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A REVIEW OF THE BIOLOGY OF THE OCEANIC SQUID *ONYCHOTEUTHIS BOREALIJAPONICA*

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Abstract

A part of the migrating population of *Onychoteuthis borealijaponica* has been utilized as an incidental catch of conventional commercial species. It propagates in the southwestern waters of Japan and feeds and matures in the cold water area off Hokkaido. At maturity females attain a length of 32 cm ML and an ovarian weight of 78 g. Spermatophores are implanted in cuts on the ventral mantle of the females. Substantial catches of this species are taken in water at temperatures of 5°C to 20°C when the squid undertake a south-north migration. An attempt is made to estimate the potential yield of this squid.

Introduction

The oceanic squid, *Onychoteuthis borealijaponica* Okada, 1927‡, was reported to be available in the market in Hokkaido (Sasaki, 1929), and recently has become more popular. This species constitutes an incidental catch of the fishery for the Japanese common squid, *Todarodes pacificus* Steenstrup. At present, the *O. borealijaponica* population is being partially exploited due to the depletion of the *T. pacificus* stock, and recent exploitation of *Ommastrephes bartrami* (Lesueur) to the east of Hokkaido (Table 1).

Table 1

Catches of *O. borealijaponica* landed in northeastern Honshu and Hokkaido.

Year	Catch in tons
1971	2 232
1972	750
1973	60
1974	5 060
1975	0
1976	2 225
1977	54
1978	77
1979	89

This paper reviews the recent contributions to the ecology of *O. borealijaponica* principally from the fishery-biological point of view.

‡ This species had not always been separated from *O. banksi* (Leach) before this name was revived by Young (1972).

1. *Juvenile Distribution.* Identification of *O. borealijaponica* and *O. banksi* is almost impossible in the very early stages of life. Planktonic juveniles of *Onychoteuthis* found in the northwestern Pacific Ocean, including Japanese waters, are thought to belong to the former species on the basis of morphological sequences which lead to identifiable specimens of advanced age.

Of the 2 002 epipelagic squid juveniles collected by 355 surface horizontal tows off the Pacific coast of western Japan, only 8 (0.4%) were identified as *O. borealijaponica* (Okutani, 1968). In contrast, 22 (1.4%) specimens were identified among 1 543 squid juveniles collected with 110 depth-discrete tows at 20 m, 50 m, 100 m and 200 m, in the seas around Ryukyu Islands, southwestern Japan (Yamamoto and Okutani, 1975). This seems to suggest that *O. borealijaponica* reproduces in the mid-layer of the ocean but not in the surface layer. In connection with this, 132 juveniles (3.8%) of this species were discovered among 3 429 squids collected with CalCOFI tows from the surface to a depth of about 150 m in the California Current (Okutani & McGowan, 1969). The greatest depth reported for a juvenile of *O. banksi* in the North Atlantic is 1 000-1 250 m (Clarke & Lu, 1974). The vertical distribution of *O. borealijaponica* is not known.

The population of *O. borealijaponica* around the Japanese Islands appears to make a north-south migration. The juvenile population is distributed exclusively in the warm water area off southwestern Japan (Kuroshio and the countercurrent areas). Adults are commercially exploited in the cold water area off Hokkaido (Subarctic and mixing water areas) where they feed, grow and mature.

2. *Growth and Maturity.* The fishing season for *O. borealijaponica* to the east of Hokkaido lasts from spring (April-June) to fall (October). The mantle length range of jigged specimens is 10-36 cm in females and 11-28 cm in males. The size range of the major constituents varies by season and by year (Figure 1). The mantle

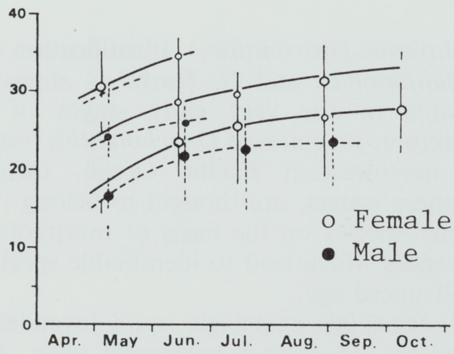

Figure 1. Seasonal change in mantle length for the 1976 catch (from Naito *et al.*, 1977).

length composition usually shows a unimodal distribution but sometimes is bimodal. The example shown by Murata and Ishii (1977) is females 17-22 cm and 25-30 cm in the 1968, 1973 and 1975 fishing seasons. The regression lines for mantle length (L) against body weight (W) obtained by them are: $W=3.6089\times10^{-5}L^{2.896}$ (female, $R=0.9861$, $N=623$) and $W=1.4073\times10^{-4}L^{2.627}$ (male, $R=0.9600$, $N=208$). The body weight of the female is 6-12% greater than the male at the same mantle length (Figure 2).

Nidamental gland length and ovarian weight have been used as indicators of sexual maturity in females. In June, during the early period of occurrence on the fishing ground, the mode of nidamental gland length is 2-3 cm, while later in August-October, it becomes 4-6 cm, showing an advancement of maturity with time. This corresponds to an increase of ovarian weight from 1-5 g in June to over 5 g after August, although a great variability among specimens exists. The increase of ovarian weight is proportional to that of mantle length up to 27-28 cm, but the ovarian weight shows an abrupt rise thereafter (Figure 3). The greatest value of ovarian weight reported by Murata and Ishii (1977) is 78.0 g for 32.3 cm mantle length. In fully mature females, namely, those with nidamental gland lengths between 6 and 10 cm and ovarian weights over 20 g, the genital organs are orange in color. The change in pigmentation starts at the genital opening then proceeds to the ovary and finally covers the nidamental gland and inner wall of the mantle.

It is well known that onychoteuthids do not possess a hectocotylized arm. A single female jigged at 43°02′N, 148°50′E on August 29, 1976, carried sperm masses implanted in the tissues of the ventral mantle (Murata & Ishii, 1977). This specimen had a cut, 67 mm long, 2 mm wide and 5 mm deep, in the ventral midline near the anterior end. This condition is similar to what Clarke (1980) described for another onychoteuthid, *Moroteuthis robsoni*. Such cuts seem to be used for implantation of spermatophores.

Murata and Ishii (1977) found that males taken during June to September were mostly sexually mature except for specimens smaller than 20 cm mantle length. Half of the males in the June catch had a testis weight between 10 and 17 g which dropped to less than 10 g in September. This drop is attributed to loading of spermatophores in the spermatophore sac as well as to consumption through copulatory activity. On the basis of the relationship between testis weight and weight of Needham's sac, advancement and decline of male genital organs from June to September is quite evident. The numbers of spermatophores carried by a single male ranged from 10-20 to 70-80.

Naito *et al.* (1977b) reported that females mature later than males like the oceanic ommastrephids *Ommastrephes bartrami* and *Todarodes pacificus*. A disappearance from the fishing ground east of Hokkaido after the fall may signal the start of the southward migration for spawning. With time, the sex ratio of the population changes. In June-July, when

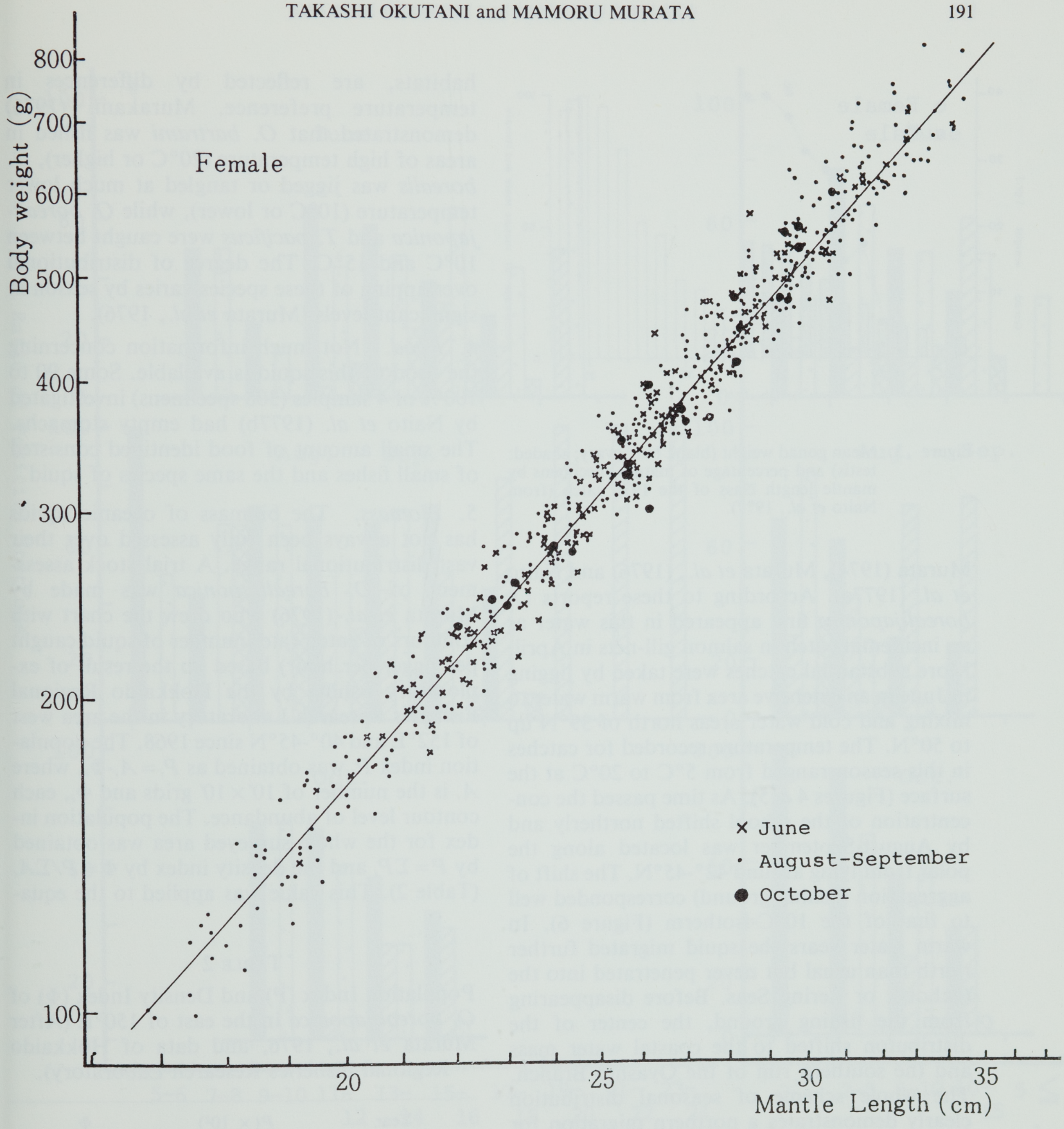

Figure 2. Relationship between mantle length and body weight (from Murata & Ishii, 1977).

schools seem to be distributed throughout the Subarctic water mass, males usually occupy half or slightly less than half of catch, but in August-September, when the fishing ground shifts westerly females are far more dominant than males (Naito *et al.*, 1977a).

3. *Distribution.* Young (1972) was the first to point out that *O. borealijaponica* replaced *O. banksi* in the cold waters of the North Pacific Ocean.

Distribution in time and space correlated with temperature preference of the *O. borealijaponica* population to the east of Hokkaido has been studied by Murakami (1975, 1976),

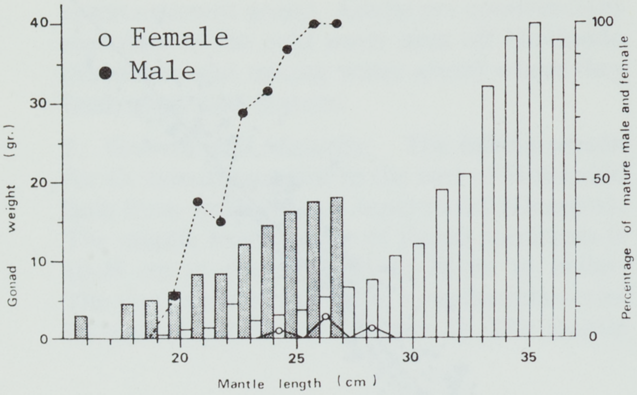

Figure 3. Mean gonad weight (blank bar: ovary; shaded: testis) and percentage of mature specimens by mantle length class of the 1976 catch (from Naito *et al.*, 1977).

Murata (1974), Murata *et al.*, (1976) and Naito *et al.* (1977a). According to these reports *O. borealijaponica* first appeared in this water as an incidental catch in salmon gill-nets in April. More substantial catches were taken by jigging in June in an extensive area from warm water to mixing and cold water areas north of 39°N up to 50°N. The temperature recorded for catches in this season ranged from 5°C to 20°C at the surface (Figures 4 & 5). As time passed the concentration of the school shifted northerly and by August-September was located along the polar front lying around 42°-45°N. The shift of aggregation (fishing ground) corresponded well to that of the 10°C-isotherm (Figure 6). In warm water years the squid migrated further north than usual but never penetrated into the Okhotsk or Bering Seas. Before disappearing from the fishing ground, the center of the distributon shifted to the coastal water mass and the southern rim of the Oyashio Branch. The whole scheme of seasonal distribution clearly demonstrates a northern migration for feeding and maturation and a southern migration for spawning.

Most of the studies cited above concerned not only this species but also other oceanic squids, such as *Ommastrephes bartrami*, *Todarodes pacificus*, *Gonatopsis borealis* and *Berryteuthis magister*. Differences in life histories, particularly migratory patterns and habitats, are reflected by differences in temperature preference. Murakami (1976) demonstrated that *O. bartrami* was fished in areas of high temperature (20°C or higher), *G. borealis* was jigged or tangled at much lower temperature (10°C or lower), while *O. borealijaponica* and *T. pacificus* were caught between 10°C and 15°C. The degree of distributional overlapping of these species varies by season in significant levels (Murata *et al.*, 1976).

4. *Food.* Not much information concerning the food of this squid is available. Some 90 to 100% of 4 samples (308 specimens) investigated by Naito *et al.* (1977b) had empty stomachs. The small amount of food identified consisted of small fishes and the same species of squid.

5. *Biomass.* The biomass of oceanic squids has not always been fully assessed over their vast distributional range. A trial stock assessment of *O. borealijaponica* was made by Murata *et al.* (1976) who drew the chart with contours of catch rate (number of squid caught per jigger per hour) based on the result of exploratory fishing by the Hokkaido Regional Fisheries Research Laboratory in the area west of 152°E and 40°-45°N since 1968. The population index P_i was obtained as $P_i = A_i \cdot \Phi_i$, where A_i is the number of 10′×10′ grids and Φ_i, each contour level of abundance. The population index for the whole surveyed area was obtained by $P = \Sigma P_i$ and the density index by $\Phi = P/\Sigma A_i$ (Table 2). This value was applied to the equa-

TABLE 2

Population Index (P) and Density Index (Φ) of *O. borealijaponica* in the east of 150°E (After Murata *et al.*, 1976, and data of Hokkaido Regional Fisheries Research Laboratory).

Year	$P(\times 10^2)$	Φ
1968	8.9	3.23
1969	3.4	1.17
1972*	49.6	4.74
1973	7.2	0.67
1974	40.9	4.91
1975	28.5	4.12
1976	48.0	5.69
1978	6.7	0.51

* For June, otherwise for August-September.

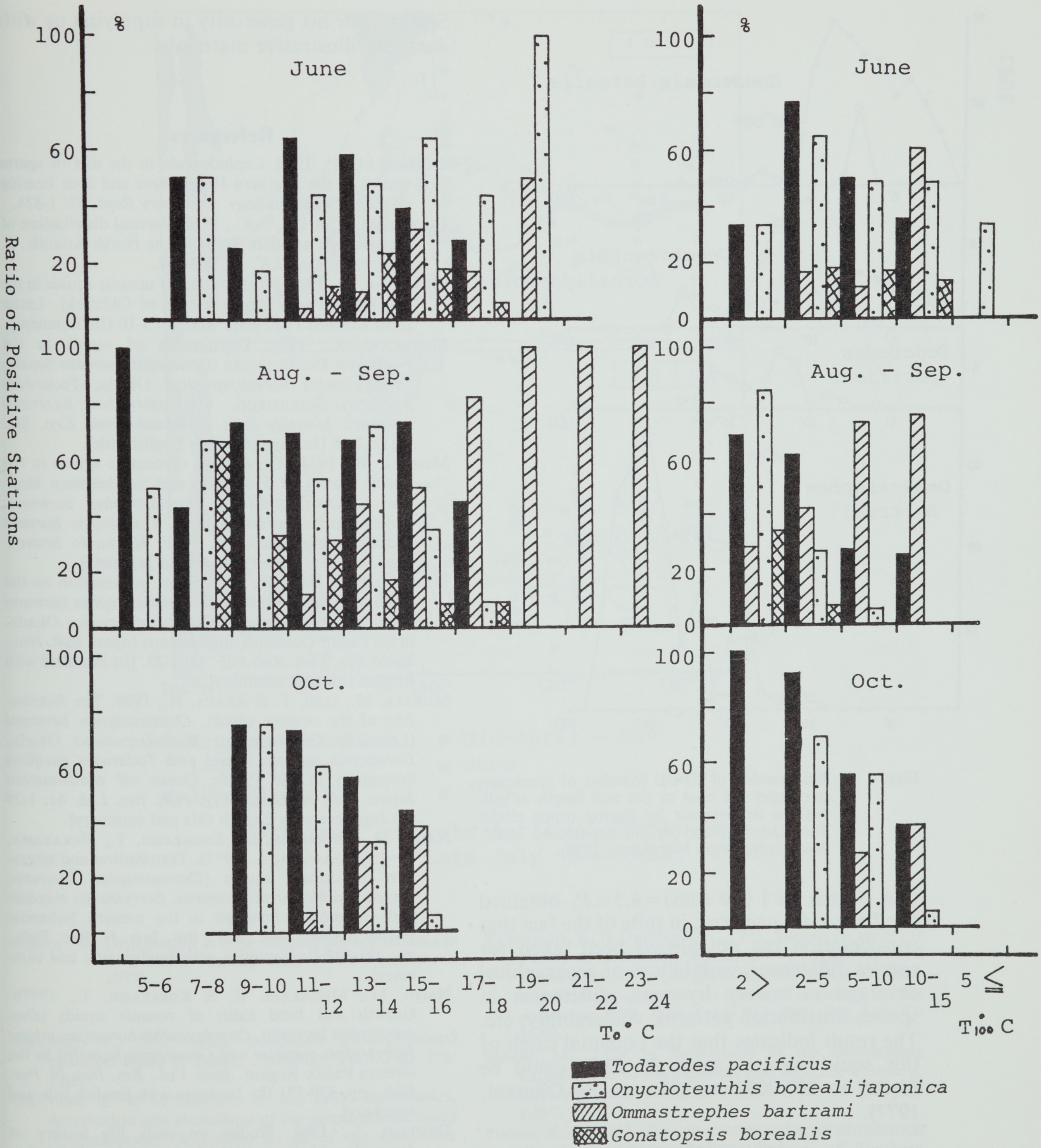

Figure 4. Relationship of positive jig stations to temperature at surface (T_0) and depth of 100 m (T_{100}) (from Murata *et al.*, 1976).

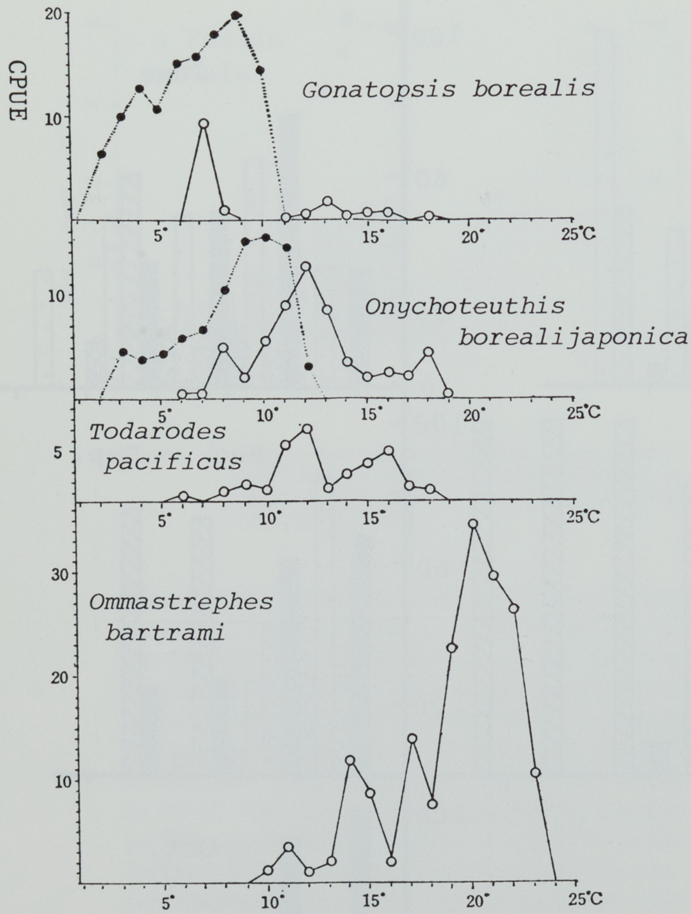

Figure 5. Relationship of CPUE (number of specimens per jigger per hour or per unit length of gill-net) to temperature by jigging (open circle: June-October) and by gill net (closed circle: April-July) (from Murakami, 1976).

tion, Catch ($\times$1 000 tons) = $4.5 \times P$, obtained for *Todarodes pacificus*, in spite of the fact that consideration has not always been taken for species differences, variabilities of geographical coverage of survey by year, differences in species distribution patterns, vulnerability, etc. The result indicates that the potential catch of this squid species (mean $P = 22.8$) could be 50 000 to 200 000 tons (Murata, in Okutani, 1977).

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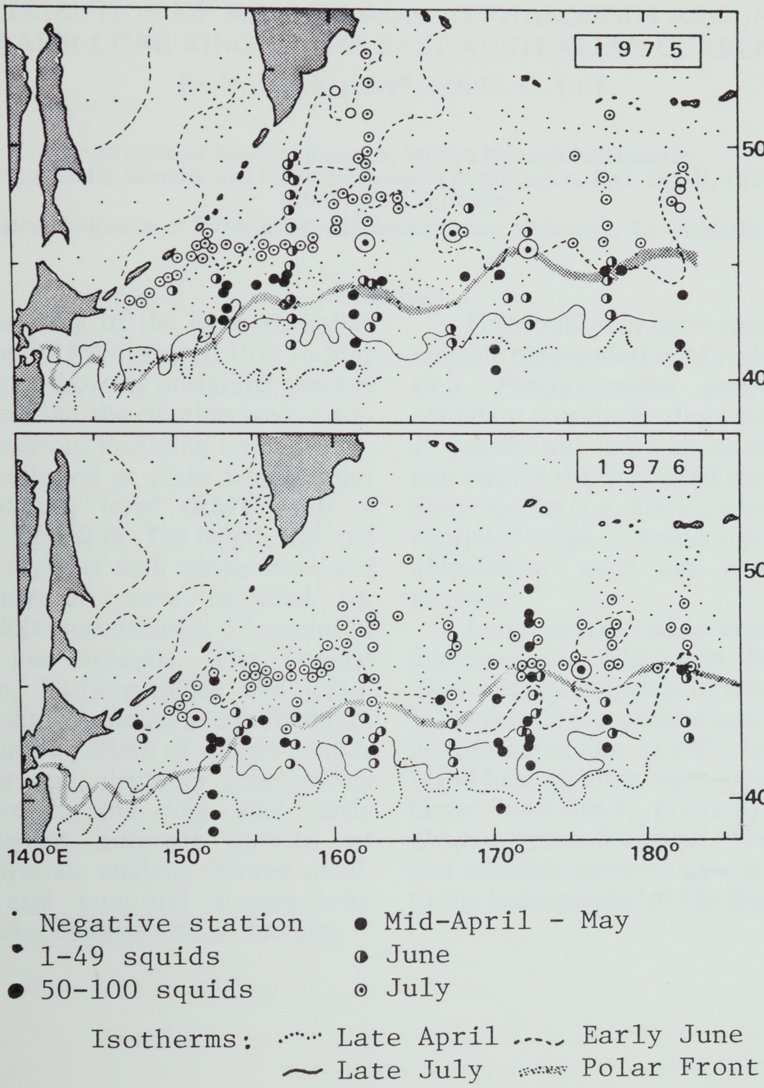

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