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## CANNIBALISM OF COD IN THE GOTLAND BASIN OF THE BALTIC SEA

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### Abstract

Cod feed mainly on *Clupeidae* and invertebrates in the Gotland basin (ICES subdivision 26, 28). Sprat, herring and *Mesidotea* are the preferable food items. Other fish species, besides *Clupeidae*, such as *Enchelyopus cimbrius*, *Pomatoschistus* sp., *Gadus morhua* *callarias*, *Osmerus eperlanus*, *Platichthys flesus* constitute from 2 to 9% by weight of the total food content of cod. Particularly important is cannibalism because of its implication for the natural mortality evaluation. Relative frequency of cannibalism is evaluated using stomach content data. Length distribution of cod consumed and occurrence of cannibalism depending from predator length are analyzed in relation to season and depth stratum. The contribution of cod in cod stomachs is found low in the central Baltic. The frequency occurrence of cannibalism increase only with the abundance of juvenile cod. Annual variability of predation and factors, influencing the amount of cannibalism in Gotland area are considered.

### Introduction

Studies on the food and feeding of cod have been part of fisheries research in the Baltic sea during the last four decades. In the 1947-1982 investigations on cod feeding was carried out in the southern Baltic (Gulf of Gdansk in the east and Kolobrzeg-Darlowo fishing grounds in the west) by Poland. Predation on cod in 1947 and 1953 was 3.9-9.0% by occurrence in cod more than 40cm in length (Chrzan, 1962). Later, in 1955-1957 in

the Gulf of Gdansk of the 2246 cod stomachs examined cod was found in 64 (Strzyzewska, 1962). Cod preyed mainly during the winter on the 1-group cod. In 1972-1974 cod feeding ecology and quantitative estimates of food consumed by southern Baltic cod population was carried out by Zalachowski (1977). At the early 1970s cod accounted about 1.8% of the total food biomass consumed. In 1977-1982 due to the reduced sprat and herring resources predation of cod increased on two-large sized prey species *Enchelyopus cimbrius* and cod (Zalachowski, 1985). Cannibalism was more pronounced in 1978 and 1979, cod made up about 22 and 15% respectively of the total fish biomass consumed. In the rest years cod reached from 2 till 5 % the weight of the fish eaten. Investigation of the food composition of cod from the central and eastern Baltic were carried out in 1947, 1948 and 1955-1957 by Naumov and Radakov (1953), Spasski and Merezinskaja (1956, 1958). The predation on fish has been found low, or 7% and 15-20% by frequency of occurrence in 1940s and 1950s respectively. Besides herring and other fish the young cod in cod stomachs was mentioned only by Naumov and Radakov (1953). In this paper on the basis of a 30-year data set the predation by cod is summarized with respect to some major prey groups *Clupeidae* and invertebrate in the central Baltic. The occurrence of other fish species such as *Gadus morhua callarias* is analyzed to estimate frequency of occurrence of cod in cod stomachs, to determine the variability in cannibalism among years in different areas in relation to prey abundance and cod distribution by depth and area.

## Material and methods

The study area is the central and eastern part of the Baltic sea (subdivision 26,28 ICES). The number of stomachs sampled by cod length groups is given in table 1. Cod were caught during random depth stratified bottom trawl surveys, mainly during 1, 2 and 4 quarters of the 1963-1990. Samples were collected with respect to depth and disaggregated according to the predator length. Stomachs were analyzed individually. The number and weight of fish and other prey occurring in stomachs were recorded separately for each predator. The total length of the fish prey was measured.

Cannibalism of cod was characterized by :

percent weight (the weight of eaten cod as a percentage from the total stomach content weight in the sample),

frequency of occurrence ( number of stomachs containing cod from total number of stomachs containing food in the sample).

## Results

Stomach samples were taken during cod feeding and spawning periods, in subdivisions 26 and 28. Relatively large number of stomachs were found completely empty. Table 1 shows proportion of empty stomachs as well as number of stomachs containing cod by subdivisions and cod length groups. Relatively high values of empty stomachs ranging from 30 to 49% of the total stomach number were found in subdivision 26 on Gotland and Gdansk spawning grounds during the first half of the year. In subdivision 28, where aggregated mainly immature as well as mature pre-spawning cod on the coastal feeding

grounds and Gotland slope, empty stomachs were less than 20-30% of the total number of stomachs.

The food of cod in the central Baltic consists from sprat, herring (*Clupeidae*), *Mesidotea entomon* and other invertebrates (Figure 1). The frequency of occurrence of large sized food items *Clupeidae* and *Mesidotea* in cod stomachs is relatively lower compared with occurrence small invertebrates. But large sized food items strongly dominated by weight in cod diet year by year (Uzars, 1994). Only in few years during investigated period the occurrence of *Clupeidae* as well as *Mesidotea* was low, each of it constituted 15%. In most cases decrease occurrence of *Clupeidae* leads to increasing predation on *Mesidotea*. The role of the other fish species in cod diet are constantly low. The occurrence of such fish as *Enchelyopus cimbrius*, *Pomatoschistus* sp., *Platyichthys flesus*, *Ammodytes* and others in the cod stomach was about 8%.

Cannibalism in the central Baltic (subdivision 26 and 28) was registered very rarely and during 1963-1990 were recorded in 300 stomachs only. Cod as prey were observed mainly in the stomachs large size cod (>35cm). Cannibalism of small cod (<30cm) was found occasionally. Both large and small cod preyed mainly on 0-1 group cod, the length 5-15cm (Figure 2). The prey lengths were similar in both areas.

In subdivision 28 cannibalism was most intensive in coastal waters at depths of 40-80m (Figure 3). But in subdivision 26 cod was reported in stomachs mainly offshore on depths below the 80m.

Figure 4 indicates seasonal variability in cannibalism. In both areas cannibalism is generally higher in late autumn (November-January) and in the spring (March-April). Obviously, it is due to overlap of the young and elder cod distribution. After settlement young fish inhabited shallow bottom water layers in late autumn. Adult cod distributed mainly on the feeding grounds along the coast and on the banks near the Gotland Deep. In the winter cod migrates to the deeper water layers. Spawners migrate to the Gotland and Gdansk spawning grounds, but young fish offshore in waters with higher temperature, particularly during the cold winters (Lablaika and Uzars, 1983). In March-April in subdivision 26 cannibalism becomes more frequent at depths about 100m.

The frequency of occurrence of cannibalism varied among the years in each area (Figure 5 and 6). Large cod preyed on cod almost yearly, but cod was found in a few stomachs. Cannibalism in subdivision 28 was registered during 1975-1980 and 1963-1964 (2-4%) by occurrence. Small cod (20-35cm) almost did not prey on cod, although during 1975-1979 a slight increase in cannibalism was reported. Higher occurrence of cannibalism by weight of cod in small cod diet in 1984 and 1987 were related to the swallow up of the large specimens.

In subdivision 26 the highest level of cod in stomach were observed in 1963-1964, 1968-1970, 1973, 1977-1978 and 1981. The highest frequency of occurrence (about 2,6-3,8%) of cod in stomachs was reported in 1973, 1977, 1981.

The percentage of "other fish" by weight in subdivision 28 was high (30-35%) at the beginning of 1960s and during the second half of 1980s. In subdivision 26 cod fed more intensively on other fish species in 1980-1990. The predation on fish except *Clupeidae*, by young cod was higher in subdivision 26 to compare with subdivision 28.

## Discussion

The number of empty stomachs, number of stomachs with food and number of stomachs containing cod indicate proportion of population preying on cod. Due to the differences in weights of cod by lengths the frequency of occurrence was preferred to the percentage weight. Although, the number of prey cod was very low, some peculiarities of cod cannibalism have been found out.

In offshore and coastal waters of central Baltic cannibalism was reported almost every year during the 1963-1990, but frequency of occurrence was relatively low. The contribution of cannibalism to the diet of cod expressed as a mean percentage weight for the investigated period constitute 2.7% of the stomach content. The mean frequency of occurrence of cod in stomachs were 0.93 and 1.05 % in subdivision 28 and 26 respectively.

In subdivision 28 occurrence of cod in stomachs tended to be somewhat higher in 1963-1964 and 1979 (about 2%) and in 1977-1978 (about 4%). In the rest of the years contribution was small or zero.

In subdivision 26 increase of the occurrence of cod in cod stomachs was observed more often than in subdivision 28. In 1963-1964, 1968-1969, 1973 and 1981 number of stomachs containing cod ranged 2.1-2.9%, but in 1977 was 3.8%.

Frequency of occurrence of cannibalism in cod appears to be related to the recruitment abundance. The higher abundant generations were observed in 1964, 1967, 1969, 1972, 1976, 1977 in the years of favourable hydrographic conditions on the Deeps of the central Baltic, when reproduction volume was distributed in all spawning grounds (Netzel, 1974; Lablaika and et al., 1975; Plikshs and et al., 1993). Besides that, frequency of cannibalism coincides with the distribution overlap of the juvenile and adult cod.

The higher occurrence of cannibalism during 1977-1978 in subdivision 28 (2 cases from 28) supports the hypothesis mentioned above. After appearance of extremely abundant generations of cod in the late 1970s, population density of cod reached its peak. Cod distribution during this years was influenced mainly by food availability. The incidence of cannibalism in cod increased in subdivision 28. Cod preyed on cod on the feeding grounds at depths above 80m during the feeding period in late autumn (November-January). Competition for food resources increased in the main cod areas. Cod from the central Baltic migrated northwards to the Gulf of Riga, Gulf of Finland and Bothnian Sea (Ojaveer and et al., 1981; Aro, 1989). Gulf of Riga at this period was high inhabited by cod, which heavily preyed on herring and eelpout. In subdivision 28 cod fed on *Mesidotea* and herring. The predation on sprat was less pronounced due to the their distribution southwards particularly at the first half of the year. The predation of cod on other fish species was not intensive although sometimes their share increased to 30% by weight, while frequency of occurrence did not exceed 15%.

In subdivision 26 cannibalism is higher to compare with subdivision 28. The increase of occurrence of cod in stomachs in subdivision 26 was found more frequent during investigated period (7 cases from 28). The increase of year-class strength leads to the increase in cannibalism. Evidently, that population density of cod in subdivision 26 is high, particularly in the first half of the year. This suggestion is in accordance with feeding peculiarities of cod by depths during the year. In subdivision 26 cannibalism is generally

higher in deeper waters (below 80m) in March-April. At this time large part of the cod population concentrated in the Deeps of the Central Baltic. On the spawning grounds feeding intensity of cod is usually low. During the spawning time 50% of mature cod is not feeding. In subdivision 26 sprat is more important as food than herring. The share of 'other fish' slightly increased in the early 1980s in relation to the food competition at the period of higher cod biomass. But at the end of the 1980s, increased proportion of 'other fish' in diet was result of the extended area of the freshwater fish during the period of low salinity (Uzars, 1994).

Studies of the feeding habits of cod in central Baltic indicate that food consist of the permanently used food items, herring, sprat, *Mesidotea* and other invertebrates. The prevalence of pelagic fish and large invertebrates (*Mesidotea* and *Mysids*) in cod diet are related to the high population density. The contribution of the other fish species particularly cod in cod stomachs is distinctly low. The frequency occurrence of cannibalism in central Baltic increase only with the abundance of juvenile cod. Cod as prey belongs to age group 0-1 with the length range 5-15cm. Peak of cannibalism occurred in 1977-1978. The comparison of cod diets before and after 1977-1978 indicate that cannibalism during mid-1960s and early 1970s as well as in 1980s was recorded occasionally or not at all.

In view of this, it seems, that predatory cod impact was most pronounced on juvenile cod of the very strong recruitment from the 1976-1977. Because of the exceptionally strong year classes, SSB of cod increased sharply and reached a record-high level in the early 1980s. From the biological point of view predation on high abundant generations are self-regulatory mechanism affecting cod stock structure and abundance. Due to the low abundance of cod as prey during long period, the predatory impact on cod stock therefore be not regarded as essential in the central Baltic.

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Table 1. Number of stomachs contained in the database by subdivision and  
and lenght group of cod for 1963-1990

Subdivision	28		26		Total
Cod lenght group	20-35	>35	20-30	>35	
Stomachs with food	10741	12448	7056	14272	44517
Empty	2863	5517	2947	13502	24829
Stomachs containing cod	21	116	13	150	300
Total	13604	17965	10003	27774	69346
Proportion of empty stomachs	21	31	30	49	

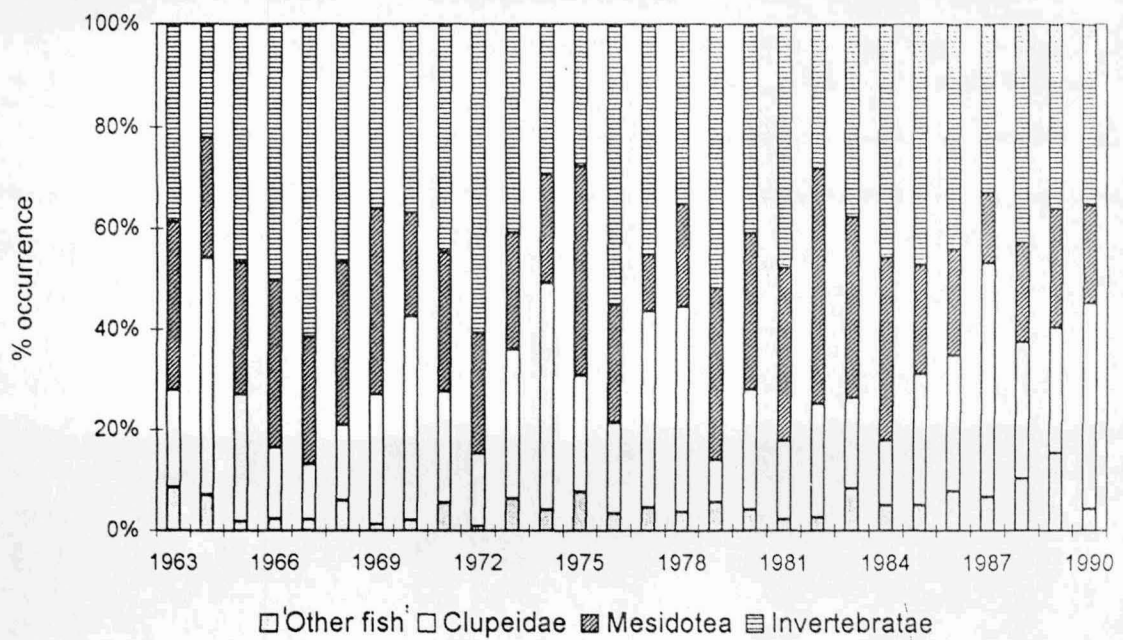


Figure 1. Frequency of occurrence (%) of Clupeidae, Mesidotea entomon, other invertebrate and 'other fish' in the cod stomachs

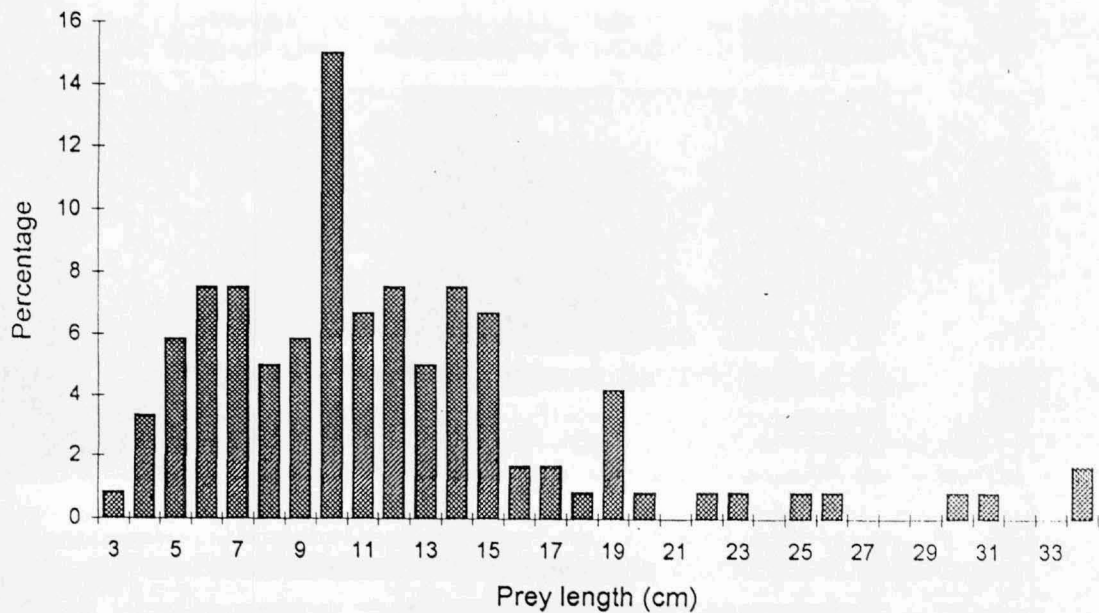


Figure 2. Length distribution of cod in stomachs. Subdivision 28+26



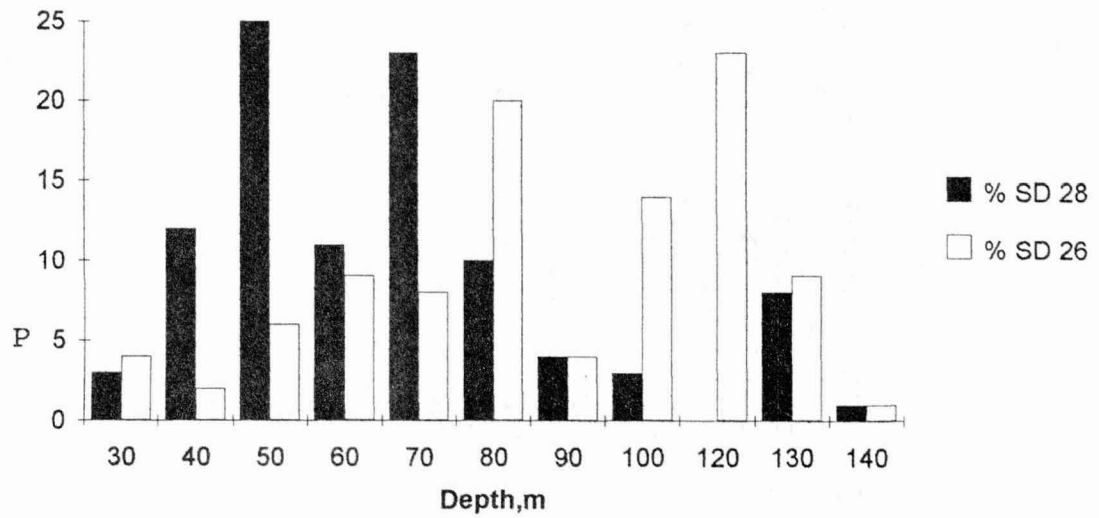


Figure 3. Variability of occurrence of cod in cod stomachs by depths in subdivisions 28 and 26

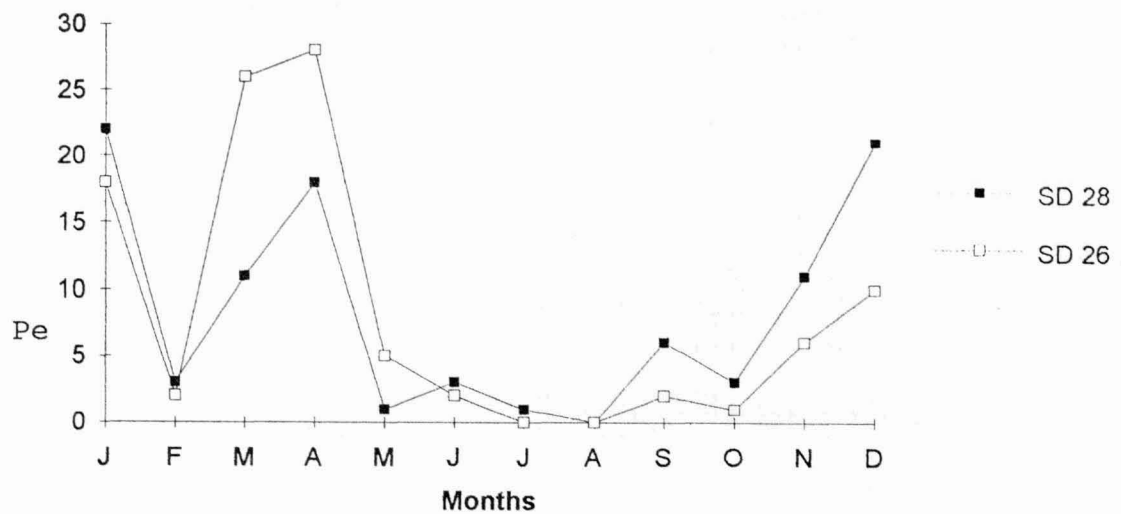
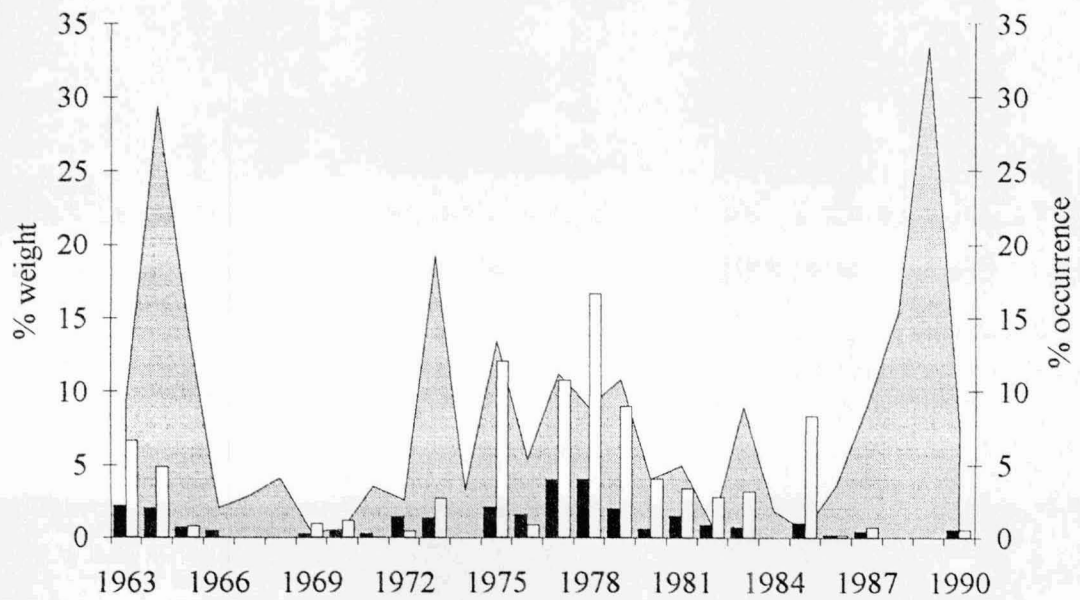


Figure 4. Relative number of cod in cod stomachs from January to December in subdivisions 28 and 26

Size group > 35 cm



Size group 20 - 35 cm

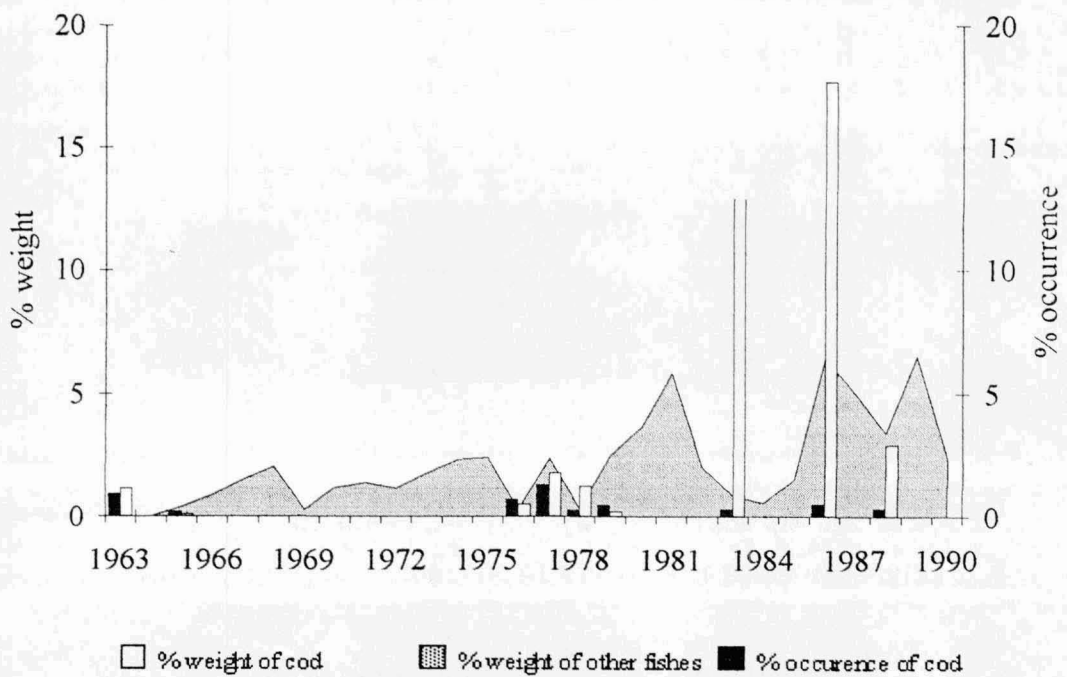
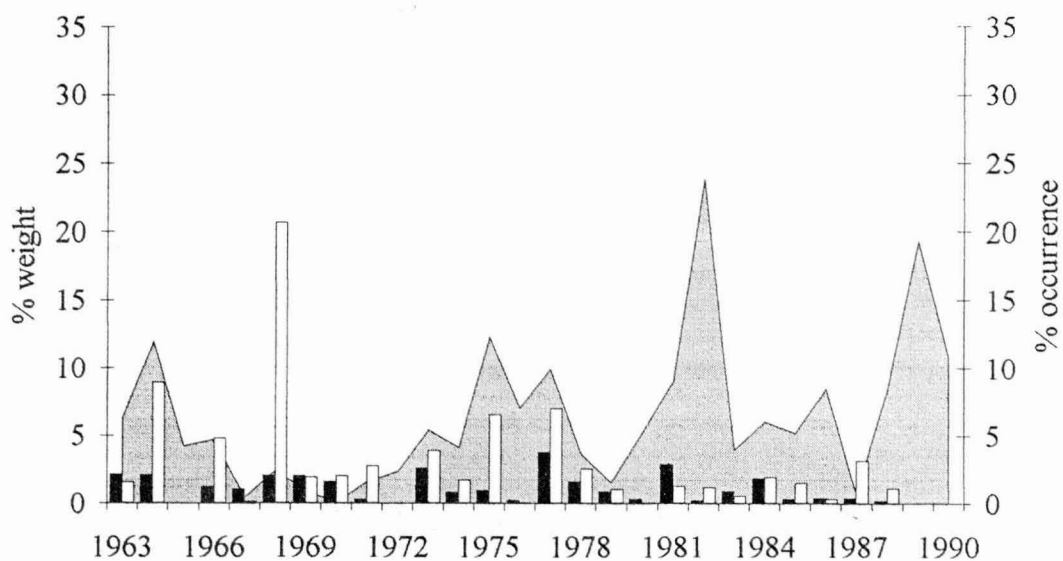


Figure 5. Predation by cod on cod by areas (SD 28) as % weight or % occurrence and "other fish" (excluding Clupeidae) as % weight

### Size group > 35 cm



### Size group 20 - 35 cm

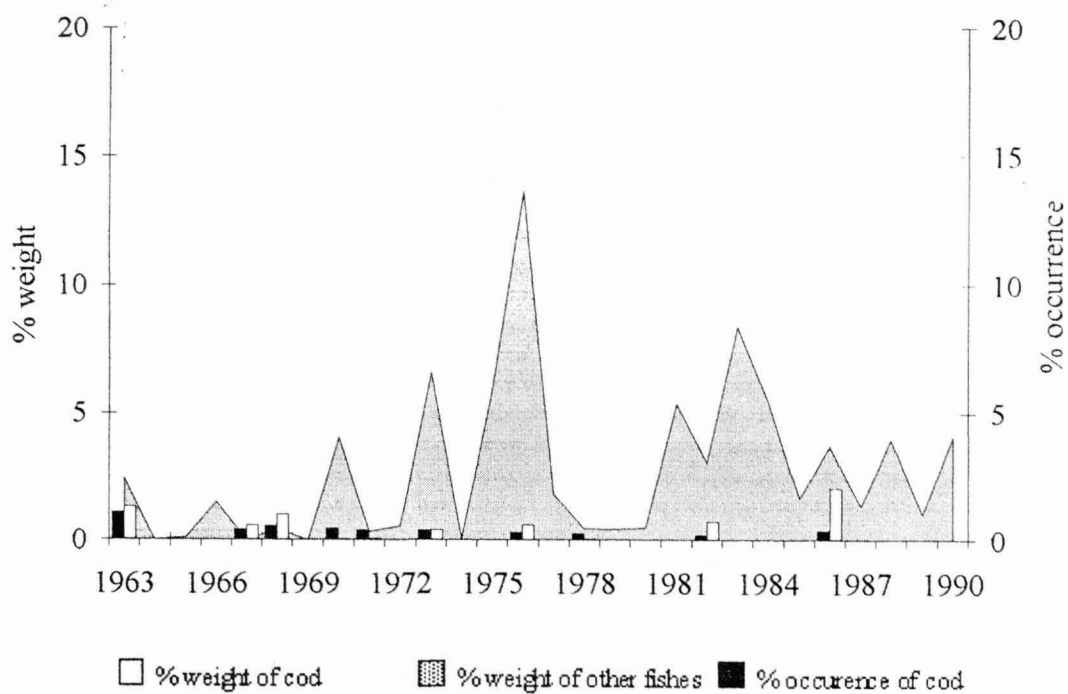


Figure 6. Predation by cod on cod by areas (SD 26) as % weight or % occurrence and "other fish" (excluding Clupeidae) as % weight