Food consumption and diet composition of cod, *Gadus morhua*, inhabiting the southwestern Gulf of St. Lawrence

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Synopsis

Stomach content analysis of commercial size cod, *Gadus morhua*, inhabiting the southwestern Gulf of St. Lawrence are presented for the period May to November 1980. Season- and size-related changes in the diet composition are indicated and the results compared to those of earlier studies. The extent of cod predation on major prey groups is evaluated by estimating their consumption by cod age-groups 3-15. The evaluation is based on the estimate of food intake by individual cod of different ages derived with the aid of a procedure based on Ursin growth theory, estimates of numbers-at-age from cohort analysis and the results of stomach content analysis.

With the exception of American plaice, *Hippoglossoides platessoides*, and snow crab, *Chionoecetes opilio*, the consumption of commercially important species was relatively low and restricted to older cod. Commercially important species accounted for less than 12% of the total food biomass consumed by cod during the study period. The remainder consisted of other fish (18%), decapods (22%), euphausiids (15%), molluscs (11%), annelids (8%), and other invertebrates (15%). Methods are suggested to improve the above estimates of total and individual prey biomasses consumed by the fish population.

Introduction

Knowledge of the total and individual prey species biomasses consumed by a fish population enables us to better understand the nutritional constraints of the population and the effect of predation on prey populations. Much of the current interest in this field has been related to predator-prey interactions involving commercially important species. Studies on gadoid predation in various ecosystems suggest that significant consumption of commercially important prey does occur and may approach or surpass the biomass harvested by the fisheries themselves (Daan 1973, 1975, Minet & Perdou 1978, Ponomarenko et al. 1978). Laevastu & Favorite (1977, 1978) suggested that an increase in the high walleye pollock, *Theragra chalcogramma*, biomass during the 1970's contributed to the disappearance of the shrimp resource and suppressed the herring resource in the eastern Bering Sea. A similar situation may have existed between cod and brown shrimp, *Crangon crangon*, in the North Sea during the early 1970's (Boddeke 1971, in Daan 1973). On the other hand, shifts in the availability of certain prey influence the growth rate of the predator species. Hence, the increased dietary contribution of crustaceans (and the decreased occurrence of fish prey) observed for cod in the North Sea (Daan 1973) and on Georges Bank in the early 1970's (Grosslein et al. 1980) has
been interpreted as suboptimal feeding conditions. Similarly, Kohler (1964) suggested that the accelerated growth of Gulf of St. Lawrence cod during the mid to late 1950's was the result of an epizootic outbreak (*Ichthyosporidium hoferi*) which left large numbers of herring vulnerable to predation.

In the southern Gulf of St. Lawrence (NAFO Div. 4T, see Fig. 1), cod support the major groundfish fishery with recent catches of about 40,000 tons (Anon. 1982). Tagging studies (McCrocken 1959, Martin & Jean 1964, Kohler 1975) have shown that the stock migrates annually from the Sydney Bight area in the early spring to the Magdalen Shallows where it remains during the summer and early fall. During this time, the cod support a fishery consisting of otter trawls, Danish seines, gillnets, and hand- and longlines. Migration back to the overwintering area occurs in late fall. Other commercially important species in 4T include herring (*Clupea harengus harengus*), American plaice (*Hippoglossoides platessoides*), white hake (*Urophycis tenuis*), capelin (*Mallotus villosus*), mackerel (*Scomber scombrus*), and snow crab (*Chionoecetes opilio*). Earlier investigations on the diet of 4T cod (Corbeil 1953, Powles 1958, Kohler 1964) have shown that herring, capelin, and flatfish are major prey items. However, studies by Waiwood (1981) and Waiwood & Elner (1982) have suggested that the diet composition has changed in recent years with decapods, particularly snow crab, contributing a higher portion of the diet.

To better understand the impact of cod predation on prey populations and how predation patterns impact on growth of the cod, it is necessary to consider both diet composition and food consumption. Current estimates of diet composition are essential since previous observations were made prior to major changes in the pattern and magnitude of fish exploitation. Seasonal changes in diet composition and consumption must also be considered. Such an approach can provide valuable insight into the dynamics of the ecosystem itself.

In the following study the biomass of major prey groups consumed by cod was evaluated in a selected area in the southern Gulf of St. Lawrence during May to November, 1980. The procedure adopted was to calculate the total food consumption by different cod age-groups and to partition this food biomass into different prey categories based on their percent occurrence in the cod diet.

### Materials and methods

#### Evaluation of food consumption

The biomass of food consumed, in 1980, by the 4T-4Vn cod stock was evaluated, using the method of Majkowski & Waiwood (1980, 1981). Since the full description and reliability of the procedure have been presented elsewhere, only a brief outline is included here.

The procedure is based on the Ursin fish growth theory (Ursin 1967, 1979, Andersen et al. 1973, Andersen & Ursin 1977). According to this theory, the growth rate of a fish can be described by the following equation:

$$\frac{dw_i}{dt} = \beta_i (1 - \alpha_i) \frac{dR_i}{dt} - k_i w_i^n - e_i (w_i, t),$$

where $\frac{dw_i}{dt}$ is the instantaneous growth rate of a cod in the i-th age-group, $\beta_i (1 - \alpha_i) \frac{dR_i}{dt}$ is the instantaneous rate of food consumption adjusted for fecal and other losses related to feeding, $k_i w_i^n$ is the instantaneous rate of losses independent of feeding (fasting catabolism), and $e_i (w_i, t)$ is the instantaneous rate of spawning. Parameters $\beta_i$, $\alpha_i$, $k_i$, and $n_i$ are defined in Table 1.

The instantaneous rate of food consumption can be described as a power function of the fish’s body weight (Ursin 1967, 1979). Hence,

$$\frac{dR_i}{dt} = \bar{R}_i w_i^{m_i},$$

1 A fish belongs to the i-th age group if it becomes i-yr-old in the year under consideration.