GROWTH AND DISTRIBUTION OF YOUNG MESONYCHOTEUTHIS HAMILTONI ROBSON (MOLLUSCA : CEPHALOPODA) : AN ANTARCTIC SQUID

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GROWTH AND DISTRIBUTION OF YOUNG *MESONYCHOTEUTHIS HAMILTONI* ROBSON (MOLLUSCA : CEPHALOPODA) : AN ANTARCTIC SQUID

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ANTARCTIC
CEPHALOPODA
MESONYCHOTEUTHIS
GROWTH
DISTRIBUTION
HYDROGRAPHY

ABSTRACT. — Thirty seven juvenile specimens and one adult specimen of the cranchiid squid *Mesonychoteuthis hamiltoni* were captured by the opening and closing RMT8 net during RRS 'Discovery' cruise 100 (1979) in the Southern Ocean. The collection extends the size range of juveniles of this species previously described and illustrated. The small specimens resemble small juveniles of *Galiteuthis glacialis*, which also occur in most hauls, but are separated on the following characters : (a) *M. hamiltoni* lacks paired tubercles at the nuchal mantle fusion, (b) *M. hamiltoni* possesses a more capacious and thicker mantle, which is freer at the nuchal fusion and less constricted posterior to the opening; (c) juvenile *M. hamiltoni* up to a size of 26.5 mm (the largest in the present collection) have very small fins, while in *G. glacialis* of this size the posterior portion of the mantle has begun to extend into a tail and prominent fins appears; (d) *M. hamiltoni* has longer tentacles until it reaches a dorsal mantle length of approximately 25 mm. All specimens of *M. hamiltoni* were captured to the south of the Antarctic Convergence, and most were captured at depths between 20 m and 500 m apparently concentrated in the upper zone of 'Warm Deep Water' beneath the surface layer. Four newly hatched specimens were captured at 55°35'S between 20 and 500 m. The adult specimen was captured in a haul which had sampled a depth horizon from 2 000 m to 2 200 m.

ANTARCTIQUE
CEPHALOPODA
MESONYCHOTEUTHIS
CROISSANCE
DISTRIBUTION
HYDROGRAPHIE

RÉSUMÉ. — Trente-sept juvéniles et un adulte de *Mesonychoteuthis hamiltoni* (Cranchiidés) ont été récoltés à l'aide d'un filet fermant à double commande pendant la Campagne 100 (1979) du N/O « Discovery » dans l'océan Sud. Cette collection étend la gamme de taille des juvéniles décrits et illustrés de l'espèce. Les petits individus ressemblent aux petits juvéniles de *Galiteuthis glacialis* qui étaient présents dans la plupart des échantillons mais s'en distinguent par les caractères suivants : (a) *M. hamiltoni* n'a pas de tubercules pairs à la fusion nucale palléale; (b) *M. hamiltoni* a un manteau plus ample et plus épais, plus libre à la fusion nucale; il est moins resserré en arrière de son ouverture; (c) les juvéniles de *M. hamiltoni* jusqu'à la taille de 26,5 mm (le plus grand exemplaire de la collection) ont de très petites nageoires, alors que chez *Galiteuthis glacialis* de la même taille, le manteau s'étire en une queue portant des nageoires bien développées; (d) *M. hamiltoni* a des tentacules plus longs atteignant jusqu'à 25 mm environ. Tous les spécimens de *M. hamiltoni* ont été capturés au Sud de la Convergence antarctique, et la plupart d'entre-eux ont été pris entre 20 et 500 m de profondeur, apparemment concentrés dans la zone supérieure de l'« eau profonde chaude », situé en-dessous de la couche superficielle. Quatre individus nouveau-nés ont été capturés à 55°35'S, entre 20 et 500 m. Le spécimen adulte provient d'un coup de filet effectué entre 2 000 et 2 200 m de profondeur.

INTRODUCTION

The Antarctic squid *Mesonychoteuthis hamiltoni* Robson is a large, rarely caught species which grows to a maximum total length of 4 m (Roper, Sweeney & Nauen, 1984). It belongs to the family Cranchiidae, sub-family Taoniinae and is closely related phylogenetically to members of the genus *Taonius* and *Galiteuthis* (Voss and Voss, 1983). Of these, *Galiteuthis glacialis* (Chun) is the only other cranchiid squid known to occur in the Southern Ocean, south of the Antarctic Convergence. A detailed description of the systematics and morphology of *G. glacialis* is given by McSweeny (1978).

Until recently all known specimens of adult *Mesonychoteuthis hamiltoni,* including the type specimen, were taken from the stomachs of sperm whales. Juveniles have been caught by nets and a description of the juvenile, based on four specimens, 59-86 mm dorsal mantle length (DML), is given by McSweeny (1970). The genus is included in the generic revision of the Cranchiidae given by Voss (1980).

Mesonychoteuthis hamiltoni is a major prey item of sperm whales in the Southern Ocean (Klumov and Yukhov, 1975; Clarke, 1980). Beaks comprise 14 % of the numbers found in sperm whale stomachs from the Antarctic and, because of the large size of the species, this represents an estimated 77 % of the biomass consumed. At South Georgia the percentage of *M. hamiltoni* beaks by numbers was still higher at 23 %. It has not been found in the stomach contents of elephant seals or Weddell seals (Clarke and McLeod, 1982a, b), wandering albatrosses (Clarke, Croxall and Prince, 1981), black-browed or grey-headed albatrosses (Clarke and Prince, 1981), or emperor or Adelie penguins (Offredo, Ridoux and Clarke, 1985). Small numbers of beaks have been found in the stomachs of sooty and light-mantled sooty albatrosses (Berruti and Harcus, 1978). The rarity of the species in the stomach contents of predators, other than sperm whales, suggests that it is a relatively deep-living form that only occasionally, if ever, approaches the surface.

In this paper we describe and illustrate the change in form during growth of juvenile *Mesonychoteuthis hamiltoni* from a size of 4.8 mm to 26.5 mm DML emphasising those external features which separate this species from the other common cranchiid squid in the Southern Ocean, *Galiteuthis glacialis.* The distribution of juveniles, sampled by opening and closing rectangular midwater trawl, is given in relation to the hydrographic structure of the Southern Ocean, and the relation between body size of juveniles and water depth is examined.

MATERIAL AND METHODS

The track of RRS 'Discovery' cruise 100 (30 January to 4 April 1979) in the Southern Ocean and the sampling stations are shown in Fig. 1. All specimens of *Mesonychoteuthis hamiltoni* were caught in an RMT8 opening and closing net (Clarke, 1969). The samples were fixed in 5 % neutral formalin and stored in Steedman's solution. Capture rate is defined here as the number of specimens caught in any 100 m depth horizon, divided by the number of hauls which sampled that horizon. Where specimens were caught in a haul that spanned a horizon > 100 m it is assumed that capture rate is consistent throughout the vertical range of the haul and the catch divided by the number of 100 m horizons sampled. A section of the Southern Ocean showing hydrographic structure (after Deacon, 1937) is shown in Fig. 5.

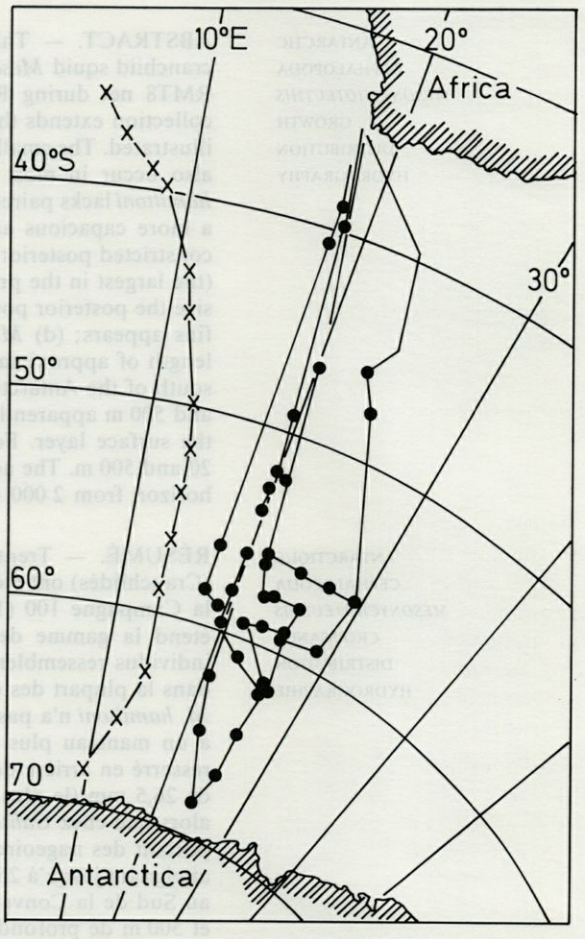


Fig. 1. — Sampling stations and track in the Southern Ocean of RRS 'Discovery' cruise 100 (1979). Stations marked by crosses are those upon which the section in Fig. 5 is based (after Deacon, 1937).

RESULTS

The size frequency distribution of the thirty seven juveniles captured (4.8 mm to 26.5 mm DML), is presented in Fig. 2. All but one sample that contained juvenile *M. hamiltoni* also contained juveniles of *G. glacialis*, and several of the samples also contained small numbers of juvenile *Alluroteuthis antarcticus*. One large, adult, female specimen of *Mesonychoteuthis* (1.17 m DML) was caught in a haul which had sampled a depth horizon from 2 000 m to 2 200 m.

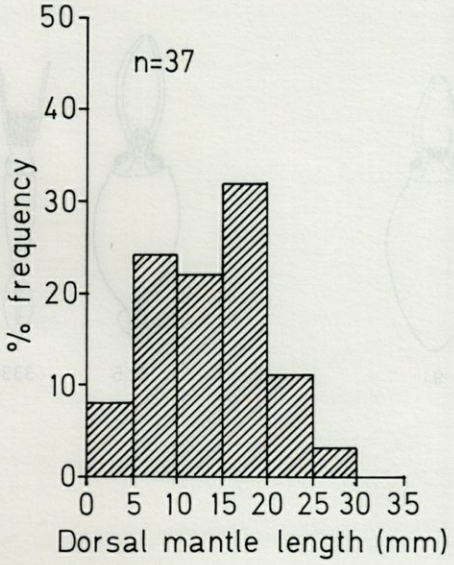


Fig. 2. — Size frequency distribution of *Mesonychoteuthis hamiltoni* captured during RRS 'Discovery' Cruise 100 in the Southern Ocean.

The change in form of juveniles during growth over the size range present in the collection is shown in Fig. 3, together with a series of *G. glacialis* juveniles, of the same size range. Because *M. hamiltoni* occurs sympatrically with *G. glacialis*, and small specimens of these two species resemble one another, it is important to emphasise the features by which they are separated :

1. Tubercles : a single tubercle occurs on the mid-line at the nuchal mantle fusion in juvenile *M. hamiltoni* (McSweeny, 1970). It is barely discernible in specimens > 20 mm DML and not visible in specimens < 20 mm DML. This feature contrasts strongly with *G. glacialis* which has paired tubercles on each side of the nuchal mantle fusion, these are apparent in individuals of all sizes.

2. Mantle : The form of the mantle in *M. hamiltoni* is more sac-like and capacious than in *G. glacialis*. The mantle is thicker in *Mesonychoteuthis* and less constricted posterior to the opening than in *Galiteuthis*. The mantle edge at the nuchal fusion is somewhat freer in *Mesonychoteuthis*.

3. Tail : In small *M. hamiltoni* (26.5 mm DML) the posterior portion of the mantle is not drawn out into a tail and the fins are very small. In *G. glacialis* the posterior portion of the mantle becomes drawn out into a tail in specimens > 20 mm DML and the fins increase in size at a much smaller DML than in *M. hamiltoni*. This feature immediately separates individuals > 20 mm DML.

4. Tentacles : The tentacles of small *M. hamiltoni* are longer than in *G. glacialis* (Fig. 4). The allometric equations relating tentacle length (TL) to DML are :

M. hamiltoni : $\log_{10}TL = 0.43 + 0.54 \log_{10}DML$ ($r = 0.899$; 18 df)

G. glacialis : $\log_{10}TL = -0.11 + 0.92 \log_{10}DML$ ($r = 0.920$; 18 df)

The t-test showed that the differences between slopes and intercepts are significant at $P < 0.01$. The lines intersect at a DML of approximately 25 mm.

The distribution of hauls, made with the RMT8 opening and closing net, and the catch of *M. hamiltoni* in relation to the hydrographic section of the Southern Ocean (Deacon, 1937), are illustrated in Figure 5. The section traverses the Southern Ocean from 35° S to 70° S and is based on data collected 5-15° west of the stations where net hauls were taken in 1979. Sampling was most intense to the south of the Antarctic Convergence. The maximum depth sampled was 3 000 m and two vertical series were taken; one at 57°30' S and the other at 68°30' S. No specimens of *M. hamiltoni* were caught north of 55° S and most individuals were caught in an area between 55° S and 59° S and in an area between 68° S and 69° S, close to the ice edge. The deepest haul to capture a juvenile sampled a horizon from 500 m to 995 m and the shallowest sampled a horizon from 0 m to 49 m. Three individuals were caught in hauls sampling 0-500 m and all other catches of juveniles were made between 20 m and 500 m. Twenty five juveniles were caught in a relatively narrow horizon immediately beneath the Antarctic surface layer which is characterised by a temperature of < 0.0° C and an oxygen tension of > 6.0 ml l^{-1} (Fig. 5). The three specimens caught in 0-500 m and the five specimens caught in 20-500 m may have been caught in this same water mass and so only three individuals are known to have come from the surface layer. Four specimens (4.8 mm, 4.9 mm, 5.2 mm, 5.9 mm DML) are apparently newly hatched from the egg. The mantles had a yolky appearance and in two specimens fragments of the chorion were still attached to the mantle. In all four specimens the head, arms and tentacles were enclosed in a membrane. These were captured at 55°35' S at depths between 20 and 500 m. The adult specimen was caught at a much greater depth, apparently in the cold bottom layer.

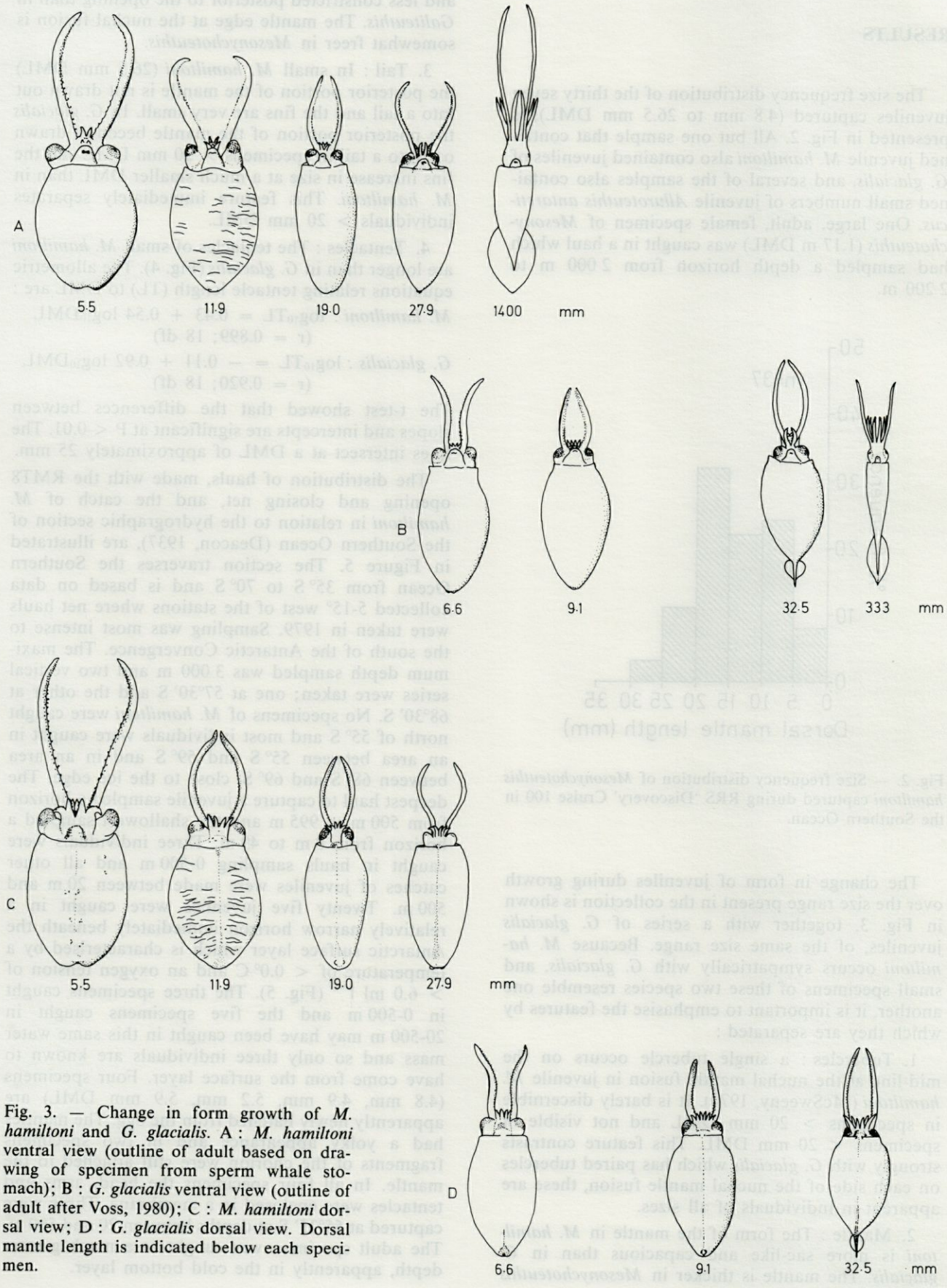


Fig. 3. — Change in form growth of *M. hamiltoni* and *G. glacialis*. A : *M. hamiltoni* ventral view (outline of adult based on drawing of specimen from sperm whale stomach); B : *G. glacialis* ventral view (outline of adult after Voss, 1980); C : *M. hamiltoni* dorsal view; D : *G. glacialis* dorsal view. Dorsal mantle length is indicated below each specimen.

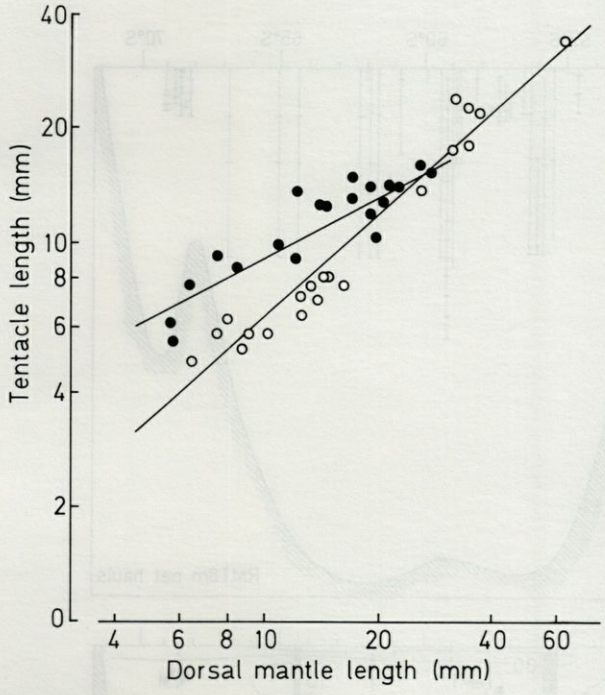


Fig. 4. — Tentacle length as a function of dorsal mantle length. Closed dots : *M. hamiltoni;* open dots : *G. glacialis.*

The number of hauls made through each 100 m depth horizon and the capture rate of juvenile *M. hamiltoni* are presented in Figure 6. The capture rate was low, despite high fishing effort, from the surface to 200 m, and was highest between 200 m and 500 m. Despite almost consistent fishing effort from 500 m to 2 000 m the capture rate below 500 m was very low.

The relation between size of juvenile *M. hamiltoni* and depth of capture is illustrated in Figure 7 (only juveniles caught within a 100 m-200 m depth horizon are included). The adult, which is the only adult known to have been caught by net, was captured at 2 000-2 200 m. It is premature to draw conclusions about the depth normally inhabited by adults.

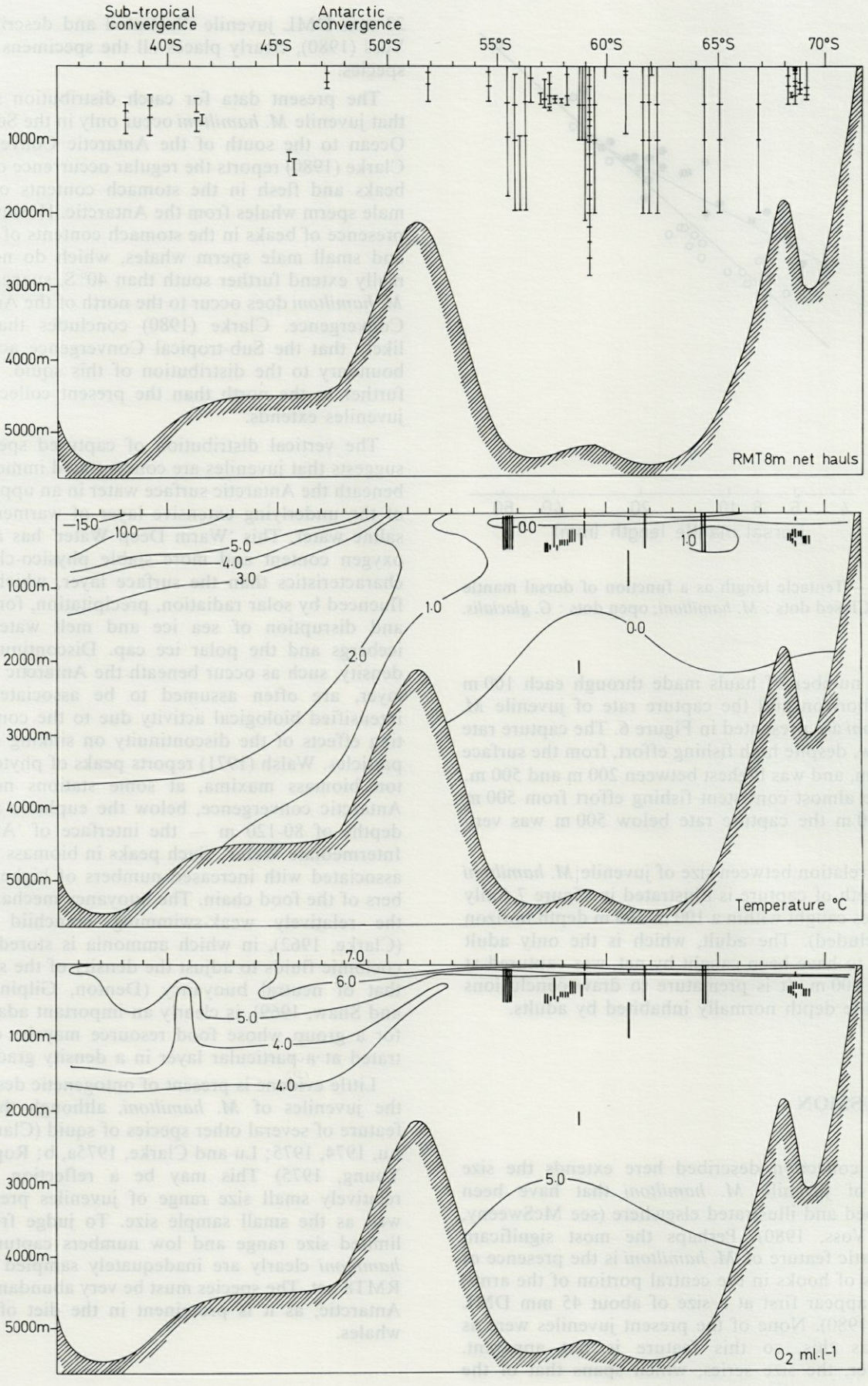
DISCUSSION

The collection described here extends the size range of juvenile *M. hamiltoni* that have been described and illustrated elsewhere (see McSweeny, 1970; Voss, 1980). Perhaps the most significant diagnostic feature of *M. hamiltoni* is the presence of a series of hooks in the central portion of the arms, which appear first at a size of about 45 mm DML (Voss, 1980). None of the present juveniles were as large as this, so this feature is not apparent. However, the size series, which spans that of the 23 mm DML juvenile illustrated and described by Voss (1980), clearly places all the specimens in this species.

The present data for catch distribution suggest that juvenile *M. hamiltoni* occur only in the Southern Ocean to the south of the Antarctic Convergence. Clarke (1980) reports the regular occurrence of adult beaks and flesh in the stomach contents of large male sperm whales from the Antarctic. However, the presence of beaks in the stomach contents of female and small male sperm whales, which do not normally extend further south than 40° S, suggests that *M. hamiltoni* does occur to the north of the Antarctic Convergence. Clarke (1980) concludes that it is likely that the Sub-tropical Convergence acts as a boundary to the distribution of this squid. This is further to the north than the present collection of juveniles extends.

The vertical distribution of captured specimens suggests that juveniles are concentrated immediately beneath the Antarctic surface water in an upper zone of the underlying extensive layer of warmer, more saline water. This 'Warm Deep Water' has a lower oxygen content and more stable physico-chemical characteristics than the surface layer, which is influenced by solar radiation, precipitation, formation and disruption of sea ice and melt water from icebergs and the polar ice cap. Discontinuities in density, such as occur beneath the Antarctic surface layer, are often assumed to be associated with intensified biological activity due to the concentrating effects of the discontinuity on sinking organic particles. Walsh (1971) reports peaks of phytoplankton biomass maxima, at some stations near the Antarctic convergence, below the euphotic zone at depths of 80-120 m — the interface of 'Antarctic Intermediate Water'. Such peaks in biomass may be associated with increased numbers of higher members of the food chain. The buoyancy mechanism of the relatively weak-swimming cranchiid squids (Clarke, 1962), in which ammonia is stored in the coelomic fluids to adjust the density of the squid to that of neutral buoyancy (Denton, Gilpin-Brown and Shaw, 1969), is clearly an important adaptation for a group whose food resource may be concentrated at a particular layer in a density gradient.

Little evidene is present of ontogenetic descent in the juveniles of *M. hamiltoni,* although this is a feature of several other species of squid (Clarke and Lu, 1974, 1975; Lu and Clarke, 1975a, b; Roper and Young, 1975) This may be a reflection of the relatively small size range of juveniles present as well as the small sample size. To judge from the limited size range and low numbers captured, *M. hamiltoni* clearly are inadequately sampled by the RMT8 net. The species must be very abundant in the Antarctic, as it is prominent in the diet of sperm whales.


Sub-tropical convergence
Antarctic convergence
40°S
45°S
50°S
55°S
60°S
65°S
70°S
1000m
2000m
3000m
4000m
5000m
RMT8m net hauls
15·0
10·0
5·0
4·0
3·0
2·0
1·0
0·0
Temperature °C
7·0
6·0
5·0
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O2 ml.l-1

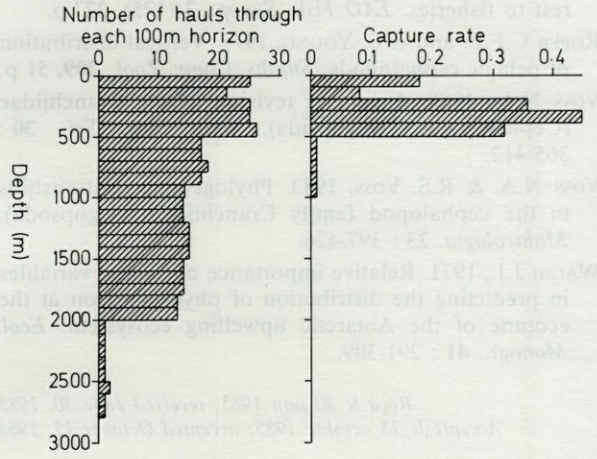

Fig. 6. — Number of hauls made through each 100 m depth horizon, compared with capture rate of *M. hamiltoni* during RRS 'Discovery' cruise 100.

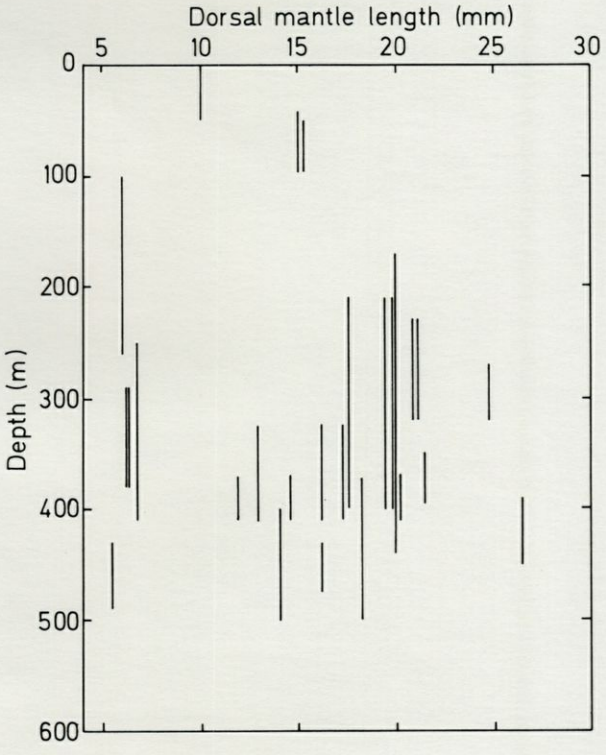

Fig. 7. — Depth distribution of *M. hamiltoni* as a functioon of dorsal mantle length. (Mostly specimens caught within 200 m depth horizon included).

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Fig. 5. — Section of Southern Ocean (after Deacon, 1937) showing position and depth of RMT8 net hauls and distribution of captured specimens in relation to temperature and oxygen. Each vertical line between tick marks represents a single haul (top section); each vertical line represents an individual specimen (centre and bottom sections).

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