	310
1998–99†	553	692	86	72	426	454	336	350	235	310
1999–00†	608	692	86	72	427	454	330	350	219	310
2000–01†	554	692	81	72	458	600	338	350	174	310
2001–02†	436	692	86	72	391	600	282	350	216	310
2002–03†	477	692	86	72	417	600	264	350	209	310
2003–04†	481	692	81	72	354	600	293	350	203	310
2004–05†	429	692	108	86	366	600	266	350	208	310
2005–06†	345	692	110	86	389	600	288	350	163	310
2006–07†	399	692	101	86	423	600	262	221	176	310

Fishstock	SPO 10			
FMA (s)	10			Total
	Landings	TAC	Landings§	TAC
1985–86*	0	–	2 906	–
1986–87†	0	10	1 091	1 420
1987–88†	0	10	1 395	1 569
1988–89†	0	10	1 513	1 664
1989–90†	0	10	1 514	1 727
1990–91†	0	10	1 467	1 737
1991–92†	0	10	1 770	2 070
1992–93†	0	10	1 650	2 072
1993–94†	0	10	1 619	2 097
1994–95†	0	10	1 769	2 098
1995–96†	0	10	1 848	2 098
1996–97†	0	10	1 888	2 098
1997–98†	0	10	1 760	1 888
1998–99†	0	10	1 635	1 888
1999–00†	0	10	1 670	1 888
2000–01†	0	10	1 607	2 034
2001–02†	0	10	1 411	2 034
2002–03†	0	10	1 453	2 034
2003–04†	0	10	1 412	2 034
2004–05†	0	10	1 377	204 8
2005–06†	0	10	1 295	2 048
2006–07†	0	10	1 362	1 919

*FSU data.
†QMS data.
§Includes landings from unknown areas before 1986-87

1.2 Recreational fisheries

Rig are caught by recreational fishers throughout New Zealand. Less that 3% of the recaptures of rig tagged around the South Island and Manawatu coasts in 1982–84 were returned by recreational fishers. Estimates of recreational landings obtained from three surveys, 1991–92 to 1993–94, 1996 and 1999–00 are given in Table 3. Recreational landings between 1991 and 1994 comprised only a small proportion (< 15%) of the total rig harvest in all Fishstocks.

Table 3: Estimated number and weight of rig 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 harvests are presented as a range to reflect the uncertainty in the estimates.

Fishstock	Survey	Number	CV%	Harvest Range (t)	Point estimate (t)
1991–92					
SPO 3	South	12 000	22	15–30	-
1992–93					
SPO 2	Central	5 000	-	5–15	-
SPO 7	Central	8 000	39	10–25	
SPO 8	Central	18 000	43	20–60	-
1993–94					
SPO 1	North	11 000	21	5–25	-
SPO 8	North	1 000	-	0–5	
1996					
SPO 1	National	28 000	31	25–45	35
SPO 2	National	4 000	-	-	-
SPO 3	National	12 000	20	10–20	15
SPO 7	National	19 000	20	20–30	24
SPO 8	National	7 000	-	-	-
1999–00					
SPO 1	National	13 000	30	12–23	-
SPO 2	National	16 000	58	9–33	-
SPO 3	National	43 000	32	39–75	-
SPO 7	National	33 000	38	21–46	-
SPO 8	National	7 000	48	5–13	-

A key component of estimating recreational harvest from diary surveys is determining the proportion of the population that fish. The Recreational Working Group has concluded that the methodological framework used for telephone interviews produced incorrect eligibility figures for the 1996 and previous surveys. Consequently the harvest estimates derived from these surveys are considered to be considerably underestimated and not reliable. However, relative comparisons can be made between stocks within these surveys. The Recreational Working Group considered that the 2000 survey using face-to-face interviews better estimated eligibility and that the derived recreational harvest estimates are believed to be more accurate. FMA2 catches are nevertheless considered to be over-estimated, probably because of an unrepresentative diarist sample. The 1999–00 Harvest estimates for each Fishstock should be evaluated with reference to the coefficient of variation.

1.3 Customary non-commercial fisheries

Maori fishers traditionally caught large numbers of "dogfish" during the last century and early this century. Rig was probably an important species, though spiny dogfish and school shark were also taken. The historical practice of having regular annual fishing expeditions, during which thousands of dogfish were sun-dried on wooden frames, is no longer prevalent. However, rig are still caught in small quantities by customary non-commercial fishers in parts of the North Island, especially the harbours of the Auckland region. Quantitative information on the current level of customary non-commercial take is not available.

1.4 Illegal Catch

Quantitative information on the level of illegal catch is not available.

1.5 Other sources of mortality

Unknown quantities of juvenile rig are caught by setnets placed in harbours and shallow bays. Quantitative information on the level of other sources of mortality is not available.

2. BIOLOGY

Rig are born at a total length (TL) of 25–30 cm. On the South Island male and female rig attain maturity at 5–6 yrs (~85cm) and 7–8 yrs (~100 cm), respectively (Francis & O'Maolagain 2000). Rig in the Hauraki Gulf mature earlier – 4 yrs for males and 5 yrs for females – and at smaller sizes (Francis & Francis 1992). Longevity is not known because few large fish have been aged, however, a male rig that was mature at tagging was recaptured after nearly 14 years of liberty, suggesting a longevity of 20 years or longer. Females reach a maximum length of 151 cm and males 126 cm TL.

Rig give birth to young during spring and summer following a 10–11 month gestation period. Most females begin a new pregnancy immediately after parturition, and therefore breed annually. The number of young produced increases exponentially with the length of the mother, and ranges from 2 to 37 (mean ~ 11). Young are generally born in shallow coastal waters, especially in harbours and estuaries, throughout North and South Islands. They grow rapidly during their first summer, and then disappear as water temperatures drop in autumn-winter. They presumably move into deeper water.

Rig make extensive coastal migrations, with one tagged female moving a least 1160 km. Over half of the tagged rig that were recaptured had moved over 50 km, and over half of the females had moved more than 200 km. Females travel further than males, and mature females travel further than immature females.

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

Table 4: Estimates of biological parameters for rig.

Fishstock	Estimate	Source
1. Natural mortality (*M*)		
All	0.2–0.3	Francis & Francis (1992a)

2. Weight = a(length) (Weight in g, length in cm fork length).

	Females		Males		
	a	b	a	b	
SPO3	3.67×10^{-7}	3.54	1.46×10^{-6}	3.22	Francis (1979)
SPO 7&8	9.86×10^{-7}	3.32	$3.85 \times 10^{-}$	3.01	Blackwell (unpubl. data)

3. von Bertalanffy growth parameters

	Females			Males			
	L_∞	k	t_o	L_∞	k	t_o	
SPO 1	90.7	0.42	-0.77	118.7	0.16	-2.02	Francis & Francis (1992a)
SPO3	87.0	0.40	-0.68	161.1	0.11	-1.91	Francis & Francis (1992a)
	Both Sexes						
	L	k	t_o				
SPO 3 &7	147.2	0.11 9	-2.35				Francis & Ó Maolagáin (2000)

3. STOCKS AND AREAS

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

Five biological rig stocks are recognised: northeast coast North Island (NECNI), statistical areas 1–11; southeast coast North Island (SECNI), 12–15; east coast South Island (ECSI), 18–30; west coast South Island (WCSI), 17, 31–36, 38; west coast North Island (WCNI), 16, 37, 39–48. ECSI and WCSI boundaries were determined from tagging studies; NECNI and SECNI were separated on the basis of differing CPUE trends before 1986; and WCNI was arbitrarily defined to be similar in size to the South Island stocks.

Fishstocks SPO 2, SPO 3 and SPO 7 correspond closely with SECNI, ECSI and WCSI biological stocks respectively. SPO 8 consists of part of the WCNI stock, and SPO 1 consists of part of the WCNI stock and the NECNI stock.

4. STOCK ASSESSMENT

There are no new data which would alter the yield estimates given in the 1997 Plenary Report. The yield estimates are based on commercial landings data only.

4.1 Estimates of fishery parameters and abundance

Standardised CPUE (kg / km net) indices had been calculated for SPO 8 and for five sub-areas in SPO 1 by modelling (GLM) non-zero catches by core vessels targeting rig with setnets between 1989–90 and 2003-04 (Blackwell *et al*. 2006). Catches had been adjusted prior to the analysis to account for changes in conversion factors over this period. In 2008 this analysis was updated using data through to the end of the 2006–07 fishing year (Figure 1).

Considering changes since the previous analysis there have been increases in CPUE for Thames, the Kaipara Harbour, the Manukau Harbour, and the SPO 1 west coastal regions and decreases in CPUE for SPO 1 eastern coastal regions and SPO 8. Apart from the increase in Thames, all recent CPUE was within the range estimated historically.

In considering the decline observed in the Manukau Harbour the Inshore working Group previously noted that "although standardised CPUE in the Manakau harbour declined, rig in this harbour do not comprise a separate population; this observation is therefore more likely to reflect changes in local conditions than a decline in the abundance of the SPO 1 west coast stock". Since 2003–04, CPUE in this area has increased to around the levels estimated in the mid 1990s.

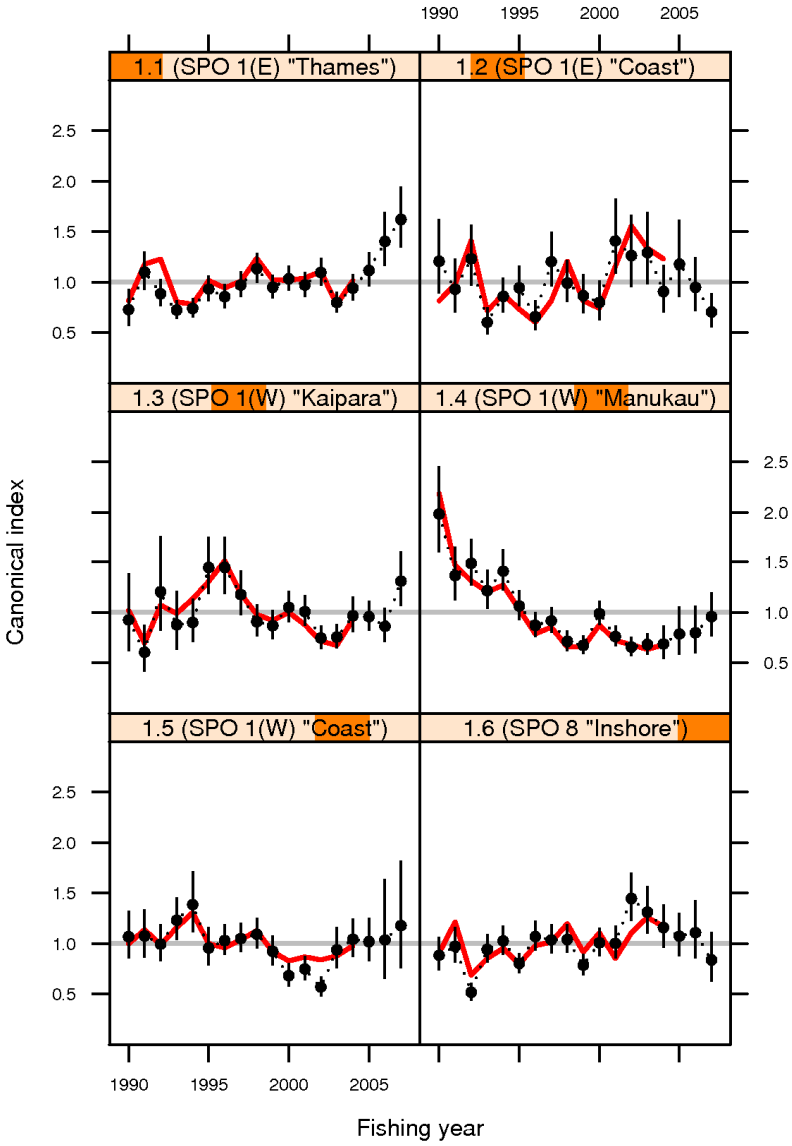


Figure 1: Standardised CPUE indices, based on non-zero, core-vessel setnet catches (calculated green weight) for SPO 1 and 8 (Manning *in prep*). Error bars represent 95% confidence intervals and the solid line represents the previous indices from Blackwell et al. (2006).

Revised indices of abundance for SPO 3 (1989–90 to 2003–04) and SPO 7 (1989–90 – 2004–05) stocks were reported as part of the AMP (SeaFIC 2005a, Starr *et al*. 2006, Starr *et al*. 2008), using standardised CPUE data from rig target setnet fisheries. The analyses assumed that setnet mesh selectivity had remained the same over the whole time period. Although there was no overall trend in CPUE indices for SPO 3 (Figure 2), the AMP Working Group concluded (in 2005) that recent declines in CPUE, annual landings and mean size of males and females suggest that abundance of SPO 3 may have declined over the last six years.

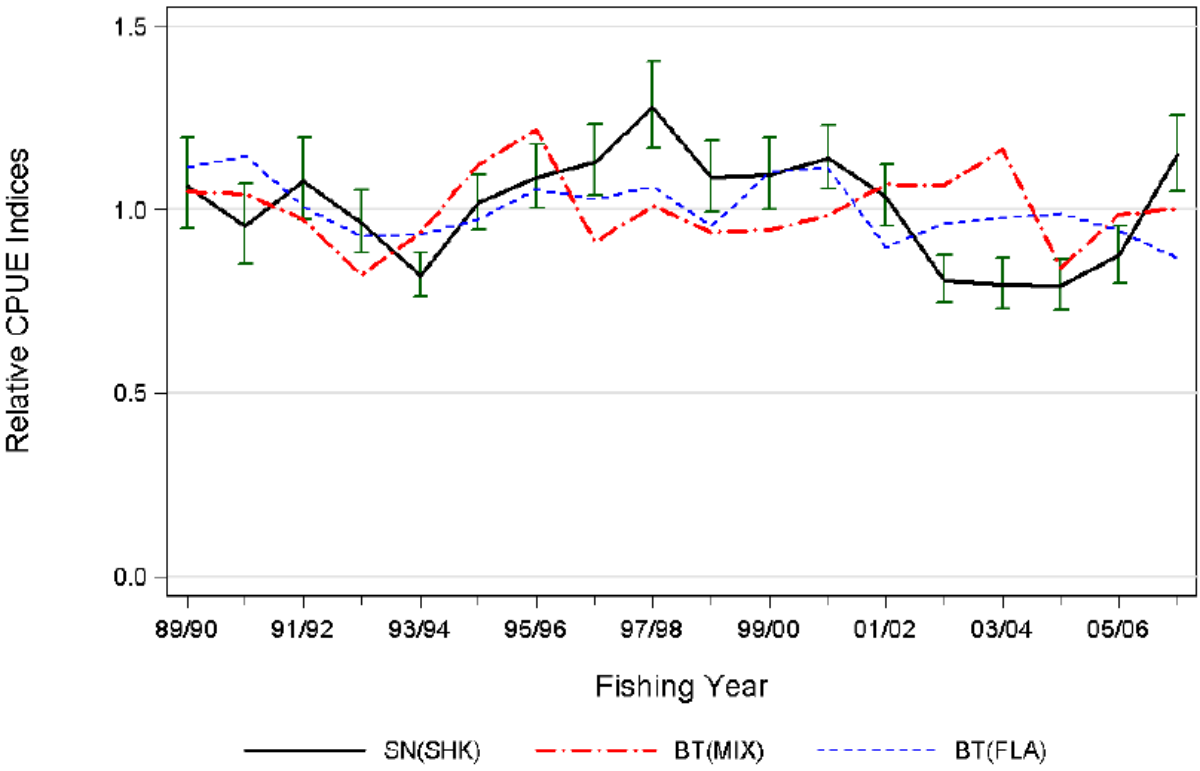


Figure 2: Lognormal standardisation of non-zero setnet catches of SPO 3,. Each series is scaled so that the geometric mean = 1. a) SN[SHK]: target shark species setnet fishery; b) BT[MIX]: mixed target species bottom trawl fishery; c) BT[FLA]: target flatfish bottom trawl fishery.

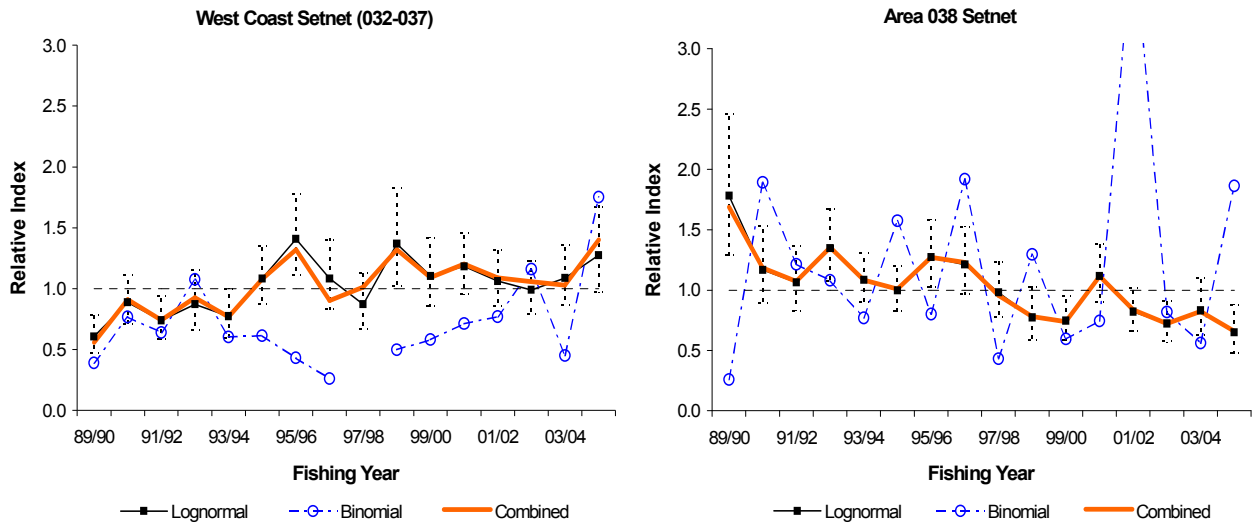


Figure 3. Plot of three standardised CPUE models: [left panel] the west coast South Island setnet fishery and [right panel] the Area 038 setnet fishery. a) a lognormal model using non-zero landings as the dependent variable (with associated 95% lognormal error bars); b) a binomial (logistic) model using a binary variable indicating a successful or zero catch of rig and c) a combined model which summarises the two sets of indices into a single trajectory.

Lognormal standardisation of non-zero setnet catches for core vessels on the west coast of the South Island (SPO 7) produced an annual index that peaked in 1995–96 and although fluctuating depicted no clear trend since then. A similar index for Tasman and Golden Bays (area 038), where about half of the annual SPO 7 catch is taken, produced an annual index that declined consistently since 1989–90 (Figure 3). Nominal CPUE (kg / 100 m of setnet) for core vessels in area 038 declined by approximately 66%

between 1976–77 and 1984–85 (Francis & Smith 1988), suggesting that there have been substantial declines in abundance in Tasman and Golden Bays prior to the current analysis. Although large rig are not effectively targeted with bottom trawl gear, the WCSI trawl survey is believed to provide reliable indices of the relative biomass of males and younger females in SPO 7. Relative biomass indices declined by more than 50% between 1995 and 2005 (Figure 4).

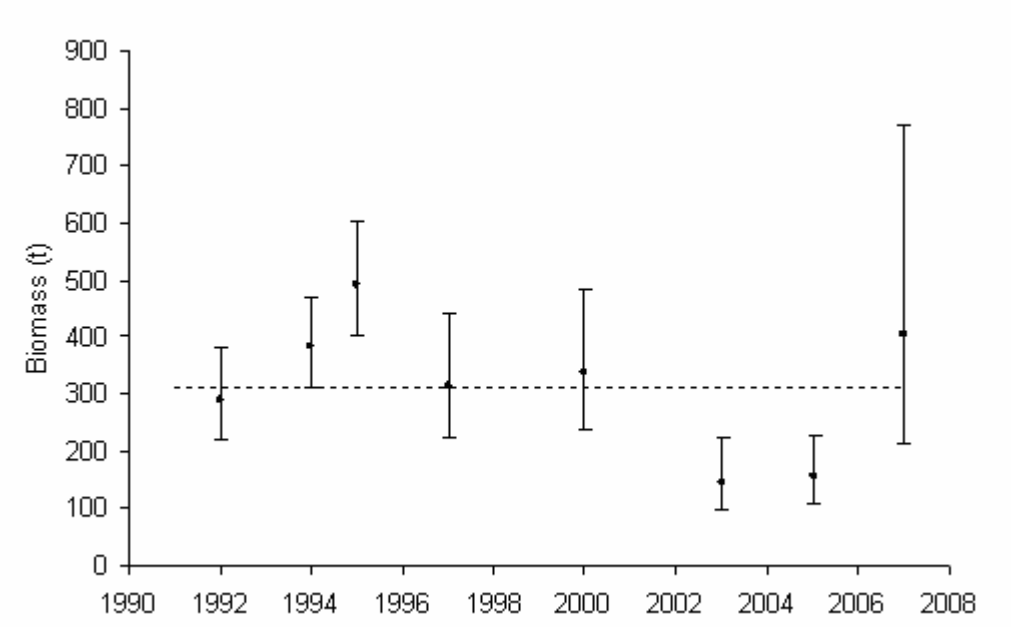


Figure 4. Plots of biomass estimates (t) for rig from the west coast South Island trawl survey by year. Error bars are approximated from the CVs assuming a lognormal distribution dashed line is the series mean.

4.2 Biomass estimates

ECSI and WCSI biomass estimates were calculated by dividing the mean reported commercial landings for the period 1981–83 by estimates of the exploitation rates in 1982–84 obtained from tagging studies. Biomass estimates were 4700–5600 t for ECSI and 3250 t for WCSI. While these estimates are out of date now estimates of current biomass are not available.

4.3 Estimation of Maximum Constant Yield (MCY)

(i) ECSI and WCSI stocks

MCY was previously estimated using the equation MCY = $0.5*M*B_{AV}$ (Method 2). However, recent work has shown that populations fished at this level have a high probability of stock collapse (i.e., falling below 20% virgin biomass) if their recruitment steepness is less than or equal to 0.5 (Francis & Francis 1992a). Rig, like all elasmobranchs, have very low fecundity. In addition, fecundity declines exponentially with the size of the mother. Therefore, it is likely that rig have a close relationship between recruitment and spawning stock biomass. It is therefore unsafe to use Method 2 for estimating MCY for rig. MCY can only be estimated using this method if an estimate of virgin biomass becomes available (in which case MCY can be determined as a percentage of B_0 as described by Francis & Francis 1992a).

No estimates of MCY are available for these stocks. This conclusion has not changed since the 1992 Plenary Report.

(ii) WCNI Stock

MCY was estimated using the equation MCY = cY_{AV} (Method 4). The period 1977–78 to 1981–82 appeared to have relatively constant effort (± 30%) and no trend in landings, so landings during these years were averaged to estimate Y_{AV}. *M* lies in the range 0.2–0.3, leading to a value of 0.7 or 0.8 for c (the natural variability factor). However, natural variability in year class strength is probably low in view of very low fecundity, so c was set at 0.9.

MCY = 0.9* 680 t = 612 t (rounded to 610 t).

Targeted setnet CPUE declined in 3 of the 4 statistical areas examined over the period used for MCY estimation, indicating that landings or effort or both varied. Therefore, this method may be inappropriate, and MCY may be less than 610 t.

The estimate of MCY has not changed since the 1989 Plenary Report.

(iii) NECNI Stock

MCY was estimated using the equation MCY = cY_{AV} (Method 4). The period 1977–78 to 1980–81 had relatively constant effort (± 15%) and no trend in landings in the Hauraki Gulf (the part of the stock range that accounts for most of the catch), so landings during these years were averaged to estimate Y_{AV}, c was set equal to 0.9.

MCY = 0.9 * 318 t = 286 t (rounded to 290 t).

The estimate of MCY has not changed since the 1988 Plenary Report.

(iv) SECNI Stock

MCY cannot be estimated explicitly. However, based on the catch history for this stock before the introduction of the QMS, the MCY is likely to be less that 70 t.

MCY < 70 t.

The estimate of MCY has not changed since the 1992 Plenary Report.

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

4.4 Estimation of Current Annual Yield (CAY)

CAY cannot be determined with available data.

Yield estimates are summarised in Table 5.

Table 5: Yield estimates (t) of rig by stock.

Parameter	Fishstock	Estimates
MCY	SPO 1 (WCNI + NECNI)	630*
	SPO 2 (SECNI)	< 70
	SPO 3 (ECSI)	Cannot be determined
	SPO 7 (WCSI)	Cannot be determined
	SPO 8 (WCNI)	270*
	SPO 10	Cannot be determined
CAY	All	Cannot be determined

* MCY estimate for the WCNI stock was apportioned pro-rata between SPO 1 and SPO 8 Fishstocks on the basis of historical catches.

4.5 Other factors

Stock mixing occurs in the South Taranaki Bight to the Cook Strait and South Westland regions, and probably elsewhere. Some regional fisheries therefore exploit more than one stock. Also, biological stock boundaries do not always coincide with Fishstock boundaries. Consequently, management by quota within Fishstocks is likely to be sub optimal for individual stocks.

The use of small mesh commercials setnets (125 mm) in the Auckland FMA probably results in a large proportion of the rig catch being immature fish. Elsewhere, the minimum size is 150 mm.

There have been several changes to the rig conversion factors over the period that SPO has been managed within the QMS. The trend has been towards lower conversion factors. While researchers correct catches for these changes in undertaking CPUE analyses, this has not been done for total

landings reported in this Working Group Report. These changes have the effect of reducing the effect of catches in recent years compared to early years, e.g. if actual catch had been constant it would appear to be declining. This has implication for historically set TACCs and any yield estimates (e.g. MCY).

5. ANALYSIS OF ADAPTIVE MANAGEMENT PROGRAMMES (AMP)

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

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

SPO 3

The SPO3 AMP was extended for one year in 2004/05 and again in 2005/06, and was fully reviewed in 2007. However, a request was made in 2006 for a full stock assessment to be done. This was not done in 2007, and SPO 3 was placed on the 2008 AMP agenda for review and a stock assessment in 2008. A stock assessment was requested for SPO 3 in response to concerns raised by fishers and regional managers in FMA 3, mainly related to the fact that the TACC has been substantially under-caught since the AMP TACC increase in 2000–01, and anecdotal reports of declining mean size, or decline in the proportion of large females, in catches in recent years.

CPUE Characterization

Effects of Conversion Factors

- The conversion factors used for raising DRE and HGU weight to greenweight for SPO3 have changed twice in the past, from 2 (60 to 1991–92), to 1.75 (1992–93 to 1999–00) to 1.55 (2000–01 to present). This has required that reported catch estimates be adjusted for these conversion factor changes, before conducting further analyses. Correcting past catch estimates using the current conversion factors has resulted in a significant reduction in estimates of past catch for SPO across the time series.

AMP History

- SPO 3 was one of the first stocks to enter an AMP with a TACC increase from 364t to 430t for 1991–92. The TACC was raised again to 600t in October 2000, following the 2000 AMP review. After full-term review in 2005, the AMP was extended for two more years under existing conditions until 2006–07. SPO 3 now remains in an AMP until this is replaced by a fisheries plan.
- After correction of past estimated catches using the latest conversion factors for dressed weight to green weight, estimated catches have been well below the TACC levels throughout the history of the fishery. Adjusted landings increased after the first TACC increase from around 250t (QMR reported landings 300t) to over 350t by 1994–95 (QMR reported landings around 400t). Catches then fluctuated between 350t and 400t (QMR 400t–450t) until the next TACC increase in 1999–00.
- Reported landings after 1999–00 are not affected by conversion factor adjustments. SPO 3 landings reached their highest level of 458t in 2000–01, approximately the previous TACC level, but well below the increased TACC of 600t. Catches have since declined, averaging only 390t over 2001–02 to 2006–07, although reaching 423t in 2006–07.

Fishery Characterization

- A historic catch series has been reconstructed for SPO 3, in preparation for conducting a stock assessment (Figure 6). Adjusted total landings increased steadily from around 200t in 1968 to a peak of almost 1 200t by 1984. Over this same period, the proportion of SPO 3 taken by setnet increased from 10% to over 80%. Adjusted reported landings then declined sharply to only about 250t by the time of entry into the QMS in 1986–87. The proportion of total SPO 3 catch taken by setnets has since remained over 70%.
- SPO 3 is by far the most important of the SPO stocks, contributing, 96% of the adjusted total reported catch of 6 975t for all SPO stocks over the period 1989–90 to 2006–07. Small catches are reported for SPO 7 and 8, and negligible amounts for SPO 1 and 2.
- Over this period, SN accounted for 73% of SPO 3 catch, 25% by bottom trawl (BT) and the remainder in Danish-seine (since 2002–03), bottom long line (BLL) and mid-water trawl (MWT).

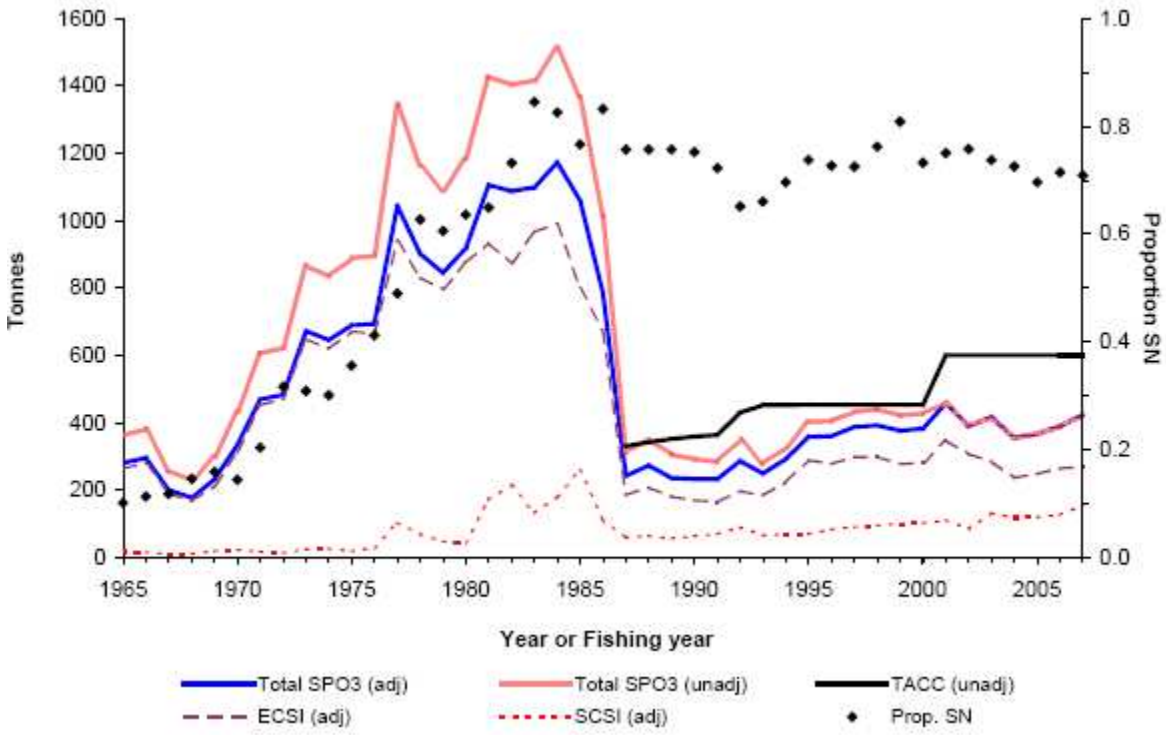


Figure 6: Summary of historical catch data for SPO 3 prepared as described in Starr (in prep.). Total landings (adjusted and unadjusted for conversion factor changes) are shown, as is the unadjusted TACC. The proportion of the total New Zealand rig catch attributed to setnet is also shown. ECSI: east coast South Island; SCSI: south coast South Island; SN: setnet.

- Approximately 70% of the setnet and the bottom trawl landings of SPO 3 have historically come from the four East Coast South Island statistical areas: areas 018 to 024: Kaikoura to Timaru, with peak landings coming from Area 022: Canterbury Bight. The remainder of the bottom trawl and setnet landings for SPO 3 are taken in Foveaux Strait and Fiordland (Areas 025 to 032).
- Setnet effort has always been high in Area 018, reflecting the target TAR setnet fishery, but there has been a drop in effort in the most recent four years. Areas 020 and 022 are now the main areas for setnet and bottom trawl landings of SPO 3, although there has been a drop in setnet effort in Area 020 in the most recent four years as well. Rig are a bycatch species in bottom trawl fisheries which target species such as red cod, barracouta and hoki, and the distribution of SPO 3 bottom trawl landings by statistical area have remained relatively consistent.

- Setnet catches are strongly seasonal, mainly taken in the spring and summer, with about 80% of the rig landings taken by the end of January. The setnet fishery in the Area 022 appears to last into February and March, somewhat later than the fisheries further north in Areas 018 and 020. The SPO 3 bottom trawl season extends longer than the setnet fishery, with about 80% of the total landings recorded by the end of April.
- The seasonal pattern of bottom trawl landings reflects the timing of the dominant red cod fishery, which usually tapers off in May. The seasonal distribution of the bottom trawl landings of rig in the lower end of the South Island differs, with more sporadic landings in the eastern end of Foveaux Strait and a more extended period for western Foveaux Strait and Fiordland.
- Over 90% of the setnet catches SPO 3 are taken by a shark species target fishery (rig, school shark, elephantfish and spiny dogfish) with the SPO being the dominant target species. Bottom trawl landings of rig are taken by fisheries directed at inshore species including flatfish, red cod and stargazer. Few rig are taken by target rig bottom trawls, although some are taken in conjunction with target fishing for elephantfish. There appears to be an increasing trend to target rig and a corresponding drop in the proportion taken as bycatch in the target school shark setnet fishery, coinciding with the increased AMP TACC and decline in Annual Catch Entitlement (ACE) values in 2000–01.
- Rig are mainly taken between 15 m and 270 m depth (median 60 m). The distribution of tows which caught or targeted rig differs with declared target species, with red cod and barracouta target tows being slightly shallower than the target stargazer tows.

CPUE Analysis

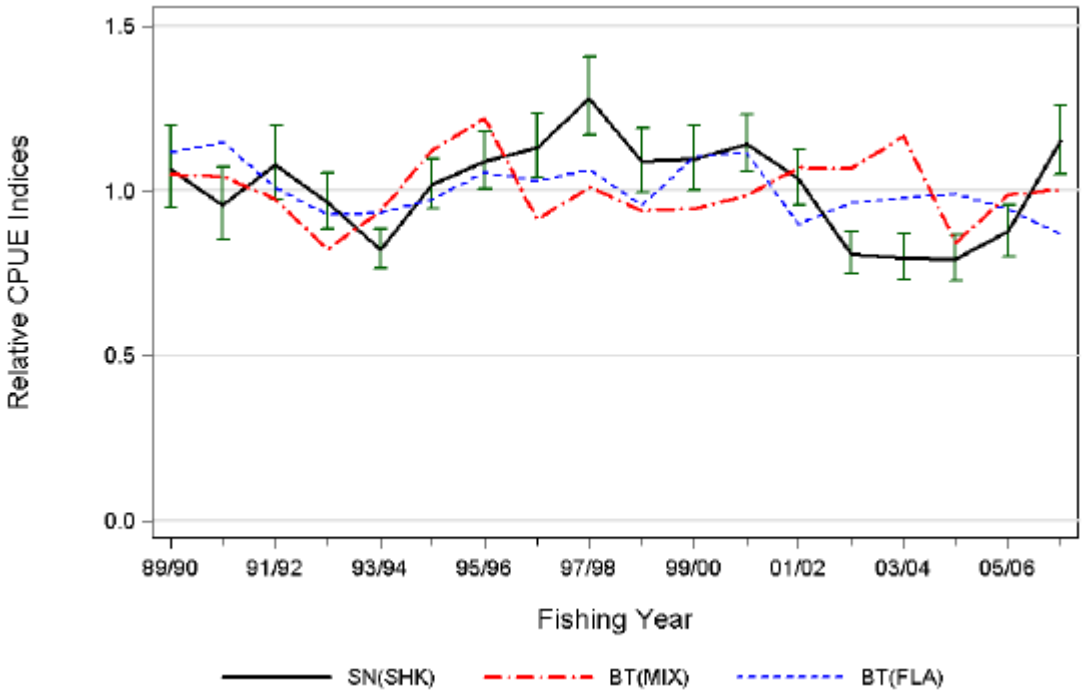


Figure 7: Comparison of the lognormal indices from the three CPUE series for SPO 3: a) SN[SHK]: target shark species setnet fishery; b) BT[MIX]: mixed target species bottom trawl fishery; c) BT[FLA]: target flatfish bottom trawl fishery. (Each series is scaled so the geometric mean = 1.)

- Three CPUE analyses were performed. The primary index is setnet catch effort data in a fishery targeted at a range of shark species (SN(SHK) - rig, school shark, elephantfish, and spiny dogfish) is a repeat of the analyses presented to the AMP Working Group from 2002 to 2007 (Starr *et al*. 2007). Two additional series based on the bycatch of SPO 3 in two bottom trawl fisheries were evaluated: the bottom trawl fishery targeted at a mixed range of species

(BT(MIX) - barracouta, red cod, tarakihi and stargazer); and bottom trawl fishery targeted at flatfish species (BT(FLA)). These two fisheries operate at different depth ranges and probably select a different size range of rig.

- The lognormal model for the setnet target shark fishery indicates that the fishery has operated at two levels: one from the beginning of the series to about 1997–98, operating just above the long-term average catch rate; followed by a lower level about 70%–80% of the long-term average (Figure 7). This lower catch rate persisted for 3 years from 2002–03 to 2004–05, but has risen over the past two fishing years to a level in 2006–07 which is slightly higher than the series average. The two bottom trawl series do not show any apparent trend (Figure 7).
- All three models show persistent declining trends in the proportion of records with zero rig landings over the entire series, indicating a steady increase in successful targeting on rig.
- Some of the observed CPUE trends may be caused by changing fishing practices, particularly in the BT(MIX) and BT(FLA) fisheries. However, recent increases may also be caused by a general improvement in the availability of this species. The three lognormal series show relatively little contrast when superimposed, particularly given the upturn in the shark setnet index in 2005–06 and 2006–07 (Figure 7).

Trawl Survey Abundance Indices

- The East Coast South Island winter trawl surveys series was resumed in May 2007 (Figure 5). The results of the 2007 survey are comparable to the five previous indices, but biomass estimates are low, CVs are high and it is uncertain whether these surveys provide a useful index of rig abundance. The distribution of positive catches is variable between surveys, and generally less than one-third of the tows catch rig. Some rig were also caught in the shallow stratum (10–30 m) only added to the 2007 survey. These survey indices must therefore be interpreted with caution.
- Survey length frequency data show consistency between the male and female distributions on each survey, but variation between surveys. Variability in length frequencies between surveys indicates that surveys may not be representatively sampling the SPO population. Specifically, very few rig greater than 100 cm are caught in surveys, while this size class is common in the commercial setnet fishery. The Southern Inshore FAWG concluded that the ECSI trawl survey was probably providing an accurate index of pre-recruit rig biomass.

Logbook Programme

- An industry setnet logbook programme was introduced into QMA 3 in 1994–95, targeted at rig, school shark, and elephantfish. The programme has collected data from inshore setnet fisheries off the eastern and southern coast of the South Island from 1994–95 to 2006–07, and a small number of sets have also been recorded from the Challenger FMA. 85% of the logbook records were collected from the Pegasus Bay / South Canterbury Bight fishery which primarily targets rig, and a few target rig sets have been recorded off Oamaru. Most of the logbook sets occurring in Southland (QMA 5) targeted school shark.
- The setnet logbook programme has obtained reasonable coverage of the SPO 3 fishery over 1995–96 to 2005–06, with the exception of 1997–98 and 2006–07. The number of sets reported per year has ranged from 52 (2006–07) to 463 (2000–01), representing six to 101 t of estimated catch. Coverage levels by catch weight for these years have ranged from 2% to 29%.
- Interest in this programme has varied over the years, declining considerably by 1997–98. Coverage improved after 1997–98, with 12 to 14 vessels participating in the programme for several years. The number of vessels participating in the programme dropped in 2002–03 to 10 vessels, with less than 10 participating in 2004–05 and 2005–06. The programme practically collapsed in 2006–07, with only 3 vessels participating, 52 sets observed and only 60 fish measured.
- The programme has been targeted at the rig fishery in Canterbury Bight, tending to oversample Area 022, and has never obtained good coverage of the small target rig fishery in Area 018. Logbooks did capture the shift to Area 020 from Area 018 which occurred in

2001–02, but coverage of Area 020 appears to have been lost in 2003–04, 2005–06 and 2006–07.

- The logbook programme has been more successful in achieving good seasonal representation, with the distribution by month being adequately representative of the fishery in all years except 1994–95, 2005–06 and 2006–07.
- Length-frequency distributions of sampled rig show no apparent trends up to about 2003–04. Males have been smaller than females, but with no apparent change in male modal length throughout the series, including 2006–07. The cumulative distributions of female rig appear to be more variable between fishing years and have shown a noticeable shift towards smaller fish in 2004–05 and 2005–06.
- The potential effect of the voluntary 4 nautical mile closure in the Canterbury Bight on mean size of rig caught was evaluated by comparing length-frequencies inside and outside the closed area. Seasonal effects appear to be stronger than inshore/offshore effects. Male rig show no size difference inside and outside of the line in either season, but autumn-winter females tend to be larger than spring-summer females. These observations do not support the contention that female rig tend to be larger inside of the 4 nm line during the fishing season.

Effects of Fishing

- 73% of the QMA 3 rig catch is taken in nearshore setnets, and the main environmental concern relates to possible mortalities of the endangered Hector's dolphins, which usually occur within 4nm of the shore. Hector's dolphin abundance in the coastal zone on the east coast South Island to 4 nautical miles offshore was calculated at 1880 individuals (CV=15.7%, lognormal 95% CI=1384–2554) during line transect surveys using a catamaran in the late 1990s (Dawson *et al*. 2004).
- In the 2005–06 fishing year coverage was undertaken in Southland (FMA 5) and the Nelson/Marlborough region (FMA 7) to monitor interactions with Hector's dolphins and seabirds. During the 2005–06 fishing year, 3 fur seals and 3 shags were recorded caught. Setnet fisheries were observed in the 2006/07 fishing year in Kaikoura (FMA 3), the west coast of the South Island (FMA 7) and in Southland (FMA 5). One dusky dolphin, one Hector's dolphin and two yellow-eyed penguins were caught.
- For the current observer year (2007–08), DOC CSP coverage of 258 inshore trawl observer days includes Statistical Areas 018, 022, 024, 025, 026 and 030 to monitor interactions with Hector's dolphins and seabirds (penguins, shearwaters, and shags). Two hundred fifty inshore trawl observer days are planned for 2008–09.
- Diving seabirds (penguins, shearwaters, shags and gannets) are also occasionally caught in setnets. The rig 3 fishery overlaps with distributions of the vulnerable yellow-eyed penguin and the white flippered penguin. These birds are particularly vulnerable to setnetting near breeding colonies. Darby and Dawson (2000) estimated that 72 yellow eyed penguins had been captured in commercial setnets between 1979 and 1997. There is insufficient information available to assess the fisheries induced mortality of white flippered penguin, Fiordland crested penguin or Stewart Island shag.
- Incidental mortality of Hector's dolphin from trawling appears to be relatively rare. One capture of a Hector's dolphin was reported by a fisherman in the red cod trawl fishery in QMA 3 in the 1997-1998 fishing year (Starr and Langley 2000). Three Hector's dolphins were self reported to be caught by a trawler in Cloudy Bay in 2006, just outside SPO 3.
- Fur seals are also occasionally caught in setnets. Fur seal interactions with trawl fisheries are relatively rare on the east coast of the South Island. However, these fisheries have too little observer coverage or too few observed captures to estimate total interactions.
- Increased TACCs under the AMP have not resulted in any increases or significant changes in trawl fishing areas or effort.
- The Working Group noted that there has been a 94% uptake of the new NCELR forms in the setnet fishery. These are designed to provide information on protected species interaction, although increased observer coverage rates will be required to validate reporting rates.

Conclusions

- Total landings of rig on the east coast of the South Island exceeding 1000 t per year over 1976 to 1986 likely caused a drop in stock abundance, reflected in declining CPUE at the time (Francis and Smith 1988), and resulting in TACC reductions when this stock was introduced into the QMS. CPUE is considered to provide a reasonable indication of abundance of this stock as long as a significant proportion of the total catch is taken in the target rig setnet fishery (Annala *et al*. 2001). Catches and CPUE gradually increased from the early 1990s to the late 1990s.
- Standardised CPUE analysis based on the target shark setnet fishery conducted since 2002 remained stable up to 1997–98, after which this index dropped to a lower level which has gradually risen since 2004–05. After correction for the change in conversion factors over time, two additional CPUE series based on the bottom trawl fishery show almost no change since 1989–90.
- The shift in the setnet fishery towards area 018 in the late 1990s and early 2000s, as well as the shift in catch away from area 022 and towards area 020 in 2001–02 and 2002–03, have probably reversed. The three year decline in landings that was discussed in the 2005 report has also since reversed, with total SPO 3 landings increasing in each year since 2003–04.
- The low stock size observed in the 1980s possibly recovered in response to reduced catches after this stock entered the QMS. Stock abundance appears to have stabilised.

AMP Review Checklist

The AMP checklist questions were not addressed, pending discussion of the requested SPO 3 stock assessment by the AMP Working Group. However, the Working Group made the following requests for additional analyses, and recommendations regarding the stock assessment:

- Additional tables of catch, effort and unstandardised CPUE by statistical area were requested, and supplied to the Working Group.
- Target species, particularly targeting on SPD, should be included as a categorical variable in CPUE standardisation, to evaluate the effect of changes in SPO reporting before and after establishment of the ACE system. Initial evaluations presented to the Working Group suggested that this did not have a major effect on standardisation.
- The historic SPO catch and effort series presented in Francis & Smith (1988) should be included in the planned SPO 3 assessment, at least as a sensitivity test. The various assumptions used to generate the historic catch series to be used in the assessment (such as under-reporting rates in certain years, extrapolation of catches from adjacent years) should also be investigated to determine whether alternate catch series should be used.

6. STATUS OF THE STOCKS

No estimates of current and reference biomass are available.

SPO 1

For SPO 1, reported landings have generally declined since 1991–92. This decline may be partially due to quota distribution problems and failure to correctly account for changes in conversion factors.

Patterns in relative abundance suggest that recent catch levels are probably sustainable in the short term and CPUE in the Manukau Harbour has increased to levels last estimated for the mid-1990s from the low point estimated for 2002–03. However, it is unknown whether the current TACC is sustainable, or whether the recent catch levels and the current TACC are at levels that will allow the stock to move towards a size that would support the maximum sustainable yield.

SPO 2

For SPO 2, reported landings have exceeded the TACC every year since 1991–92. This does not take into account the failure to correctly account for changes in conversion factors which would lead to actual catches being underestimated in recent years relative to earlier catches. In 1997, agreement

could not be reached on whether recent catch levels or the current TACC are sustainable. It is not known whether recent catches and the current TACC are at levels that will allow the stock to move towards a size that would support the maximum sustainable yield.

SPO 3

SPO 3 is being managed within an AMP (the TACC was increased for the second time to 600 t in 2000–01). Recent catch levels are thought to be sustainable in the short-term, but it is not known if the TACC is sustainable because catches have averaged about 1/3 below the TACC since 2000–01. It is not known if recent catches or the current TACC are at levels that will allow the stock to move towards a size that would support the maximum sustainable yield.

SPO 7

SPO 7 is being managed within a stakeholder lead fisheries plan, prior to that it was managed within an AMP. The AMP FAWG concluded in 2006 based on a stock assessment, that SPO 7 was below B_{MSY} and that neither current catches nor the TACC were sustainable. Based on this assessment, the TACC was reduced for 2006–07 to 221 t.

SPO 8

For SPO 8, landings increased until 1995–96 and then have declined steadily; the current catch was 176 t in 2006–07. Some of this decline could be due to a failure to account for changes in conversion factors. All recorded landings have been less than the TACC. Recent catch levels are probably sustainable in the short term. However, it is unknown whether the current TACC is sustainable, or whether the recent catch levels and the current TACC are at levels that will allow the stock to move towards a size that would support the maximum sustainable yield.

Yield estimates, TACCs and reported landings of rig are summarised in Table 6.

Table 6: Summary of yield estimates (t), TACCs (t) and reported landings (t) of rig for the most recent fishing year.

				2006–07	2006–07
Fishstocks		FMA	MCY	Actual TACC	Reported landings
SPO 1	Auckland (East) (West)	1 & 9	630	692	399
SPO 2	Central (East)	2	< 70	86	101
SPO 3	South-East (Coast) (Chatham), Southland and Sub-Antarctic	3, 4, 5 & 6	–	600	423
SPO 7	Challenger	7	–	350	262
SPO 8	Central (West)	8	270	310	176
SPO 10	Kermadec	10	–	10	0
Total				2048	1362

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