

Short note

Seasonal and annual variation in the diet of Atlantic cod (*Gadus morhua*) in relation to the abundance of capelin (*Mallotus villosus*) off eastern Newfoundland, Canada

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The importance of capelin as prey for cod has long been known (Thompson, 1943; and see Lilly (1987) for a review); however, no studies have been conducted on how the highly dynamic seasonal and yearly variations in capelin abundance affect cod diet. We studied the occurrence of capelin in cod stomachs in relation to the relative abundance of capelin at Witless Bay, Newfoundland (47°15'N 52°46'W), during June, July, and August, 1982–1984. The mean number of capelin per stomach and the per cent occurrence of stomachs containing capelin were determined for each collection of stomachs. A total of 680 stomachs were examined. Cod were sampled from those caught in gillnets by fishermen and averaged 66 cm ± 8 (s.d.) in 1983 and 62 cm ± 8 (s.d.) in 1984. Relative abundance of capelin in the local habitat was determined by conducting hydroacoustic surveys around Gull Island in Witless Bay, the same area where cod were collected for stomach content analysis. Only hydroacoustic surveys conducted within three days of cod stomach collections were analysed. Further details of hydroacoustic surveys including quantification of acoustic echograms are described by Piatt (1989).

A Kolmogorov–Smirnov two-sample test (Siegel, 1956) was used to compare the relative cumulative frequencies of capelin in cod stomachs and the relative abundance of capelin in the local habitat. There was no significant difference between these cumulative frequencies (Fig. 1, $p > 0.05$). The occurrence of capelin in cod stomachs changed throughout the summer, but only in relation to the relative abundance of capelin (Fig. 1). When capelin abundance was high, consumption, as indicated by the mean number of capelin in cod stomachs, was high. When abundance decreased, consumption decreased.

During the first three weeks of June capelin were not

abundant in the study area (Fig. 1). The frequency of capelin in cod stomachs was low (Fig. 1), and the proportion of stomachs containing other prey, especially invertebrates, was high (Fig. 2). Capelin became abundant in late June and in early July when they arrived nearshore to spawn on beaches and subtidally off eastern Newfoundland (Templeman, 1948). The frequency of capelin in cod stomachs and the proportion of cod feeding on capelin increased considerably during this period of high relative capelin abundance (Figs. 1, 2). In 1984 during this period of high capelin abundance,

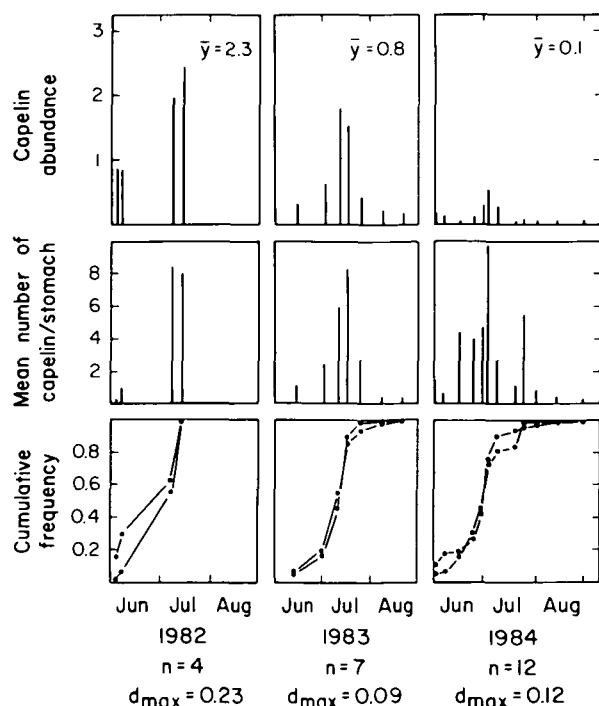


Figure 1. Relative abundance of capelin, mean number of capelin in cod stomachs, and the cumulative frequencies of capelin in stomachs and in the local habitat at Witless Bay.

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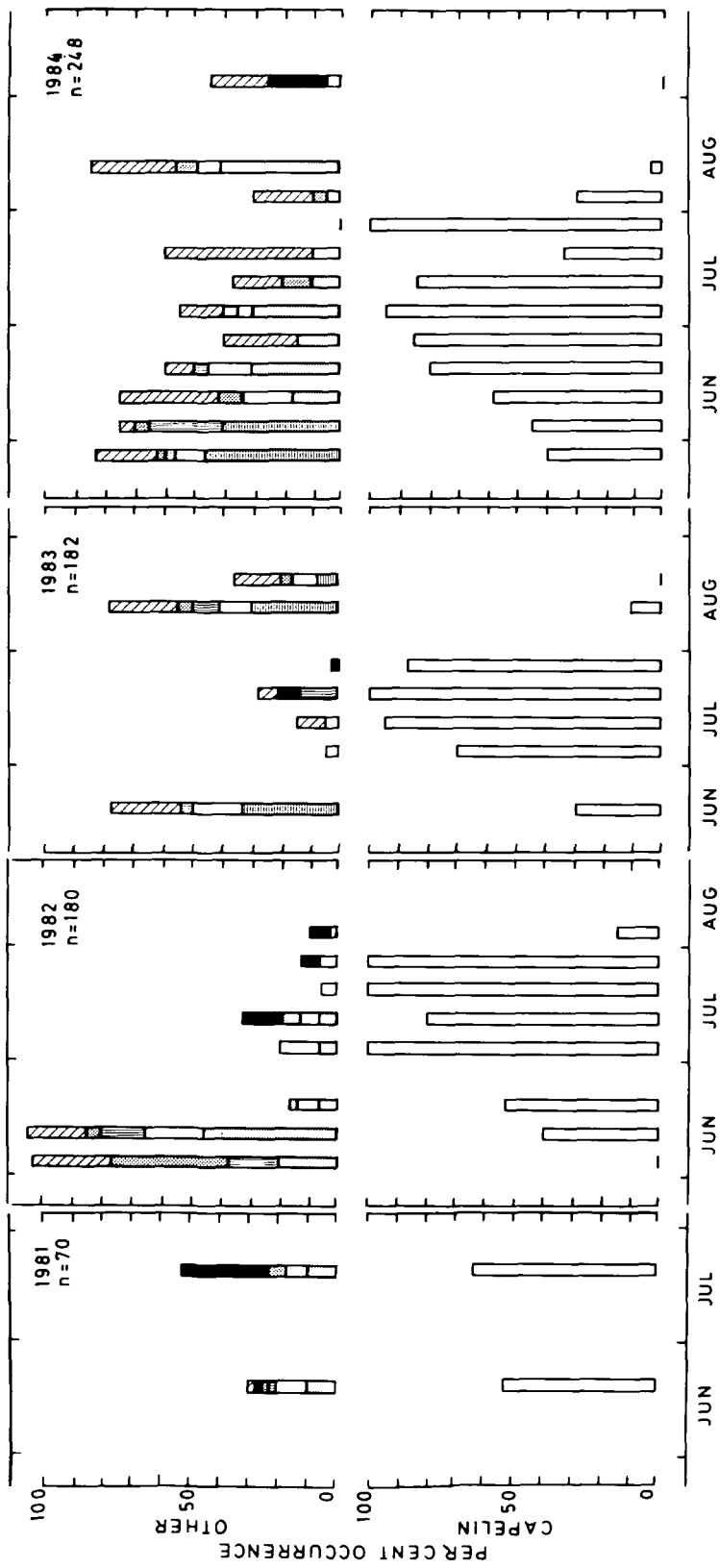


Figure 2. Seasonal variation in occurrence of food items by percentage in cod stomachs at Witless Bay. Per cent occurrence = the number of stomachs containing food item "X" divided by the number of stomachs in the sample, expressed as a percentage. For example, during the first week of June 1982, no stomachs contained capelin, 20% of stomachs contained shrimp, 9.7% euphausiids, 40% amphipods, and 26.7% contained other food items. Key for other food items: dots = amphipods, open blocks = crabs, solid blocks = shrimp, vertical lines = euphausiids, horizontal lines = shrimp, diagonal lines = all other food items.

they constituted 85.1% of the total prey biomass taken by cod. Cod stomachs were seldom empty during this time. In late July and in August, capelin abundance was low (Fig. 1) owing to offshore migration of capelin and a high, natural postspawning mortality (Templeman, 1948). The mean number of capelin in cod stomachs decreased during this time as did the proportion of cod feeding on capelin. Invertebrates once again became important food items in August (Fig. 2). This cycle repeated itself each summer, with capelin abundance and predation on capelin peaking in July (Figs. 1, 2).

Shrimp (primarily *Pandalus* spp.) and euphausiids were the next most important food items taken by cod (Fig. 2). These species were often present in stomachs throughout the summer but were most abundant from late May to early June and in August. Although squid are often important prey for cod in late summer (Lilly and Osborne, 1984), squid were not abundant off Newfoundland in 1982, 1983, and 1984 (E. Dawe, unpublished, Department of Fisheries and Oceans, St. John's, Newfoundland, Canada) and were also rare in cod stomachs. Occasional prey included mysids, gastropods, pelecypods, sea cucumbers, starfish, brittle stars, polychaetes, tunicates, sea anemones, and ctenophores. Other fishes taken by cod were sandlance (*Ammodytes* spp.), juvenile cod, redfish (*Sebastes* spp.), and flatfishes.

In July 1982, 95.0% of cod stomachs examined contained capelin (Fig. 2). The proportion of stomachs containing capelin in July decreased to 87.9% in 1983 and to 78.5% in 1984 (Fig. 2). This decrease in the percentage of cod taking capelin corresponded with the annual index of local capelin abundance which also decreased from 2.3 in 1982, to 0.8 in 1983, to 0.1 in 1984 (Fig. 1). In addition to affecting diet we believe that capelin abundance may be an important variable influencing the number of cod and other capelin predators that migrate into the Witless Bay area during summer. Lear *et al.* (1986) have reported that landings of cod in the Witless Bay region decreased each year from 1982 to 1984. Similarly, Piatt *et al.* (1989) have shown that the abundance of baleen whales observed at Witless Bay also decreased over the same period. Capelin abundance also accounted for 63% of the total variation in the numbers of baleen whales seen during June, July, and August in 1983 and 1984 at Witless Bay. While we believe that capelin abundance was the most important factor influencing catches of cod and the numbers of

baleen whales during summer, other factors may also be important in determining catches of cod off eastern Newfoundland (Lear *et al.*, 1986).

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