Predator stomachs as sampling tools for prey distribution: cod and capelin

by

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Abstract

The goal of this study was to evaluate the use of prey contents in predator stomachs as an indication of prey distribution for a specific predator-prey system, cod-capelin in the spring in NAFO division 3L. There was strong evidence that the amount of capelin found in cod stomachs is an indicator of the amount of capelin in the region around the cod sampling point, as indicated by acoustic samples. There was no significant effect of the number of cod in the trawl on the amount of capelin found in cod stomachs. The results of this study indicate that, at least for this system, the cod stomach can be viewed as a sampling tool for the distribution and abundance of capelin.

Résume

Le but de l'étude était d'évaluer l'utilisation du contenu stomacal des prédateurs comme indication de la répartition des proies dans le cas d'un système prédateur-proie spécifique, c.-à-d. morue-capelan, au printemps dans la division 3L de l'OPANO. Il y avait de fortes indications que la quantité de capelans trouvés dans l'estomac des morues est un indicateur de la quantité de capelans dans la région où se trouve le point d'échantillonnage de la morue, comme l'indiquent les échantillonnages acoustiques. Le nombre de morues dans le chalut n'avait pas d'effet important sur la quantité de capelans dans l'estomac des morues. Cette étude révèle que, pour ce système du moins, l'estomac de la morue peut être considéré comme un outil d'échantillonnage pour établir la répartition et l'abondance du capelan.

One of the common methods for estimating stock biomass of marine fish is the trawl survey, in which trawl samples are taken over the area of the stock, usually in either a grid pattern or a random or stratified random pattern. These surveys often include subsampling of the fish for later analysis of stomach contents (e.g., Daan 1987, Magnusson and Palsson 1989, Mehl 1989, Lilly 1991). Since for some types of prey the stomach contents can be identified to species, the question arises whether the predators can be viewed as a sampling tool for the distribution and (perhaps) abundance of the prey species, at least within the stock area of the predator. In other words, is the amount of prey in predator stomachs an indication of local and/or regional prey abundance?

A potential problem with this idea is that the amount of a prey species found in a predator's stomach may not be independent of the local abundance of the predator. It is possible that large numbers of predators in an area result in lower mean prey abundance per unit predator stomach, either because of intraspecific feeding interference among the predators or because of localized prey depletion due to the predator feeding. The goal of this study was to evaluate the use of prey contents in predator stomachs as an indication of prey distribution for a specific predator-prey system, cod-capelin in the Northwest Atlantic.

The data were collected during the spring (April to June) of 1985, 1986, 1987, and 1988, on the northern portion of the Grand Bank off Newfoundland (NAFO division 3L). Two datasets were used in the analysis. The first was data of capelin content in cod stomachs. The cod stomachs were collected during depth-stratified bottom trawl surveys (Doubleday 1981). Only stomachs of cod in the appropriate length range for predation on capelin (36 to 71 cm) were included in our analyses. The average amount of capelin per unit of cod per sampling location (Lilly 1991) was calculated as

$$F = \frac{1}{n} \sum_{j=1}^{n} \frac{W_j}{L_j^3} \times 10^4$$

where W_j is the weight of capelin in cod stomach j, L_j is the length of cod j and n is the number of cod in the sample.

In the second dataset biomass of capelin was estimated along acoustic survey transects in a systematic zigzag pattern. Details of the acoustic survey method are given in Miller et al. (1982) and Miller and Carscadden (1984). We averaged the capelin biomass estimates over 10 min periods, producing a capelin biomass (g/m^2) estimate for every 3.1 km of the transects.

To determine whether the amount of capelin measured in cod stomachs was a measure of the capelin biomass in the local environment, one would ideally like to have an estimate of the capelin biomass from the acoustic survey to match with each point estimate of capelin in cod stomachs from the bottom trawl survey. However, the two surveys were conducted using different vessels and although they were both conducted in the spring and in NAFO division 3L, they followed different courses through the area. The subset of the data that is useful for our purposes is therefore the data from those points in time and space at which the two vessels passed near to each other.

Since we did not have *a priori* criteria for "nearness" of the two vessels, we conducted a series of correlations between the capelin in cod stomachs (from the trawl survey) and the capelin density estimate (from the acoustic survey), for varying time and space differences between the two. For each stomach content point we determined whether there were any capelin biomass points within the selected time-space window. If there were more than one capelin biomass point in the window they were averaged. In all cases only capelin biomass points that occurred before the stomach content point were considered since the stomach contents reflect the capelin biomass when

the capelin were consumed (most likely sometime in the previous four days). Correlations between the stomach content values (log-transformed) and the mean capelin biomass (log-transformed) were first conducted for all 64 possible combinations of 8 distances (5, 10, 15, 20, 25, 30, 35 and 40 km) between the vessels and 8 time differences (12, 24, 36, 48, 60, 72, 84, and 96 h). The number of points in the correlations ranged from 0 to 65. All correlations that included at least 8 points (48 of 64) were positive. Correlations were the highest in the time difference range 36 to 60 h and distance range 15 to 25 km. Correlations were then calculated for all combinations of time differences (one hour steps) and distances (1 km steps) within this range. Most correlations in this range were greater than 0.5; the highest was 0.85 for a time-space window of 43 h time difference and 19 km distance (10 points in the correlation). The highest correlation with 20 or more points occurred for a time-space window of 47 h and 20 km. The correlation was 0.745 (p=0.0002). These data are plotted in Figure 1.

From the correlation analyses there is strong evidence that the amount of capelin found in cod stomachs is an indicator of the amount of capelin in the region around the cod sampling point. However, as stated above, there is the possibility that the number of cod in the area may affect the amount of capelin in cod stomachs, thus making the stomach content data a biased index of capelin biomass. To test for this we conducted a multiple regression analysis using the amount of capelin in cod stomach as the dependent variable and both capelin biomass in the environment and number of cod (in the 36 to 71 cm size range) caught in the trawl as dependent variables, for the points in Figure 1. All three variables were log-transformed. The results are shown in Table 1. There was no significant (p=0.77) effect of the number of cod in the trawl on the amount of capelin found in cod stomachs.

Table 1. Results of multiple regression analysis with *ln*(amount of capelin in cod stomachs) as dependent variable and *ln*(capelin biomass) and *ln*(number of cod) as dependent variables.

Source	Type III SS	Estimate	Prob. Type I Error
Intercept		0.278	0.3976
ln(cap. bio.)	2.238	0.240	0.0004
ln(no. cod)	0.010	-.022	0.7731

The results of this study indicate that, at least for this system, the cod stomach can be viewed as a sampling tool for the distribution and abundance of capelin. This is potentially very useful for cases in which no survey estimates are available for capelin but a cod survey with stomach sampling has been conducted. The results are particularly encouraging because they indicate a strong relationship even though the estimates from both surveys are known to be highly variable (Nakashima 1981, Carscadden et al. 1989) and the two surveys were not co-incident in space and time. Presumably the correlations would be stronger still if such co-incident data were available.

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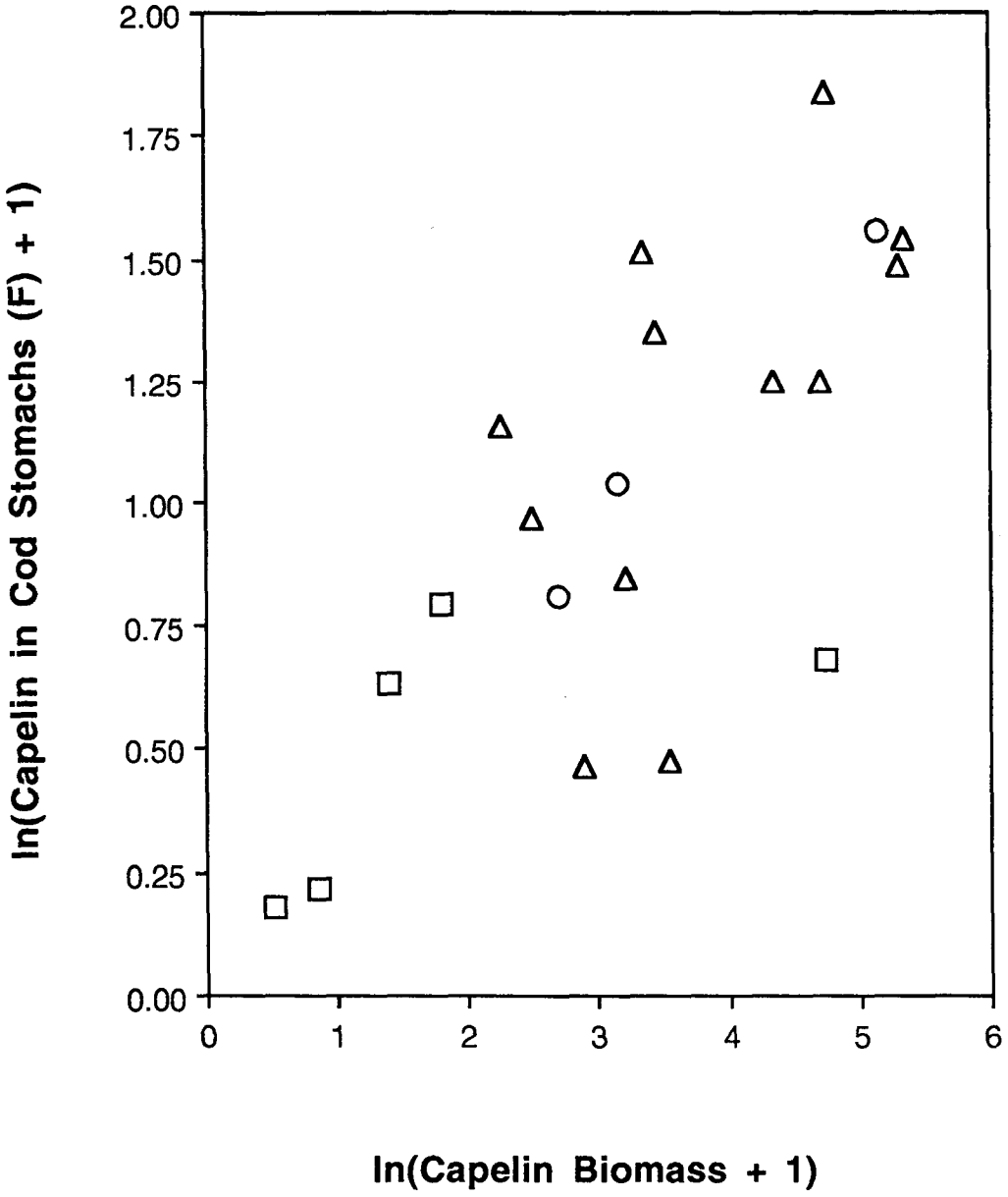

Figure 1. Relationship between the capelin content in cod stomachs and the capelin biomass in the local environment on the northern portion of the Grand Bank. Capelin in cod stomachs is *F* (see text). Data include all trawl stations for which there were capelin biomass samples from the acoustic survey within 47 h before and within 20 km distance (see text for more details). Triangles are data from 1985, circles from 1987, and squares from 1988.