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Feeding Habits of the Squid, *Todarodes sagittatus*, in North Norwegian Waters

by

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Gut contents analysis was carried out on squid, Todarodes sagittatus, caught by jigging in the coastal waters off northern Norway. Prey was comprised, predominantly, of pelagic species with polychaetes, molluscs, crustaceans and fish being the major prey categories. Analysis of data using percentage occurrence and relative frequency of occurrence indices provided evidence for an ontogenetic shift in dietary composition, there being an increased reliance on fish prey as the squid increased in size. Fish prey were identified to species using otoliths recovered from the squid guts and prey size calculated from fish size v otolith size regressions.

SPECIAL SESSION ON SQUIDS

INTRODUCTION

Although squids are thought to hold a key position in the food webs of polar regions comparatively little is known about their feeding habits and food selection. The majority of information available consists, solely, of a list of the types of food organisms consumed. The feeding habits of squid from other regions have been examined in somewhat more detail and the results from a number of studies have shown that many species feed on pelagic or semi-pelagic prey. Some authors have also found that there is a change in dietary composition with increasing squid size (see Mangold, 1983 for review).

The majority of studies are of a predominantly descriptive nature and few attempts have been made to examine squid feeding habits in relation to prey availability.

In the current study the feeding habits of the squid Todarodes sagittatus have been examined and attempts made to relate the ontogenetic shifts in dietary composition to changes in abundance of prey organisms.

MATERIALS AND METHODS

Squid, Todarodes sagittatus, were collected at various stations along the north Norwegian coast (between Andenes and Kamøyfjord) (Fig. 1) during the period Octobed 1982 - October 1983. Squid were taken by jigging at depths varying from 0 - 50 m. In all, a total of 10 samples, varying in size from 10 to 170 individuals were taken in the course of 9 research cruises. Relatively few (97) male squid were taken and numbers of males within a sample varied between 0 and 53 individuals. Consequently, the investigation was restricted to an examination of the feeding habits of the female squid. Immediately following capture the dorsal mantle length of each squid was measured to the nearest 0.5 cm. The alimentary tract of the squid was retained for later analysis of gut contents in the laboratory. Squid were usually dissected shortly after capture and the entire alimentary tract removed and frozen in liquid nitrogen before being stored at -20^{o}C, but on some occassions whole squid were frozen and the alimentary tract dissected out in the laboratory. In the laboratory the alimentary tract was openned, the contents transferred to a petri dish and then examined under a binocular microscope (Wild M3) at a magnification of 6.4 - 40 x using direct illumination. The gut contents were generally of a pulp/soup-like consistency which precluded the division of the food remains for volumetric or gravimetric analysis of specific prey species. Prey species were identified using 'key' fragments of skeletal tissue such as jaw elements, parapodia, otoliths and shell remains. Skeletal elements of invertebrate species are oftem used in identification and are well described in the literature but reference to fish otolith form and structure is relatively scarce. Consequently, samples of a number of common fish species were collected, otoliths removed and these used as aids in the identification of fish prey species. The plotting of otolith size v fish size relationships allowed the size of the fish prey to be estimated.

RESULTS

A total of 20 prey types from five major animal groups (Chaetognatha, Mollusca, Crustacea and Pisces) were identified in the squid gut contents (Table I). In order to investigate the relative contributions of the different prey categories to the diet and to examine the possibility of ontogenetic shifts in dietary composition the results were expressed in the form of two feeding indices. The feeding indices were calculated as follows :-

1) The percentage occurrence of a given dietary component was calculated as the percentage of guts which containned the particular component. It is, therefore, a measure of the proportion of squid, within the sample, that had consumed a particular prey category.
2) The relative frequency of occurrence of a given prey category was calculated by dividing the number of observations of a given prey by the sum of observations of all prey categories and then multiplying by 100. This index does not indicate how many squid have consumed a particular prey but gives an estimate of how often a given prey appears in the diet relative to another.

The feeding indices of different prey categories for different size groups of squid are shown in Fig. 2 and the results indicate that there is a general trend towards a decreased reliance on crustacea and an increased reliance on fish prey with increasing squid size.

The relationship between the size of fish prey (back-calculated from otolith length) and squid length is shown in Fig. 3. These results indicate that squid of all sizes consume small fish (1.5 - 3 cm.) but that the size range of fish prey taken increases with increasing predator size.

DISCUSSION

The prey species consumed, with the exception of Nereis pelagica, were of pelagic origin. Nereis is usually considered as being a bottom-living species but does have a pelagic swarming phase. The parapodia recovered from the squid guts were characteristic of this free-swimming heteronereid, suggesting that the nereids were taken pelagically. This reliance on pelagic food organisms by Todarodes sagittatus is in general agreement with previous findings (Wiborg, 1978; 1981) although, occassionally, benthic prey has been recorded (Jonsson, 1980). The size range of the prey types consumed varied considerably, from calanoid copepods of a few millimetres in length to fish exceeding 15 cm. in length and it was, therefore, of interest to study the relationship between predator size and prey size and tp examine whether there were any ontogenetic shifts in dietary composition. Such changes in dietary composition can be investigated by examining and comparing changes in the feeding indices with increasing squid size. The increase in the relative frequency of occurrence of fish in the diet with increasing squid size points to an increased reliance on fish prey as the squid grow. The question arises whether this increase in relative frequency of fish in the diet is brought about merely by increased consumption of fish, by the replacement of other prey categories or by a combination of both. Examination of the percentage occurrence indices shows that the percentage occurrence of fish in the diet increases with squid size, whilst at the same time, the percentage occurrence of other prey types, particularly crustaceans, tends to decline with increasing predator size. Consequently, the increase in relative frequency of fish in the diet is the result of both an increased consumption of fish and a reduction in consumption of other prey items.

The growth of the squid is relatively rapid during the autumn and winter (Fig. 4) and the changes in dietary composition accompanying the general increase in squid size could be due to seasonal variations in availability of different food organisms rather than to shifts in prey preference with increasing size. The evidence does not, however, point to temporal changes in prey abundance as being the major cause of the dietary shift. The seasonal changes in abundance of krill and other larger pelagic crustaceans in north Norwegian waters have been little studied, but in inner Balsfjord the maximum abundance occurs during the summer months, followed by a sharp decline and then a gradual increase during the autumn to reach a second minor peak in December/January (Hopkins, 1981). Thus, crustacean prey may be increasing in abundance during the time at which squid would be expected to be reducing their reliance upon this prey category and it is unlikely, therefore, that the reduced consumption of crustacean prey is due to a reduction in prey availability. Secondly, despite the relatively limited size range of squid taken within samples, there is evidence of within sample variations in prey composition related to squid size. Data from the five largest samples were tested (Spearman Rank Correlation) and in four out of five cases there was a negative correlation between the percentage occurrence of crustaceans in the diet and squid size. Positive correlations between squid size and occurrence of fish were found for four of the samples tested. Thus, there are clear size related differences in food composition independent of any seasonal variations in the abundance of prey organisms.

The fish prey consumed by the squid was comprised, largely, of 0- and I-group fish of a number of species and prey length ranged from approximately 1.5 to 16 cm. There was a general trend for the range of size of fish prey to increase with increasing squid size (Fig. 3), that is, all groups of squid consumed small fish but larger squid also preyed upon larger fish. Consequently, as new and larger fish prey became 'potential prey' the 'absolute' amount of available fish prey would be expected to increase. Similar increases in prey availability for the other prey groups would not occur by this mechanism since the variations in size of the crustacean and polychaete prey were very restricted when compared with the range of size of fish prey consumed (Table I). Thus, the dietary shift is probably partially due to an increase in the amount of available fish prey as larger fish become 'potential prey' with increasing squid size. It may also be necessary to invoke the concept of prey preference in order to explain the shift away from crustacean prey.

More information is required before this can be either confirmed or rejected. Specifically, information is required regarding the changes in the relative proportions of potential prey organisms in the environment thereby enabling prey selectivity to be quantified.

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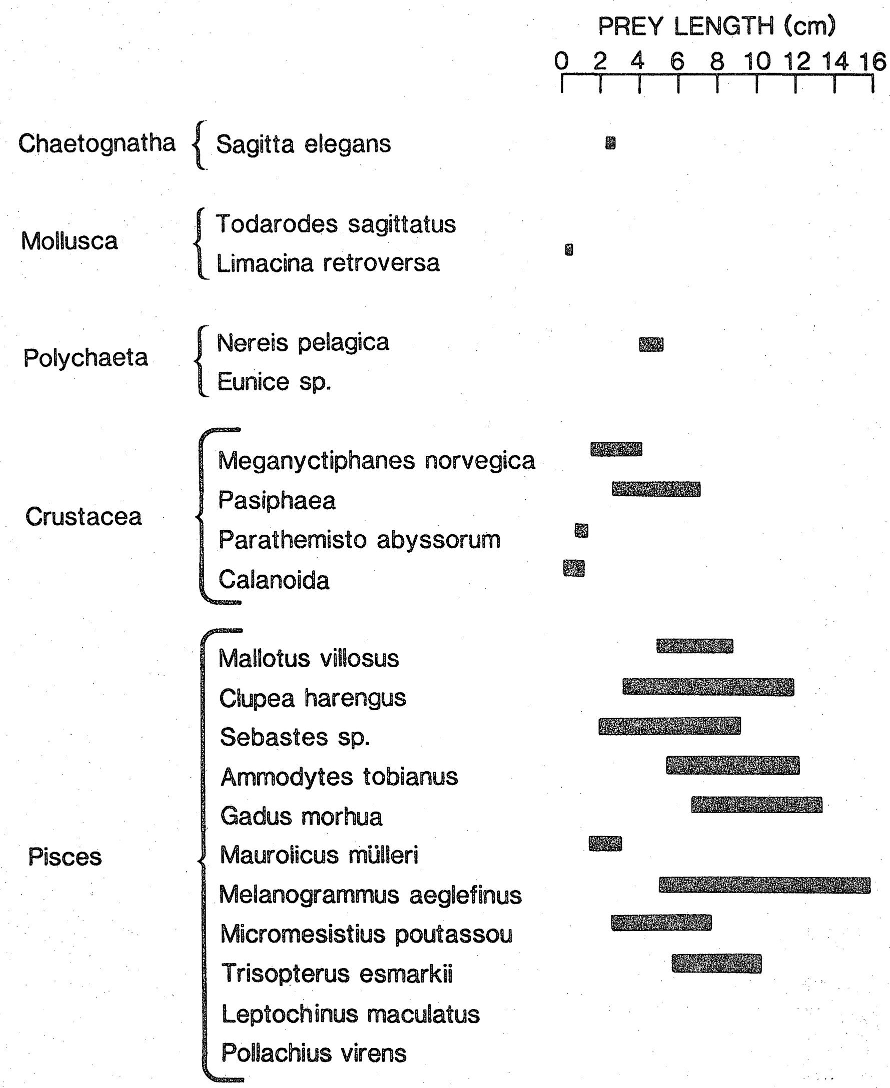
Table I. Summary of types and relative sizes of prey organisms consumed by the squid, <u>Todarodes sagittatus</u>



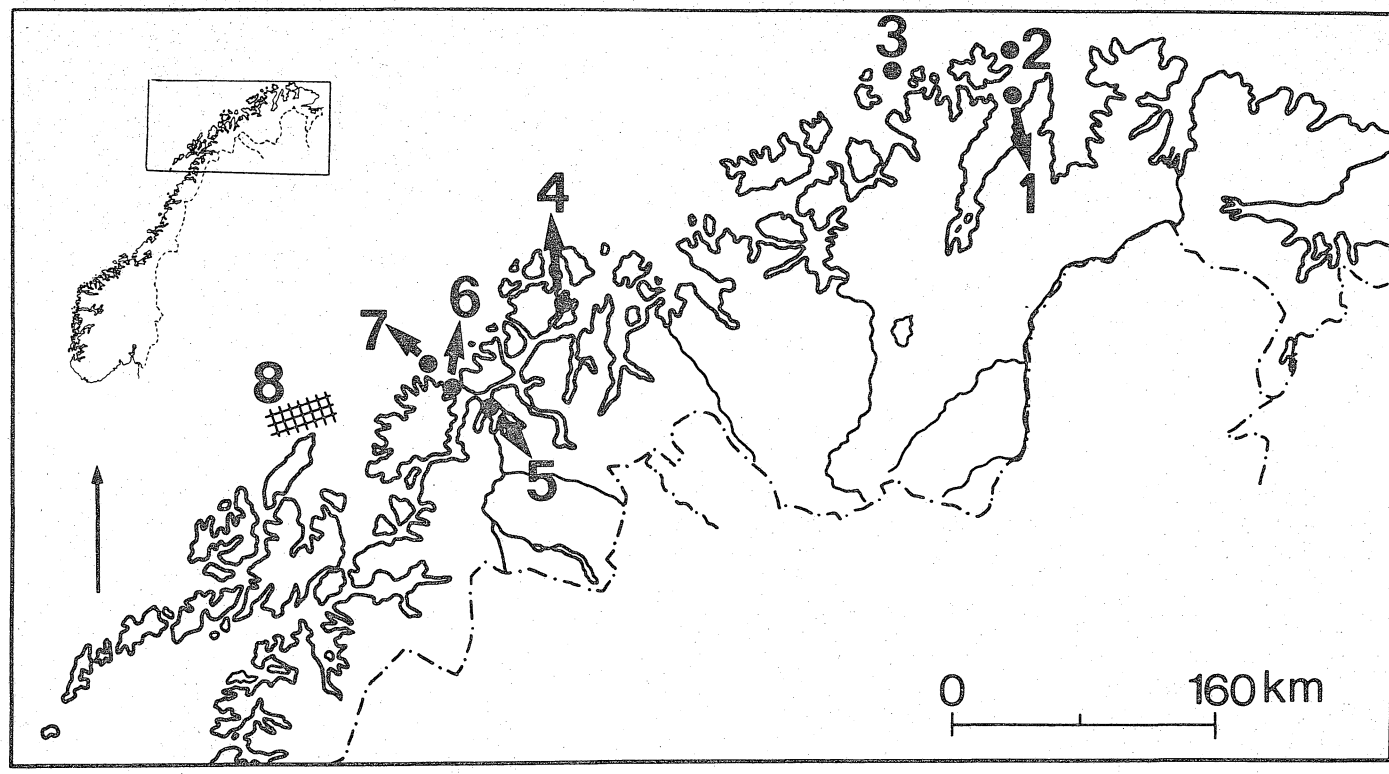


Figure 1. Map showing positions of sampling stations along the north Norwegian coast.

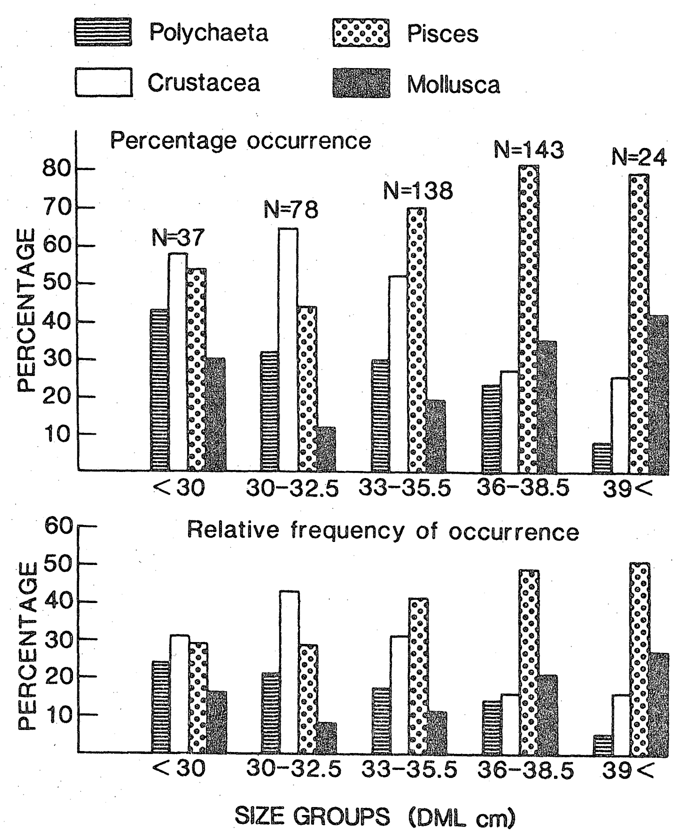


Figure 2. Changes in food composition with increasing size of squid, assessed using two feeding indices :- Percentage occurrence and relative frequency of occurrence.

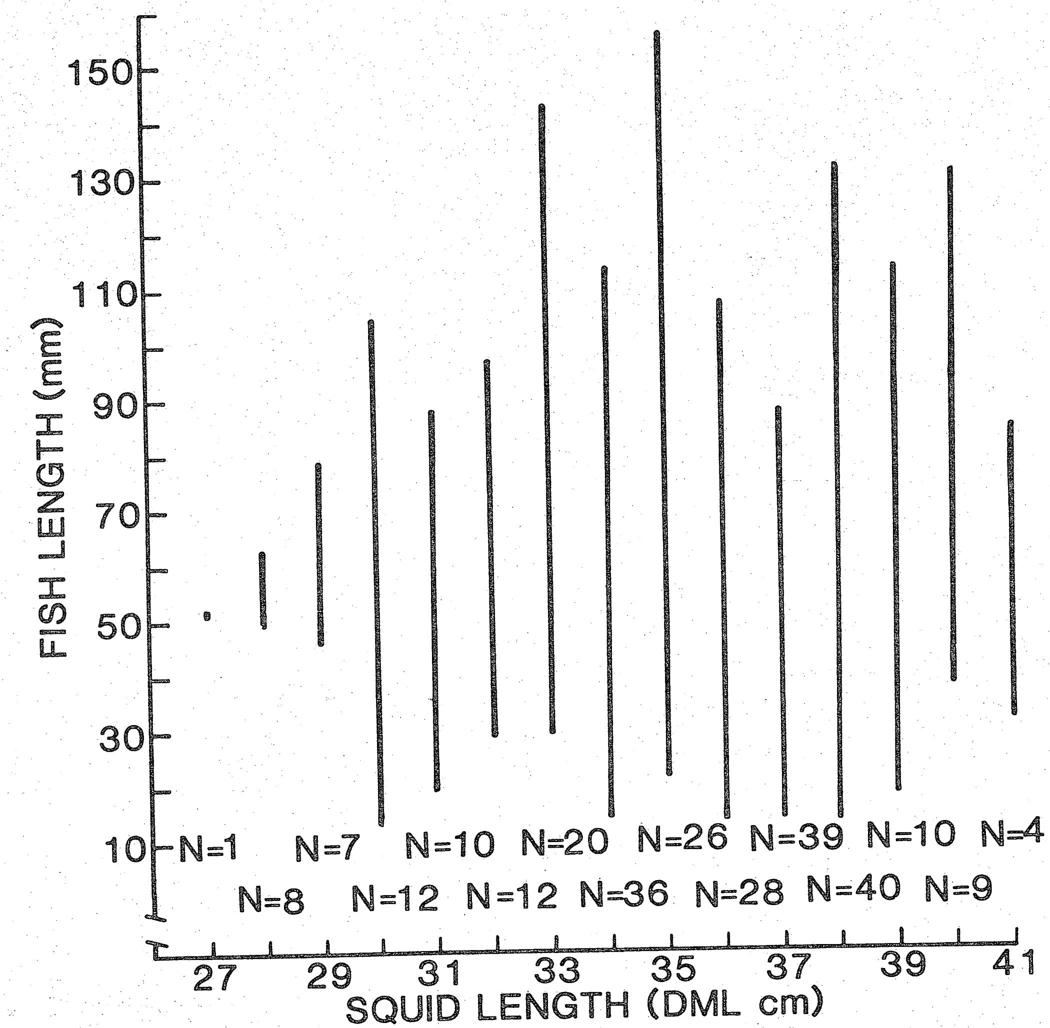


Figure 3. Relationship between squid size and size of fish prey consumed.

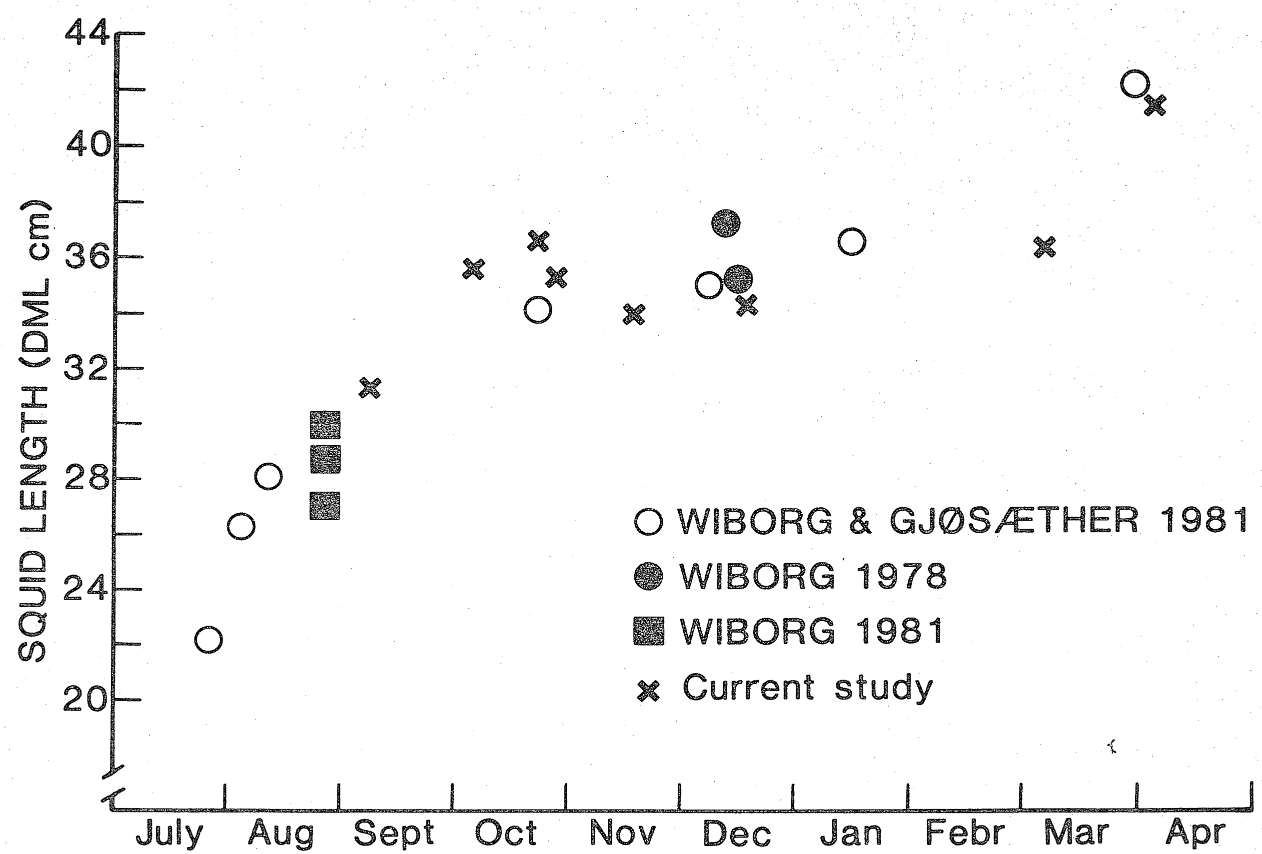


Figure 4. 'Growth curve' for the squid _Todarodes sagittatus_, plotted using mean lengths of samples taken at different times of the year.
Data from various sources.