Feeding Habit of Hoki *Macruronus novaezelandiade* (HECTOR) in Waters around New Zealand

Chin-Lau Kuo*1 and Syoiti TANAKA*2

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In order to elucidate the feeding habit of the species, the condition of stomach, kinds and condition of the stomach contents were examined. Hoki are omnivores, and the range of the food contents is wide, including prochordates, crustacea, molluscs and mesopelagic fishes. In these stomach contents, myctophids and small shrimps are the most abundant ones. Although scales and mud appear in the stomach frequently, it is assumed that scales are the remnants of myctophids, and mud is swallowed into stomach when small shrimps are eaten. Change of feeding habit with growth is observed, and is considered to be connected with the finding that the larger fish inhabit in deeper areas. The diurnal feeding periodicity is not clear. This may be partly due to the fact that the time of the sampling is concentrated in 0600-1400 of the day. The feeding activity is found to be the highest in autumn. This may be a pattern of feeding behavior before the coming spawning season in winter.

Studies concerning the feeding habit of hoki are rather scarce. MYNTOV*3 stated that hoki are omnivorous and occupy the third or fourth trophic level of the food chain. SATO*4 noted that the main foods of hoki are euphausids, shrimps and myctophids, and the large sized fish feed on molluscs and fishes of small or medium size in addition to those mentioned above.

This is the third paper in a series of studies concerning the biological aspects of hoki. In this study, the dominant food items, the changing of feeding habit by age, the diurnal and seasonal change of feeding activity are discussed.

**Material and Methods**

In this study, two sets of trawl records from the research-exploratory fishing vessel SHINKAI-MARU,8,4 which operated from April 1975 through March 1976 and from April 1976 through March 1977 were used. In these records, the degree of fullness of the stomach is divided into empty, half, stuff and turn-inside-out. Empty is that nothing can be found in the stomach. Half or stuff indicates the stomach half or fully filled with foods. Turn-inside-out is that the stomach is turned inside out and pushed out of the mouth.

In the records, the condition of the stomach contents is divided into digested, half-digested and no-digested, according to the degree of digestion of the contents. When the condition of the stomach contents is half-digested or no-digested, the species could be identified, and the number of fish from which a certain kind of food items occurred is recorded and expressed as percentage of the total number of fish.5) Using this occurrence rate of food items in the stomach, the dominant food items are discussed.

From the occurrence rate of the main food species in various length classes, the change of feeding habit with growth is demonstrated. The time interval or season in which the fish with empty stomach or digested stomach contents appeared least often is considered to be the height of the feeding activity.

**Results and Discussions**

**Dominant Food Items**

The occurrence rate of various kinds of food items is shown in Fig. 1. The occurrence of fishes, scale, mud and unidentified material is high. The fishes and unidentified material are those stomach contents being half-digested or digested and cannot be identified. We are not sure what kind of fish the scales came from. But since the

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*1 Present address: Dept. of Fishery Biology, Taiwan Fisheries Research Institute, Keelung, Taiwan, Republic of China (郭慶老：台灣省水產試驗所漁業生物系).
*2 Ocean Research Institute, University of Tokyo, Nakano, Tokyo 164, Japan (田中昌一：東京大学海洋研究所).
myctophids are so often eaten by hoki, and their scales dropped so easily that the scales are assumed to be the myctophids'. The mud is presumably swallowed into the stomach together with the small shrimps, because the most dense concentration zone of hoki is formed at 5–30 m above the bottom of the continental slope,6) the bottom of the habitat of hoki is always covered with mud,1) and the shrimps are eaten by hoki often.

Excluding fishes, scale, mud and unidentified material, the ranking of the occurrence is in the order of small shrimps, myctophids, euphausids, synodontidae, and galatheid in the EAST region; myctophids, small shrimps, cephalopoda, salpa and mysidacea in the NORTHWEST region; small shrimps, myctophids, amphipoda, mysidacea and salpa in the SOUTH region. Although the rankings of the occurrence differ slightly among three regions, small shrimps and myctophids appeared most often in the stomach contents of hoki.

In the study of distribution and migration, hoki are found to spend the day at depths near the bottom of the continental slope and to move to the upper layers during the night (in press). As small shrimps and myctophids are known to be micro-nektons that take diel vertical migration and occupy an important position in the food chain for linking the pelagic and bathyal zones.7,8) Therefore, this movement pattern of hoki is considered to be connected with the diel vertical migration of the small shrimps and myctophids.

### Changing of Feeding Habit with Growth

Figure 2 shows the occurrence rate of main food items in the three regions. In the EAST region, the occurrence rate of fishes and myctophids decreased with growth, while that of small shrimps increased. In the NORTHWEST region, the occurrence rate of fishes, myctophids and small shrimps decreased with growth firstly, but that of fishes and myctophids turned to increase beyond 100 cm. In the SOUTH region, although the change of the occurrence rate was not so obvious, a trend of decrease was observed for fishes, and an increase for small shrimps. This change of feeding habit is considered to be connected with the finding that the large fish tend to inhabit in deep areas of the continental slope. However, we have
Diurnal Feeding Periodicity

The occurrence rate of the fish with empty stomach and the fish with digested food contents by time of trawling is shown in Fig. 3. In the EAST region, the occurrence rate of empty stomach was high (about 50%) in any time interval, and particularly low rate of digested food contents was not found. In the NORTHWEST region, the occurrence rate of empty stomach was about 60% in any time interval. The occurrence rate of digested food in the time interval 1000–1400 was slightly high, but was almost the same for the other time intervals. In the SOUTH region, the occurrence rate of empty stomach and digested food was slightly low in 1800–2200, but the difference was not so significant.

From these results, it is known that the occurrence rate of empty stomach is generally high, and the diurnal feeding periodicity is not clear. This may be due to the fact that the time of the sampl-
Seasonal Change of Feeding Activity

Seasonal change of the occurrence of the fish with empty stomach and the fish with digested stomach contents was shown in Fig. 4. Because there was no sample in autumn in the NORTHWEST region, we could not find the peak period of the feeding activity. But in the EAST as well as in the SOUTH region, the occurrence of empty stomach and digested food contents was the lowest in autumn. From this result, the feeding activity is thought to be the highest in autumn. As the spawning season of hoki was estimated to be in winter (in press), this enhancement of feeding activity in autumn is considered to be a pattern of feeding behavior before the coming spawning season in winter.

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References