New Zealand Fisheries Assessment Research Document 88/34

Arrow squid

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ARROW SQUID

(Nototodarus sloanii and N. gouldi)

This document contains an overview of the New Zealand arrow squid fishery. It is divided into the following sections:

- an introduction, giving a brief synopsis of the fishery;
- history of management;
- biology;
- stock separation;
- stock assessment.

INTRODUCTION

The New Zealand arrow squid fishery is based on two related species of the family Ommastrephidae. Nototodarus gouldi is generally found around mainland New Zealand north of the Subtropical Convergence, whereas N. sloanii is found in and to the south of the convergence zone (Mattlin et al. 1985; Smith 1985; Figure 1). For convenience, N. gouldi will be referred to as Gould's arrow squid and N. sloanii as southern arrow squid. Gould's arrow squid are also found in Australian waters while southern arrow squid are found only within the New Zealand EEZ. They are very similar in appearance, though it is possible to tell them apart by eye. Detailed descriptions of both species are given in Smith et al. (1987).

The fishing season begins in December and can run until June. Squid are caught by trawl and specialized jigging vessels from New Zealand, Japan and Korea, by jig vessels from Taiwan, and by trawlers from the Soviet Union.

Major fishing grounds are off the Taranaki coast and the area in and around Tasman Bay for Gould's arrow squid, and off the east coast of South Island, Chatham Rise, around Stewart Island, and the Snares and Aucklands Shelves for southern arrow squid.

The major markets for New Zealand squid are Japan and Taiwan, though other markets include Australia, North America, Europe and the Middle East. New Zealand owned and operated companies are experiencing difficulty in gaining access to the Asian markets. There is a small local demand.

Although the two New Zealand arrow squid species are separated geographically by the Subtropical Convergence, they are managed as one species. The fishery tends to concentrate on Gould's arrow squid early in the season, then move on to southern arrow squid. When catch rates on one of the species drop, the fleet moves on to another area which often means the other species. The fishery is therefore self regulating, in that the quota system does not force the fleet to continue fishing on one of the species when catch rates are low.

Three other ommastrephid species (Todarodes filippovae, Martialia hyadesi and Ommastrephes bartrami) are found in New Zealand's waters. They are not present in sufficient quantities to support commercial fisheries either singularly or together.

The loliginid squid Sepioteuthis australis, or broad squid, is found in the near-shore waters around North Island. It is taken in small numbers both as bycatch and as a target species, but the resource does not appear sufficiently large to support a major fishery.

Only the two Nototodarus species are managed by quota.

HISTORY OF MANAGEMENT

For the first year after the declaration of the EEZ, management was by allocation of a tonnage quota for both jiggers and trawlers. The following year a tonnage allocation continued for trawlers, but for jiggers, management was switched to control by effort; i.e. 180 jig vessels were allowed to fish within the zone and no specific limit was placed on tonnage caught. The number of jig vessels allowed was based on an average Catch Per Unit Effort (CPUE) of 2.20 t per vessel-day and an average fishing season of 100 days. This equated to about 40 000 t per year. A separate quota of 30 000 t was set for the Aucklands Shelf trawl fishery, with an additional 20 000 t for trawlers in the remainder of the zone. This was based on a catch limit of about 90 000 t per season, or 15% of the original biomass estimate of 600 000 t (see below). An exploitation rate of about 40% of the stock is considered by many as an acceptable level of fishing mortality for squid (Caddy 1981, 1983). However, because we had no satisfactory estimate of the actual stock size, a conservative approach was taken.

There was a gradual increase in the amount of effort by jig vessels as fishing masters gained experience in the New Zealand region. This pushed the actual jig-caught catch well beyond the intended 40 000 t. To limit this effort a quota system was re-established in 1985-86. Trawlers were covered under the ITQ system. The agreed upon TAC for the 1985-86 fishing season was 105 000 t, of which 54 000 t was allocated to jiggers. This increase put the TAC in line with maximum catches, and was to remain for 3-5 years in order to assess the fishery at that level. For the 1986-87 fishing season the TAC therefore remained at 105 000 t, allocated as: 48 600 t (jig), 26 400 t (all methods), and 30 000 t (Southern Islands trawl fishery).

It was recommended that the TAC for 1987-88 remain at 105 000 t. However, approval had been given for as many as 25 New Zealand owned squid jig vessels to enter the fishery. In order to accommodate this increase by local industry, the quota was raised to 121 010 t. There were no significant biological data on which to base this increase.

The present allocation of the squid TAC is:

Kermadec Area	all methods	10 t
Auckland, Central, Challenger, SE Southland, Subantarctic (except Southern Islands) areas	jigging	57 705 t
	all methods	30 962 t
Southern Islands	all methods	32 333 t
TOTAL		121 010 t

All arrow squid came under the ITQ system from 1 November 1987, with the exception of those taken from the Auckland Fishery Management Area north of 36°S.

Catch data for jiggers and trawlers are given in Figure 2 and Tables 1 and 2.

BIOLOGY

Arrow squid are found in waters over the continental shelf to a depth of about 500 m, though they are most abundant in water depths less than 300 m. They are seasonal in abundance and patchy in distribution. Individuals of both species live for about one year, spawn once, and die. Post-spawned squid are in very poor condition and are not suitable for human consumption. Some spawning probably occurs year round, though there are two major peaks; one in spring and one in autumn. Growth is rapid and may exceed 30 mm per month. They are voracious predators and feed on fish, macrozooplankton, and other squid. During the fishing season squid are found in large schools which tend to be segregated by size; very small and very large squid rarely are found together (Mattlin *et al*. 1985)

STOCK SEPARATION

It is assumed that the stock of *N. gouldi* (the northern species) is a single stock, and also that the mainland stocks of *N. sloanii* comprise a unit stock for management purposes, though the detailed structure of these stocks is not fully understood.

There is no genetic or morphological evidence to suggest separate subspecies for arrow squid in New Zealand as suggested by Kawakami and Okutani (1981; Smith *et al*. 1987). With the exception of the Aucklands Shelf, there is little evidence to support the suggestion by Kawakami (1976) that there are eight subpopulations of arrow squid within the New Zealand region (Smith *et al*. 1987).

The Aucklands Shelf squid fishery has been allocated a separate quota because of uncertainty as to its relationship with southern arrow squid found elsewhere in the zone. Size frequency data obtained through the Scientific Observer Programme reinforce our belief that the Aucklands Shelf squid are to some degree isolated from those found to the north of this area (Figure 3).

STOCK ASSESSMENT

BIOMASS ESTIMATION

Initially, an estimated biomass of 600 000 t for the entire New Zealand region was calculated by the areal expansion method based on 1978-79 commercial catch data from both the jig and trawl fisheries. However, this figure should not be accepted as an accurate estimate of stock size. Because of the short life span and rapid growth of arrow squid, dramatic changes in biomass estimates both between seasons and within seasons can be expected, hence biomass estimates alone are not particularly

meaningful. For example, an estimate of 157 500 t (c.v. = 32%) was calculated for the southern area (all of area E and part of area F, including the Snares Shelf). It was based on data collected during the 1982 **SHINKAI MARU** random trawl survey (swept area equalled the distance between wingtips). An estimate calculated for the Snares Shelf and Aucklands Shelf from these cruise data was 112 000 t, compared with an estimate of 35 000 t from data collected in the same area by the same vessel the previous year.

MAXIMUM CONSTANT YIELD

Maximum Constant Yield was estimated from

$$MCY = cMSY$$

where c was set at 0.6 because these squid are fast growing, short-lived, and their population sizes are highly variable. MSY was estimated from the surplus production model

$$MSY = -a^2/4b$$

where a = y intercept and b = slope of a regression of catch per unit effort (CPUE) on effort (tonnes per vessel-day; Sissenwine 1978).

The resulting equation was CPUE = 4.92 - 0.0000868 E, from which

$$MSY = \frac{4.92^2}{4 \times 0.0000868}$$

i.e. MSY = 69 700 tonnes and MCY = 41 800 t.

For the Aucklands Shelf fishery CPUE (tonnes per hour trawled) was calculated for trawlers. Large trawlers (over 1 000 t) appeared to have similar catch rates regardless of size, and CPUE was calculated for all these vessels combined, for each year from 1978-79 to 1986-87, by dividing total catch by total hours trawled. Smaller trawlers (less than 1 000 t) had lower catch rates. Their effort was standardised to that of large trawlers by dividing the catch of small trawlers by the CPUE of large trawlers in order to express the effort of the small trawlers in terms of standard large-trawler-hours (SLT hours). Total catch in each season was then divided by the total SLT hours to calculate CPUE, and CPUE was plotted against effort (E) for each season. The resulting equation was

$$CPUE = 2.499 - 0.0000463E$$

from which

$$MSY = \frac{2.449^2}{4 \times 0.0000463}$$

i.e. MSY = 32 400 t and MCY = 19 400 t.

Estimates of MSY and MCY for the mainland stocks and for the Aucklands Shelf are, then, as follows:

Mainland fisheries:	MSY = 69 700 t;	MCY = 41 800 t
Aucklands Shelf:	MSY = 32 400 t;	MCY = 19 400 t

We should note, however, that the concept of MSY as a Maximum Sustainable Yield from year to year is not realistic for squid fisheries which exploit a new population each year. The equivalent of MSY is really the average catch over time which could be expected from a constant fishing mortality set at a level which would result in the maximum yield from the stock in each year. The annual yield can be expected to be variable, from a low at MCY level, to a high at some point well above the MSY levels indicated above. If the fisheries are operating at around MSY levels, we should expect annual catches to vary around the indicated levels, exceeding MSY about as often as they fall short of it.

In practice, the mainland fisheries have exceeded 69 700 t only once in the 7 seasons for which data are available since 1980-81. The Aucklands shelf fishery has exceeded the indicated MSY of 32 400 t only twice (including once only by a very small amount) in eight seasons since 1978-79. This indicates that the estimated MSY values are probably conservative, particularly for the main islands fisheries, in that there is little evidence to indicate that past catches have had a deleterious effect on squid stocks.

CURRENT AVAILABLE YIELD

Because of the short life span and rapid growth of arrow squid it is not possible to estimate current biomass except during the course of the fishing season, and in any case the biomass varies greatly even during the season. It is therefore not possible to estimate the Current Available Yield.

FACTORS MODIFYING YIELD ESTIMATES

The Aucklands Shelf has been limited by quota since 1978. The mainland fisheries are also now under quota, and jigging effort has also been under limits in the past. This has an effect on the MSY estimates calculated above, and results in the estimates being conservative. It is very possible that the stocks have never been fished to their maximum in any one season, though the MCY appears to have been exceeded in most years.

For the future, the large catches of squid now being taken in the Falkland Islands fishery are causing a surplus of squid on the world market and consequently the price of squid is depressed. This is likely to cause a significant reduction in effort in the New Zealand squid fisheries at least in the short term.

NON-COMMERCIAL INTERESTS

There are no known Maori, recreational or other non-commercial interests in the arrow squid fisheries.

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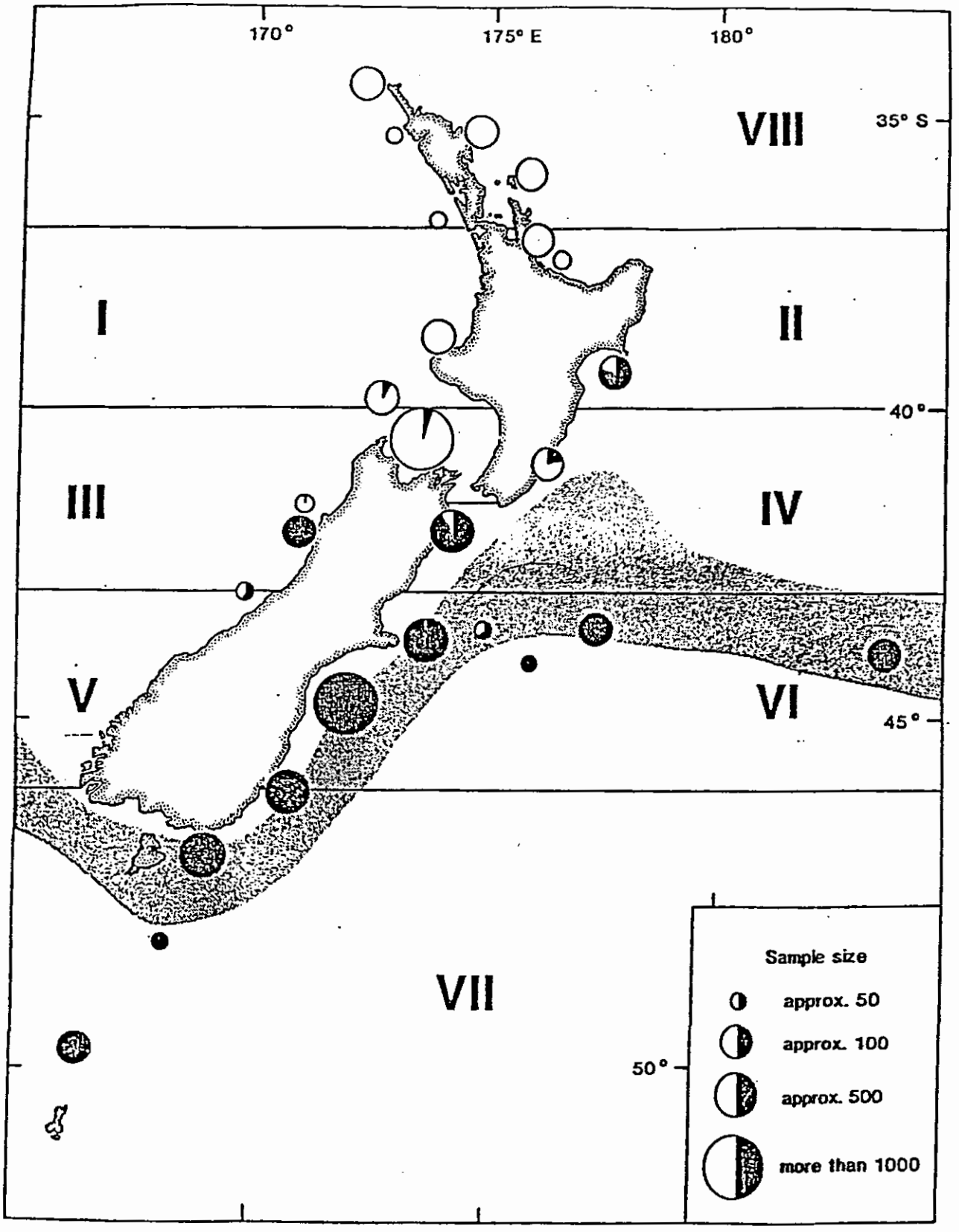


Fig. 1: Distribution of *Nototodarus gouldi* (open circles) and *N. sloanii* (closed circles) within the New Zealand region. The region has been divided into eight areas based on distribution of fishing effort (refer to Data Report Series). Grey zone indicates the Subtropical Convergence (after Smith 1985).

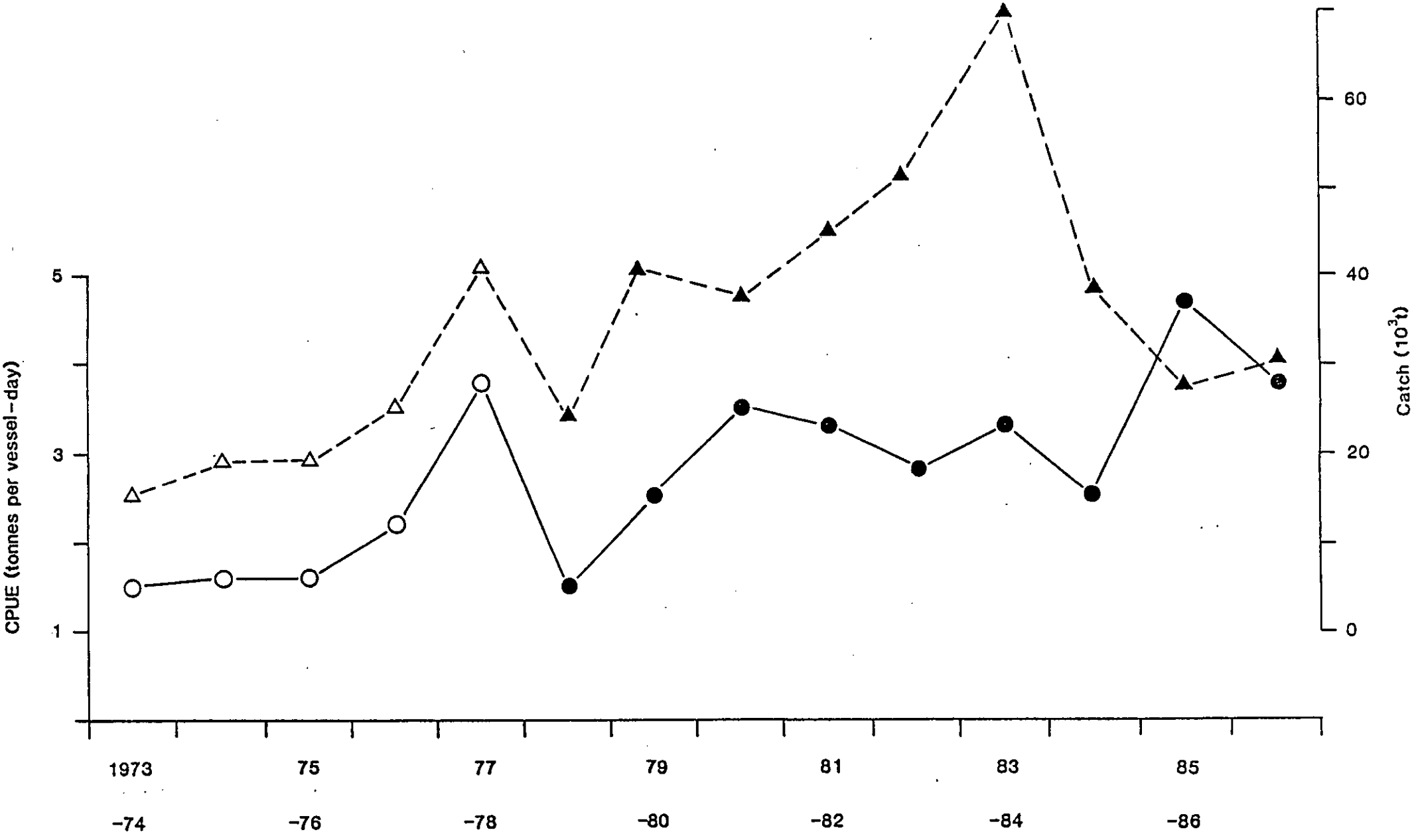


Figure 2. Arrow squid CPUE (circles) and total catch data (triangles) for the jig fleet (open symbols are for data from Japanese vessels only).

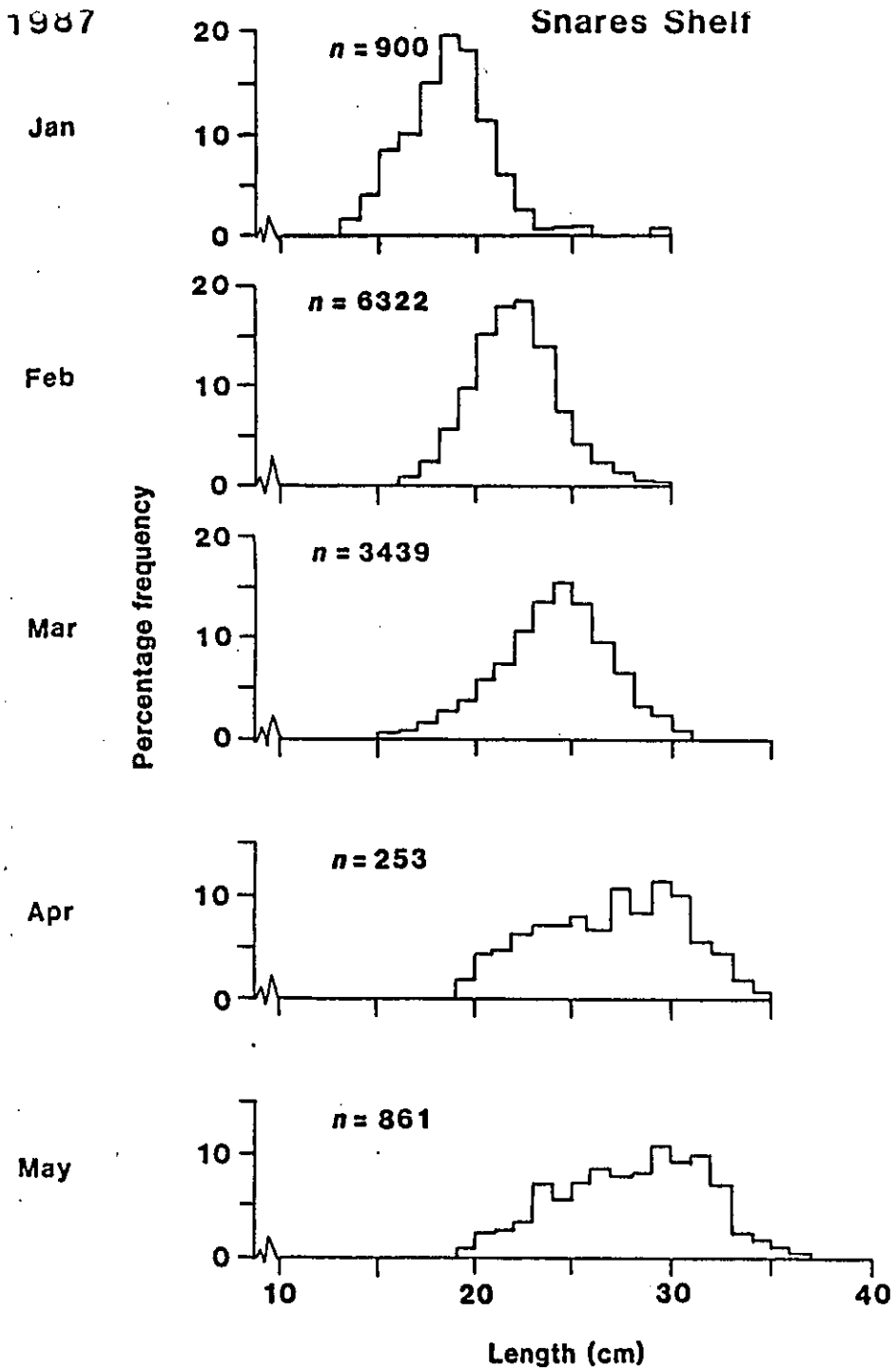
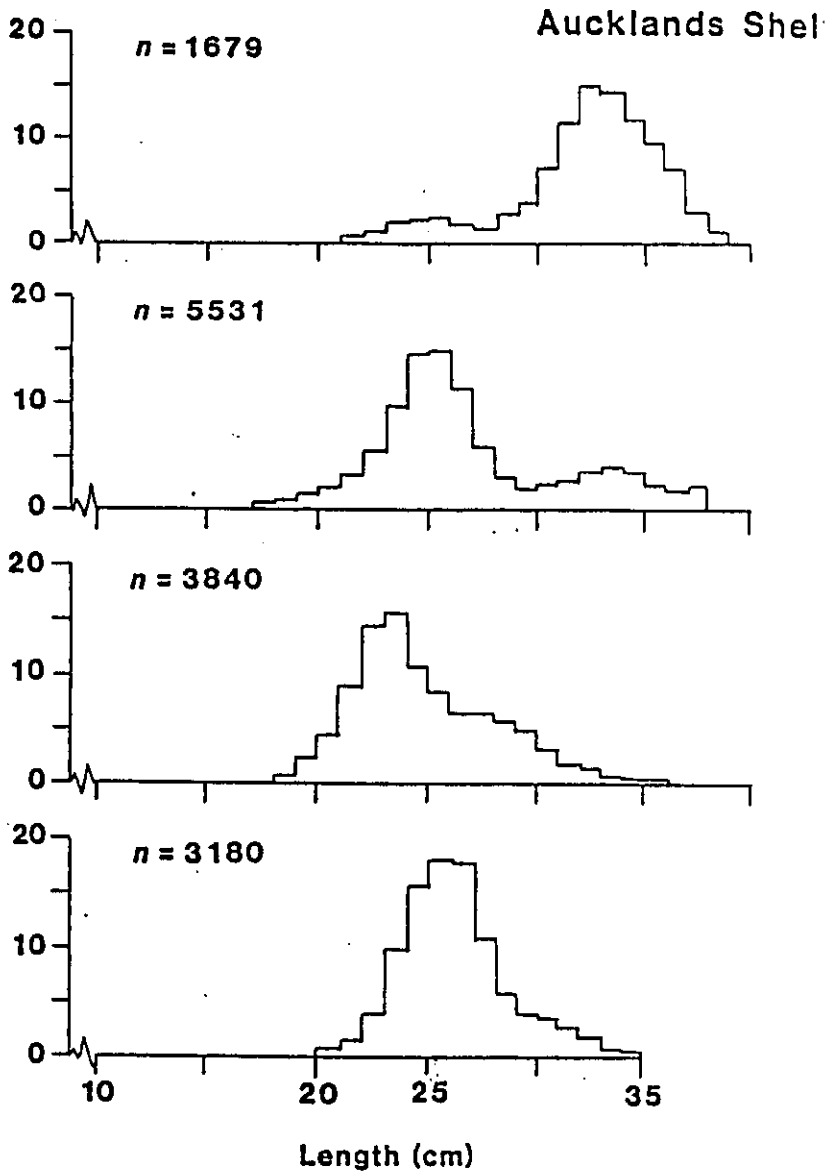


Fig. 3: Length frequency of southern arrow squid from the Snares and Aucklands Shelfs.



	AREA								No Position Given	Total Catch (t)	CPUE
	I	II	III	IV	V	VI	VII	VIII			
1980-81	983 3%	0	20,110 53%	89 <1%	0	15,789 42%	780 2%		52 <1%	37,803	3.5
1981-82	5,608 12%	0	16,498 37%	16 <1%	0	21,227 48%	1,261 3%		39 <1%	44,649	3.3
1982-83	9,962 19%	0	28,750 56%	10 <1%	0	8,212 16%	4,376 8%		5 <1%	51,315	2.8
1983-84	1,637 2%	0	4,427 6%	2 <1%	4 <1%	16,335 24%	47,045 68%	1 <1%	57 <1%	69,508	3.3
1984-85	591 1%	0	5,099 13%	<1 <1%	0	14,412 38%	18,127 47%	0	8 <1%	38,237[1]	2.5
1985-86	122 <1%	0	7,514 27%	0	7 <1%	4,217 15%	15,839 57%	0	0	27,754	4.7
1986-87[2]										30,365	3.8

TABLE 1. Jig squid catch (t) by area (refer to Figure 1). Percentages are the proportion of the catch from each area. [1]Does not include 281.5 t from one vessel for which logbooks are not held. [2]Provisional. Catch per unit effort (CPUE) is given in tonnes per vessel-day, where one vessel-day is a 24 hour period during which some fishing took place.

TABLE 2. Trawled squid catch (tonnes) by area for the New Zealand EEZ.

Factory refers to New Zealand deepwater factory trawlers. Other domestic trawlers are not included.

UND refers to undefined areas.

No data are available for the 1980-81 fishing year.

TABLE 2

Apr 78 - Mar 79

	NEW ZEALAND		FOREIGN LICENSED			
AREA	FACTORY	CHARTERED	JAPAN	KOREA	USSR	TOTAL
A						
B						
C(M)		4	56			60
C(-)		181	2,287			2,468
D		64		4		68
E(A)		278	86		8,459	8,823
E(B)			<1			<1
E(C)			<1		17	17
E(P)		2	<1		2	4
F(E)			72		<1	72
F(W)			91			91
G			51	646		697
H			235	205		440
UND		4		1		5
TOTAL		533	2,878	856	8,478	12,745

Apr 79 - Mar 80

	NEW ZEALAND		FOREIGN LICENSED			
AREA	FACTORY	CHARTERED	JAPAN	KOREA	USSR	TOTAL
A						
B			10			10
C(M)		62				62
C(-)		579			1	580
D		435	252	516		1,203
E(A)		10,000	11,207	9	10,611	31,827
E(B)			4			4
E(C)			13		67	80
E(P)		<1	<1		4	4
F(E)		281	280	76	11	648
F(W)		109	20	44	8	181
G		13				13
H		23	43	130		196
UND		4	4		22	30
TOTAL		11,506	11,833	775	10,724	34,838

TABLE 2 Cont.

Apr 81 - Mar 82

	NEW ZEALAND		FOREIGN LICENSED			
AREA	FACTORY	CHARTERED	JAPAN	KOREA	USSR	TOTAL
A						
B						
C(M)		71				71
C(-)		174				174
D		60	23	<1		83
E(A)		24,174	5,895	1,097	7,333	38,499
E(B)					12	12
E(C)		43	<1		34	77
E(P)		1			10	11
F(E)		1,042	1,036	83		2,161
F(W)		107	218	13		338
G		22				22
H		156	112	28		296
UND		43			2	45
TOTAL		25,893	7,284	1,221	7,391	41,789

Apr 82 - Mar 83

	NEW ZEALAND		FOREIGN LICENSED			
AREA	FACTORY	CHARTERED	JAPAN	KOREA	USSR	TOTAL
A						
B						
C(M)		41	<1			41
C(-)		46	<1			46
D	1	277	38	7		323
E(A)	118	17,240	3,815	1,707	9,836	32,716
E(B)			1			1
E(C)		18	1		7	26
E(P)		531	2	6	441	980
F(E)	248	2,265	755	30		3,298
F(W)	18	101	203	4		326
G		43				43
H		162	149	<1		311
UND		<1				<1
TOTAL	385	20,724	4,964	1,754	10,284	38,111

TABLE 2 Cont.

Apr 83 - Sep 83

	NEW ZEALAND		FOREIGN LICENSED			
AREA	FACTORY	CHARTERED	JAPAN	KOREA	USSR	TOTAL
A						
B						
C(M)		265				265
C(-)		525				525
D	2	2,659	2,051	218		4,930
E(A)	64	2,660	367	1,077	4,062	8,230
E(B)			<1			<1
E(C)			<1		32	32
E(P)					5	5
F(E)	41	2,121	312	74		2,548
F(W)		22	56	2		80
G		37				37
H		8	31	108		147
UND		13			2	15
TOTAL	107	8,310	2,817	1,479	4,101	16,814

Oct 83 - Sep 84

	NEW ZEALAND		FOREIGN LICENSED			
AREA	FACTORY	CHARTERED	JAPAN	KOREA	USSR	TOTAL
A						
B						
C(M)	<1	43				43
C(-)		121				121
D	<1	667	76	159		902
E(A)		12,365	2,273	1,469	5,884	21,991
E(B)			<1	3	15	18
E(C)					45	45
E(P)		99			19	118
F(E)	52	5,346	894	590		6,882
F(W)	5	4,593	2,767	503		7,868
G		50				50
H		171	147	56		374
UND	2		<1			2
TOTAL	59	23,455	6,157	2,780	5,963	38,414

TABLE 2 Cont.

Oct 84 - Sep 85

	NEW ZEALAND		FOREIGN LICENSED			
AREA	FACTORY	CHARTERED	JAPAN	KOREA	USSR	TOTAL
A						
B						
C(M)	<1	90				90
C(-)		451				451
D	<1	947	53	168		1,168
E(A)	220	16,208	3,238	1,180	7,485	28,331
E(B)			<1	9		9
E(C)		7	<1		58	65
E(P)		14	<1	2	871	887
F(E)	185	10,827	2,437	393		13,842
F(W)	227	4,273	945	520		5,965
G		21				21
H		198	46	24		268
UND		1				1
TOTAL	632	33,037	6,719	2,296	8,414	51,098

Oct 85 - Sep 86

	NEW ZEALAND		FOREIGN LICENSED			
AREA	FACTORY	CHARTERED	JAPAN	KOREA	USSR	TOTAL
A						
B						
C(M)	<1	88				88
C(-)	<1	420				420
D	3	121	33	34		191
E(A)	8	14,298	3,326	678	7,536	25,846
E(B)						
E(C)		1	<1		34	35
E(P)		58	<1	4	663	725
F(E)	15	8,598	1,966	129	14	10,722
F(W)	29	4,110	1,171	496		5,806
G		62				62
H		66	29	22		117
UND						
TOTAL	55	27,822	6,525	1,363	8,247	44,012