

THE BIOLOGY OF JIG-CAUGHT ARROW SQUID (*NOTOTODARUS* SPP.) IN NEW ZEALAND WATERS

BY P. E. ROBERTS

Fisheries Research Division, Wellington, New Zealand.

* Present address: Marine Science Laboratories,
Queenscliff, Victoria, Australia.

Abstract

Two species of *Nototodarus* occur in New Zealand waters. They are caught by jigging from December to May. *N. sloani* is found in northern (warmer) waters; while *Nototodarus* sp. occurs in southern (colder) waters. Growth rates for both species are 2.5-4.0 cm ML per month for younger squid, and 1.5-3.0 cm ML per month for older squid, with a total life span of at least 12 months. Possible spawning grounds are inferred from presence of mated females. The general ecology is discussed.

Taxonomy

Nototodarus sloani (Gray, 1845) was described from specimens collected in Waitemata Harbour off the north-east coast of New Zealand (36°40'S latitude). *Nototodarus sloani* is distributed north of the subtropical convergence zone and is replaced by an undescribed species of *Nototodarus* which has its centre of distribution within and south of the convergence zone. The two species can be easily distinguished by examination of the male hectocotyliised ventral arms (see Smith *et al.*, 1981).

Current studies indicate that *N. sloani* has geographically distinct large and small growth forms. Arrow squid of both sexes from western New Zealand, mature at 26-35 cm ML (maximum mantle length 42 cm) and fully ripe females weigh up to 1800 g, while those from north-east New Zealand mature at 20-25 cm ML (maximum 32 cm) and fully ripe females weigh up to 600 g. The undescribed arrow squid from south and south-eastern waters is similar in growth characteristics to the western population of *N. sloani*.

The jig fishery

In New Zealand coastal waters, arrow squid are caught by traditional Japanese jig fishing methods. Vessels of 99-500+ gross registered tonnes, with between 50 and 80 2000-4000 watt lamps are used with a mix of hand and automatic jigging machines.

Annual catches of both species of arrow squid range between 13,000 and 40,000 tonnes.

The vessels usually fish a 90-120 day season between December and April with mean catch rates of 1.5-3.9 tonnes per vessel-day (Table 1). Catch rate varies with vessel size. In the 1978-79 season catch data from 57 vessels showed that CPUE was highest for vessels of 400-499 GRT (Table 2), although the 99 t vessels also had high catch rates.

The jig vessels fish throughout central and southern New Zealand waters but tend to concentrate in specific areas which are becoming traditional fishing grounds. The main fishing areas are evident in the summaries of catch (Figure 1).

Growth rate

Time series of mantle length frequency groups present a confusing picture comprising a mix of modal groups at any one time and no clear indication of consistent increase in one mode in one area. Analyses of about 150,000 measurements (Figures 2, 3) from jigging vessels fishing the 1978-79 season indicates that within the exploited length range both *N. sloani* and *Nototodarus* sp. have similar growth rates of 2.5-4.0 cm ML per month for smaller squid (18-24 cm, 200-400 g) and 1.5-3.0 cm ML per month for larger squid (24-33 cm, 400-900 g).

From these data it is inferred that arrow squids of the two species increase from 18 cm to 28 cm in males and to 33 cm in females in 4½-8 months.

The length-frequency graphs also indicate similar growth rates for very large arrow

TABLE 1

Catch (tonnes) and Catch Per Unit Effort (tonnes per vessel day) of Arrow Squid Caught by Japanese, Taiwanese, and Korean Jigging Vessels 1972-80 in New Zealand Waters

	1972/73	1973/74	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80*
No. vessels	72	157	154	138	135	130	174	182
No. days	3 452	9 605	11 939	12 918	12 437	10 900	16 440	16 074
Total Catch	13 532	14 856	19 201	20 977	26 296	41 750	24 524	40 300
CPUE	3.92	1.55	1.61	1.62	2.11	3.83	1.49	2.51

* Figures for this year preliminary.

TABLE 2

Variation in catch and catch rate (CPUE) of squid for 57 jig fishing vessels during the 1978-79 squid season

Vessel size	No. vessels	Catch (t)	CPUE (t/day)
<100 t	9	1 184	1.45
100-199	1	75	1.29
200-298	23	2 328	1.13
300-399	10	1 350	1.33
400-499	10	1 912	1.83
500+	4	332	1.04
	57	7 203	1.35

squids, with the maximum size of males increasing from 27.5 to 34.5 cm ML in 100 days (2.1 cm per month), and for females from 29.5 to 40.5 cm ML in 100 days (3.0 cm ML per month). These data indicate that over the exploited size range arrow squid grow from 18 to 35 cm (male) or to 40 cm (female) in approximately 7½ to 11 months, suggesting a total life span of greater than 12 months.

The stock of *N. sloani* occurring off the north-east of New Zealand, as yet unexploited by the foreign jig fleet, has quite different growth characters from those of *N. sloani* of the west coast stock. The north-eastern squid mature at a smaller length and weight, but like the other stocks appear to have at least two spawning seasons (summer and winter). Insufficient data exist from which growth rates can be described for this stock.

Spawning groups

The mantle length frequency graphs (Figures 2, 3) also show that small squid (i.e. "juveniles" < 18 cm mantle length) were frequently caught.

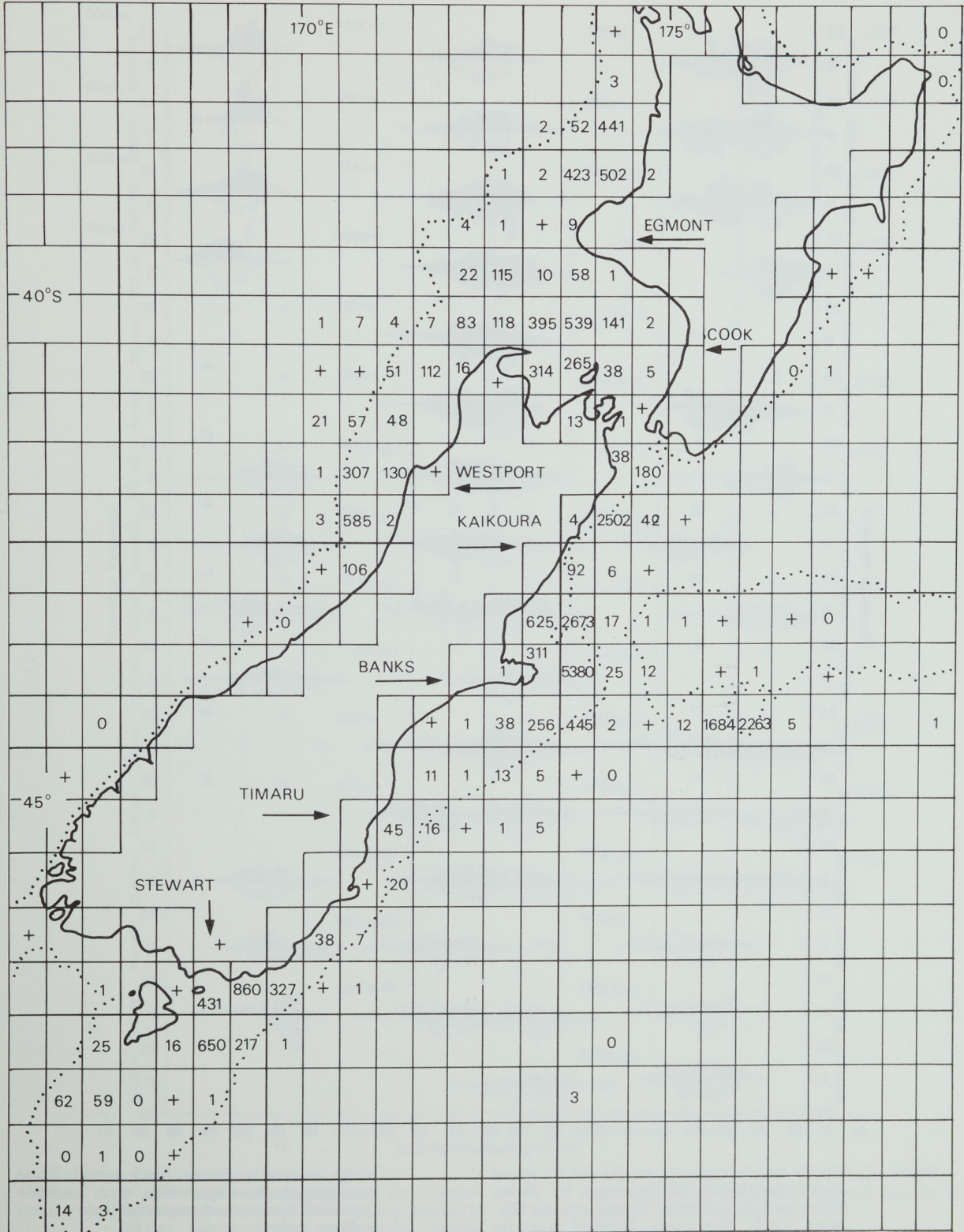
In Cook Strait (western New Zealand) *N. sloani* (Figure 2, centre) juveniles were abundant in late December and mid-March, while off Banks Peninsula (eastern New Zealand) *Nototodarus* sp. juveniles were abundant in catches during January and April. These data suggest that at least two spawning groups support the stocks of each species.

The occurrence of a large proportion of mated females (i.e., those implanted with spermatophore sacs around the buccal mass) was used as an indication of possible spawning grounds of arrow squid. In the western waters *N. sloani* apparently has a major spawning in April, probably in the Egmont region where most females over 26 cm ML were implanted with spermatophores from March to mid-May (Figure 2, left). There was no similar indication of a spawning ground for east coast squid (*Nototodarus* sp.) (Figure 3). (Note: subsequent trawl data suggest at least two spawning periods in the Banks region: July and December).

Ecology

Sea surface temperature and salinity data collected by observers during the 1978-79 season have been compiled by 10 day time periods and 0.5° squares of latitude and longitude (Table 3). These data show that squid are caught over a wide range of temperature and salinity values. Catch rates (CPUE) were higher in colder, low salinity water, perhaps reflecting the higher abundance (or catchability) of *Nototodarus* sp. over *N. sloani* during the 1978-79 season.

Figure 1. Catch (tonnes) of arrow squid by 0.5° squares of latitude and longitude for the 1978-79 jig-season (174 vessels, 16, 440 vessel-days, 24,524 tonnes).



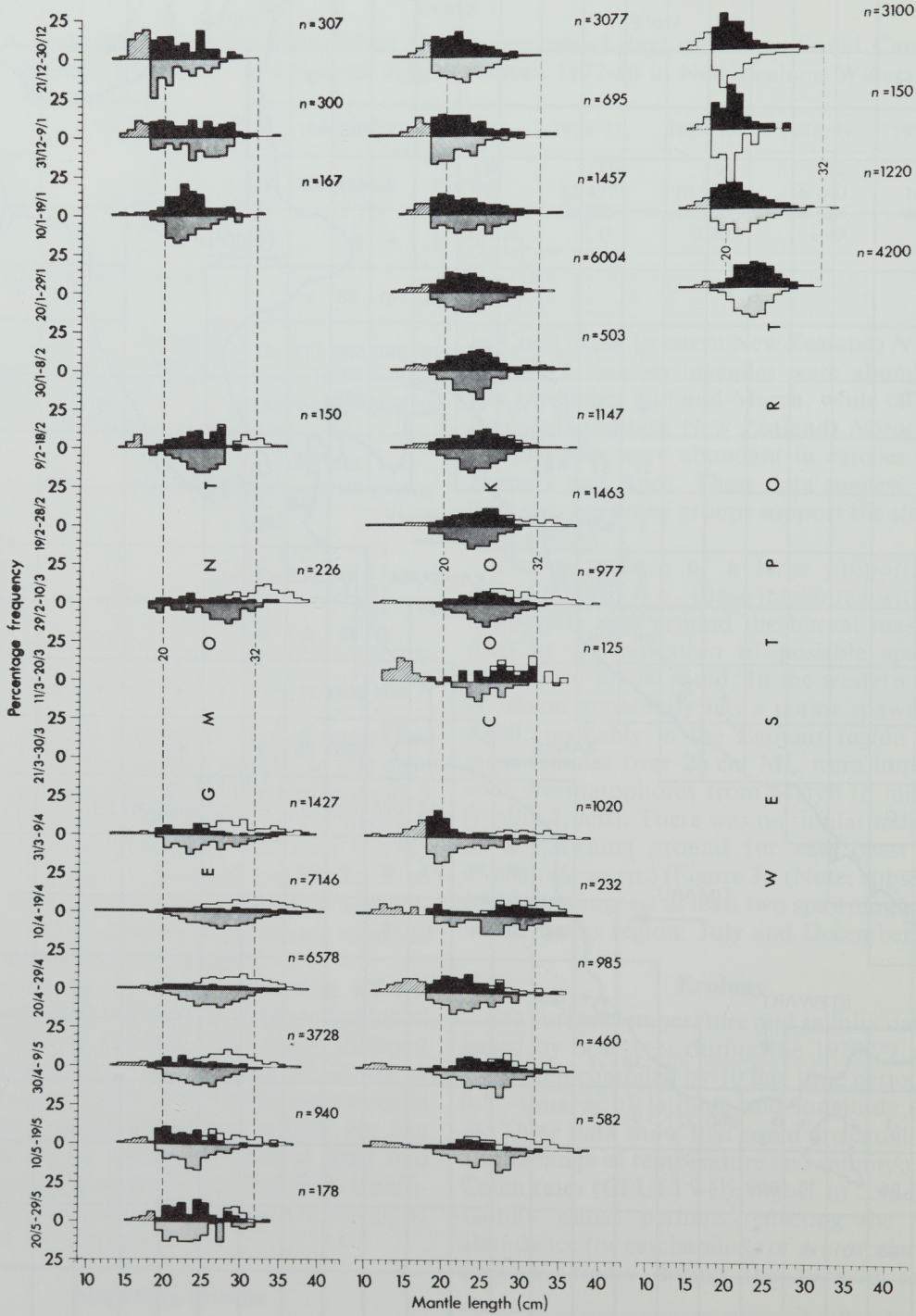


Figure 2. Mantle length-frequency graphs for *N. sloani* during the 1978-79 fishing season by 10-day fishing periods and major fishing grounds (Egmont, Cook, West-port). Hatched areas in-

dicate unsexed specimens, black areas indicate uncopulated females, white areas indicate copulated females and grey areas (below lines) indicate males.

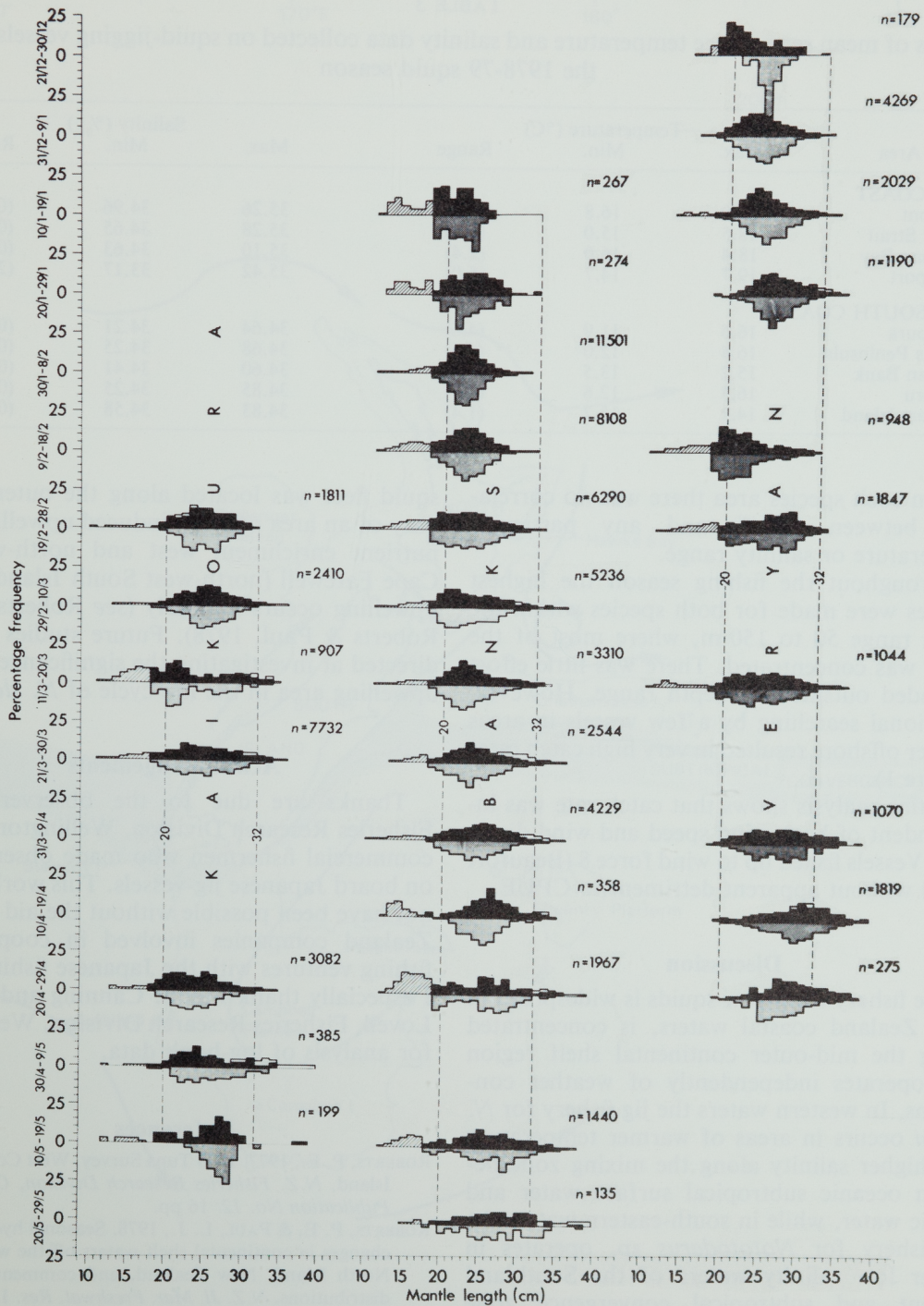


Figure 3. Mantle length-frequency graphs for *Nototodarus* sp. during the 1978-79 fishing season by 10-day fishing periods and major fishing

grounds (Karkoura, Banks, Veryan). See Fig. 2 legend for key.

TABLE 3

Ranges of mean sea surface temperature and salinity data collected on squid-jigging vessels during the 1978-79 squid season

Fishing Area	Temperature (°C)			Salinity (‰)		
	Max.	Min.	Range	Max.	Min.	Range
WEST COAST						
Egmont	19.0	16.8	(2.2)	35.26	34.96	(0.30)
Cook Strait	18.5	15.0	(3.5)	35.28	34.65	(0.63)
Tasman Bay	18.4	16.0	(2.4)	35.10	34.63	(0.47)
Westport	19.7	14.7	(5.0)	35.42	33.17	(2.25)
EAST/SOUTH COASTS						
Kaikoura	16.5	11.9	(4.6)	34.64	34.21	(0.43)
Banks Peninsula	16.4	12.0	(4.4)	34.68	34.25	(0.43)
Veryan Bank	15.2	13.5	(1.7)	34.60	34.41	(0.19)
Timaru	16.3	12.6	(3.7)	34.85	34.25	(0.60)
Stewart Island	14.1	12.7	(1.4)	34.83	34.58	(0.25)

Within each species area there was no correlation between CPUE and any particular temperature or salinity range.

Throughout the fishing season the highest catches were made for both species within the depth range 50 to 150 m, where most of the effort was concentrated. There was little effort expended outside this depth range. However, occasional searching by a few vessels in areas further offshore resulted in very high catch rates (Figure 1).

Initial analysis shows that catch rate was independent of both wind speed and wind direction. Vessels fished up to wind force 8 (Beaufort scale) without apparent detriment to CPUE.

Discussion

The fishery for arrow squids is widespread in New Zealand coastal waters, is concentrated along the mid-outer continental shelf region and operates independently of weather conditions. In western waters the jig fishery for *N. sloani* occurs in areas of warmer temperature and higher salinity along the mixing zone between oceanic subtropical surface water and neritic water, while in south-eastern waters the jig fishery for *Nototodarus* sp. operates in colder low salinity waters of the Southland current and subtropical convergence zone (Figure 4).

Recent satellite images of the Cook Strait region show that in January-February 1981 the

squid fleet was located along the outer boundary of an area of wind-induced upwelling and nutrient enrichment west and north-west of Cape Farewell (north-west South Island). This upwelling occurs regularly (see Roberts, 1977; Roberts & Paul, 1978). Future studies will be directed at investigating the significance of this upwelling area in the life cycle of *N. sloani*.

Acknowledgements

Thanks are due to the observers from Fisheries Research Division, Wellington and to commercial fishermen who made observations on board Japanese jig-vessels. This work would not have been possible without the aid of New Zealand companies involved in cooperative-fishing ventures with the Japanese fishing fleet. I especially thank Mr. S. Canning and Mr. B. Lovell, Fisheries Research Division, Wellington for analysis of log-book data.

References

- ROBERTS, P. E., 1977. 1973 Tuna Survey, West Coast South Island. *N.Z. Fisheries Research Division, Occasional Publication No. 12*: 16 pp.
- ROBERTS, P. E. & PAUL, L. J., 1978. Seasonal hydrological changes in continental shelf waters off the west coast, North Island, New Zealand, and comments on fish distributions. *N.Z. Jl. Mar. Freshwat. Res.* 12: 323-39.
- SMITH, P. J., ROBERTS, P. E., & HURST, R. J., 1981. Evidence for two species of arrow squid in the New Zealand fishery. *N.Z. Jl. Mar. Freshwat. Res.* 15: 247-53.

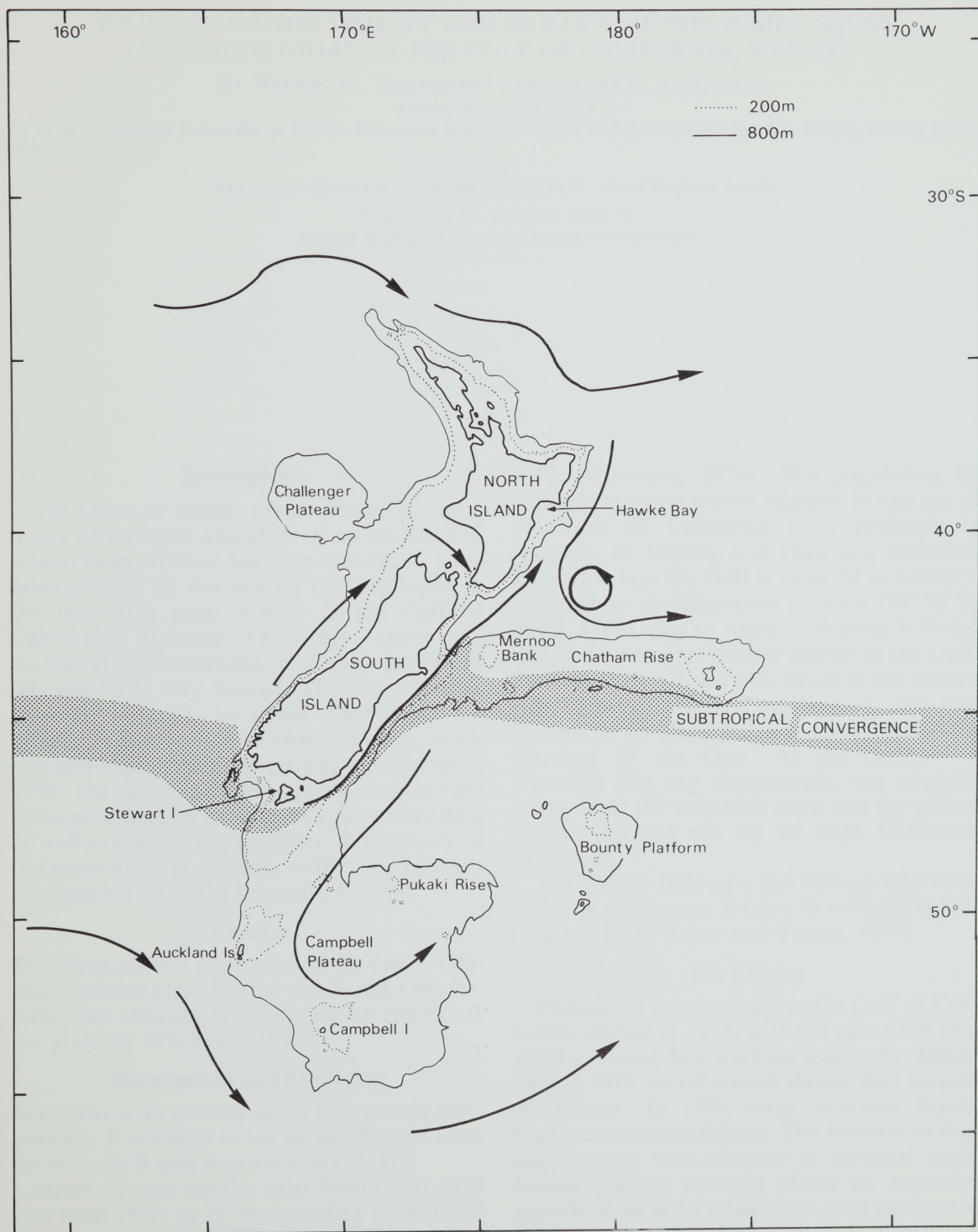


Figure 4. Major bathymetric features and surface currents of the New Zealand region.