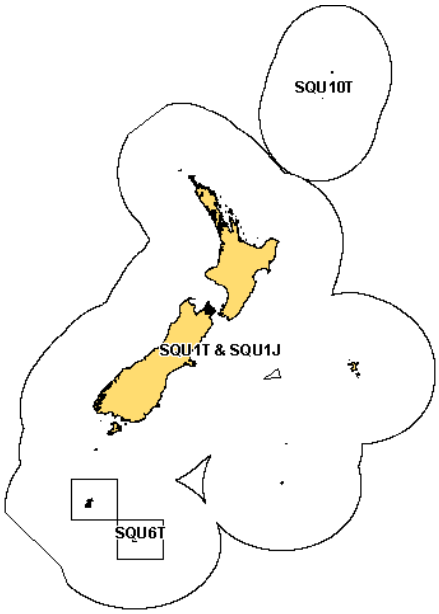
ARROW SQUID (SQU)

(*Nototodarus gouldi*, *N. sloanii*)



1. FISHERY SUMMARY

(a) Commercial fisheries

The New Zealand arrow squid fishery is based on two related species. *Nototodarus gouldi* is found around mainland New Zealand north of the Subtropical Convergence, whereas *N. sloanii* is found in and to the south of the convergence zone.

Except for the Southern Islands fishery, for which a separate TACC is set, the two species are managed as a single fishery within an overall TACC. The Southern Islands fishery (SQU 6T) is almost entirely a trawl fishery. Although the species (*N. sloanii*) is the same as that found around the south of the South Island, there is evidence to suggest that the Auckland Island shelf stock is different from the mainland stocks. Because the Auckland Island shelf squid are readily accessible to trawlers, and because they can be caught with little finfish bycatch and are therefore an attractive resource for trawlers, a quota has been set separately for the Southern Islands.

The New Zealand squid fishery began in the late 1970s and reached a peak in the early 1980s when over 200 squid jigging vessels came to fish in the New Zealand EEZ. The discovery and exploitation of the large squid stocks in the southwest Atlantic substantially increased the supply of squid to the Asian markets causing the price to fall. In the early 1980s, Japanese squid jiggers would fish in New Zealand for a short time before continuing on to the southwest Atlantic. In the late 1980s, the jiggers stopped transit fishing in New Zealand and the number of jiggers fishing declined from over 200 in 1983 to around 15 in 1994. The jig catch in SQU 1J declined from 53 872 t in 1988–89 to 4865 t in 1992–93 but increased significantly to over 30 000 t in 1994–95, before declining to just over 9000 t in 1997–98. The jig catch declined to low levels for the next 5 years but has increased in 2004–05 to 8981 t.

From 1986 to 1998 the trawl catch fluctuated between about 30 000–60 000 t, but in the last few years dropped to much lower levels as the impact of management measures to protect the Hooker's sea lion (*Phocarctos hookeri*) restricted the catch from SQU 6T.

Recent catch data are given in Table 1. A breakdown of catch by foreign licensed nation to 1993–94 is given in the 1995 Plenary report. It has not been updated here because of the relatively low foreign licensed catch in recent years.

Catch and effort data from the SQU 1T fishery show that the catch occurs between December and May, with peak harvest from January to April. The catch has been taken from the Snares shelf on the south coast of the South Island right through to the Mernoo Bank (east cost), but statistical area 28 (Snares shelf and Snares Island region) has accounted for over 77% of the total in recent years. Based on observer data, squid accounts for 67% of the total catch in the target trawl fishery, with bycatch principally of barracouta, jack mackerel, silver warehou and spiny dogfish.

For 2005-06 a 10% in-season increase to the SQU 1T TACC has been approved by the Minister of Fisheries. The catch for December –March was 40% higher than the average over the previous 8 years and catch rates were double the average, indicating an increased abundance of squid. In 2003-04, a 30% in-season increase to the TACC was agreed, but catches did not reach the higher limit. Note that the TACC automatically reverts to the original value at the end of the fishing year.

Table 1: Reported catches (t) and TACs (t) of arrow squid from 1986–87 to 2005–06. Source – QMS.

Fishstock	SQU1J*		SQU1T*		SQU6T†		SQU10T‡		Total	
	Landings	TAC	Landings	TAC	Landings	TAC	Landings	TAC	Landings	TAC
1986–87	32 394	57 705	25 621	30 962	16 025	32 333	0	10	74 040	121 010
1987–88	40 312	57 705	21 983	30 962	7021	32 333	0	10	69 316	121 010
1988–89	53 872	62 996	26 825	36 081	33 462	35 933	0	10	114 160	135 080
1989–90	13 895	76 136	13 161	47 986	19 859	42 118	0	10	46 915	166 250
1990–91	11 562	46 087	18 680	42 284	10 658	30 190	0	10	40 900	118 571
1991–92	12 985	45 766	36 653	42 284	10 861	30 190	0	10	60 509	118 571
1992–93	4865	49 891	30 862	42 615	1551	30 369	0	10	37 278	122 875
1993–94	6524	49 891	33 434	42 615	34 534	30 369	0	10	74 492	122 875
1994–95	33 615	49 891	35 017	42 741	30 683	30 369	0	10	99 315	123 011
1995–96	30 805	49 891	17 823	42 741	14 041	30 369	0	10	62 668	123 011
1996–97	20 792	50 212	24 769	42 741	19 843	30 369	0	10	65 403	123 332
1997–98	9329	50 212	28 687	44 741	7344	32 369	0	10	45 362	127 332
1998–99	3240	50 212	23 362	44 741	950	32 369	0	10	27 553	127 332
1999–00	1457	50 212	13 049	44 741	6241	32 369	0	10	20 747	127 332
2000–01	521	50 212	31 297	44 741	3254	32 369	<1	10	35 071	127 332
2001–02	799	50 212	35 872	44 741	11 502	32 369	0	10	48 173	127 332
2002–03	2 896	50 212	33 936	44 741	6887	32 369	0	10	43 720	127 332
2003–04	2 267	50 212	48 060	58 163#	34 635	32 369	0	10	84 962	127 332
2004-05	8 981	50 212	49 780	44 741	27 314	32 369	0	10	86 075	127 332
2005-06	5 844	50 212	49 149	44 741	17 425	32 369	0	10	72 418	127 332

* All areas except Southern Islands and Kermadec.
† Southern Islands.
‡ Kermadec.
# In season increase of 30% for 2003-04.

Sea lion interactions – Squid 6T

Landings in SQU 6T have been irregular over time, caused by both the variable availability of squid and also the seasonal closures caused by sea lion incidental mortality. Table 2 shows the estimates of sea lion mortalities and the fishery-related mortality limits (FRML) set for each year. Since 1995-96, the FRML has been reached in nine of eleven fishing years. In 2000-01 the industry voluntarily withdrew most vessels before the FRML was met. In 2004-05, the industry withdrew from the fishery when the FRML was reached on the 15th of April. In 2002-03 and 2003-04, the FRML was reached and the fishery closed under the operational plan in place, only to be subsequently reopened by court decisions (High Court, Court of Appeal respectively

In 2005-06 the FRML was originally set at 97. However, following consultation mid-season, the Minister of Fisheries decided to increase the FRML to 150 in order to allow the fishery to take advantage of apparent increased squid abundance. The total estimated bycatch of sea lions was 110 for 2005-06. The Minister of Fisheries has set the FRML at 93 for the 2006-07 fishing year.

Table 2: Squid 6T fishery – estimated mortalities of sea lions from 1987–88 to 2004–05.

	SQU6T		Sea lion	Estimated	Closure
	Landings	TAC	FRML	mortalities[f]	date
1987–88	7021	32 333	-	33	
1988–89	33 462	35 933	-	141	
1989–90	19 859	42 118	-	117	
1990–91	10 658	30 190	-	21	
1991–92	10 861	30 190	32	82	
1992–93	1551	30 369	63	17	
1993–94	34 534	30 369	63	32	
1994–95	30 683	30 369	69	109	
1995–96	14 041	30 369	73	101	4 May
1996–97	19 843	30 369	79	123	28 May
1997–98	7344	32 369	63	62	27 Mar
1998–99	950	32 369	64	14	
1999–00	6241	32 369	65	71	8 Mar
2000–01	3254	32 369	75	67	a
2001–02	11 502	32 369	79	84	13 Apr
2002–03	6887	32 369	70	39	b
2003–04	34 635	32 369	62	118	c
2004-05	27 314	32 369	115	115	20 Apr[d]
2005-06	17 425	32 369	150	110	e

a The fishery was not officially closed in 2000/01. Industry voluntarily withdrew most vessels on 7 March 2001.

b Under the Operational Plan the SQU 6T fishery was closed on 29 March 2003 when the FRML count reached 79 sea lions. A High Court ruling in April 2003 allowed for continued fishing in SQU 6T and established a separate procedure for estimating sea lion mortalities resulting in the 39 mortalities indicated. Fishers had voluntarily withdrawn from SQU 6T as at the end of June.

c Under the Operational Plan the SQU 6T fishery was closed on 22 March 2004 when the FRML count reached 62 sea lions. A Court of Appeal ruling in April 2004 set aside the 2003-04 Operational Plan and allowed for continued fishing in SQU 6T providing incidental NZSL captures did not exceed 124. Industry withdrew from the SQU 6T fishery before they reached the Court established mortality limit as estimated using the procedures set out in the 2003-04 Operational Plan.

d Fishers voluntarily withdrew from the SQU 6T fishery upon reaching the 115 animal FRML on 17 April 2005.

e In 2005-06 the FRML was initially set at 97 animals, and the Minister chose to increase this mid-season to 150, on the basis of there being a squid utilisation opportunity. Fishing had practically ceased by early May 2006.

f The method of determining the estimated mortalities of sea lions, varies over the history of the fishery. In early years determination of sea lion mortality was based on observer data. The use of SLEDs in recent years has resulted in few sea lion mortalities being observed. Therefore recent 'estimated mortalities' are based on a pre-determined strike rate (5.3%), which is the seven year average from the observer data.

Interactions with seabirds

Vessels targeting arrow squid also incidentally catch seabirds. Seabird species returned for autopsy from the squid fishery in 2003-04 and 2004-05 (in decreasing numbers) were; White-capped albatross, Sooty shearwater, White-chinned petrel, Buller's albatross, Salvin's albatross, Southern royal albatross, Campbell Albatross, Grey-backed storm petrel and White-headed petrel (Baird & Smith, 2007). Baird (2005) summarised observed seabird captures in the arrow squid target fishery for the fishing years 1998-99 to 2002-03 and calculated total seabird captures for the areas with adequate observer coverage using ratio based estimations. Baird and Smith (2007) summarised observed seabird captures and used both ratio-based and model-based predictions to estimate the total seabird captures for 2003-04 and 2004-05 (Table 3).

Table 3 Estimates of total seabird capture in the arrow squid fishery 1998–99 to 2004-05 (1998-99 to 2002-03 from Baird 2005 FAR2005/02, 2003-04 to 2004-05 from Baird and Smith 2007 draft AEBR). CV.s in parentheses; + birds were observed caught but totals were not estimated as coverage was less than 10%, * indicates where estimates were made and observer coverage was less than 10%, - no observations available, # indicates where number of seabirds are from where observed effort covered 100% of fishery effort. All estimates are ratio-estimators except those denoted with [m] which are model-based.

Fishing year	PUYS	SQU 6T	STEW	CHAT	ECSI	PUKA
1998-99	+	+	268 (20)	+	+	-
1999-00	-	82 (19)	93 (34)	+	+	-
2000-01	+	42[#]	276 (5)	+	+	-
2001-02	+	195 (19)	515 (13)	-	+	-
2002-03	53 (39)	129 (16)	612 (16)	+	+	-
2003-04	-	325 (16)[m]	502 (17)[m]	-	-	19 (93)*
2004-05	33 (36)	414 (15)[m]	877 (12)[m]	-	-	-

During the 2005-06 fishing year a large trial of mitigation devices was conducted in the squid fishery. 18 vessels were involved in the trial which used observations of seabird heavily contacting the trawl warps ('warps strikes') to quantify the effect of using three mitigation devices; paired tori lines, four boom bird bafflers and warp scarers. Few warp strikes occurred in the absence of offal discharge. When offal was present the tori lines were most effective at reducing warp strikes. All mitigation devices were more effective for reducing large birds warp strikes than for small birds. There was however a large number of strikes of birds on the tori lines, similar to the number of strikes on unmitigated warps (Abraham et al., in press).

(b) Recreational fisheries

The amount of arrow squid caught by recreational fishers is not known.

(c) Maori customary fisheries

No quantitative information is available on the current level of Maori customary take.

(d) Illegal catch

There is no quantitative information available on the level of illegal catch.

(e) Other sources of mortality

No information is available on other sources of mortality.

2. BIOLOGY

Two species of arrow squid are caught in the New Zealand fishery. Both species are found over the continental shelf in water up to 500 m depth, though they are most prevalent in water less than 300 m depth. Both species are sexually dimorphic, though similar in biology and appearance. Individuals can be identified to species level based on sucker counts on Arm I and differences in the hectocotylized arm of males.

Recent work on the banding of statoliths from *N. sloanii* suggests that the animals live for around 1 year. Growth is rapid. Modal analysis of research data has shown increases of 3.0–4.5 cm per month for Gould's arrow squid measuring between 10 and 34 cm Dorsal Mantle Length (DML).

Estimated ages suggest that *N. sloanii* hatches in July and August, with spawning occurring in June and July. It also appears that *N. gouldi* may spawn one to two months before *N. sloanii*, although there are some indications that *N. sloanii* spawns at other times of the year. All squid taken by the fishery do not appear to have spawned.

Tagging experiments indicate that arrow squid can travel on average about 1.1 km per day with a range of 0.14–5.6 km per day.

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

Table 4: Estimates of biological parameters.

Fishstock	Estimate				Source
1. Weight = a (length)^b (Weight in g, length in cm dorsal length)					
			a	b	
N. gouldi	≤ 12 cm DML		0.0738	2.63	Mattlin et al. (1985)
N. sloanii	≥ 12 cm DML		0.0290	3.00	
2. von Bertalanffy growth parameters					
	K	**t_0**	**L_∞**		
N. gouldi	2.1–3.6	0	35		Gibson & Jones (1993)
N. sloanii	2.0–2.8	0	35		

3. STOCKS AND AREAS

There are no new data which would alter the stock boundaries given in previous assessment documents. It is assumed that the stock of *N. gouldi* (the northern species) is a single stock, and that *N. sloanii* around the mainland comprises a unit stock for management purposes, though the detailed structure of these stocks is not fully understood. The distribution of the two species is largely geographically separate but those occurring around the mainland are combined for management purposes. The Auckland Islands Shelf stock of *N. sloanii* appears to be different from the mainland stock and is managed separately.

4. STOCK ASSESSMENT

There are no new data which would alter the conclusions regarding yield estimates given in the 1998 Plenary Report. These conclusions have not changed since the 1990 Plenary Report.

Arrow squid live for one year, spawn once then die. Every squid fishing season is therefore based on what amounts to a new stock. It is not possible to calculate reliable yield estimates from historical catch and effort data for a resource which has not yet hatched, even when including data which are just one year old. Furthermore, because of the short life span and rapid growth of arrow squid, it is not possible to estimate the biomass prior to the fishing season. Moreover, the biomass increases rapidly during the season and then decreases to low levels as the animals spawn and die.

(a) Estimates of fishery parameters and abundance

No estimates are available.

(b) Biomass estimates

Biomass estimates are not available for squid.

(c) Estimation of Maximum Constant Yield (MCY)

It is not possible to estimate MCY.

(d) Estimation of Current Annual Yield (CAY)

It is not possible to estimate CAY.

(e) Other yield estimates and stock assessment results

There are no other yield estimates of stock assessment results available for arrow squid.

(f) Other factors

N. gouldi spawns one to two months before *N. sloanii*. This means that at any given time *N. gouldi* is older and larger than *N. sloanii*. The annual squid jigging fishery begins on *N. gouldii* and at some time during the season the biomass of *N. sloanii* will exceed that of *N. gouldi* and the fleet will move south. If *N. sloanii* are abundant the fleet will remain in the south fishing for *N. sloanii*. If *N. sloanii* are less abundant the fleet will return north and resume fishing *N. gouldi*.

5. STATUS OF THE STOCKS

No estimates of current and reference biomass are available. There is also no proven method at this time to estimate yields from the squid fishery before a fishing season begins based on biomass estimates or CPUE data.

Because squid live for about one year, spawn and then die, and because the fishery is so variable, it is not practical to predict future stock size in advance of the fishing season. As a consequence, it is not possible to estimate a long-term sustainable yield for squid, nor determine if recent catch levels or the current TACC will allow the stock to move towards a size that will support the MSY. There will be some years in which economic or other factors will prevent the TACC from being fully taken, while in other years the TACC may be lower than the potential yield. It is not known whether New Zealand squid stocks have ever been stressed through fishing mortality.

There is continuing concern about the bycatch of sea lions in the Southern Islands trawl squid fishery (SQU 6T) that has been addressed by a management plan restricting the total number of kills per season.

TACCs and reported landings for the 2005/06 fishing year are summarised in Table 4.

Table 5: Summary of TACCs (t) and reported landings (t) of arrow squid for the most recent fishing year.

Fishstock	2005–06 Actual TACC	2005–06 Reported landings
SQU 1J	50 212	5844
SQU 1T	44 741	49 149
SQU 6T	32 369	17 425
SQU 10T	10	0
Total	127 332	72 418

6. FOR FURTHER INFORMATION

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