NOT TO BE CITED WITHOUT PRIOR REFERENCE TO THE AUTHOR(S)

Northwest Atlantic



Fisheries Organization

Serial No. N230

NAFO SCR Doc. 80/IX/155

# ANNUAL MEETING OF SCIENTIFIC COUNCIL - SEPTEMBER 1980

# Size Relationship in the Predation by Atlantic Cod, Gadus morhua (L.), on Capelin, Mallotus villosus (Müller), and Sand Lance, Ammodytes dubius Reinhardt

by

G. R. Lilly, and A. M. Fleming<sup>1</sup> Department of Fisheries and Oceans, Research and Resource Services Northwest Atlantic Fisheries Center, P. O. Box 5667 St. John's, Newfoundland, Canada

## ABSTRACT

The minimum length at which cod can prey on adult capelin and sand launce is about 35 cm, but smaller cod can prey on juveniles of both species. The size range of cod preying intensively on capelin is aproximately 40-70 cm, but the upper limite is imprecise. Intensity of predation by cod on capelin and sand launce is highly variable.

#### INTRODUCTION

This paper examines size-relationships in the predation by Atlantic cod, <u>Gadus morhua</u> (L.), on capelin, <u>Mallotus villosus</u> (Müller), and sand launce, <u>Ammodytes dubius</u> Reinhardt. Capelin is a major prey of cod throughout the Labrador and Newfoundland area exclusive of the Flemish Cap, and sand launce is particularly important on the Grand Bank and St. Pierre Bank (Thompson 1943, Popova 1962). Capelin stocks in 2+3K and 3LNOPs have recently declined significantly (Anon. 1979), whereas sand launce on the Grand Bank appears to have increased in abundance (G. H. Winters pers. comm.). Examination of the effects of these changes on the feeding behaviour, growth and reproduction of cod requires knowledge of the size range of cod likely to be affected.

The size and quantity of capelin and sand launce in the stomachs of cod of a wide size range were examined in several regions where cod were feeding predominantly on these prey.

# MATERIALS AND METHODS

Cod were sampled from inshore and offshore areas of 3L by means of commercial cod trap, gillnet and otter trawl (Table 1). A few additional cod were obtained from 3NO in June 1978 to supplement measurements of sand launce occurring in cod stomachs. The cod were measured to the nearest cm. Stomachs were excised and preserved in 10% formalin.

Stomach examination involved separating food items into taxonomic categories, the level of identification varying with the relative importance of the prey. Items in each taxon were placed briefly on paper towelling to remove excess liquid, and then weighed to the nearest 0.1 g. Capelin and sand launce were measured to the nearest mm total length whenever digestion was not too far advanced. No correction was applied for any shrinkage which may have occurred.

<sup>1</sup>Present address: 14 Amherst Heights St. John's, Newfoundland A1E 3J1 A partial stomach fullness index (PSFI) was calculated to permit comparison of quantities of capelin and sand launce in stomachs of cod of various sizes. The PSFI of prey category  $\rm P_i$  in fish  $\rm F_i$  is

$$PSFI_{ij} = \frac{weight of P_i}{(length of F_i)^3} \times 10^5$$

and the average partial stomach fullness of prey category P; is

$$\frac{1}{n} \sum_{j=1}^{U} PSFI_{ij}$$

where n is the number of fish. The total stomach fullness index of fish  $F_i$  is

where m is the number of prey categories.

The importance of capelin or sand launce within each sample was also assessed from percentage occurrence and percentage contribution to total weight of stomach contents.

For purposes of comparison of prey at different body lengths of predator, the cod were combined in 5- or 10-cm length groups. Any group with less than 4 fish was excluded from the analysis.

#### RESULTS

# PREY LENGTH AND PREDATOR LENGTH

The minimum length at which cod can prey on adult capelin is about 35 cm (Fig. 1a). The minimum length for predation on adult sand launce is between 30 and 35 cm (Fig. 1b). Smaller cod can ingest smaller individuals of both prey species, but there are insufficient data to define accurately for either prey the maximum value of the ratio of prey length to cod length.

#### STOMACH FULLNESS AND PREDATOR LENGTH

A changing prey spectrum with increasing body size is illustrated in cod caught in the Avalon Channel in May 1968. Cod have previously been reported to feed heavily on capelin in this area in spring (Seliverstov and Kovalev 1976), but as shown in Fig. 2, small cod less than 35 cm preyed predominantly on euphausiids. Capelin was the major prey of cod of 35 cm to about 90 cm. Crab, a minor component in 35-90 cm fish, was the major food of cod greater than 90 cm. The total fullness index was highest in the cod 30-50 cm in length, and decreased progressively with increasing body size.

The pattern of change in prey spectrum and stomach fullness with increasing body size shown in Fig. 2 typifies the patterns seen in the limited data presently available, but variations have been found, examples of which follow.

The inshore commercial trap fishery in late spring and summer catches relatively small cod (Templeman and Fleming 1956) which feed almost exclusively on capelin (Templeman 1965). In a combined sample from Bonavista and St. John's (Fig. 3a) the PSFI for capelin was high (almost 6) in the smaller cod and decreased with increasing body size.

In a sample taken by research gillnet in Bonavista and Trinity Bay in May 1967, most cod were not feeding intensively on capelin (Fig. 3b), but capelin was the dominant prey in the smaller individuals in this sample of large fish. Crabs and shrimp were the other important prey.

In a sample taken near Cape Bonavista in March 1967 cod of a broad size range were preying intensively and almost exclusively on capelin (Fig. 3c).

Even large cod of 80-90 cm were preying intensively on capelin (PSFI about 8), and stomach fullness was higher than recorded in trap cod (Fig. 3a). The cod were in relatively deep and warm water (228-278 m;  $0.7-1.4^{\circ}C$ ). Capelin were not taken in the bottom trawl. They may have been in the colder (< $0^{\circ}C$ ) water above, for large concentrations of capelin have been reported overwintering in cold midwater depths in nearby Trinity Bay at this time of year (Winters 1968, 1969). Some of the capelin were just 10-11 cm in length.

In a sample taken on the northwestern Grand Bank in July 1966 the pattern of predation (Fig. 3d) was very similar to that in the previous sample (Fig. 3c), except that intensity of feeding was much lower. Note that even cod in the 20-30 cm size class were preying on capelin, presumably selecting the smaller 10-11 cm capelin found sufficiently intact in larger cod to permit measurement.

The feeding pattern when cod were feeding on sand launce on the northeastern Grand Bank (Fig. 4) was very similar to that found when cod were feeding on capelin. Cod of 20-30 cm did feed on sand launce, but the major prey were gammarid amphipods. With increasing cod size the predation on sand launce became more intense, attaining a maximum in cod of 50-70 cm. In this size range stomach fullness in the 1967 sample was almost twice as high as in the 1966 sample.

#### DISCUSSION

The data in this paper were selected to show that the intensity of predation by cod on capelin and sand launce varies with the predator's size and with geographic location. Geographical and temporal comparisons of feeding behaviour are often based on frequency of occurrence of a given prey or its percentage contribution by weight or volume to the total stomach contents. These data can be misleading indicators of feeding intensity. For example, in the two samples of cod preying on sand launce on the northeastern Grand Bank (Fig. 4), the frequency of occurrence and percentage by weight were similar in the two years (Table 1), but the stomach fullness index was much higher in 1967 than in 1966 (Table 1, Fig. 4).

The change in prey spectrum with increasing length of cod shown in Fig. 2-4 corresponds with the observations of other investigators (for example, Powles 1958, Daan 1973, Minet and Perodou 1978). Small cod tend to feed on crustaceans, such as mysids, euphausiids, amphipods and shrimp, medium size cod feed on small fish, such as capelin and sand launce, and large cod feed on crabs and medium-sized fish, such as Pleuronectidae.

The size range of cod preying on capelin is not easily defined. Cod must be about 35 cm to feed on adult capelin, but even cod less than 30 cm can feed on juvenile capelin (Fig. 1, and 3; and Powles 1958). Cod with the highest PSFI for capelin are approximately 40-70 cm in length, but there is no precise upper limit, and even cod up to 100 cm or more may prey on capelin under favourable circumstances of high availability. The size range of cod that feeds on capelin has previously been described as 30-70 cm (Popova 1962), 35-70 cm (Turuk 1968) and 30-60 cm (Stanek 1975).

Cod are presumed to prey primarily on adult capelin. However, there are reports of predation on 10-12 cm capelin (presumably 2-yr-olds) in northern 3L in March (Templeman 1965, and this paper) and on offshore banks of 3K and 3L in summer (Popova 1962, and this paper). There is also one report of cod feeding on 1-yr-olds (7-10 cm) inshore in 3K in August (Templeman 1948). Cod in Greenland have been reported feeding on 2-yr-old (10-14 cm) and 1-yr-old (3.5-6 cm) capelin (Hansen 1949).

The intense predation by cod on capelin in inshore areas during the capelin spawning season (Fig. 2a) is well known (Thompson 1943, Templeman 1965). However, predation may be intense at other times as well. For example, large concentrations of capelin appear to be available to cod concentrated in relatively warm water (0.5-1.5°C) just below the Labrador Current, such as in the Cape Bonavista area in March 1967 (this paper) and on the northern Grand Bank in March 1961 (Templeman 1965). These capelin may be within the cold water of the Labrador Current and accessible to vertically migrating cod.

The size range of cod feeding on sand launce appears to correspond very closely to the size feeding on capelin, with respect to both the total size range involved and the sizes showing the highest fullness indices. In this respect capelin and sand launce occupy very similar roles in the diet of cod.

- 4 -

#### ACKNOWLEDGEMENTS

We are indebted to T. Collier for examination of cod stomachs and supervision of several students who assisted in the study. We also thank C. Mullins for drafting the figures.

### REFERENCES

Anon. 1979. Report of standing committee on research and statistics. Report of <u>ad hoc</u> working paper on capelin. ICNAF Redbook 1979, p. 33.

- Daan, N. 1973. A quantitative analysis of the food intake of North Sea cod, Gadus morhua. Neth. J. Sea. Res. 6: 479-517.
- Hansen, P. M. 1949. Studies on the biology of the cod in Greenland waters. Rapp. P.-v. Réun. Cons. Perm. Int. Explor. Mer. 123: 1-77.
- Minet, J. P. and J. B. Perodou. 1978. Predation of cod, <u>Gadus morhua on</u> capelin, <u>Mallotus villosus</u>, off eastern Newfoundland and in the Gulf of St. Lawrence. ICNAF Res. Bull. 13: 11-20.
- Popova, O. A. 1962. Some data on the feeding of cod in the Newfoundland area of the Northwest Atlantic. <u>In</u>. Sov. Fish. Invest. Northw. Atl. VINRO-PINRO, MOSCOW (Isreal Program for Scientific Translation 1963).
- Powles, P. M. 1958. Studies of the reproduction and feeding of Atlantic cod (<u>Gadus callarias</u> L.) in the southwestern Gulf. of St. Lawrence. J. Fish. Res. Board Can. 15: 1383-1402.
- Seliverstov, A. S., and S. M. Kovalev. 1976. Size of the capelin spawning stock on the Grand Newfoundland Bank. ICNAF Res. Doc. 76/vi/51, Ser. No. 3837.
- Stanek, E. 1975. The percentage of capelin in the stomach contents of cod in ICNAF Subareas 2 and 3. ICNAF Res. Doc. 75/5, Ser. No. 3433.

Templeman, W. 1948. The life history of the capelin (<u>Mallotus villosus</u> 0. F. Müller) in Newfoundland waters. Gov't. Nfld. Lab., Res. Serv. Bull. No. 117, 151 p.

1965. Some instances of cod and haddock behaviour and concentrations in the Newfoundland and Labrador areas in relation to food. ICNAF, Spec. Publ. 6: 449-461.

Templeman, W., and A. M. Fleming. 1956. The Bonavista longlining experiment, 1950-53. Fish. Res. Board Can. Bull. 109.

- Thompson, H. 1943. A biological and economic study of cod (<u>Gadus callaris</u> L.) in the Newfoundland area including Labrador. Nfld. Dep. Nat. Res., Res. Bull. 14, 160 p.
- Turuk, T. N. 1968. Seasonal changes of cod feeding in the Labrador and Newfoundland areas in 1964-1966. Trudy PINRO, 23: 370-382. (Fish. Res. Board Can. Transl. Ser. No. 1937).
- Winters, G. H. 1968. Fishery investigations and groundfish landings in Newfoundland, 1967. Capelin. Fish. Res. Board Can., Biol. Stn., St. John's, Circular 15: 17–23.

1969. Migrations of coastal capelin in Trinity Bay. Ibid 16: 10-11.

# Table 1.

Details of cod stomach collections. (N=number of stomachs;F.O.=frequency of occurrence;P.Wt.=percentage contribution by weight;O.T.=otter trawl;G.N.=gillnet)

Date	Gear	N	F.0.	P. Wt.	PSFI	
	• • • • • • • • • • • • • • • • • • •		· · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·		
5/68	0.T.	134	51	47	1.52	
7/68 7/69	Trap	149	88	99	4.50	11 <sup>1</sup> 4
5/67	G.N.	146	33	50	1.02	
3/67	0.T.	117	85	96	5.82	
7/66	0.T.	80	45	74	1.01	
						* 1
7/66	0.T.	103	58	83	2.45	
6/67	0.T.	63	57	89	4.71	·
	Date 5/68 7/69 5/67 3/67 7/66 7/66 6/67	Date Gear   5/68 0.T.   7/68 Trap   5/67 G.N.   3/67 0.T.   7/66 0.T.   7/66 0.T.   6/67 0.T.	Date Gear N   5/68 0.T. 134   7/68 Trap 149   7/69 G.N. 146   3/67 O.T. 117   7/66 O.T. 80   7/66 O.T. 103   6/67 O.T. 63	Date Gear N F.O.   5/68 O.T. 134 51   7/68 Trap 149 88   5/67 G.N. 146 33   3/67 O.T. 117 85   7/66 O.T. 80 45   7/66 O.T. 103 58   6/67 O.T. 63 57	DateGearNF.O.P. Wt.5/68O.T.13451477/68Trap14988997/69G.N.14633505/67G.N.14633503/67O.T.11785967/66O.T.8045747/66O.T.10358836/67O.T.635789	Date Gear N F.O. P. Wt. PSFI   5/68 0.T. 134 51 47 1.52   7/68 Trap 149 88 99 4.50   5/67 G.N. 146 33 50 1.02   3/67 O.T. 117 85 96 5.82   7/66 O.T. 80 45 74 1.01   7/66 O.T. 103 58 83 2.45   6/67 O.T. 63 57 89 4.71



Fig. 1. Relationships between length of cod and length of (A) capelin and (B) sand launce. Capelin data from northern Grand Bank and near Cape Bonavista. Sand launce data from northeastern and southern Grand Bank.

- 6 -







Fig. 3. Relationship between cod length and partial stomach fullness indices. (A) Trap: St. John's and Bonavista (B) Gillnet: Bonavista and Trinity Bays: (C) & (D) Otter trawl.



Fig. 3(cont'd) Symbols as in (A).

- 9 -

ີ. ະ



