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Food and feeding of the American plaice (*Hippoglossoides platessoides* F.) on Saint-Pierre Bank (ICNAF Subdiv. 3Ps) and on Cape Breton Shelf (ICNAF Subdiv. 4Vn)

by

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Abstract.

This study contributes to the knowledge of food and feeding of the American plaice on the St. Pierre bank and off Cape Breton Island (ICNAF Subdiv. 3 Ps and 4 Vn).

The foods principally consumed are echinoderms, molluscs, crustaceans, polychaetes and fish. The diet of the St. Pierre bank plaice is different from that of the Cape Breton plaice. Small plaice feed mainly upon crustaceans, polychaetes and upon small brittle stars and bivalves. Adults eat more sea urchins, big bivalves, crabs, ascidians and fish. In the two regions studied, the diet of the plaice varies with the season and the temperature of waters in which it lives. In fall and especially in winter, a drastic reduction in feeding can be noted. Feeding intensity also varies throughout the day.

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I. - Introduction.

There is little information on the food and feeding of the American plaice Hippoglossoides platessoides in the Newfoundland and Nova-Scotia areas.

However, attention must be drawn to studies by **HUNTSMAN** (1918) and by KOMAROVA on the food of the Barents sea plaice (in **ANDRIYATCHEV**, 1954). More recently, research by POWLES (1965) in the southwestern Gulf of St. Lawrence (ICNAF Division 4 T) has provided valuable data on the organisms consumed by the plaice, on the feeding intensity in relation to size and to the season, and on the feeding competition occuring between this species and cod.

As part of seasonal groundfish surveys, our study contributes to the knowledge of food and feeding of the American plaice on the St. Pierre bank and off Cape Breton Island. It supplies further information

on the effect that location, size, sex, bottom temperature, season and period of the day may have on the diet and feeding behaviour of the American plaice in these regions.

II. - Material and methods.

The material used in this research was collected by the author in 1971 and 1972, during four seasonal cruises of the R/V CRYOS on the St. Pierre bank and the Cape Breton shelf. The dates of the samplings are as follows :

- In 3 Ps, in summer (11-23 July 1971), in fall (9-14 November 1971), in winter (7-22 February 1972) and in spring (4-12 May 1972).
- In 4 Vn, in summer (24-27 July 1971), in fall (25-28 November 1971), and in spring (18-24 May 1972). Ice conditions in this region during the winter of 1971-1972 prevented trawling and thus deprived us of data.

The position of the trawl hauls is shown in fig. 1. The bottom trawl used had the following specifications :
- 31.20 m headline mounted on 30.80 m,
- 17.70 m groundrope with steel-bobbins,
- 140 mm mesh in the wings and body and 50 mm in the codend.

On board, after each haul, the stomachs were immediately removed from a sample of males and females. A label was attached to the thread ligaturing the opening of the stomach giving the following information : sex, total length, weight of the fish, as well as the number of the set which provided details as to position, date, time of the catch, depth, nature of the ground and near-bottom temperature. The stomachs were quickly stored in jars containing 8 % formalin in order to avoid deterioration of the stomach contents.

In the laboratory, each stomach was drained and dissected and the organisms contained in it seperated by species when possible or by systematic group (genus or family) when they were too far digested to make the distinction. The pebbles and shell debris, the vegetal or animal fragments were also grouped. Each species was weighed to the hundredth of a gram.

Simultaneously, the stage of repletion of each stomach was noted using the criteria 0 to 4 :
- 0 : stomach empty
- 1 : stomach one-quarter full
- 2 : stomach half-full
- 3 : stomach three-quarters full
- 4 : stomach completely full.

For each species or group, the stage of digestion was noted using four categories from the most recently ingested foods (stage A) to those having undergone the digestive process to a greater and greater degree (stages B, C and D). In this study, we have used only the data concerning the recently ingested food and for this reason we describe stage A for the main systematic groups :

- Annelids : whole animal, with all its segments and appendices, and no signs of digestive attack.
- Molluscs : whole animal, adhering securely to the shell.
- Crustaceans : whole animal, without change in colour and with firm consistency.
- Brittle stars and sea stars : whole animal, with arms intact and plates rigidly locked together.
- Sea urchins : whole and full animal, with its test unbroken and with all its spines.
- Fish : whole and fresh animal, with its scales, skin and colours and showing no signs of digestive attack.

In addition, we set up a reference collection of the specimens in good condition to help us in determining the organisms too far digested. For each numbered stomach, an individual sheet was established reporting all the observations made on board and in the laboratory, as described above.

In all, 932 stomachs were sampled and examined for this study (564 on the St. Pierre bank during four seasonal cruises and 368 off Cape Breton Island during three cruises).

III. - Results.

1 - Food of the American plaice : main groups observed.

Upon examination of the Table 1 we see the main groups of organisms used as food by the American plaice in the two sectors studied. We must nevertheless comment on and give further details about the data on this table.

- Echinoderms are the group found most frequently in the stomachs which we examined. Among this phylum, few representatives of holoturians were found : genus Cucumaria and Thyone. As for sea stars, the only species found was Ctenodiscus crispatus. On the other hand, brittle stars were plentiful : Ophiura sarsi, O. robusta and Ophiopholis aculeata. The sea urchins are also important components of the stomachs : a large proportion of Strongylocentrotus droebbachiensis, a little less of Echinarachnius parma and only one specimen containing Schizaster fragilis in 3 Ps.

- Molluscs are the second most important food group for the plaice, due mainly to pelecypods found in large numbers : Yoldia myalis and Y. thraciaeformis. A few instances of Y. sapotilla and Nuculana tenuisulcata are found as further representatives of the Protobranchia. Among the Filibranchia, Chlamys islandicus is the most frequent. As for the Eulamellibranchia, we must note the presence of Clinocardium ciliatum and Serripes groenlandicus with lesser numbers of Siliqua costata and Cyrtodaria siliqua and a few specimens of the genera Astarte, Tellina, Macoma and Spisula. Gasteropods are quite scarce and small in size. Margarites cinerea, M. helicina and M. groenlandica account for two-thirds of this group, the remainder including Turbonilla interrupta, Velutina laevigata, Natica clausa and Polinices groenlandica. A single representative of the Polyplacophora (Lepidochiton marmorea) was found twice in 3 Ps.

- Crustaceans constitute the third food group, mainly because of numerous amphipod families (Anonyx nugax, Euthemisto sp., Caprella sp. Stegocephalus sp., Ampelisca sp., Talorchestia sp., etc...) and euphausids (Meganyctiphanes norvegica). We also find Mysis mixta for the mysids, Diastylis polita for cumaceans and Idotea phosphorea for isopods. Among decapods, are Macrura (Pandalus borealis, Sabinea sarsi and Spirontocaris spp.), Anomura (Pagurus sp.) and Brachyura (Hyas coarctatus and H. araneus).

- Polychaetes are present in the stomach contents : Aphrodite aculeata, Nereis spp., Nephthys sp. and mainly Onuphis conchilega for Errantia ; Pectinaria granulata, Amphitrite sp. and mostly Potamilla sp. for Sedentaria. Phascolosoma sp. represents the sipunculids order.

- Teleosts are also consumed as food by plaice : the most abundant is the sand-launce Ammodytes americanus, and small Sebastes mentella and Glyptocephalus cynoglossus, and more rare fish such as Antimora rostrata or non-identified Myctophidae, Paralepididae and Zoarcidae.

- Cnidaria (Antennularia sp., Pennatula borealis, Renilla reniformis and especially Bolocera tuediae), Lophophoroidea (Membranipora monostachys and Hemithyris psittacea) and ascidians (Styellidae family) were also found.

2 - Geographic variation in the diet of the American plaice : comparison of food between 3 Ps and 4 Vn.

Certain differences in the diet of the plaice can be noticed on examining the relative importance of each food group contained in the stomachs sampled on the St. Pierre bank and on the Cape Breton banks (Table 1).

The American plaice, off Cape Breton Island does not eat any ascidians and eats less fish (1.4 %), cnidaria and molluscs (mainly Protobranchia) than the plaice of St. Pierre bank. On the other hand, it consumes

more polychaetes (23.3 %), lophophoroidea, crustaceans (38.8 %, especially amphipods and cumaceans) and echinoderms (94 %, mainly a large quantity of brittle stars).

On St. Pierre bank, echinoderms (mostly brittle stars) are also the most important food group, but their proportion is not as large. The diet in this region is therefore more varied and balanced.

3 - Variation of the diet in relation to the size and sex, in 3 Ps and 4 Vn.

The diet of the plaice varies with its size. This variation has repercussions on the diets of the two sexes since the females reach greater sizes than the males. These differences are roughly the same in the two regions. Details are given in Tables 2 A and 2 B.

In general, brittle stars are consumed in equally large quantities by the small and large plaice. This is due to a change in species: Ophiura robusta and small Ophiopholis aculeata for the small fish and Ophiura sarsi and big O. aculeata for the large. As size increases, there is a greater percentage of sea urchins consumed.

The percentages of Protobranchia molluscs decrease with the size. We must however point out that the small specimens eat more Yoldia myalis and the large ones Y. thraciaeformis. The percentage of Filibranchia (Chlamys islandicus) increases with the size and that of Eulamellibranchia is greatest at the medium sizes.

The percentages of crustaceans isopods, amphipods, euphausids and decapods Macrura (shrimps) also diminish with the size. It is clear that these small organisms constitute a choice food for the young plaice (20 - 35 cm). On the other hand, crabs (Brachyura) are ingested in greater quantity by the large fish (46 - 70 cm).

Fish are more frequently found in the stomachs of the larger plaice. We must note however that the small plaice of the St. Pierre bank consume larvae and very young non-identified fish; this fact is expressed by relatively large percentages of this dietary form.

The consumption of polychaetes diminishes as the size of the plaice increases. This is true both for Errantia and Sedentaria.

Finally, the percentages of ascidians (on the St. Pierre bank only) increase with the size groups.

These changes in diet described above (which are due to varying capacities for ingestion of food of a given size) mean that the females, always larger, consume a different type of food. Therefore, the females eat less crustaceans (especially less isopods, amphipods and euphausids), less polychaetes but more echinoderms (large brittle stars and sea urchins) and more molluscs (Protobranchia).

4 - Seasonal variation in diet on the St. Pierre and Cape Breton banks.

The diet of the plaice varies with the season, depending on the type and quantity of food available.

In order to make this phenomenon clear, we have noted the relative quantity of each food group in the non-empty stomachs and expressed the results in percentage (Table 3).

- On St. Pierre bank, it is worth noting the importance of Protobranchia molluscs (32.6 %) in fall, while in spring almost all the molluscs ingested are Eulamellibranchia (9.9 %). For the crustaceans, there is a significant change : abundance of euphausids in fall (20.7 %), replaced by amphipods in winter (12.3 %) and by crabs (7.6 %) in spring. The sea urchins are ingested more often in spring (32.0 %) while the brittle stars are more frequent in winter (33.3 %). Almost all the fish ingested in spring are sand launces (4.1 %) while in fall, the redfish and witch are more numerous (1.2 %).

- On the Cape Breton shelf, Protobranchia molluscs are also principally consumed in fall (6.3 %), while in spring the Eulamellibranchia are again more frequent (5.7 %). In this region, amphipods and euphausids are eaten mainly in summer (2.5 and 2.6 %). The brittle stars represent the greater majority (52.0 %) of echinoderms eaten in spring, while the sea urchins are the most frequently found in fall (22.0 %). Sedentaria polychaetes seem to be more abundant in summer (13.3 %). Here again, the sand launces account for the fish consumption of the plaice in spring.

5 - Variation of the diet in relation to bottom temperatures, in 3 Ps and 4 Vn.

In each season, the temperature was taken at each sampling station in order to have information about the thermic environment of the American plaice. Apart from a few details, the variations of the diet are the same in the two regions studied (Table 4).

Echinoderms form the basis of the food (70 to 95 %) in cold and temperate waters (-1 to 4° C). The brittle stars make up the majority of food (44 to 55 %) between 0 and 4° C, while the sea urchins also contribute and are still abundant in waters colder than 0° C. In warmer waters, the percentages decrease.

Protobranchia molluscs replace the former group in the warmer waters (4 and more than 6° C) covering the St. Pierre bank (63 to 72 %). The same group is found at similar temperatures in 4 Vn but to a lesser degree, since here the maximum percentage lies between 0 and 2° C where Yoldia myalis and Naculana sp. are more abundant than Y. thraciaeformis. Between 4 and 6° C, the gasteropods and Eulamellibranchia (Clinocardium

ciliatum) are more abundant. Other Eulamellibranchia (Serripes groenlandicus and mostly Cyrtodaria siliqua) and Filibranchia (Chlamys islandicus) are also found in cold waters (from -1 to 2° C) in both regions.

The polychaetes are ingested at high temperatures (4 to more than 6° C) but in greater quantity off Cape Breton Island (close to 50 %) replacing the Protobranchia molluscs.

Crustaceans of small size (mysids, cumaceans, isopods, amphipods and euphausids) and crabs are generally eaten in larger numbers in cold waters (-1 to 2° C).

On St. Pierre bank, ascidians are only eaten at low temperatures (-1 to 2° C).

As for the fish, a distinction must be made between the sand launces and Myctophydae consumed in cold waters (-1 to 2° C) and the Scorpaenidae and Pleuronectidae in warmer waters (mainly between 4 and 6° C).

6 - Variation of the feeding intensity of the American plaice, in 3 Ps and 4 Vn.

During our various cruises, in 1971 and 1972, when sampling the material for this study or sexing the American plaice, we noted considerable variations in the repletion of the stomachs. Firstly, for a given cruise, the majority of the fish were all fed to the same degree, which led us to wonder whether there really was a seasonal variation in feeding activity and if so, in what proportion. Secondly, it seemed that similar variations could exist at different times of the day. We thus tried to determine whether precise rules controlled feeding intensity during the day.

a - Seasonal variation in feeding intensity.

In addition to the seasonal changes in the diet already mentioned for both regions, the American plaice undergoes considerable seasonal variations in the intensity of its feeding (Table 5).

On the St. Pierre bank as on the Cape Breton shelf, the feeding intensity of the plaice is drastically reduced during winter (65 % of the stomachs examined on St. Pierre bank, were empty). In spring, the plaice begins feeding once again and the activity reaches its maximum in summer, then decreases in fall.

It must be noted that off Cape Breton Island, the percentage of empty stomachs is always greater than that observed on the St. Pierre bank, even in spring and summer (7.0 % instead of 0.7 %). This divergence becomes still greater in fall (percentage doubled) and probably in winter where the lack of samplings deprives us of data.

These seasonal fluctuations in the feeding intensity of the American plaice and especially its drastic reduction during the winter

months have also been reported for the plaice of the southwestern Gulf of St. Lawrence by POWLES (1965).

From a study of the repletion of the non-empty stomachs examined on the St. Pierre bank (Table 5), it can be seen that the plaice feeds little when it resumes feeding in spring (most of the stomachs are half-full) ; it feeds more in summertime when the percentage of full stomachs is almost doubled ; in fall, the quantities ingested diminish again until they reach the winter situation described above.

Off Cape Breton Island, the resumption of feeding also takes place progressively (majority of half-full stomachs in spring) but in contrast to what happens on the St. Pierre bank, the percentage of half-full stomachs becomes still greater in summer (almost 84 %).

b - Variation of the feeding intensity during the day.

From the examination of the stomachs in each time division, for all the cruises, a variation of the percentage of empty stomachs can be distinguished throughout the day (Tables 6 and 7).

The percentage of recently ingested food (stage of digestion A described above) also varies, but inversely.

At the times when the stomachs found empty are very numerous, the other stomachs examined contain food ingested a long time ago (stages of digestion C and D). These periods of the day correspond to the moments of minimal feeding intensity.

At the times when empty stomachs are few, the others are filled with freshly ingested food. Feeding intensity is therefore at its maximum at these moments.

Figure 2 shows clearly this relationship between the percentage of fresh food and the percentage of empty stomachs in relation to the moment of the day, on the St. Pierre bank and off Cape Breton Island. In both regions, our observations led us to believe that at sunrise (05.00 h to 07.00 h St Pierre local time *) and at sunset (17.00 h to 19.00 h), the feeding intensity of the plaice is greater. In the other hand, in the middle of the day (11.00 h to 13.00 h), the feeding intensity is great on the St. Pierre bank but very weak on the Cape Breton banks. These geographic differences are difficult to explain.

IV. - Conclusions and Discussion.

From this study on the feeding of the American plaice on the St. Pierre bank and the Cape Breton shelf, we draw the following conclusions :

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* St. Pierre local time = GMT - 3 hours.

1 - The food of the plaice is made up principally of echinoderms (brittle stars and sea urchins), molluscs (pelecypods), crustaceans (amphipods, euphausids and decapods), polychaetes and fish (sand launce). These foods seem to form the basis of the alimentation of the plaice in this region as a whole since they have also been found by POWLES (1965) in the Gulf of St. Lawrence.

Therefore, the greater part of the food supply consists mainly of organisms living on the bottom (echinoderms, molluscs, Reptantia crustaceans, polychaetes, ascidians, cnidaria, etc...) but also of organisms living in free water and being more or less in contact with the bottom (Natantia crustaceans, fish, etc...).

2 - The diet of the plaice in 3 Ps is different from that of the plaice in 4 Vn. In 4 Vn, it eats no ascidians, less fish, cnidaria, molluscs but more annelids, lophophoroidea, crustaceans and echinoderms. In 4 Ps, the diet is varied.

These differences must not be explained by a particular choice of plaice for its food ; it feeds on what it finds where it lives. The explanation lies rather in an influence of the relative distribution and abundance, in each region, of the organisms used as food. A species or a group missing from certain seabeds will be replaced as food by others, thus modifying the diet of the plaice.

3 - The diet of the plaice also varies with the size of the fish. Small plaice eat more crustaceans (isopods, amphipods, euphausids and shrimps), polychaetes, small brittle stars and small pelecypods. The large fish ingest more sea urchins, big molluscs, crabs, ascidians and fish. These results correspond to the data given by POWLES (1965).

The variations with size are obviously due to different capacities for ingestion, the criterion of choice being the size of the prey. These variations have indirect repercussions on the diet of the two sexes : the females being larger, have a different diet than the males.

4 - Seasonal variation of the diet has also been revealed in this paper. The only point in common between the two regions is the ingestion of sand launces and Eulamellibranchia in spring and of Protobranchia in fall. Otner than this, the variations are peculiar to each region and clearly defined especially for echinoderms and crustaceans.

These fluctuations with the seasons show that at a certain time of year when a prey becomes abundant, the plaice feeds upon it, not hesitating to leave the bottom if necessary (sand launces, amphipods, euphausids).

5 - The variations of the diet in relation to bottom temperature have also been shown. It is quite evident that they are connected to the ecology of the various food groups : an organism found in the stomach of a plaice living in water of 0° C will necessarily be an animal whose optimal, or at least vital, temperature is close to 0° C. Considering a given range of temperature, some organisms have become more abundant, others more scarce and this is how the surrounding temperature influences the diet of the plaice.

6 - The feeding intensity of the plaice varies with the season in both of the regions studied. A reduction in feeding can be observed in fall and especially during the winter months. This reduction is more marked on the Cape Breton shelf than on the St. Pierre bank.

The degree of feeding activity during the spring and summer months depends on the abundance of certain organisms used as prey but also on the physiological cycle of the plaice. These months correspond to the period following the reproduction during which the plaice store up energy for growth and also for the next maturation of its gonads.

The results of POWLES (1965) show that this winter reduction in feeding intensity is still greater in the Magdalen Shallows (93.1 %). These geographic differences may perhaps be explained by the peculiar thermic conditions which govern these three regions in winter, or by the different benthic fauna.

7 - We have studied the variation in the feeding intensity of the plaice throughout the day. In general, it is known that the plaice has a maximum feeding activity on the bottom during the daytime and that it leaves the bottom and swims freely at all depths during the night (de GROOT, 1964).

The great feeding activity which we have observed at sunrise can be explained by the fact that this species seeks its food using principally the sense of vision (highly developped optic lobes) as reported by de GROOT (1969). In fact, as the intensity of the light increases and the plaice returns to the bottom, it resumes the feeding activity that it had ceased during the night. For the other times of the day when this activity is just as great, we are obliged to acknowledge the influence of the digestive physiology of this species. Indeed, BARRINGTON (1957) points out that although, in fish, complete digestion can last from 24 hours up to several days, the food remains in the stomach for only several hours. We may then suppose that, once the stomach is empty, the plaice resumes feeding.

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Table 1. Geographic variation in the diet of the American plaice, measured by frequency of occurrence of organisms in the stomachs.

Stomach contents	3 Ps			4 Vn		
	N° of stomachs	% N	% n	N° of stomachs	% N	% n
Cnidaria	35	6.2	7.9	16	4.3	5.9
Boloceridae	31	5.5	7.0	16	4.3	5.9
Others	4	0.7	0.9	0	0	0
Annelida	67	11.9	15.2	86	23.3	31.6
Polychaeta errantia	6	1.1	1.4	18	4.9	6.6
Polychaeta sedentaria	58	10.3	13.1	62	16.8	22,8
Sipunculida	3	0.5	0.7	6	1.6	2.2
Lophophoroidea	4	0.8	0.9	8	2.2	2,9
Bryozoa	1	0.2	0,2	8	2.2	2.9
Brachiopoda	2	0.4	0.5	0	0	0
Priapuloidea	1	0.2	0,2	0	0	0
Mollusca	208	36.9	47.0	120	32.7	44.1
Polyplacophora	2	0,4	0.5	0	0	0
Gastéropoda	12	2.1	2,7	15	4.1	5.5
Pelecypoda Protobranchia	127	22.5	28.7	36	9.8	13.2
Filibranchia	17	3,0	3,8	22	6.0	8.1
Eulamellibranchia	48	8.5	10.8	47	12.8	17.3
Not identified	2	0.4	0.5	0	0	0
Crustacea	178	31.6	40,3	143	38.8	52.4
Mysidacea	2	0.4	0.5	8	2.2	2.9
Cumacea	2	0.4	0.5	24	6.5	8.3
Isopoda	21	3.7	4.7	6	1.5	2,2
Amphipoda	73	12.9	16.5	63	17,1	23.2
Euphausiacea	42	7.5	9.5	14	3,8	5.1
Decapoda Macrura	7	1.2	1.6	15	4.1	5.5
Anomura	5	0,9	1,1	2	0,5	0,7
Brachyura	20	3.5	4.5	8	2,2	2,9
Not identified	6	1.1	1.4	3	0,8	1.1
Echinodermata	382	67.8	86.3	346	94.0	127.2
Holoturidea	2	0.4	0,5	1	0.3	0,4
Asteroidea	2	0.4	0.5	2	0.5	0.7
Ophiuroidea	229	40.6	51,7	247	67.1	90,8
Echinoidea	149	26.4	33.6	96	26.1	35.3
Ascidiacea	36	6.4	8.1	0	0	0
Teleostei	36	6.4	8.1	5	1.4	1.9
Paralepididae	1	0.2	0,2	0	0	0
Myctophidae	2	0.4	0.5	0	0	0
Moridae	0	0	0	1	0,3	0.4
Zoarcidae	3	0.5	0.7	0	0	0
Ammodytidae	13	2.3	2.9	1	0.3	0,4
Scorpaenidae	3	0.5	0.7	0	0	0
Pleuronectidae	4	0.7	0.9	0	0	0
Not identified	10	1.8	2.3	3	0,8	1.1
Pebbles and shells fragments	78	13.8	17.6	56	15.2	20.6
Vegetal fragments	3	0.5	0,7	5	1.4	1.9
Animal fragments not identified or identified but not separated	43	7.6	9,7	7	1.9	2.6
N° stomachs examined (N)	564	/	/	368	/	/
N° stomachs with food (n)	443	/	/	272	/	/

Table 2A. Variation in the diet of the American plaice in Subdiv. 3Ps, according to length and sex (%).

	MALES					FEMALES					
	<25cm	25-35cm	36-45cm	>45cm	TOTAL	<25cm	25-35cm	36-45cm	46-55cm	>55cm	TOTAL
Cnidaria					0.9						0.6
Boloceridae			1.1	1.6	0.9			0.6	0.2	1.4	0.6
Others		0.1		0.2	*		*		*	*	*
Annelida					7.2						5.1
Polychaeta errentia		2.5	1.7		1.3		2.9	0.9	0.2	0.1	0.8
Polychaeta sedentaria	28.5	9.8	3.6	*	5.2	25.0	15.4	1.9	1.6	1.0	4.3
Sipunculida			0.8	1.3	0.7						0
Lophophoroidea					*						*
Bryozoa			*		*				*		*
Brachiopoda				0.1	*			0.1			*
Priapuloidea		0.2			*						0
Mollusca					20.2						28.5
Polyplacophora					0				0.1		*
Gasteropoda		1.3	0.2	0.9	0.8			3.6	0.3		1.0
Pelecypoda Protobranchia		27.3	18.5	3.2	15.4		14.0	43.5	23.1	8.2	22.0
Filibranchia		*	0.4	0.8	0.4				0.2	0.9	0.3
Eulamellibranchia		2.0	7.8	1.2	3.6	0.1	0.7	3.4	7.8	5.9	4.8
Not identified		*			*		2.4				0.4
Crustacea					17.7						11.6
Mysidacea			0.2		*	2.3					0.1
Cumacea					0		1.3		*		0.2
Isopoda		0.9	1.9	1.7	1.5		2.0	1.1	0.2	0.1	0.7
Amphipoda	23.3	5.1	8.2	1.1	5.5	21.4	4.3	1.0	1.7	*	2.0
Euphausiacea	15.9	18.1	4.0	0.3	7.5		13.9	6.9	1.6	*	4.3
Decapoda Macrura		3.4	0.1	*	1.1		1.7	0.2	*		0.3
Anomura			1.2	0.4	0.5		0	0.5	0	0.1	0.1
Brachyura			2.2	2.0	1.4		0.1	0.3	5.2	4.9	3.4
Not identified		0.4	0.2		0.2		1.1	1.2		*	0.5
Echinodermata					41.4						41.9
Holoturidea			0.1		*				0.6		0.2
Asteroidea					0			*	*		*
Ophiuroidea	23.4	14.6	21.2	34.6	23.8	35.4	23.5	15.5	22.9	36.7	25.4
Echinoidea		2.7	15.1	35.3	17.6	11.8	2.6	7.7	18.4	29.5	16.3
Ascidiacea	0.3	3.3	5.4	6.6	5.0			6.0	6.7	2.9	4.2
Teleostei					3.8						3.4
Paralepididae					0	4.0					0.1
Myctophidae		1.4			0.4					0.2	0.1
Moridae					0						0
Zoarcidae		0.2			*		3.2				0.5
Ammodytidae			3.5	1.9	1.8			0.9	2.5	1.4	1.3
Scorpaenidae				0.8	0.3			0.6			0.1
Pleuronectidae				0.3	0.1			*	0.6		0.2
Not identified	8.6	2.9	*		1.8		7.0		0.3	*	1.1
Pebbles and shells fragments		1.5	0.9	1.3	1.2		*	1.5	2.9	3.6	2.2
Vegetal fragments				1.6	0.5						0
Animal fragments not identified or identified but not separated		2.2	1.6	2.6	2.1		1.9	2.0	2.6	3.1	2.4
TOTAL %	100.0	99.9	99.9	99.8	100.0	100.0	100.0	99.9	100.0	100.0	99.9
No. Stomachs examined	7	56	62	62	187	8	38	66	71	73	256

* = Traces

Table 2B. Variation in the diet of the American plaice in Subdiv. 4Vn, according to length and sex (%).

	MALES					FEMALES					
	<25cm	25-35cm	36-45cm	>45cm	TOTAL	<25cm	25-35cm	36-45cm	46-55cm	>55cm	TOTAL
Cnidaria					2.1						0.5
Boloceridae		3.5			2.1		2.2	0.1	0.1	0.1	0.5
Others					0			*		0.2	*
Annelida					17.6						7.9
Polychaeta errantia		4.8	5.7		4.8		6.6	2.6	0.1		2.3
Polychaeta sedentaria	0.8	18.0	0.9	25.0	11.9	30.3	15.3	3.3	0.4	0.4	5.3
Sipunculida		1.5			0.9		0.9	0.3			0.3
Lophophoroidea					*						*
Bryozoa		*	0.1		*			*			*
Brachiopoda					0						0
Priapuloidea					0						0
Mollusca					9.6						8.2
Polyplacophora					0						0
Gasteropoda		1.7	1.4		1.5		0.1	4.1	*	0.7	1.5
Pelecypoda Protobranchia		5.5	3.2		4.3		5.9	4.6	0.6		3.0
Filibranchia			0.2	7.9	0.3		0.4	0.8	2.0	5.1	1.5
Eulamellibranchia	0.8	3.1	4.4	*	3.4	8.3	3.6	1.7	2.1		2.2
Not identified		0.2			0.1						0
Crustacea					7.5						4.0
Mysidacea		0.6			0.4		0.1	0.8			0.3
Cumacea	7.0	1.1			0.9	0.2	0.1				*
Isopoda		0.3			0.2		0.1				*
Amphipoda	2.3	2.3	2.8	*	2.4	7.0	0.5	0.2	*		0.4
Euphausiacea		1.8	*		1.1	16.7	2.7	2.0	0.4		1.8
Decapoda Macrura		2.2	0.1	0.2	1.4	7.1		2.0	0.1		0.9
Anomura			0.6		0.2		1.2				0.5
Brachyura		*	0.4		0.2		0.3	0.4	0.1		0.2
Not identified	27.6		*		0.7		0.6				0.1
Echinodermata					57.8						71.9
Holoturidea					0		2.2				0.5
Asteroidea		0.3			0.2			0.1			*
Ophiuroidea	51.5	42.1	52.1	15.6	44.8	30.4	30.7	54.7	49.9	42.8	46.2
Echinoidea		8.6	18.5	38.1	12.8		19.9	14.9	36.8	39.7	25.2
Ascidiacea					0						0
Teleostei					1.2						0.5
Paralepididae					0						0
Myctophidae					0						0
Moridae					0			1.6			0.5
Zoarcidae					0						0
Ammodytidae			1.9		0.7						0
Scorpaenidae					0						0
Pleuronectidae					0						0
Not identified			1.4		0.5						0
Pebbles and shells fragments		1.3	5.9	13.2	3.3		4.1	5.4	7.3	4.3	5.5
Vegetal fragments			*		*			*	*	0.1	*
Animal fragments not identified or identified but not separated	10.0	0.9	0.3		0.9		2.4	0.4	*	6.6	1.4
TOTAL %	100.0	99.8	99.9	100.0	100.0	100.0	99.9	100.0	99.9	100.0	99.9
No. Stomachs examined	3	72	41	4	120	4	32	51	48	17	152

* = Traces

Table 3. Seasonal variation in the diet of the American plaice (%).

	3 Ps				4 Vn		
	Summer 11-23 July 1971	Fall 9-14-Nov. 1971	Winter 7-22 Feb. 1972	Spring 4-12 May 1972	Summer 24-27 July 1971	Fall 25-28 Nov. 1971	Spring 18-24 May 1972
Cnidaria	0.2	0	2.2	1.5	*	0.1	4.5
Boloceridae	0.1	0	2.2	1.5	*	*	4.5
Others	0.1	0	*	*	0	0.1	0
Annelida	9.7	5.4	12.6	0.7	16.2	13.4	4.5
Polychaeta errantia	0.3	2.0	3.1	0.4	2.8	4.8	3.0
Polychaeta sedentaria	8.5	3.4	9.5	0.3	13.3	7.5	0.7
Sipunculida	0.9	0	0	0	0.1	1.1	0.8
Lophophoroidea	0.2	0	0	*	*	0	*
Bryozoa	*	0	0	*	*	0	*
Brachiopoda	0.1	0	0	0	0	0	0
Priapuloidea	0.1	0	0	0	0	0	0
Mollusca	29.6	37.5	21.4	10.9	5.9	9.2	13.3
Polyplacophora	*	0	0	*	0	0	0
Gasteropoda	0.3	2.6	0	0.5	0.2	0.9	4.3
Pelecypoda Protobranchia	27.5	32.6	16.9	0	2.3	6.3	2.7
Filibranchia	0.7	*	0	0.5	1.1	1.1	0.6
Eulamellibranchia	0.5	2.3	4.5	9.9	2.2	0.4	5.7
Not identified	0.6	0	0	0	0.1	0	*
Crustacea	8.0	24.7	16.4	10.9	6.3	2.8	4.0
Mysidacea	0	0.2	0	0.1	0	0	0
Cumacea	0	0.4	0	*	0.3	0	0.7
Isopoda	0.7	1.1	*	1.5	0.2	0	0
Amphipoda	4.9	0.7	12.3	1.7	2.9	0.2	0.4
Euphausiacea	0.6	20.7	0	0	2.6	0	1.4
Decapoda Macrura	0.8	0.1	3.5	*	0.8	1.3	1.4
Anomura	0.7	0	0.6	*	*	0.1	0
Brachyura	0.2	0.3	0	7.6	0.2	0.2	0.1
Not identified	0.1	1.2	0	*	0.7	0.2	0
Echinodermata	39.6	20.2	40.3	61.8	62.3	55.4	71.3
Holoturidea	0	0.1	0	0.3	0.6	0	0
Asteroidea	*	*	0	0	0	0.1	0.3
Ophiuroidea	25.0	15.4	33.3	29.5	43.1	45.3	52.3
Echinoidea	14.6	4.7	7.0	32.0	18.6	22.0	19.0
Ascidiacea	2.9	4.5	1.2	7.2	0	0	0
Teleostei	4.7	2.6	0	4.3	0	1.7	1.1
Paralepididae	0.2	0	0	0	0	0	0
Myctophidae	0.7	0	0	0	0	0	0
Moridae	0	0	0	0	0	1.0	0
Zoarcidae	0.9	0	0	0	0	*	0
Ammodytidae	0	0.9	0	4.1	0	*	1.1
Scorpaenidae	0	0.7	0	0	0	0	0
Pleuronectidae	0	0.3	0	0	0	0	*
Not identified	2.9	0.5	0	0.2	0	0.7	*
Pebbles and shells fragments	2.1	2.0	2.4	1.0	6.1	5.8	0.3
Vegetal fragments	0	0	2.4	0	*	0.1	*
Animal fragments not identified or identified but not separated	2.7	3.0	0.9	1.6	1.1	1.5	0.9
Total %	99.7	99.9	99.8	99.9	99.9	100.0	99.9
No stomachs with food	146	116	41	140	119	80	73

* = Traces

Table 4. Variation in the diet of the American plaice in relation to bottom temperature (%).

		3 Ps					4 Vn				
		-1 - 0°C	0 - 2°C	2 - 3°C *	4 - 6°C	> 6°C	-1 - 0°C	0 - 2°C	2 - 4°C	4 - 6°C	> 6°C
CNIDARIA		0.7	1.3	0.8	0.1	0	NO DATA	2.9	0.8	0	NO DATA
ANNELIDA	Polychaeta Errantia	1.1	0.9	0.1	0.1	0		0.8	4.0	11.1	
	Polychaeta Sedentaria	0.6	*	0	17.9	16.9		2.3	2.5	38.4	
MOLLUSCA	Gasteropoda	1.1	0.1	0	*	0.6		0.2	0.1	8.3	
	Pelecypoda Protobranchia	0	0	0	63.2	72.0		1.8	2.4	1.5	
	Filibranchia	0	0.7	2.2	0	0		1.6	1.1	0	
	Eulamellibranchia	10.7	6.7	0.1	0	0		3.5	2.4	4.1	
CRUSTACEA	Mysidacea-Cumacea-Isopoda	1.3	1.7	0	0	0.4		2.3	0.3	0.1	
	Amphipoda	7.4	6.6	0.4	0.3	2.7		3.4	0.3	0.7	
	Euphausiacea	0.3	0.7	0	*	0		2.3	1.9	0	
	Decapoda Macrura	0	1.2	0	1.6	0		1.1	1.9	0.1	
	Anomura	0.3	0.9	0.2	0	0		0	0.5	0	
	Brachyura	10.4	1.6	1.1	0	0		0.1	0.2	0	
ECHINODERMATA	Ophiuroidea	16.4	43.7	56.1	3.8	5.8		54.9	54.3	26.7	
	Echinoidea	36.9	26.2	39.0	4.0	0.2		21.9	26.8	9.0	
ASCIDIACEA		9.4	4.9	0	0	*		0	0	0	
PISCES	Myctophidae	0.2	0	0	0	0		0	0	0	
	Zoarcidae	0	0	0	1.9	0		0	0	0	
	Ammodytidae	3.2	2.6	0	0	0		0.9	0	0	
	Others	0	0.2	0	7.1	1.4		*	0.5	0	
TOTAL %		100.0	100.0	100.0	100.0	100.0		100.0	100.0	100.0	
N° stomachs with food. 610		91	132	16	73	43		90	126	39	

* No data for 3-4° C

Table 5. Seasonal variation in the feeding intensity of the American plaice.

Stomachs empty - stage of Repletion 0
Stomachs half-full - stages of Repletion 1 and 2
Stomachs full - stages of Repletion 3 and 4

	3 Ps				4 Vn		
	Spring 4-12 May 1972	Summer 11-23 July 1971	Fall 9-14 Nov. 1971	Winter 7-22 Feb. 1972	Spring 16-24 May 1972	Summer 24-27 July 1971	Fall 25-26 Nov. 1971
No. Stomachs examined	142	147	159	116	79	128	161
No. Stomachs empty	2	1	43	75	6	9	81
% empty	1.4	0.7	27.0	64.7	7.6	7.0	50.3
% half-full	69.7	55.7	49.7	27.5	69.9	83.6	46.6
% full	28.9	43.6	23.3	7.8	22.8	9.4	3.1

Table 6. Variation in the feeding intensity of the American plaice throughout the day, in Subdiv. 3Ps.
% Fresh food = % food at stage of Digestion A.

Time divisions	05.00 07.00 h	07.01 09.00 h	09.01 11.00 h	11.01 13.00 h	13.01 15.00 h	15.01 17.00 h	17.01 19.00 h	19.01 22.00 h
No. Stomachs examined	127	115	30	19	115	72	65	21
No. Stomachs empty	16	42	7	0	23	26	4	3
% Stomachs empty	12.6	36.5	23.3	0	20.0	36.1	6.2	14.3
% Fresh food	25.4	10.0	0	10.0	6.1	2.1	12.5	14.1

Table 7. Variation in the feeding intensity of the American plaice throughout the day, in Subdiv. 4Vn.
% Fresh food = % food at stage of Digestion A.

Time divisions	05.00 07.00 h	07.01 09.00 h	09.01 11.00 h	11.01 13.00 h	13.01 15.00 h	15.01 17.00 h	17.01 19.00 h	19.01 22.00 h
No. Stomachs examined	102	20	60	70	39	35	12	30
No. Stomachs empty	20	3	14	37	9	4	0	9
% Stomachs empty	19.7	15.0	23.3	52.9	23.1	11.4	0	30.0
% Fresh food	6.3	9.0	4.1	4.7	3.0	14.1	20.9	4.3

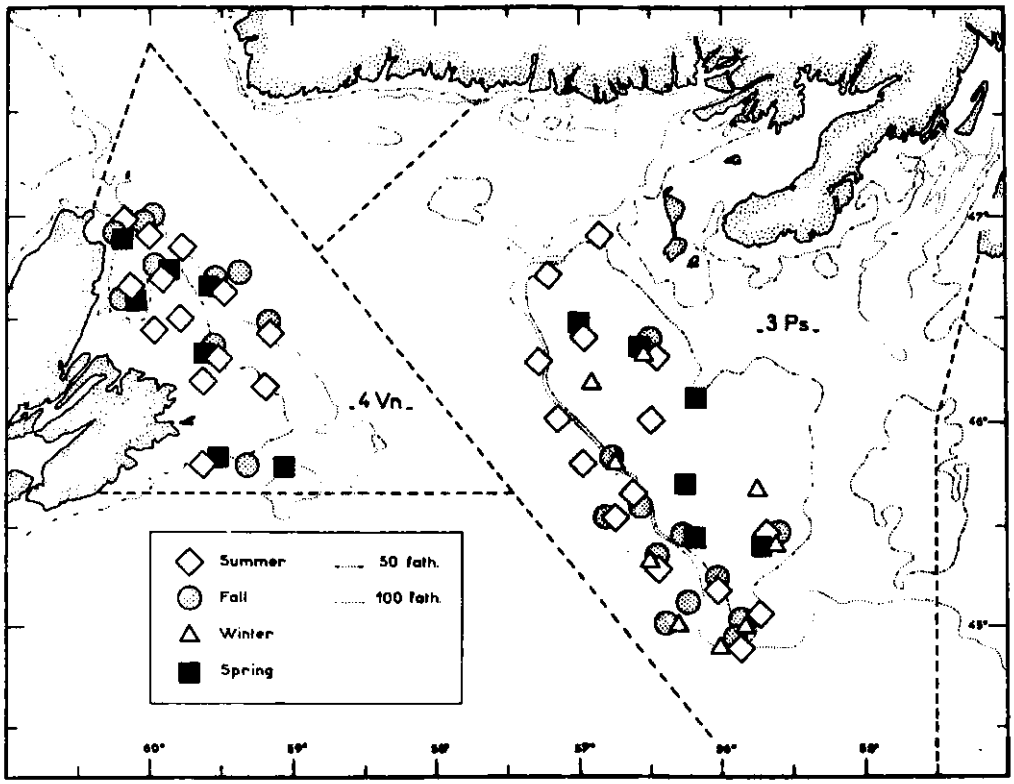

Fig. 1. Position of stomach sampling stations in ICNAF Subdiv. 3Ps and 4Vn, during the four seasonal cruises of the R/V *Cryos*.

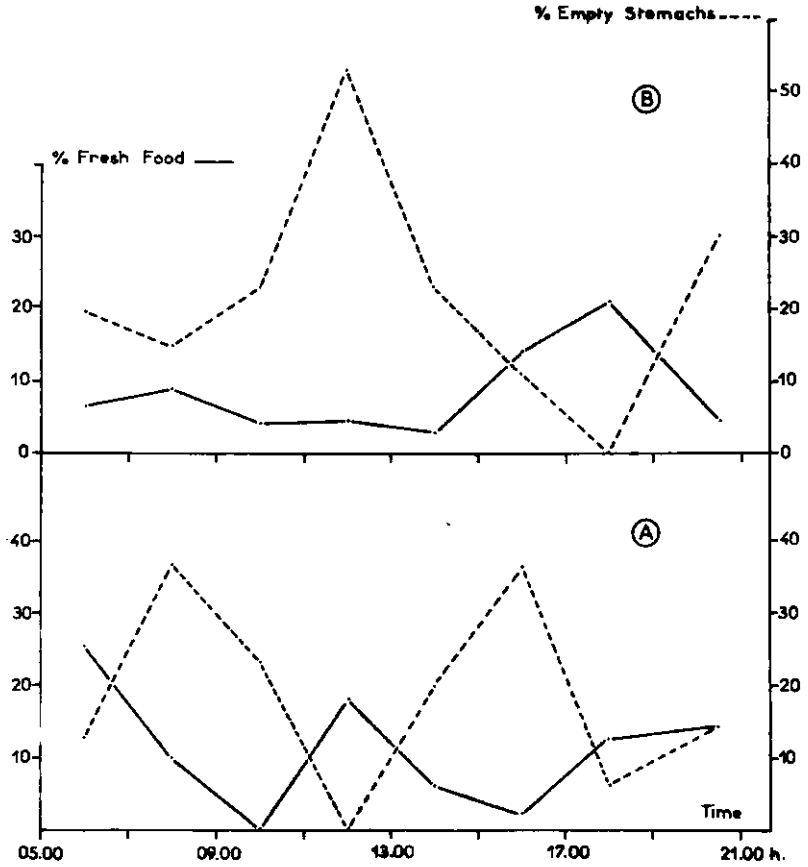

Fig. 2. Relationship between the percentage of empty stomachs and the percentage of recently ingested food, throughout the day.
A - Subdiv. 3Ps; B - Subdiv. 4Vn.