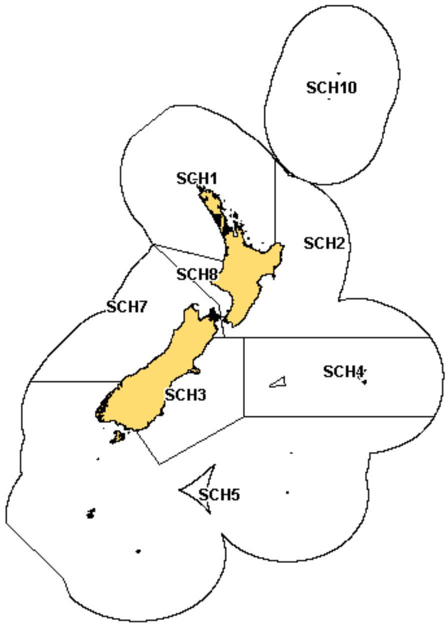
SCHOOL SHARK (SCH)

(*Galeorhinus galeus*)
Tupere, Tope, Makohuarau



1. FISHERY SUMMARY

1.1 Commercial fisheries

This moderate-sized shark has supported a variety of fisheries around New Zealand from the early 1940s onwards. Landings rose steeply from the late 1970s until 1983 (Table 1), with the intensification of setnetting targeting this and other species, and a general decline in availability of other, previously more desirable, coastal species. However, because of the earlier discarding and under-reporting, this recorded rise in landings does not reflect an equal rise in catches. After a small decline in 1984–85, catches decreased by about 50% from 1986 onwards because of reduced quotas within the QMS (Table 2). From 1987–88 to 1991–92 total reported landings were around 2200–2500 t. In 1995–96 total landings increased markedly to 3387 t and the total TACC (3107 t) was exceeded for the first time. Landings have remained around the TACC level since 1995–96. TACCs for SCH 3, 5, 7 & 8 were increased by between 5% (SCH 5) and 20% (the remainder) under AMP management in October 2004. From the 1st October 2007 the TACC for SCH 1 was increased to 689 t, at that time a TAC was set for the first time at 893 t with 102 t, 68 t and 34 t being allocated to customary, recreational and other sources of motility respectively.

Table 1: Reported domestic landings (t) of school shark from 1948 to 1983.

Year	Landings	Year	Landings	Year	Landings	Year	Landings
1948	75	1957	301	1966	316	1975	518
1949	124	1958	323	1967	376	1976	914
1950	147	1959	304	1968	360	1977	1 231
1951	157	1960	308	1969	390	1978	161
1952	179	1961	362	1970	450	1979	481
1953	142	1962	354	1971	597	1980	1 788
1954	185	1963	380	1972	335	1981	2 716
1955	180	1964	342	1973	400	1982	2 965
1956	164	1965	359	1974	459	1983	3 918

Source: MAF data.

During the period of high landings in the mid 1980s setnetting was the main fishing method, providing about half the total catch, with lining accounting for one-third of the catch, and trawling the remainder. There were large regional variations.
Earlier data on landings by method are not available. Data since the introduction of CELRs in 1988–89 are generally incomplete, biased, and the catch-by-method of bycatch species (including school shark in many fisheries) is not fully recorded – however, these data have been analysed to provide a characterisation of the school shark fisheries (Paul & Saunders 2000).

School shark are also caught by the foreign licensed fleet of tuna longliners fishing offshore in the EEZ to well beyond the shelf edge and above 4000 m bottom depths. The catch is probably small but cannot be quantified.

Table 2: Reported landings (t) of school shark by Fishstock from 1983–84 to 2005–07 and actual TACCs (t) from 1986–87 to 2006–07.

Fishstock	SCH 1		SCH 2		SCH 3		SCH 4		SCH 5	
FMA (s)	1 & 9		2		3		4		5 & 6	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1983–84*	1 087	–	298	–	630	–	8	–	792	–
1984–85*	861	–	237	–	505	–	12	–	995	–
1985–86*	787	–	214	–	370	–	23	–	647	–
1986–87†	418	560	137	160	283	270	19	200	382	610
1987–88†	530	604	123	168	320	289	22	200	529	613
1988–89†	483	624	134	188	222	294	25	200	494	615
1989–90†	585	652	154	197	272	305	27	235	450	635
1990–91†	559	664	139	198	227	318	21	239	480	649
1991–92†	596	664	161	198	264	318	34	239	612	686
1992–93†	820	664	202	199	220	320	38	239	593	686
1993–94†	658	667	156	199	202	322	41	239	624	686
1994–95†	658	668	159	199	237	322	86	239	656	694
1995–96†	804	668	212	199	296	322	229	239	690	694
1996–97†	793	668	228	199	290	322	179	239	662	694
1997–98†	764	668	214	199	270	322	127	239	623	694
1998–99†	783	668	275	199	331	322	100	239	714	694
1999–00†	820	668	250	199	341	322	97	239	706	694
2000–01†	799	668	178	199	364	322	100	239	724	694
2001–02†	691	668	208	199	324	322	93	239	673	708
2002–03†	689	668	225	199	410	322	130	239	746	708
2003–04†	758	668	187	199	323	322	149	239	727	708
2004–05†	694	668	201	199	424	387	206	239	743	743
2005–06†	634	668	177	199	325	387	183	239	712	743
2006–07†	661	668	200	199	376	387	88	239	738	743

Fishstock	SCH 7		SCH 8		SCH 7			
FMA (s)	7		8		10		Total	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings§	TACC
1983–84*	1 039	–	694	–	0	–	4 776	–
1984–85*	1 030	–	698	–	0	–	4 501	–
1985–86*	851	–	652	–	0	–	3 717	–
1986–87†	454	470	229	310	0	10	1 946	2 590
1987–88†	515	500	374	345	0	10	2 367	2 729
1988–89†	532	522	419	433	0	10	2 309	2 886
1989–90†	516	524	371	438	0	10	2 377	2 996
1990–91†	420	531	369	441	0	10	2 215	3 050
1991–92†	431	531	409	441	0	10	2 508	3 086
1992–93†	482	531	484	441	0	10	2 839	3 089
1993–94†	473	531	448	441	0	10	2 603	3 093
1994–95†	370	534	417	441	0	10	2 583	3 105
1995–96†	635	534	521	441	0	10	3 387	3 107
1995–96†	542	534	459	441	0	10	3 153	3 107
1997–98†	471	534	447	441	0	10	2 917	3 107
1998–99†	681	534	533	441	0	10	3 421	3 107
1999–00†	639	534	469	441	0	10	3 324	3 107
2000–01†	576	534	453	441	0	10	3 193	3 107
2001–02†	501	534	449	441	0	10	2 913	3 121
2002–03†	512	534	448	441	0	10	3 161	3 121
2003–04†	574	534	405	441	0	10	3 124	3 121
2004–05†	546	641	554	529	0	10	3 368	3 416
2005–06†	568	641	503	529	0	10	3 102	3 416
2006–07†	582	641	533	529	0	10	3 179	3 416

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

1.2 Recreational fisheries

Although school shark is a listed gamefish and is regularly caught by recreational fishers, it is not considered to be a particularly desirable target species at the present time. Recreational catch records have been obtained from diary surveys undertaken in 1991–94, 1996 and 1999–00 (Tables 3 and 4). The most recent nationwide recreational survey was undertaken in 2001, but the results are still under review and are not currently available.

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-estimate, 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.

Recreational harvest estimates obtained for school shark stocks during the 1999–00 survey ranged from < 1% to 14% of the commercial catch in the respective QMAs over the same period. Disproportionately low numbers of tag returns from recreational fishers confirm that they are a minor source of school shark fishing mortality.

Table 3: Estimated number and weight of school sharks harvested by recreational fishers relative to Fishstock and survey. Surveys were carried out in different years in the Ministry of Fisheries regions: South in 1991–92, Central in 1992–93 and North in 1993–94 (Teirney *et al.* 1997).

		Total		
Fishstock	Survey	Number	CV (%)	Survey harvest (t)
SCH 1	North	17 000	24	10–170
SCH 1	Central	1 000	–	0–10
SCH 2	Central	13 000	27	25–45
SCH 3	South	6 000	33	15–35
SCH 5	South	1 000	–	0–10
SCH 7	Central	9 000	84	10–35
SCH 7	South	3 000	–	5–15
SCH 8	Central	7 000	45	10–30

Table 4: Estimates of annual number and weight of school shark harvested by recreational fishers from national diary surveys in 1996 (Bradford 1998) and Dec1999-Nov 2000 (Boyd & Reilly 2005). The mean weights used to convert numbers to catch weight are considered the best available estimates. Estimated harvest is also presented as a range to reflect the uncertainty in the point estimates.

Fishstock	Number caught	CV (%)	Estimated harvest range (t)	Point estimate (t)
1996				
SCH 1	23 000	17	35–55	46
SCH 2	5 000	–	–	–
SCH 3	3 000	–	–	–
SCH 5	1 000	–	–	–
SCH 7	8 000	24	5–25	16
SCH 8	11 000	22	15–25	21
1999–00				
SCH 1	27 000	42	38-93	66
SCH 2	7 000	30	13-24	18
SCH 3	19 000	46	26-70	48
SCH 5	3 000	66	2-11	7
SCH 7	23 000	56	26-91	58
SCH 8	3 000	55	4-13	8

1.3 Customary non-commercial fisheries
Maori fishers made extensive use of school shark in pre-European times for food, oil, and skin. There is no quantitative information on the current level of customary non-commercial take.

1.4 Illegal catch
There is no quantifiable information on the level of illegal catch. There is an unknown amount of unreported offshore trawl and pelagic longline catch of school shark, either landed (under another name, or in "mixed") or discarded.

1.5 Other sources of mortality
There is an unknown discarded bycatch of juvenile, mainly first-year, school shark taken in harbour and bay setnets. Quantitative information is not available on the level of other sources of mortality.

2. BIOLOGY

School sharks are distributed across the shelf, generally being inshore in summer and offshore in winter. They extend in smaller numbers near the seafloor down the upper continental slope, to at least 600 m. The capture of school sharks by tuna longliners shows that their distribution extends well offshore, up to 180 nm off the South Island, and 400 nm off northern New Zealand towards the Kermadec Islands. They feed predominantly on small fish and cephalopods (octopus and squid).

Growth rates have not been estimated for New Zealand fish, but in Australia and South America school sharks are slow growing and long-lived (Grant *et al.*. 1979, Olsen 1984, Peres & Vooren 1991). They are difficult to age by conventional methods, but up to 45 vertebral rings can be counted. Growth is fastest for the first few years, slows appreciably between 5 and 15 years, and is negligible at older ages, particularly after 20. Results from an Australian long-term tag recovery suggest a maximum age of at least 50 years. Age-at-maturity has been estimated at 12–17 years for males and 13 to 15 years for females (Francis & Mulligan 1998). The size range of commercially caught maturing and adult school shark is 90–170 cm total length (TL), with a broad mode at 110–130 cm TL, which varies with area, season and depth.

Breeding is not annual; it has generally been assumed to be biennial, but recent work on a Brazilian stock suggests that females have a 3-year cycle (Peres & Vooren 1991). Fecundity (pup number) increases from 5–10 in small females to over 40 in the largest. Mating is believed to occur in deep water, probably in winter. Release of pups occurs during spring and early summer (November-January), apparently earlier in the north of the country than in the south. Nursery grounds include harbours, shallow bays and sheltered coasts. The pups remain in the shallow nursery grounds during their first one or two years and subsequently disperse across the shelf. The geographic location of the most important pupping and nursery grounds in New Zealand is not known.

The combination of late maturity, slow growth, and low fecundity gives a low overall productivity. In Australia, M has been estimated as 0.1.

New Zealand tagging studies have shown that school shark may move considerable distances, including trans-Tasman migrations (for details see the 1995 Plenary Report).

Biological parameters relevant to stock assessment are shown in Table 5.

Table 5: Estimates of biological parameters for school shark.

Fishstock	Estimate		Source
1. Weight = a (length)^b (Weight in g, length in cm fork length)			
	Both sexes combined		
	a	b	
SCH 1	0.0003	3.58	McGregor (unpub.)
SCH 3	0.0035	3.08	McGregor (unpub.)
SCH 5	0.0181	2.72	McGregor (unpub.)
SCH 5	0.0068	2.94	Hurst *et al*. (1990)
SCH 7	0.0061	2.94	Blackwell (unpub.)
SCH 8	0.0104	2.84	Blackwell (unpub.)
2. Estimate of *M* for Australia			
	0.1		Grant *et al*. (1979), Olsen (1984)

3. STOCKS AND AREAS

Although tagged fish movements suggest that there is a single biological stock, there are no definitive data on which to base changes to the stock boundaries used in previous assessment documents. The majority of recaptures have been within the same QMA. Stock boundaries are based on these QMAs, and are essentially in place to prevent localised depletion.

4. STOCK ASSESSMENT

There are no new data which would alter the yield estimates given in the 1996 Plenary Report. The yield estimates are based on commercial landings data.

4.1 Estimates of fishery parameters and abundance

Standardisation of bycatch (trawl, setnet and line, Ayers *et al*. 2004) and target (setnet, see section on AMP analysis) school shark CPUE produced indices that were flat or declining around the North Island and flat or increasing around the South Island. Although abundance of South Island fish stocks appears to have increased, this could have been to due to southward displacement of North Island fish.

In 2008, CPUE was calculated for several target and bycatch fisheries in SCH 1 and 2 using data to the end of the 2005-06 fishing year (Manning, *in prep*). While the goal was to identify a separate target and bycatch CPUE series for SCH 1W, SCH 1E, and SCH 2, no acceptable target CPUE series were found. The three bycatch series were for the snapper longline fishery in the eastern part of SCH 1 (SCH E: BLL-SNA), the mixed trawl fishery in the western part of SCH 1 (SCH 1W: BT-MIX), and the tarakihi target trawl fishery in SCH 2 (SCH 2: BT-TAR). These are provided in Figure 1. Aside from the first data point in the SCH 2 series, there is little difference between the start and end points in any of the CPUE series, suggesting no large changes in abundance over the period.

In interpreting these indices the NINSWG noted that there was no catch composition data available for school sharks taken in any of the fisheries for which CPUE indices were developed. They considered that while this information was always needed for any CPUE series, it was particularly important for species such as school sharks for which changes in the abundance of large females will have important consequences for sustainability. Obtaining this information should be a priority if these series are to be considered as longer term approaches to monitoring abundance.

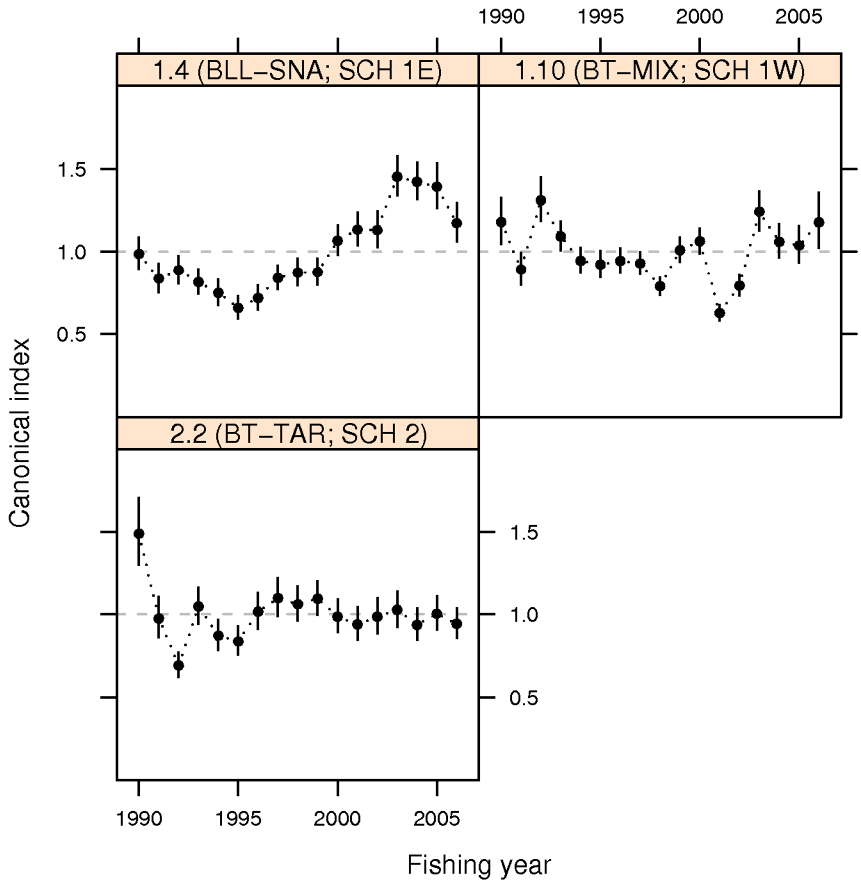


Figure 1: Canonical CPUE indices with 95% confidence intervals for the two SCH 1 CPUE series (top) and one SCH 2 CPUE series (bottom).

4.2 Biomass estimates

Estimates of current and reference biomass are not available.

4.3 Estimation of Maximum Constant Yield (MCY)

(i) North and South Islands (all areas except SCH 4 and SCH 5)

MCY was estimated using the equation, MCY = cY_{AV} (method 4). Y_{AV} was the average of reported domestic catches from 1955 to 1975 (360 t). This represents a relatively stable period of landings and (to a lesser extent) effort, when the fishery was probably largely under-developed. The species was landed by both line and trawl. The proportion of the fish taken as bycatch by the latter method being landed probably increased with time as its value increased. The fishery increased in size, and effort by lines and nets increased substantially, during the period from 1980 to 1983.

The value of c was set at 0.9, based on an Australian estimate of $M = 0.1$, and because variability in year class strength is probably low because of low fecundity.

MCY = 0.9 * 360 t = 324 t (rounded to 325 t)

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

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

(ii) Chatham Rise (SCH 4)

Because the fishery has been largely unexploited, MCY cannot be estimated.

(iii) Southland + Sub-Antarctic area (SCH 5)

MCY was not estimated because the pattern of exploitation on the stock is not known and catches have been constrained by the TACC.

4.4 Estimation of Current Annual Yield (CAY)

Current biomass cannot be estimated, so CAY cannot be determined.
Yield estimates are summarised in Table 6.

Table 6: Yield estimates (t).

Parameter	Fishstock	Estimate
MCY	All except SCH 4 and 5	325
CAY	All	Cannot be determined

4.5 Other yield estimates and stock assessment results

No information is available.

4.6 Other factors

In Australia, recruitment overfishing has occurred to such an extent that the stock is considered seriously threatened and harsh management measures are being imposed. The Australian modelling work indicates that the cumulative removal of the largest, highly fecund females has produced a situation where, although the faster-growing young adults are still being caught in moderate (but declining) numbers, a stock collapse is very probable. A long period (decades) at a very low fishing level seems necessary for stock rebuilding.

The most important conclusion from this for New Zealand is that fishing pressure on large mature females should be minimised to maintain the productivity of this species. For the current CPUE series for SCH 1 and 2 there is no information on the sizes and sex composition of the catch so it is nt known if these series are monitoring the relative abundance of mature females.

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 Adaptive Management Programme 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.

SCH 3

The SCH 3 TACC was increased from 322 t to 387 t under an AMP on 1 October 2004.

Mid-Term Review of SCH 3 AMP in 2007

In 2007 the AMP FAWG reviewed the performance of the logbook monitoring programme (Starr *et al*. 2007a). The Working Group noted:

Fishery Characterisation

- SCH 3 TACC was raised from 322 t to 387 t on 1 Oct 2004 under the AMP. An additional 115 t for recreational and customary catches brought the total TAC to 502 t.

- SCH 3 catches were below the TACC from 1987–88 to 1997–98, and exceeded that TACC slightly from 1998–99 to 2002–03, and in the first year of the increased TACC in 2004–05. Catches have since dropped to the 2003–04 level.
- SCH conversion factors have not changed since 1993–94, when DRE and HGU factors changed slightly from 2 to 1.95 and 1.85 respectively. Adjustment of past estimated catches to use recent conversion factors has therefore had little effect on catch estimates.
- About 56% of the school shark catch in area 3 is taken in setnets, and 37% in bottom trawl, with 6% catches by bottom longline since ~1994–95.
- 50% of the SCH 3 catch is taken in the Pegasus Bay – Canterbury Bight area, although the majority of the setnet catch is taken off Kaikoura or Timaru, each accounting for ~1–3 of the setnet catch. The bottom trawl catch is all taken in the Pegasus Bay and Canterbury Bight area, fairly evenly distributed across the year.
- There does not appear to be any trend in distribution of catch or effort over time, and these fisheries have not changed substantially.
- The setnet fishery is somewhat seasonal, with setnet catches being made mainly from October - February. The trawl fishery is less seasonal, but with lower catches over June - September.
- Setnet SCH catches are mainly taken in targeted SCH and SPO setnet fisheries. Trawl catches are made in red cod (northern area), barracouta (Pegasus Bay) flatfish and tarakihi targeted (southern area) fisheries.
- The main change observed recently in this fishery has been the recent reduction of setnet effort and catch, particularly off Kaikoura, possibly as a result of withdrawal of some fishermen from this area.
- School shark are generally taken in <150 m depth in most fisheries, although they are caught at depths of 400 m or more in the hoki trawl and ling and bluenose longline fisheries.

CPUE Analysis

- A single shark-targeted (elephant fish, school shark, rig or spiny dogfish) setnet fishery is considered to provide the CPUE index most representative of school shark abundance.
- CPUE for this fishery definition were standardised using a lognormal model based on non-zero catches. In additional, a binomial model was used to investigate the effect of changing proportion of non-zero catches.
- Unstandardised CPUE shows a 33% drop from 1989–90 to 1992–93, followed by a steady increase thereafter. Lognormal standardisation flattens this trend substantially, resulting in a flat trend since 1992–93. This is primarily a result of shifts in targeting behaviour among vessels, which have caused higher SCH catch rates in recent years.
- The model chooses vessel as the most important explanatory variable, and does not accept statistical area. However, vessels are relatively area-specific in this fishery, so there is confounding between vessel and area effects, such that vessel may act as a proxy for area.
- These targeting shifts also resulted in a steady increase in proportion non-zero catches, particularly for 1990–91 to a peak in 2000–01. The binomial model therefore provides a fairly strong signal, resulting in the combined model again showing a slightly increasing (more optimistic) trend in recent years. However, the binomial model does not substantially alter the trend and the combined model closely resembles the lognormal model. As with other fisheries assessed under the AMP the binomial model seems to reflect reporting trends rather than biomass trends.

Logbook Programme

- The logbook programme was introduced in 1994–95 to cover rig, school shark and elephantfish, although primarily designed to monitor rig catches.
- Coverage levels (for SCH catch) have varied between ~6% and ~16% (excluding 1994–95 and 1997–98, when coverage was very low), but participation and coverage have recently declined from a peak of 16.6% in 2001–02 to 4.4% in 2005–06.

- The number of participating vessels has declined from 11 to12 for 1999–02 to 9 vessels in 2002–03 and 7 vessels since 2004–05. The number of sharks sampled has declined from >1000 to 290 in the same period.
- Coverage by area has not been particularly good, with the Canterbury Bight being over-sampled and the other areas under-sampled. Seasonal coverage also focuses more on the first half of the season, dropping off thereafter.
- Sex ratios have remained at approximately 50:50 throughout the fishery. Length-frequency distribution of male SCH has not changed significantly since 1995. However, a mode of large female SCH evident from 1995 to ~2002–03 has since disappeared from catches.
- The working group noted that fairly constant availability of large females was mainly seen in the Otago area, and that the loss of the large female mode needed to be investigated further to ascertain whether was just an area effect (reduction of fishing effort off Otago), or whether it did represent a decline in abundance of large females. There are also anecdotal reports of the industry releasing larger female sharks in this fishery.
- Analysis of male maturity of sampled fish indicates a size-at-50% maturity of ~110 to 120 cm, which approximates current biological understanding, and is the same as was found for SCH 5.

Additional Analyses

- The working group noted that there was now a long time-series of logbook data, which might provide better effort data and finer spatial resolution that the CELR data upon which most analyses had been based. Logbook data should be evaluated to see whether they can be used for CPUE analysis.
- In particular, logbook data should be used to see whether there have been any area effects that might explain the apparently stable overall CPUE trend, while large female abundance appears to be declining.
- The Working Group also noted last year's recommendation that logbook data should be collected from the trawl fishery (e.g., the BAR targeting fishery).

Effects of Fishing

Setnet Fisheries

- 50% of the school shark catch is taken in near-shore setnets, and the main environmental concern relates to possible mortalities of the endangered Hector's dolphins, which usually occur within 4 nm of the shore. Diving seabirds (penguins, shearwaters, shags and gannets) are also occasionally caught in setnets, of which the vulnerable yellow-eyed penguin is of most concern.
- The 1997–98 Department of Conservation (DOC) Conservation Services Programme (CSP) observed 8 setnet entanglements of Hector's dolphins resulting in six mortalities and the dolphin strike rate was estimated to be ~3% of sets observed at the time.
- In response, a maximum allowable fishing mortality of 3 dolphins – year was set for the Canterbury setnet area (Waiau to Waitaki Rivers) from 2002 onwards. Setnet users have also agreed to the voluntary use of pingers on nets, and use is increasing as suitable pingers become available on the market.
- Setnet fishing has been specifically prohibited between 1 November to the end of February annually, and setnet fishing may not be conducted at night during the rest of the year, in the Banks Peninsula Marine Mammal Sanctuary.
- Setnet fishers have also adopted a Code of Practice that includes staying away from penguin colonies, setting over 20 m deep, avoid fishing in murky water <30 m deep and not setting when Hectors dolphins or yellow-eyed penguins are active in the vicinity. South East Finfish Management Ltd has also implemented additional voluntary area closures.

Trawl Fisheries

- Increased TACCs under the AMP have not resulted in any increases or significant changes in SCH trawl fishing areas or effort. The ECSI inshore trawl areas have been trawled for decades, and benthic impacts of these trawlers has not increased as a result of the AMP.
- From 12 January 2006, trawlers over 28 m length are required to deploy suitable bird scaring devices to prevent warp strikes during trawling.
- One Hector's dolphin capture was reported in the red cod trawl fishery in 1997–98, but none have been reported since, and none were observed in 187 observed trawls in 1999–00. Trawlers have been advised not to haul when dolphins are active in the vicinity, and to keep sonar on when hauling.

Observer Programs

- Although a substantial number of observer days have been budgeted for under the CSP, actual coverage levels are poor, achieving only 17% of planned setnet coverage and 6% of planned trawl coverage in 2000–01. There are difficulties in deploying observers on small vessels, but industry also reports poor co-ordination between the CSP and fishermen to plan deployments.
- In response, the industry is trialling electronic (video) at-sea monitoring systems for observation and recording of incidental bycatches and marine mammal interactions.
- The Working Group expressed concern at the apparent lack of clearly documented objectives to underpin the incidental mortality observer work undertaken in terms of the CSP observer days. Clear objectives and associated quantitative performance measures needed to be agreed upon.

Conclusions

- After the initial sharp decline in 1988–89, standardised annual abundance indices for SCH 3 appear to have been stable, and at a slightly higher level since 1999–00 than the period 1992–93 – 1998–99. Unstandardised CPUE and the proportion of non-zero SCH catches have been increasing gradually since the initial drop, apparently as result of increased targeting for school shark.
- Average catches over the past two years were at the level of the revised TACC, and it appears that these catch levels are sustainable in the short-term. However, it is not known whether these catch levels are sustainable in the long-term, or will allow the stock to move towards a size that will support maximum sustainable yield.

SCH 5

The SCH 5 TACC was increased from 708 t to 743 t under an AMP on 1 October 2004.

Mid-term Review of SCH 5 AMP in 2007

In 2007 the AMP FAWG reviewed the performance of the logbook monitoring programme (Starr *et al*, 2007b) after one year of the current 5-year term. The Working Group noted:

Fishery Characterisation

- The SCH 5 TACC was raised by 5% from 708 t – 743 t on 1 October 2004. An additional 51 t for recreational and customary catches brought the total TAC to 794 t.
- Following the initial 50% decline in catch from 1984–85 to 1987–88, catches remained somewhat below the TACC until 1997–98, and have at about TACC level since then.
- Over the period 1995–96 till 1998–99, reported estimated catches on CELR forms were substantially below landed catches. SCH conversion factors have not changed since 1993–94, when DRE and HGU factors changed slightly from 2 to 1.95 and 1.85 respectively. However, adjustment from the old GUT conversion factor and substantial MEA (fishmeal) reporting increased catch estimates by 30% in 1990–91.

- 86% of the SCH 5 catch is taken in the shark targeted setnet fishery, and only small quantities as bycatches in the bottom trawl (7%) and bottom longline (5%) fisheries, with bottom trawl and longline catch proportion increasing slightly since 1999–00
- About 50% of the SCH 5 catch is taken in statistical areas 25 (eastern Stewart Island) and 27 (eastern Foveaux Strait), and a third of the catch is taken from statistical area 30 (western Foveaux Strait).
- Setnet catches are mainly made between the months of October to April, across the three main fishing areas. Bottom trawl catches are evenly distributed across the year, mainly in the Western Foveaux Strait.
- Setnet SCH catches are almost entirely made in the SCH targeted setnet fishery, with a small catch in the rig targeted fishery. Trawl bycatches come primarily from the stargazer fishery (all areas), with lesser contributions from the flatfish (inshore areas 25 and 30) and squid, ling and hoki fisheries (areas 27 and 29). Bottom longline bycatches of school shark are evenly distributed across the targeted SCH fishery and the hapuka and ling targeted longlines, mostly in the western-most statistical areas.
- School shark are generally taken in <150 m depth in most fisheries, although they are caught at depths of 400 m or more in the hoki trawl and ling and bluenose longline fisheries.

CPUE Analysis

- A single shark-targeted (elephant fish, school shark, rig or spiny dogfish) setnet fishery is considered to provide the CPUE index most representative of school shark abundance.
- CPUE for this fishery definition were standardised using a lognormal model based on non-zero catches. In additional, a binomial model was used to investigate the effect of changing proportion of non-zero catches.
- Unstandardised CPUE shows a ~50% decline from the peak in 1991–92 to 1994–95, and fluctuates around a fairly stable average thereafter. Lognormal standardisation has relatively little effect on this trend, reducing the magnitude of the original CPUE decline to about 25% of original to the series average from 1994–95 to 2000–01. The standardised index then declines by a further 20% - 25% in 2001–02 to a new level which has been maintained.
- There is little pattern in the year effects in the binomial model, and the combined model is very similar to the log-normal model.
- Uncertainty around this standardisation is fairly high, and there were substantial changes in the vessels participating mid-way through the fishery. Diagnostics also indicate some problems with the model fit, and the log transformation used may not be appropriate. Few vessels (4 - 9) remained in the core vessel selection for this analysis, and this makes the analysis susceptible to other factors (e.g., economic) that affect vessel performance.
- Factors such as net-length, season, target and area show strong year effects in the model, more so than for the SCH 3 analysis. Many of these effects seem to relate to the changes in the targeted setnet SCH fishery, and it may be appropriate to attempt a separate analysis for the targeted setnet fishery only.
- The Working Group concluded that there are many problems with this CPUE standardisation, and that it is possible that the index is tracking factors other than stock abundance. It is not clear that this standardised CPUE provides a representative index of SCH 5 abundance.

Logbook Programme

- The logbook programme was introduced in 1994–95 to cover rig, school shark and elephantfish, although initially primarily designed to monitor rig catches.
- From an introductory high of 52% in 1995–96, coverage levels (for SCH catch) declined to 7% in 1998–99, increased again to 45% in 2001–02 and have since declined steadily to 8% in2005–05.
- The number of participating vessels has declined from 5 in 1995–96 to only 1 since 2004–05. The number of sharks sampled declined from 1092 in 1995–96 to only 110 in 1998–99, but

has fluctuated between 300 and 650 per year since then, with 490 sharks being sampled in 2005–06.

- Logbook coverage of this small fishery has been fairly well spread across areas and seasons, although seasonal coverage has been poorer in some years.
- There has been no difference between mean length of males and females caught, and no changes in mean lengths over time. In contrast with the SCH 3 fishery, there appears to have been no decline in the proportion of larger females caught in this fishery.
- Analysis of male maturity of sampled fish indicates a size-at-50% maturity of ~110 to 120 cm, which approximates current biological understanding, and is the same as found for SCH 3.

Effects of Fishing

- 86% of the QMA 5 school shark catch is taken in near-shore setnets, and the main environmental concern relates to possible mortalities of the endangered Hector's dolphins, which usually occur within 4 nm of the shore. Of particular concern is that a genetically distinct population of Hector's dolphins occurs around Te Waewae Bay, separate from the ECSI population. Initial surveys estimated this population to consist of only ~89 animals, but recent work suggests the population may number from 300 - 650 animals.
- One beach-cast dolphin mortality at Orepuki Beach on the eastern side of Te Waewae Bay has been attributed to setnet entanglement. No dolphin mortalities have been observed or recorded in the trawl fishery in this area
- Diving seabirds (penguins, shearwaters, shags and gannets) are also occasionally caught in setnets, of which the vulnerable yellow-eyed penguin is of most concern. Distribution of the nationally endangered Fiordland crested penguin and the vulnerable endemic Stewart Island shag also extends to this area, and they are vulnerable to setnetting near breeding colonies.
- Setnet fisheries are likely to have negligible impact on seabed physical characteristics and benthic communities, particularly in the turbulent near-shore zone in which they are typically used.
- The small TACC increase under the AMP is unlikely to result in any increase or spread in trawling effort. The South Island stargazer and flatfish trawl areas have been trawled for decades, and benthic impacts of these trawlers has not increased as a result of the AMP.
- The Working Group noted the need to quote references when referring to published rates of interaction between vulnerable species and fishing activities, and the importance of quoting actual data (observer reports or recorded interactions) to substantiate evaluations of the effects of fishing. Reports to the AMP Working Group should also emphasise any incremental effects that may have resulted from the AMP TACC increases.

Conclusions

- Standardised CPUE for this fishery suggests declines for 1991–92 to 1994–95, and again from 2000–01 to 2001–02. Standardisation did not change the unstandardised index much, and the index remains highly variable, with high uncertainty and strong year effects by vessel, area and net length. It appears that the index may be responding to factors other than abundance, such as economic factors that affect the individual performance of the few core vessels in this fishery.
- Coupled with the sustained catches and the absence of evidence of any decline in mean size or proportion of large sharks in the catch, this suggest that the index may be indicative of a small and relatively stable fishery operating on a fairly large stock, with fluctuations resulting mainly from short-term changes in targeting or availability to specific vessels.
- Sustained catches at TACC levels for the past decade suggest that these catch levels are sustainable, at least in the short to medium term.

SCH 7

The SCH 7 TACC was increased from 534 t to 641 t under an AMP on 1 October 2004.

Two year Review of SCH 7 AMP in 2007

In 2007 the AMP FAWG reviewed the performance of the AMP that was presented by Starr *et al*. (2007c). The Working Group noted:

Fishery Characterisation

- There are many conversion factor issues that need to be assessed by the Methods Working Group. The conversion factors that have changed over time should be tabulated and the reasons for those changes need to be documented.
- The catch of this fishery was spread almost evenly between the bottom trawl, bottom longline and setnet fishing methods.
- The bottom trawl fishery is distributed across a wide range of areas and across time. This fishery occurs year round. The main target species for this fishery were BAR, TAR, FLA, HOK and RCO.
- The bottom longline fishery occurs mostly in the eastern Cook Strait but there is also a lot of effort along the southern area. Effort is low in Cook Strait but catch is high. This fishery occurs year round but with slightly more effort in the summer months. SCH is the main target species.
- The setnet fishery increases in areas 34, 35 and 36 after 1999–00. This fishery occurs year round but with slightly more effort in the late summer months. SCH and SPO are the main target species.

CPUE Analysis

- The CPUE analysis was based on setnet data only. The trawl data are not used because they are thought to at best represent a recruitment index because larger fish can avoid the net.
- The data included target catch of SPO, SPD, ELE and SCH.
- The SCH catch percentage is fairly consistent despite fluctuations in targeting, catch rate, reporting rate and declining percentage of zero catches.
- The standardisation of the CPUE data created peaks in catch rates during periods where there are none in the unstandardised series. In recent years, the standardised series lies below the unstandardised series, adjusting for changes in target behaviour, statistical area fished and the amount of net used.
- A further analysis was performed to test for effects resulting from an increasing trend in the mean number of fishing days represented in each trip stratum (the lowest level of data aggregation in the CPUE analysis). This test was preformed by summarising the data on a daily basis by trip rather than at the trip-stratum level (where days within a trip are summed across method of capture, target species and statistical area). This analysis indicated that, for this data set, the data summarisation had little effect on the estimated CPUE series.
- It was recommended to overlay the CPUE trends for all SCH stocks, as there are some inverse relationships e.g., in SCH 7&8.
- It was noted that the data preparation procedure may produce anomalous results as it drops trips where a vessel fished in straddling statistical areas and which reported landings to both valid Fishstocks. This procedure resulted in the apparent contradiction of some vessels which were included in the analysis but which reported little or no catch of SCH 7. There is little that can be done about this problem as it is a failure in the current reporting system which does not distinguish properly between Fishstocks when fishing in straddling statistical areas.

Logbook Programme

- The programme was re-assessed and is only reliable from 2004. Prior to that the data were not effectively collected.
- Not enough samples of biological data have been collected from the setnet fishery to make any meaningful deductions.

- Bottom trawl fishery is specifically for the inshore component of the fishery and there are a high number of vessels participating.
- Good sampling and good biological data collection.
- Bottom longline fishery has good coverage overall but is lower at WCSI and in area 38, but has poor coverage in latter part of the year.

Effects of Fishing

- The SCH 7 TACC was increased by 20% in 2004, but was still under caught by 11%.
- The assessment of the impacts on Hector's dolphins suggest a low interaction rate however, there were 14 mortalities reported in recreational nets since 2000 and zero in commercial nets. This seems unlikely.
- Reporting is required in instances where there is a code of practice so that details of the level of compliance to the code of practice (CoP) can be assessed. Data quality should also be reported so that the CoP assessment can be evaluated.
- In 25 observer days two spotted shags and one pied shag were caught.

Conclusions

- The Working Group accepted the SCH 7 CPUE analysis as being representative of the fishery.
- The Working Group noted that the problem of ambiguous landings likely makes the binomial part of the analysis suspect. The Working Group recommended that consideration be given to performing a joint analysis for SCH 7 and SCH 8 for the full term review so that more trips can be included in the analysis.

SCH 8

The SCH 8 TACC was increased from 441 t to 529 t under an AMP on 1 October 2004.

Two Year Review of SCH 8 AMP in 2007

In 2007 the AMP FAWG reviewed the performance of the two year term of the AMP presented by Starr *et al*. (2007d). The Working Group noted:

Fishery Characterisation

- 60% of the catch is landed by setnet with 20 and 10% coming from the bottom longline and bottom trawl respectively.
- Most of the catch is from areas 39, 40 and 41. There is some suggestion that catch has increased in area 41 but there has been no associated effort increase.
- The catch occurs year round with a slight drop in the winter months.
- Most of the catch is made by a setnet fishery which is targeting SCH and SPO. The bottom longline fishery is mainly targeted at SCH although some catches are made in the target HPB and BNS bottom longline fishery. The relatively small trawl fishery taking SCH 8 is mainly targeted at GUR, TRE and TAR.

CPUE Analysis

- The CPUE analysis was based on setnet data only. Trawl data are not used because they are thought to represent a recruitment index because larger fish can avoid the net.
- The Working Group recommended that future analyses should drop target species as an explanatory variable in the analysis.
- The series calculated for this Fishstock appears to be inversely related to the SCH 7 series, suggesting that school shark may be moving between these two QMAs. The WG suggested that a combined SCH 7 and SCH 8 analysis could be considered for the full term review.

- The standardisation procedure did not alter the unstandardised CPUE trend very much, except in the most recent two years, where the effect was to flatten a strong increasing trend, possibly to adjust for the effect of increasing length of net set.
- A further analysis was performed to test for effects resulting from an increasing trend in the mean number of fishing days represented in each trip stratum (the lowest level of data aggregation in the CPUE analysis). This test was preformed by summarising the data on a daily basis by trip rather than at the trip-stratum level (where days within a trip are summed across method of capture, target species and statistical area). This analysis indicated that, for this data set, the data summarisation had little effect on the estimated CPUE series.

Logbook Programme

- Not enough samples from the setnet fishery for biological data to make any meaningful deductions. Samples were not collected so as to be representative of the fishery.
- Bottom trawl fishery is mostly from the southern area and area 41 has a lot of fishing but is under sampled.
- Bottom longline fishery has good coverage as an overall percentage but poor coverage north of Cape Egmont. No sampling in second half of the season or area 41, but good overall coverage as in total 47% of the fishery was covered.

Effects of Fishing

- SCH 8 TACC was increased by 20 % and the current catch is within 5% of the TACC.
- There are particular concerns related to potential impacts on the endangered Maui dolphins population along the North Island west coast.
- An attempt was made to address the primary threat to these dolphins by the implementation of a 4 nm near-shore setnet closure along the North Island west coast.
- The report stated that there were no Maui dolphins seen in the area during an aerial survey. However, concerns were raised where that statement was based on the results from a single aerial survey. It is known that Maui dolphins have been known to occur south to New Plymouth, but reports south of Kahia Harbour are thought to be rare.
- It was suggested that there exists information on the capture of Maui dolphins in recreational setnet which should be included in the report, as there were no reports of commercially caught dolphins, which seems unlikely as they fish in similar areas.

Conclusions

- The Working Group accepted the SCH 8 CPUE analysis as being representative of the fishery.

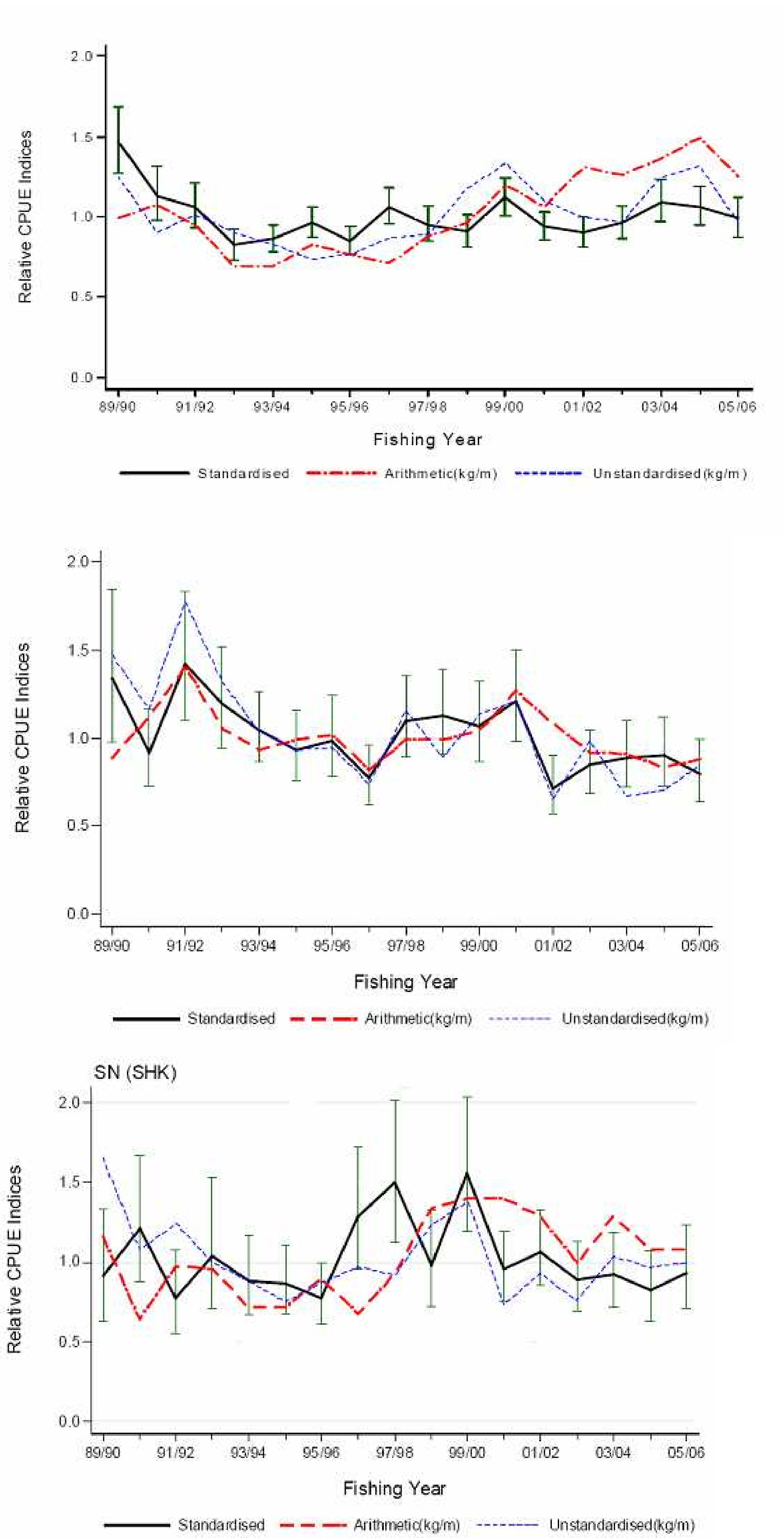


Figure 2: Relative CPUE indices for SCH 3 (top), SCH 5 (middle), and SCH 8 (bottom) using the lognormal non-zero model based on the shark setnet fishery. Error bars are ± 2*SE. Also shown are two unstandardised series from the same data:

6. STATUS OF THE STOCKS

Estimates of current absolute biomass are not available.

School shark TACs were originally set at half the 1983 catch because of apparently declining catch rates and concern about the undoubtedly low productivity of the species. However, catches and actual TACCs have steadily increased since 1986–87. CPUE indices are characterised by high uncertainty, though, there are no indications that current catches are not sustainable in the short-term. However, it is not known whether recent catch levels or the current TACCs are sustainable in the long-term, or if they are at levels that will allow the stocks to move towards a size that will support the maximum sustainable yield.

Yield estimates, reported landings and TACCs for the 2006–07 fishing year are summarised in Table 7.

Table 7: Summary of yield estimates (t), TACCs (t) and reported landings (t) of school shark for the most recent fishing year.

Fishstock		QMA	MCY Estimates	2006–07 Actual TACC	2006–07 Reported Landings
SCH 1	Auckland (East) (West)	1 & 9		668	660
SCH 2	Central (East)	2		199	200
SCH 3	South-east (Coast)	3		387	376
SCH 4	South-east (Chatham)	4		239	88
SCH 5	Southland and Sub-Antarctic	5 & 6		743	738
SCH 7	Challenger	7		641	582
SCH 8	Central (West)	8		529	534
SCH 10	Kermadec	10		10	0
Total				3 416	3 179

7. FOR FURTHER INFORMATION

Anon. 1990. Management meets industry. Papers from the Southern Shark Fishery seminars held in Victor Harbour, Phillip Island and Hobart, October 1989.

Ayers D., Paul LJ., Sanders BM. 2004. Estimation of catch per unit effort analyses for school shark (*Galeorhinus galeus*) from bycatch and target fisheries in New Zealand, 1989-90 to 2001-02. New Zealand Fisheries Assessment Report 2006/26. 121p.

Boyd RO., Reilly JL. 2005. 1999–2000 national marine recreational fishing survey: harvest estimates. Draft New Zealand Fisheries Assessment Report.

Bradford E. 1998. Harvest estimates from the 1996 national recreational fishing surveys. New Zealand Fisheries Assessment Research Document. 1998/16. 27p.

Bradford E. 2001. Standardised catch rate indices for New Zealand school shark, *Galeorhinus galeus,* in New Zealand, 1989–90 to 1998–99. New Zealand Fisheries Assessment Report 2001/33. 75p.

Campbell D., Battaglene T., Pascoe S. 1991. Management options for the Southern Shark Fishery – an economic analysis. Australian Bureau of Agricultural and Resource Economics Discussion Paper 91.12. 43p.

Coutin P., Bruce B., Paul L. 1992. New Zealand school sharks cross the Tasman Sea. Australian Fisheries 51(3): 24–25.

Francis MP. 1998. New Zealand shark fisheries: development, size and management. Marine and Freshwater Research 49: 579–591.

Francis MP., Mulligan KP. 1998. Age and growth of New Zealand school shark, *Galeorhinus galeus*. New Zealand Journal of Marine and Freshwater Research 32(3): 427–440.

Grant CJ., Sandland RL., Olsen AM. 1979. Estimation of growth, mortality and yield per recruit of the Australian school shark, *Galeorhinus australis* (Macleay), from tag recoveries. Australian Journal of Marine and Freshwater Research 30(5): 625–637.

Hurst RJ., Bagley NW., McGregor GA., Francis MP. 1999. Movements of the New Zealand school shark, *Galeorhinus galeus*, from tag returns. New Zealand Journal of Marine and Freshwater Research 33(1): 29–48.

Hurst RJ., Bagley NW., Uozumi Y. 1990. New Zealand-Japan trawl survey of shelf and upper slope species off southern New Zealand, June 1986. N.Z. Fisheries Technical Report No. 18. 50p.

Livingston ME., Uozumi Y., Berben PH. 1991. Abundance, distribution, and spawning condition of hoki and other mid-slope fish on the Chatham Rise, July 1986. New Zealand Fisheries Technical Report No. 25. 47p.

Lydon GJ., Middleton DAJ., Starr PJ. 2006. Performance of the SCH 7 and SCH 8 Logbook Programmes. AMP-WG-06–06. (Unpublished manuscript available from the NZ Seafood Industry Council, Wellington).

Olsen AM. 1984. Synopsis of biological data on the school shark, *Galeorhinus australis* (Macleay 1881). FAO Fisheries Synopsis No. *139*. 42p.

Paul LJ. 1988. School shark. New Zealand Fisheries Assessment Research Document 1988–27. 32p.

Paul LJ. 1991. Overseas travel report: "Sharks Down Under" conference, Taronga Zoo, Sydney, February 1991. MAF Fisheries Greta Point Internal Report No. 176. 137 p. (Draft report held in MAF Fisheries Greta Point library, Wellington).

Paul LJ., Saunders B. 2001. A description of the commercial fishery for school shark, *Galeorhinus galeus,* in New Zealand, 1945 to 1999. New Zealand Fisheries Assessment Report 2001/32. 63p.

Peres MB., Vooren CM. 1991. Sexual development, reproductive cycle, and fecundity of the school shark *Galeorhinus galeus* off southern Brazil. Fishery Bulletin, U.S. 89(4): 655–667.

Seafood Industry Council (SeaFIC). 2003a. SCH 3 Adaptive Management Programme Proposal for the 2004-05 Fishing year. 50p. (Unpublished report held at the Seafood Industry Council, Wellington).

Seafood Industry Council (SeaFIC). 2003b. SCH 5 Adaptive Management Programme Proposal for the 2004-05 Fishing year. 49p. (Unpublished report held at the Seafood Industry Council, Wellington).
Seafood Industry Council (SeaFIC). 2003c. SCH 7 Adaptive Management Programme Proposal for the 2004-05 Fishing year. 42p. (Unpublished report held at the Seafood Industry Council, Wellington).
Seafood Industry Council (SeaFIC). 2003d. SCH 8 Adaptive Management Programme Proposal for the 2004-05 Fishing year. 42p. (Unpublished report held at the Seafood Industry Council, Wellington).
Starr PJ. 2005. CPUE indices for groper, *Polyprion* spp., when targeted and as a bycatch in four New Zealand fisheries, 1990-2003. New Zealand Fisheries Assessment Report 2005/51. 29p.
Starr PJ., Kendrick TH., Lydon GJ., and Bentley N. 2007a. Report to the Adaptive Management Programme Fishery Assessment Working Group: Two year review of the SCH 3 Adaptive Management Programme. AMP-WG-07–08. (Unpublished manuscript available from the NZ Seafood Industry Council, Wellington).
Starr PJ., Kendrick TH., Lydon GJ., and Bentley N. 2007b. Report to the Adaptive Management Programme Fishery Assessment Working Group: Two year review of the SCH 5 Adaptive Management Programme. AMP-WG-07–09. (Unpublished manuscript available from the NZ Seafood Industry Council, Wellington).
Starr PJ., Kendrick TH., Lydon GJ., Bentley N. 2007c. Report to the Adaptive Management Programme Fishery Assessment Working Group: Two year review of the SCH 7 Adaptive Management Programme. AMP-WG-07–15. (Unpublished manuscript available from the NZ Seafood Industry Council, Wellington).
Starr PJ., Kendrick TH., Lydon GJ., Bentley N. 2007d. Report to the Adaptive Management Programme Fishery Assessment Working Group: Two year review of the SCH 8 Adaptive Management Programme. AMP-WG-07–16. (Unpublished manuscript available from the NZ Seafood Industry Council, Wellington).
Teirney LD., Kilner AR., Millar RE., Bradford E., Bell JD. 1997. Estimation of recreational catch from 1991–92 to 1993–94. New Zealand Fisheries Assessment Research Document 1997/15. 43p.