Biological data on squid caught in the fishery off south-eastern Australia:

A pilot study

Final Report to the

Australian Fisheries Management Authority

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Background

Arrow squid (also called Gould's squid) are endemic to Australia and distributed from southern Queensland to the central coast of Western Australia (Kailola *et al*. 1993). They are distinguished by their extended, cylindrical mantle that tapers to a pointed posterior end with two dorso-ventrally flattened triangular fins extending from this point down one third the mantle length.

Historically, significant catches of squid have occurred off south-eastern Australia, mainly from an area 30 nm off Portland, Victoria (Fig. 1) where they are believed to aggregate for spawning (Wadley 1995). Arrow squid (*Nototodarus gouldi*) made up the bulk of the catch, but other species of commercial importance were also caught, including southern calamari (*Sepioteuthis australis*), offshore red ocean squid (*Ommastrephes bartrami*) and southern ocean arrow squid (*Todarodes filippovae*). Historically, much of the catch was by foreign vessels jigging in the Australian Fishing Zone (AFZ) (Fig. 1). Under the OCS arrangements made in 1995, squid taken beyond the 3-mile state limit are under Commonwealth jurisdiction. Foreign fishing has continued under these arrangements, with access being granted to Japanese, Korean and other Asian vessels, but there has been rapidly increasing interest by the domestic fleet with the expansion of local markets and the possibility of exports (Wadley 1995). Although the domestic fleet consists of a number of specialised squid jigging vessels, a significant amount of the catch is also taken by trawlers working in the South East Fishery (SEF). Squid is not included under SEF quotas and as such, it is a valuable and increasingly important by-catch. In general, recognition of the potential value of the squid resource off south eastern Australia is fuelling the current rapid expansion in the fishery.

Concern from industry and scientists regarding the rapidly increasing fishing effort on the aggregations of squid off Portland has prompted calls for increased monitoring of the catches. Although some research has been undertaken on the biology and fishery for squid in these areas (eg. Harrison 1979; Winstanley et al. 1983; Dunning 1988), and catch and effort information is collected, these data have not proved sufficient to support formal assessment of the status of the stocks (Wadley 1995). It is envisaged that this pilot study is the first step towards the development of a detailed research program which will collect information to address this problem.

The aims of the pilot project were to:

? Collect information on the species composition, length-frequency and sex ratio of squid caught and retained by jiggers and trawlers operating out of Portland;

? Improve our knowledge of the fishery and develop sampling methods and data collection procedures that could be used as the basis of developing a more substantial research proposal.

? Provide a brief summary of the information collected in the pilot survey to the Australian Fisheries Management Authority (AFMA).

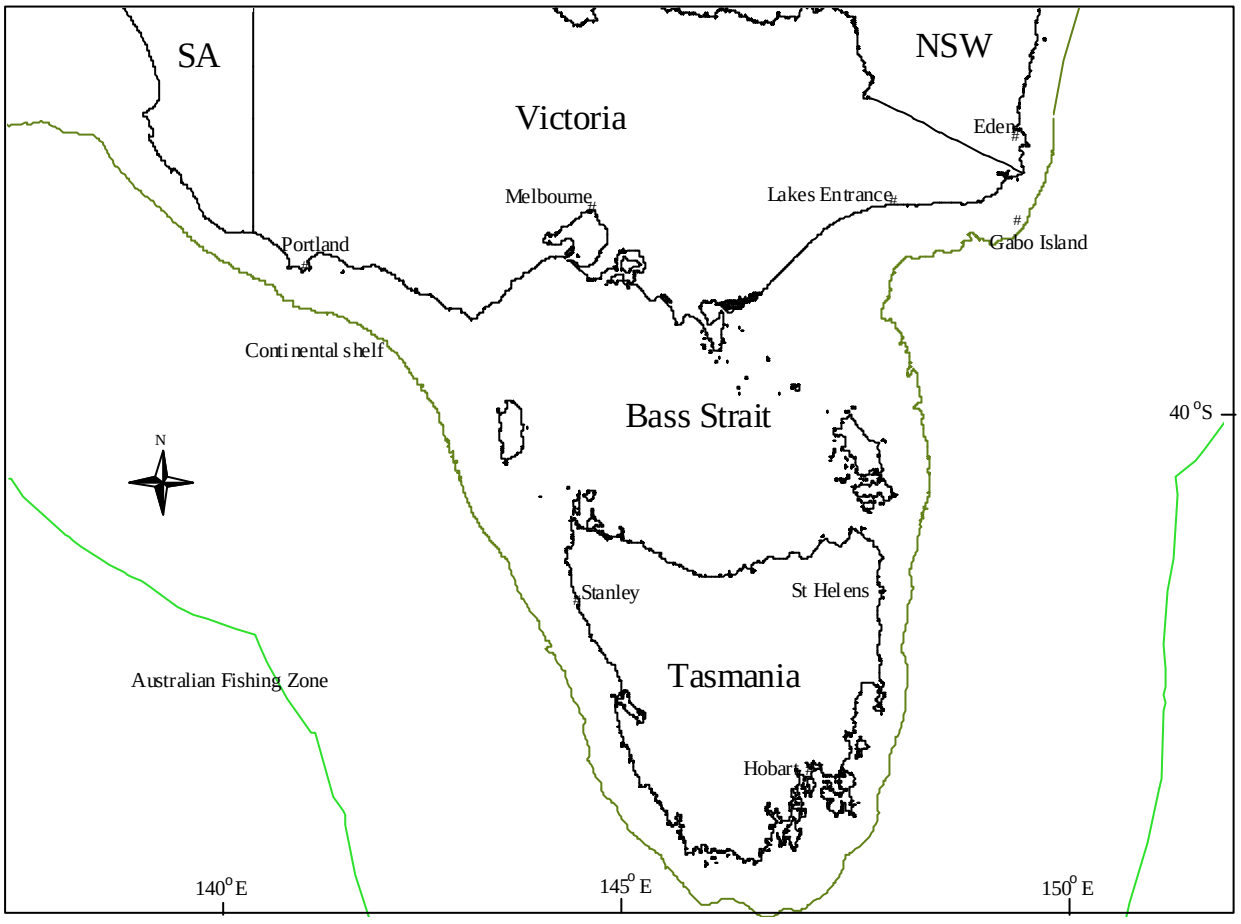

Figure 1. Arrow squid (*Nototodarus gouldi*) are caught throughout south eastern Australian waters. The fishery often targets the large aggregations which form off Portland from May to July.

Materials and Methods

General description of squid jigging methods

The jigging vessels observed in this report were mostly modified commercial scallop boats operating out of Port Fairy and Portland. These boats usually leave port mid afternoon to be on the fishing grounds by dusk when they begin fishing. Before fishing commences a sea anchor (approx. 18m long) is deployed from the bow, allowing the vessel to drift with the tide.

The vessels operate a number of squid jig machines (usually 6 at least), with each machine consisting of two monofilament lines approximately 100m long. At the end of each line is a 1.8 kg weight, with 20 squid jigs spaced one metre apart above this. A lower number of jigs per line can be used if catch rates are particularly high, reducing the likelihood of line breakage.

Due to squid concentrating at different depths on any given night, the jigging machines can be adjusted to fish at a variety of depths. The speed and action of jig retrieval can also be altered by the fisher. Approximately 4m above the vessels' main deck, about thirty 2000-watt lights act as an attractant for squid prey, hence luring feeding squid to the jigs.

Catch rates are often spasmodic even when high numbers of squid are being caught. On most squid vessels the lights and jigging machines remain on for the entire night until before daybreak when the squid stop being caught. The vessels usually then return to port with their catch.

Data collection

The study was undertaken on boats working out of Port Fairy and Portland between May and July 1997. Two separate methods were used to collect information depending on whether the catch was from trawlers or jigging vessels. Trawler catches were measured when the boats returned to port and unloaded. On squid jigging vessels, however, observers were placed onboard during normal fishing operations, allowing us to collect more detailed operational information. Because there was no grading of squid by the deckhands, sub-samples of the catch could be taken by the fish-bin and measured at a convenient time and location. Information on the species composition and length-frequency of all squid caught or a representative sub-sample of the catch was collected.

Having undertaken a few trips, two data sheets were developed: one for recording general length-frequency information; the other for individual biological data. Both had a section to record the appropriate operational data (Appendix 1).

Biological data on the captured squid were collected as follows. The mantle length (to the nearest cm) was measured from the anterodorsal protuberance to the apex of the tail fin (Fig. 2). The total length of a subsample of animals was also measured to provide a relationship between mantle length and total length. Total length was measured from the apex of the tail fin to the end of the longest arm. As a general rule, mantle length is used in preference to total length because arms can be easily damaged or stretched (O'Sullivan 1980). Regressions of total length against mantle length are provided. Where possible, the sex of the squid was determined, but in some length-frequency measurements, the sex was not recorded. Males were most easily recognised by the hectocotylisation of the right-hand ventral arm, in which the suckers at the distal end are modified as papillae for passing spermatophores during copulation. The drained wet weight of the squid was measured to the nearest 10g.

Data analysis

The biological information collected on squid caught during this pilot study is represented through a range of length-frequency histograms and regression plots. Due to the preliminary nature of the project, detailed statistical analyses have not been undertaken, but qualitative comparisons have been made where appropriate. These comparisons are restricted to describing the length-frequency and length-weight relationships of the different sexes and determining the differences between male and female squid and the catches of jiggers and trawlers.

Length-frequency histograms and regression analyses were undertaken using 1 cm length classes. Comparison of regressions was made using analysis of variance (ANOVA).

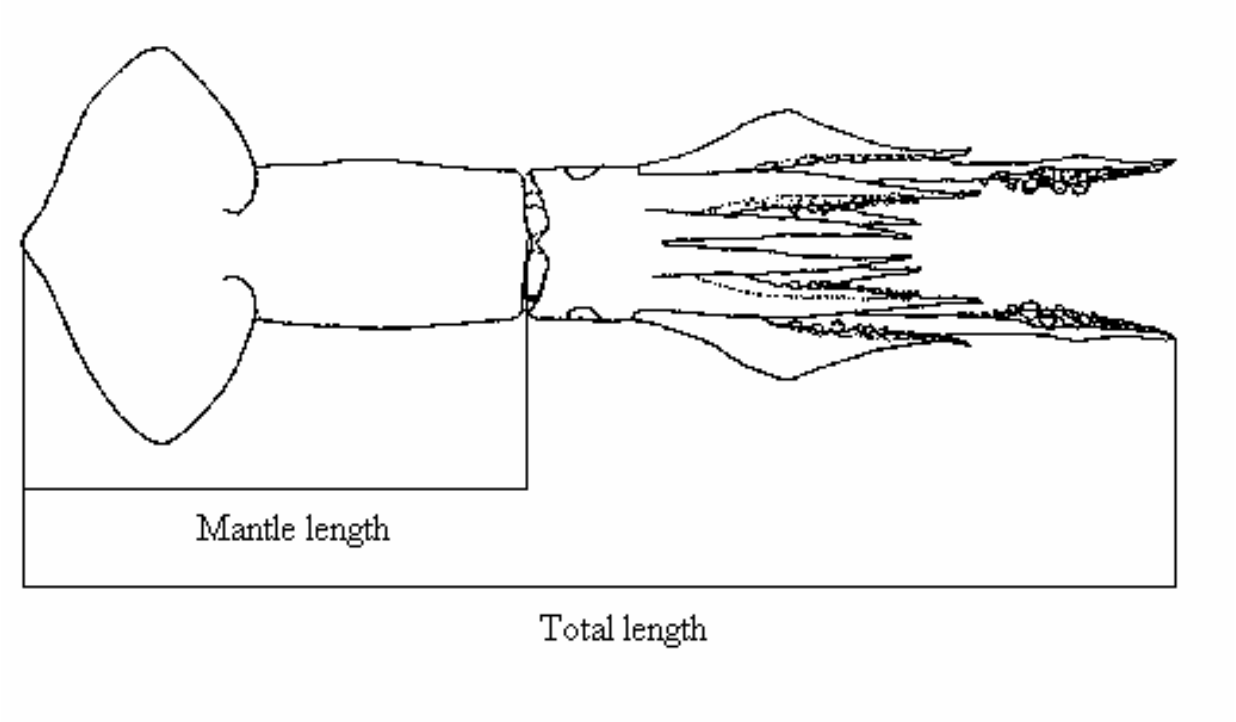

Figure 2. Dorsal view of an arrow squid (*Nototodarus gouldi*) showing measurements taken for mantle length (ML) and total length (TL). Males were distinguished by hectocotylisation (modification of suckers into papillae) of the right-hand ventral arm.

Results and Discussion

The project was not initiated until late May, so information obtained in this report is restricted to the last 2 months of the main jigging season. Jigging finished in mid-June, when market prices of squid dropped and they also became more difficult to catch on a jig. Squid remained a part of the trawl bycatch through out June and July. Seven fishing trips aboard jigging vessels were monitored, while the catches from three trips by trawlers were measured at port. A total of 2529 *N. gouldi* were sampled from the catches of both jiggers (2079) and trawlers (450). Length-frequency information was collected on all of these squid and further biological information was collected on a sample of 459 animals. Details of the various data collection periods are shown in Table 1. *Nototodarus gouldi* was the predominant catch of jiggers and the only retained catch by the trawlers. The following results on the length-frequency and biology are based on this species only.

Table 1. Number of squid sampled for length-frequency and other biological information (sex, total length, weight) from jiggers and trawlers working off the southern Victorian coast between May and July 1997.

Date	Method	Number of squid measured	
		Length-frequency	Biological
15 May 1997	Jig	89	49
17 May 1997	Jig	399	
30 May1997	Jig	394	
03 June1997	Jig	289	
04 June1997	Jig		56
09 June1997	Jig	449	
10 June1997	Jig		135
11 June1997	Jig		104
12 June1997	Jig		115
19 June1997	Trawl	188	
27 June1997	Trawl	186	
28 July1997	Trawl	76	
Total		2070	459

Biological data

Although the overall ratio of males and females (1068:924) in the sampled catches pooled across fishing method was close to 1:1, a chi-square test revealed there were significantly more males caught ($? ^{2}_{(0.05,1)} ? 10.41, p ? 0.0012$). There was a notable difference in the length-frequency of male and female *N. gouldi* (Fig. 3 a,b). Males generally ranged between 20 and 34 cm mantle length (ML) with a mean of 28.6 cm and a mode of 29 cm. In contrast, approximately a third of the females sampled were 34 cm or larger. This gave the females a far broader size distribution and a higher mean length (30.0 cm) and mode (33 cm).

Very similar results were found by Machida (1980) who found that male squid only reached lengths of 35 cm ML whilst females reached 40 cm ML. He also found that they could weigh up to 1.5 kg. This study found the heaviest male (1.3 kg) caught was more than 0.6 kg lighter than the corresponding female (1.9 kg). Most males were between 0.75 and 1.0 kg, whilst females were generally between 0.75 and 1.5 kg.

Fig. 3a

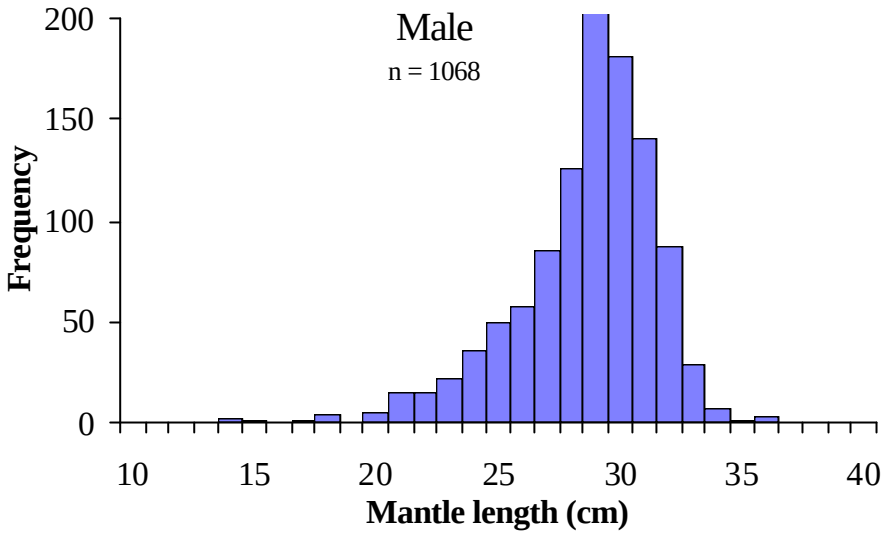

Fig. 3b

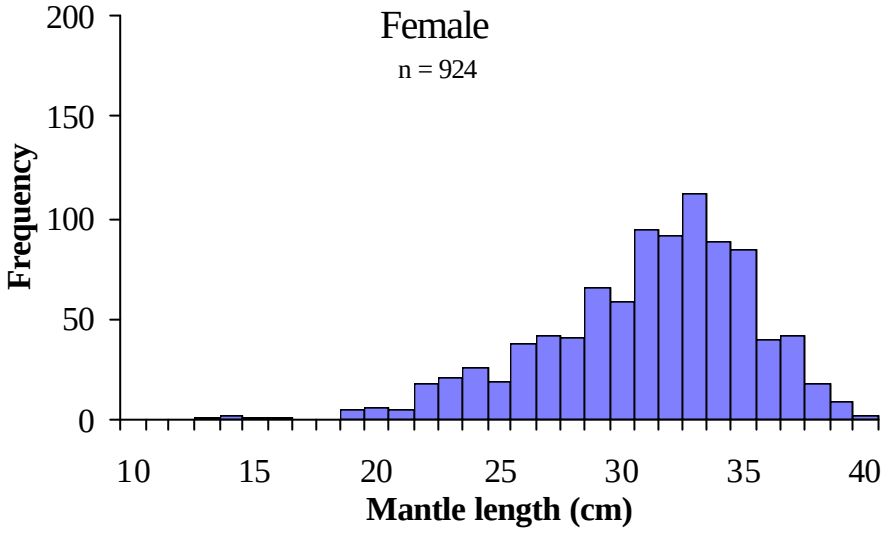

Figure 3. Size distribution of a) male and b) female *N. gouldi* sampled from trawl and jig catches off the western Victorian coast.

Although the size distribution of the sexes was quite different with females being generally and having a broader range, the length weight relationships for males and females showed very similar trends. Regression of weight against mantle length yielded the equations $W = 1.58?10^{-4} ? ML^{2.52}$ and $W = 4.51?10^{-5} ? ML^{2.87}$ for males and females respectively (Fig. 4 a,b). Although there were significant differences between the regressions for each sex, this is more likely to reflect the differences in the size range than any major difference between the weights for any given length.

Fig. 4a

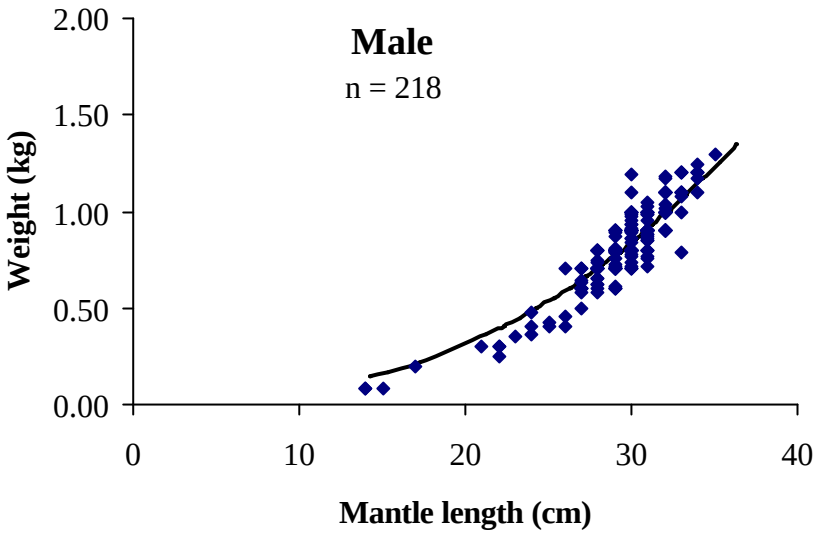

Fig. 4b

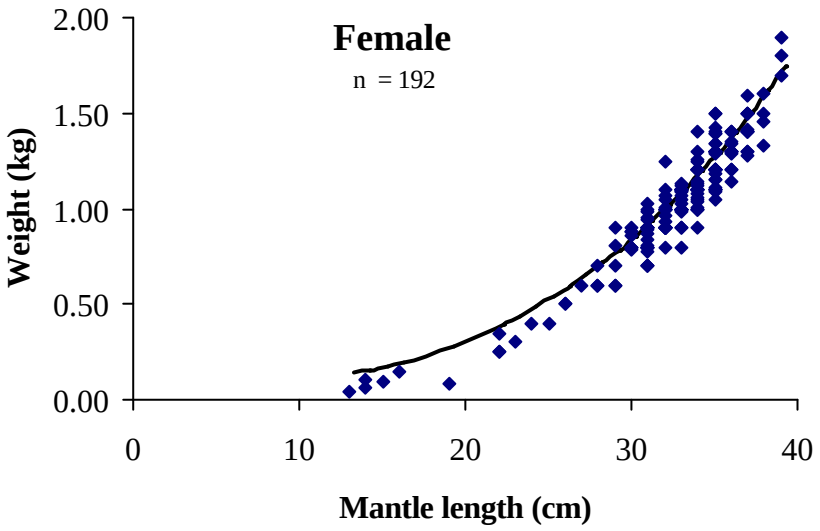

Figure 4. Length-weight regressions for: a) male; and b) female *N. gouldi* sampled from pooled trawl and jig catches off the western Victorian coast.

Although we did not undertake any ageing studies, it is estimated that *N. gouldi* may reach a maximum age of 12-18 months (Anon, 1993). It is thought arrow squid matures and breeds in cooler southern waters, then migrates north to spawn in warmer areas. Spawning is terminal in squid (Australian Broadcasting Commission Production).

As mentioned previously mantle length is the preferred measurement, nevertheless, it is worthwhile establishing the total length-mantle length relationship so conversions can be made. Although there were slight differences between the regressions of total length against mantle length for male (TL = 2.12 × ML + 0.54) and female (TL = 2.16 × ML + 0.60) *N. gouldi* the regression lines were very similar over the rage of data collected (Fig. 5).

Fig. 5

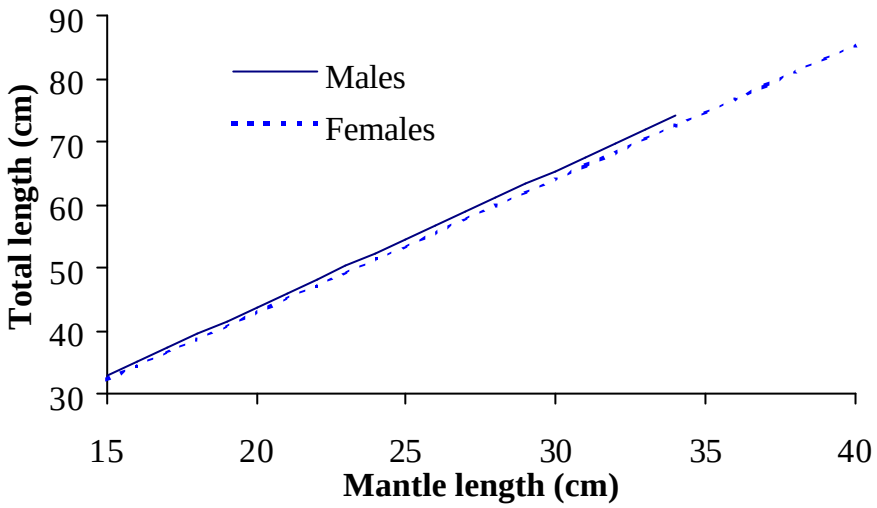

Figure 5. Regression of total length against mantle length for male (TL = 2.12 × ML + 0.54) and female (TL = 2.16 × ML + 0.60) *N. gouldi* pooled over gear.

Differences between jigging and trawling

It appeared that the size frequency of squid caught by trawlers was quite similar to that of jiggers. The length-frequency of female squid showed a broad range distribution regardless of fishing method. Similar sex ratios were obtained by the two methods. Jigging caught 54% males while trawling resulted in a 53 % male catch. Interestingly, the male and female mantle length modes were exactly the same (29 and 33 cm respectively) for both methods. (Fig. 6). Although these results are only based on a small pilot study, the fact that the trawlers and jiggers are working in similar areas and catching similar sized squid, suggests that they are catching squid from the same population. A more extensive sampling project with increased temporal and spatial coverage will need to be undertaken to better understand the distribution and movements of this population.

Fig. 6a

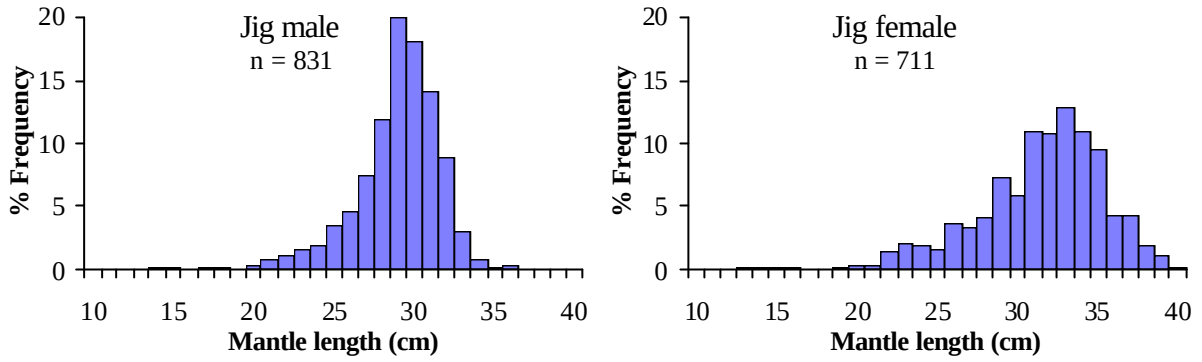

Fig. 6b

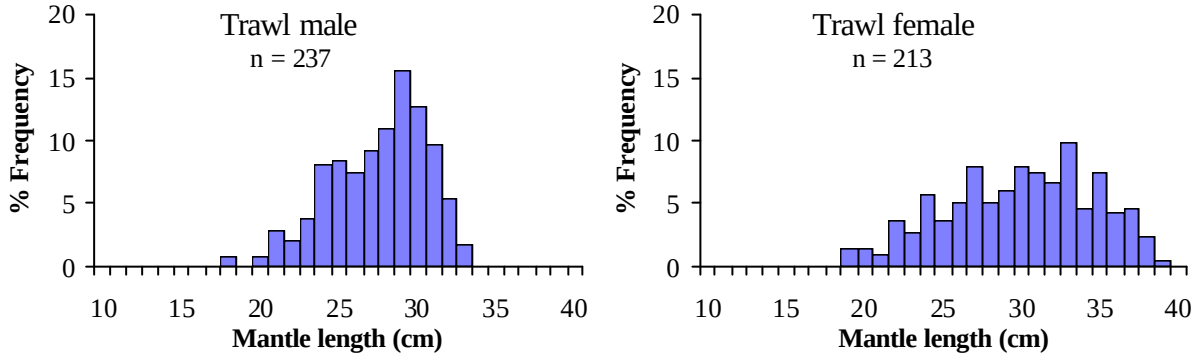

Figure 6 Length-frequency histograms of sampled catches of male and female *N. gouldi* caught by: a) squid jigging vessels; and b) SEF otter-boards trawlers with a codend mesh of 90 mm.

Although there is no size limit on *N. gouldi*, results from this project revealed that any squid under about 20 cm were discarded by the fisher. Presumably this is mainly a market driven aspect of the fishery. Throughout the project, only 72 of the 2079 arrow squid caught by jiggers were discarded, representing less than 4% of the catch. It is uncertain what level of discarding of squid occurs on trawlers. They are not a quota species, however, and observers have revealed that most squid are retained.

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Distribution

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Appendix 1. Data collection sheets

AFMA PILOT SQUID PROJECT

OPERATIONAL DATA

Date	Vessel	Skipper	Port Landed	Zone	Area Fished
Gear Type	Gear Size	Jig Length (m)	No. of Jigs	Depth (m)	Lat.
Set time	Haul time				Long.

LENGTH FREQUENCY DATA

Mantle Length (cm)	Species Sample (kg) Caught (kg) Retained?		Y / N	Mantle Length (cm)	Species Sample (kg) Caught (kg) Retained?		Y / N	Mantle Length (cm)	Species Sample (kg) Caught (kg) Retained?		Y / N
	M	F	U		M	F	U		M	F	U
0				0				0			
1				1				1			
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AFMA PILOT SQUID PROJECT

MARINE & FRESHWATER RESOURCES INSTITUTE

OPERATIONAL DATA

Date	Vessel	Skipper	Port Landed	Zone	Area Fished
Gear Type	Gear Size	Jig Length (m)	No. of Jigs	Depth (m)	Lat.
Set time	Haul time	Sample (kg)	Landed (kg)		Long.

BIOLOGICAL DATA

No.	Species	Sex M/F/U	Mantle Length (cm)	Total Length (cm)	Total Weight (kg)	Mated Y / N	Gonad Index 1 2 3 4 5 6	Retained Y / N	Comments
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3									
4									
5									
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