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11.

The Food of Post-larval Haddock with Reference to the annual Fluctuations in the Haddock Broods.

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In connexion with the study of the annual fluctuations in the broods of the haddock in Scottish waters, an examination of the food of the post-larval stages was undertaken with a view to determining whether variations in the plankton, such as relative abundance of the food organisms and their time of appearance from year to year influence the survival of the broods of the haddock at this critical stage in their life history.

The larvae were extracted from the plankton during the routine examination of the collections the nets in use being the 1-metre cheese-cloth towed horizontally for a quarter of an hour at surface, mid-water and bottom and the 2-metre cheese-cloth hauled vertically.

An area was selected to cover the main Scottish haddock spawning grounds in the North Sea from the latitude of Aberdeen northwards and west of the Orkney and Shetland islands. This was divided into three sub-areas which will be referred to as Central, Northern, and Western. Central includes the Western and Central North Sea south of $59^1/_2$°N., Northern, the North Sea to the north of $59^1/_2$°N., and Western, the area to the west of the Orkneys and Shetlands. Collections made by the Standard Fine Silk Net, hauled vertically, were available from most of the stations at which larvae were recorded and, as these give the most representative picture of the small plankton organisms on which the baby haddock feed, they were used for comparison with the food contents.

Material.

Post-larval haddock occur in the plankton collections normally from March to June, being most abundant in April and May. From the material available, collections were chosen to cover the extent of the three areas as far as possible in 1934 and 1935 but all the areas are not represented each month. Owing to a somewhat later spawning of the haddock in 1935 no larvae were captured in March of that year although the Central and Northern areas were sampled at least as extensively as usual, and the larvae taken in June 1935 were not examined as only larger sizes were available.

Method.

The material, taken as it was from the ordinary plankton collections, had been preserved in formalin. When a specimen had been measured the gut was removed under a binocular dissecting microscope by making a cut in the region of the oesophagus and dissecting out the alimentary tract entire. In the case of the smallest fish no sharp differentiation could be made between stomach and intestines and for the sake of uniformity none was made in the larger sizes as the food contents of the intestine could as a rule be quite easily identified. The gut contents were then spread on one or more slides and examined under an 8 mm. object-glass, higher magnification being used when necessary. The condition of the food was such that it was found possible to identify practically the whole of the contents and counts were made of the organisms. In some of the very small fish, the food or part of it consisted of fine granular matter, the nature and origin of which could not be determined but the amount of this was so small that it has no significant effect on the results.

Food. — Relative Importance of the Food Organisms.

Tables I and II[1]) show the numbers of the most important organisms taken by the haddock at successive sizes from 3·5 mm. upwards in 1934 and 1935 respectively. The absolute predominance of copepod nauplii is at once evident in both cases. Copepodids and adult copepods are next in importance, their numbers rising with increase in the size of the fish, and copepod ova are also well represented especially in the smaller sizes. Copepods indeed, in all stages from egg to adult formed almost 90 % of the total food contents. Carrying the analysis further we find that nearly 70 % of the diet is made up of nauplius stages alone while copepodids and adults account for no more than about 12 % and copepod ova for 7 % of the whole.

With the exception of one or two records of *Podon* and *Evadne*, the only other crustacean food consisted of early stages and ova of euphausids but they are of small importance in the food as they formed only about 1 % of the stomach contents.

The remainder of the food is made up chiefly of larval molluscs and organisms of the microplankton and falls slightly short of 10 % of the total.

Food and its Relation to Size.

A complete list of the organisms found in the stomachs of the post-larval haddock during the period of this investigation is given in Table III. The importance of copepods — both adults and developmental stages — in the diet of the haddock during the early stages of its life history has already been stressed. The copepod species taken are, as is to be expected, those which occur most commonly in the plankton of our area. *Calanus* which, owing to its abundance in the plankton, heads the list, is of importance in the food chiefly in its nauplius stages. Early nauplius stages were eaten by even the smallest fish. The stomachs of fish under 4 mm. in size usually contained very little but already at 4 mm. an average content of almost three nauplii per fish was recorded. Ova of *Calanus* were also taken by the youngest fish. The highest average numbers of nauplii per stomach occur in fish of 12—15 mm.; above this size they are partially and gradually replaced by copepodid stages and adults of the smaller copepod species, although instances of heavy feeding on nauplii have been noted among the larger fish. Small copepodids are eaten by fish of 6—7 mm. copepodid stage V and adults by the largest sizes examined only, which indicates the probability that they would form an important factor in the food of the larger pelagic stages before the bottom feeding habit is acquired. A very large proportion of the nauplii referred to as "calanoid" in the tables of distribution were those of *Calanus* but those of *Pseudocalanus*, *Metridia*, *Temora* and *Acartia* were included for the sake of simplicity.

[1]) See pages 62—66.

Table III.

Copepods
Calanus finmarchicus
Pseudocalanus minutus
Temora longicornis
Centropages typicus
Acartia clausi
Paracalanus parvus
Microcalanus pusillus
Stephos lamellatus
Oithona helgolandica
— *spinirostris*
Harpacticoid

Copepodids
Calanus finmarchicus
Pseudocalanus minutus
Metridia lucens
Temora longicornis
Acartia clausi
Microcalanus pusillus
Oithona helgolandica
— *spinirostris*

Nauplii
Calanus
Pseudocalanus
Metridia
Temora
Acartia
Oithona
Longipedia
Microsetella

Ova
Calanus
Pseudocalanus
Centropages
Oithona ovisacs

Euphausids
Furciliae
Calyptopes
Nauplii
Ova

Cladocera
Podon intermedius
Evadne nordmanni

Molluscs
Limacina retroversa
Lamellibranch juvs.
Gastropod —

Tintinnids
Stenosemella nucula Jörg.
— *ventricosa* Jörg.
Acanthostemella norvegica (Dad.)
Favella denticulata (Ehrbg.) Jörg.

Diatoms
Coscinodiscus centralis
— *subbulliens*
— *radiatus*
— *marginatus*
— spp.
Chaetoceros borealis
— *decipiens*
— *constrictus*
— *contortus*
— *debilis*
— spp.
Bacteriastrum sp.
Thalassiosira decipiens
— sp.
Rhizosolenia styliformis
Cerataulina bergonii
Hyalodiscus stelliger
Paralia sulcata
Nitzschia seriata
Thalassiothrix nitzschioides
Pinnularia sp.
Fragilaria sp.

Dinoflagellates
Peridinium depressum
Dinophysis sp.
Glenodinium sp.

Round cells (plant?)

Next in importance to *Calanus* is the copepod *Oithona*. Both *O. helgolandica* and *O. spinirostris* occur, the former being considerably the more common. The two species were not separated in the examination of the food. It forms a poor second to *Calanus*, however, its nauplii being outnumbered by the "calanoids" in the proportion of 6:1, but owing doubtless to its small size as well as to its frequency in the plankton it takes first place among the adults, having been found in the mature state in fish of 6 and 7 mm. while copepodids were taken at 5 mm. There is no evidence in these records, however, that its small nauplii are taken in preference to the calanoids on account of size by even the smallest fish, though this may depend on availability. It is followed by *Pseudocalanus* which is common in all stages from egg to adult, mature females being taken freely by fish of 12 mm. and over and occasionally by those of smaller size. *Temora*, *Acartia* and *Metridia*, which are similar in size, occur quite frequently but with less regularity and in much smaller numbers, while the remaining copepod species on the list furnish only occasional records.

The rest of the crustacean food is of minor importance. Euphausids are represented chiefly by nauplius and calyptopis stages most of which were shown by reference to the plankton to be those of *Thysanoessa*. They were found in fish of 12 mm. and upwards and are probably of increasing importance in the food of the later pelagic stages. The small cladocerans *Podon* and *Evadne* were observed only occasionally throughout.

Apart from the tintinnids which according to size are more appropriately dealt with along with the organisms of the phytoplankton, the principal non-crustacean food consists of molluscs. Of these *Limacina* is the most important followed by larval lamellibranchs. Larval gastropods occurred but very occasionally. Combining the numbers of *Limacina* and lamellibranchs for the two seasons of the investigation we find that they form less than 2·5 % of the total food. The *Limacina* were found mostly in the smaller fish and were themselves very small; some indeed must have been practically newly-hatched.

Microplankton organisms were represented in the food by tintinnids, diatoms and dinoflagellates. As is to be expected, these organisms figure only in the stomachs of the smallest fish and drop out of the picture when a size of 5·5—6 mm. is reached, as reference to Tables I and II shows. When they were observed in the contents of the stomachs of larger fish, e. g., over 12 mm. as was occasionally the case, they were not tabulated as it was thought probable that they had escaped from the burst guts of ingested copepods. Numerically the microplankton organisms form only about 7 % of the total food. This percentage figure is in itself misleading owing to the minute size of the organisms it represents. While the young *Limacina* and lamellibranchs and perhaps the larger of the *Coscinodiscus* spp. among the diatoms approach the same order of size as the smallest units among the copepods, viz., the ova, the remainder, tintinnids, diatoms and dinoflagellates are very much smaller. A striking example is afforded by the tininnid *Stenosemella nucula* which numerically accounted for over 8 % of the food organisms in 1934. It would require over 40 of its small vase-shaped tests to equal a *Calanus* egg in volume and its frequency in the 1934 material is the chief reason that the percentage of non-crustacean food in 1934 is nearly double that in 1935. Far from being weighted in their favour, therefore, the percentages of crustacean food would have been relatively still higher if calculated on a volumetric basis.

Further examination of the counts shows that of the 422 micro-organisms enumerated about 65 % consists of the *Stenosemella nucula* referred to above which with its tiny tests covered with minute particles of inorganic matter seems a very unpromising article of diet. It is impossible to say even from a microscopic examination whether the tests, when ingested, contained the tintinnid organism or whether they were empty and discarded. Nevertheless 273 of these were counted in the stomach contents as against 19 belonging to the other species of tintinnids observed. The list of species of diatoms identified looks formidable but they are in themselves so small and so few in number that their presence in the food contents is of little importance.

If it be granted that practically all the microplankton consumed as food is taken by the smallest sizes and that it ceases to have significance in fish of over 5 mm., we find that only 26 fish out of a total of 167 measuring from 3·5 to 5 mm. or 15 % fed on microplankton only, 30 % on nauplii only and 40 % on a mixed diet, while the stomachs of the remaining 15 % contained no food. Further work on these early stages might modify these results somewhat, but so far as the present investigation goes, there is no evidence that microplankton organisms form an essential part of the food of even the earliest feeding stages.

Yolk-Sac Stages and Feeding.

The yolk-sac in varying degrees of absorption was observed in 19 specimens, 9 of which measured 3·5 mm., 9, 4 mm., and 1, 4·5 mm. The stomachs of 9 of these irrespective of size contained no food. In those which had been feeding, the food was similar in character and amount to that taken by fish of corresponding size which showed no yolk-sac. That the presence of yolk-sac is no deterrant to the taking of food is shown by the following examples: the stomach of one fish 3·5 mm. in size contained 3 calanoid nauplii (Stage II or III), 2 nauplii of *Oithona* and 1 ovum of *Calanus*, while another at 4 mm. contained 1 calanoid nauplius (Stage IV), 4 nauplii of *Oithona*, 3 *Acanthostomella* and a fragment of a chain of *Chaetoceros decipiens*. It is evident from examples such as these that the haddock in its earliest stages is capable as soon as it feeds at all of ingesting the nauplii which form the mainstay of its food during its subsequent post-larval existence.

Amount of Food in the Stomachs.

Very few of the fish examined had no food in their stomachs and the majority had been feeding heavily. Only 32 of the 316 stomachs examined were empty and more than half this number is accounted for by the fact that in the 1935 material special attention was paid to the smallest sizes, a larger proportion of which contained no food. Actually 22 of the 32 empty stomachs were taken from fish measuring 3·5 and 4 mm. The remainder is so small a fraction of the whole that it precludes the possibility of explaining absence of food in the stomachs by lack of suitable food in the environment.

The numbers of copepod nauplii which form a very high percentage of the food, may be used to give a rough estimate of the degree of feeding. Table IV shows the average number of nauplii found in the stomachs at successive sizes. The decrease in numbers in the largest specimens is to be explained by the partial change in diet at this stage to copepodids and adult copepods.

Table IV.

Size of Fish mm.	3·5	4	4·5	5	6	7	8	9	10	11	12	13	14	15
Av. No. of Nauplii p. Fish.	0·6	2·8	6	10	14	18	21	20	19	17	56	50	33	31

The following selected examples of intensive feeding will convey some idea of the amazing capacity of the baby haddock. The stomach contents of individual specimens were as follows: —

5 mm.
22 Calanoid nauplii
5 Nauplii of *Oithona*
5 Copepod ova
Bacteriastrum (part of a chain)

8 mm.
1 Copepodid of *Microcalanus*
6 — of *Oithona*
3 Calanoid nauplii
2 Nauplii of *Oithona*
2 — of *Longipedia*
2 Ova of *Calanus*
6 *Limacina*
3 *Coscinodiscus*

19 mm.
50 *Oithona* (adults)
2 *Acartia* (adults)
2 *Pseudocalanus* (adults)
1 *Paracalanus* (adults)
21 Copepodids of *Calanus*
24 — of *Acartia*
3 — of *Pseudocalanus*
2 — of *Metridia*
4 — of *Oithona*
140 Calanoid Nauplii
1 Euphausid calyptopis
7 — nauplii
2 *Limacina*

Parasites.

Only two trematodes were observed during the course of the work in fish of 8 mm. and 13 mm. respectively. This is in marked contrast to the condition prevailing in the post-larval herring in which the writer found a heavy infection both of trematodes and cestodes even in the very young stages (Ogilvie, 1927).

The Food and its Relation to the Plankton.

As copepod nauplii form such a large proportion of the food their presence in adequate numbers in the plankton must be of supreme importance to the welfare of the post-larval haddock and also one of the controlling factors in brood survival. The plankton collections on which the following data are based, are from vertical hauls made with the Standard F. S. net at the same stations and times at which the larvae examined were captured. The average volumes of those collections for the different months and areas are given in Table V, column 2. The fluctuations in volume of the plankton were very considerable, values varying from 1 c. c. to 110 c. c., settled volume having been recorded during the period of the investigations but these depend largely, especially in the spring months, on the quantity of phytoplankton and particularly of diatoms present. As phytoplankton organisms have been shown to be of minor importance in the food of the larvae, counts were made of the nauplii in the collections. Each collection was made up to a standard quantity by the addition of liquid. It was then stirred well and a fixed amount withdrawn in a pipette and run into a petri dish. Using the same magnification throughout, the nauplii in a certain number of fields of a binocular microscope were counted and it is from these figures that the "average relative counts" have been compiled. The counts are thus not absolute but are strictly comparable *inter se* and represent the relative abundance of nauplii at the different stations. The average values of these counts are given in Table V, col. 3.

Table V.

Year	Month	Area	Number of Stations	Average Volumes of Plankton Collections	Average Relative Counts of Nauplii
1934	March	Central	2	5·5 c.c.	49
		Northern	3	25·0	72
		Western	2	28·0	42
	April	Central	4	11·0	144
		Western	10	18·0	109
	May	Central	5	29·0	99
		Northern	12	22·0	106
1935	March	Central	7	7·0	19
		Northern	15	5·5	43
	April	Central	8	26·0	214
		Northern	9	22·0	168
	May	Central	8	15·0	178
		Western	9	33·0	250

In the early part of the year an increased influx of water from the Atlantic takes place normally round the N. of Shetland into the North Sea. This water pushes before it and carries with it plankton which helps to replenish the stock in the North Sea and also produces conditions favourable to the growth and rapid multiplication of species already present. These conditions are reflected in the volumes of the plankton samples as shown in Table V, col. 2. The low values which occur in March may be taken to represent winter conditions before the spring increase has taken effect. In March 1934 the scarcity of plankton is confined to the central area and the effects of the increase are already apparent in the high volumes of plankton recorded in the north and west. In March 1935 the scarcity extends over the north as well indicating that the Atlantic effect was later in that area.

The results of the examination of the macroplankton samples taken during this period, which show that the plankton made its appearance later in that year, confirm these observations. No haddock larvae were taken in the collections in March 1935 though sampling was carried out as usual and over a similar area. This was probably due to a later spawning.

If we now consider the main source of food of the larvae, viz., the nauplii, we find that the lowest average counts also occur in March of both years and for similar reasons. These values, however, do not vary directly with the volumes of plankton and when the general conditions for March are such as have been described, they probably depend to some extent on the amount of breeding of indigenous copepod species of which *Pseudocalanus* is the most important. The question what constitutes a sufficient diet for the larvae depends on so many interrelated factors that it cannot be settled from the data available here, but a comparison of the numbers of nauplii found in the stomachs with those in the plankton may be helpful. In Table VI alongside the average relative counts of nauplii in the plankton,

Table VI.

Year	Month	Area	Average Counts of Nauplii in the Plankton	Average Numbers of Nauplii in Stomach Content
1934	April	Central	144	3
		Western	109	12
	May	Central	99	24
		Northern	106	24
1935	April	Central	214	29
		Northern	168	7
	May	Central	178	16
		Western	250	14

the average numbers of nauplii in the stomachs have been arranged. In this case the figures for April and May only have been used as during that period normal conditions with regard to plankton, and hatching and feeding of larvae may be presumed to be established. When these figures are correlated, we find that from the lowest count of nauplii in the plankton — 99 in the Central area in May 1934 — the larvae were able to obtain a stomach content of 24 nauplii per fish. As this value is the highest but one recorded, the inference is that in every case the nauplii in the water were more than sufficient for the requirements of the fish. This applies to the larvae in general irrespective of size and to normal feeding conditions. At the beginning of the hatching season, however, the period covered by our March records, conditions are far otherwise. Nauplii are very much scarcer — broadly speaking the counts are less than half the lowest figures obtained in April and May. Larvae if present are newly-hatched and in their fragile and feeble condition probably require to be surrounded by an even greater concentration of nauplii to obtain an adequate supply of food than the older stages which are more capable of active movement in catching their prey. Regarded from the point of view of food supply alone, it would seem probable that there is a considerable mortality of newly-hatched larvae especially at the beginning of the season before normal feeding conditions have been established.

When all this has been said, however, certain points remain for which no satisfactory explanation has been found. The most striking of those is the lack of correspondence between the counts of nauplii and the stomach content of the fish. In Table VI the fluctuations in the average counts of nauplii in the plankton are only such as might have been expected but the differences in the average stomach content of nauplii are surprising, being actually about four times as great. Taking 16 nauplii as a fair average for the stomach content, feeding was conspicuously poor in April 1934, particularly in the Central area where the count of nauplii in the plankton was the highest for the season and also in April 1935 in the Northern area where again there was obviously no scarcity of nauplii. It was at first considered possible that the latter low feeding value — an average stomach content of 7 nauplii — might have been influenced by the large number of early larvae with small feeding capacity examined but a further analysis of both this and the unusually high value of 29 for the Central area in the same month, made by separating the fish into two groups below and above 5 mm. respectively showed little alteration in the relative proportions.

April 1935	Average Counts of Nauplii in Plankton	Average Stomach Content of Nauplii	
Central	214	29 in 21 fish 3·5—12 mm.	11 in 7 fish up to and including 5 mm. 38 in 14 fish over 5 mm.
North	168	7 in 95 fish 3·5—12 mm.	5·7 in 76 fish up to and including 5 mm. 14 in 19 fish over 5 mm.

Further reference to Table VI shows that the feeding values for May 1934 were well above the average though the counts of nauplii were low, while the highest count of all — 250 in May, 1935 — gave an under-average feeding value of 14. Obviously there are factors at work here which our present data are insufficient to explain, but it is at least evident that the degree of feeding as represented by the average number of nauplii found in the stomachs is not directly dependent on the number of nauplii in the plankton and that the abundance of nauplii during the season of post-larval feeding in 1935 had no direct bearing on the successful haddock brood of that year.

With the exception of the nauplii the organisms in the plankton were not counted and so a detailed correlation of the plankton and the food is not possible.That selection in the wide sense is exercised by the larvae is abundantly proved by the uniformity of the food taken and is apparent even in the earliest feeding stages, but generally speaking little discrimination is made between the different elements of the copepod food except with regard to size. Ova and early nauplii are taken by the smallest fish and older nauplii, copepodids and adults by the larger sizes. The copepods which are commonest in the area, viz., *Calanus*, *Pseudocalanus* and *Oithona*, also preponderate in the food and fluctuations in the relative numbers of those and one or two additional species are reflected in the stomach contents. For instance *Pseudocalanus* which is probably the most generally distributed copepod in our waters was observed to be specially abundant both in the food and in the plankton in May 1935 in the Western area, *Temora* in May 1934 in the Central, *Oithona* in April 1935 in the Northern area and *Acartia* in May 1935 in the Western, while *Calanus* copepodids and nauplii were numerically conspicuous in the Central area in May 1934. Up to a point of course this is only to be expected but these and similar correspondences occur with sufficient frequency to indicate at least that the abundance of a particular species in the food is due to its predominance in the plankton rather than to its deliberate selection by the fish. While the "calanoids" were by far the most generally abundant of the nauplii in the food, there was an exception to this condition in April 1935 in the Northern area when the nauplii of *Oithona* outnumbered them by more than 2 to 1. This reversal of the usual relative proportions indicates an unusually high concentration of *Oithona* nauplii in the plankton rather than preference on the part of the fish for this particular kind of nauplii. The *Oithona* nauplii were much in excess of the "calanoid" both in larvae under 5 mm. and in the larger sizes.

In the case of the remaining constituents, the correspondence between food and plankton is less marked but this is mainly due to the smaller number of organisms dealt with. It is tempting at least in the case of the very young larvae to regard the non-crustacean elements and particularly the organisms of the microplankton as a sort of stop-gap to be made use of when there is a shortage of nauplii. For instance in March 1934 when the average counts of nauplii were the lowest recorded (except in March 1935 when there were no larvae) the numbers of microplankton organisms in the stomachs were higher than at any other time during the investigation. The actual figures are given in the following table:

March 1934.

	Central	Northern	Western
Number of Larvae..	9	10	7
Size in mm.........	4·0—4·5	3·5—5·5	4·0—5·0
Microplankton Organisms in Food..	63	42	73
Average Counts of Nauplii in Plankton	49	72	42

Admittedly too much stress must not be laid on isolated observations of this kind and a similar combination of conditions which might have served as a control did not recur during the period of the work.

While correspondence between food and plankton is the rule, a few exceptional cases may be mentioned. The adult *Oithona* found in the food were practically all males. This was particularly noticeable in the Western area in May 1935 when *Oithona* was very abundant. In the food of the fish examined for that month, 138 specimens were counted of which only 3 were females. Usually the numbers were small but the stomach of one fish 14 mm. in length contained 56 male *Oithona* and another of 19 mm. contained 50. In average plankton samples females considerably outnumber males and in the collection taken at the same station as the latter of these specimens, the proportion of females to males was found to be 12 to 1.

The case of the nauplii of *Longipedia* is somewhat similar. These, though not actually rare in the plankton, occur only sparsely. In the food of the fish examined for April 1935, 22 of these were counted, two fish of 6·5 and 8·5 mm. respectively each containing 8. In the plankton at this season, nauplii of *Balanus* which have a certain superficial resemblance to those of *Longipedia*, also occurred but no single instance of their occurrence in the food was noted either at this time or during the whole course of the investigation. Similar instances are mentioned by Lebour (1917) who found *Euterpina acutifrons* in greater numbers in the food of post-larval fish than in the plankton, and *Oncaea* in the food though not recorded in the plankton.

The tintinnid *Stenosemella nucula* referred to above which occurred in considerable numbers in the food of the smaller sizes, was so rare in the plankton samples that at first it was overlooked. In this case, however, the explanation of the discrepancy may be that owing to its minute size it passed through the meshes of the net.

Finally it may have been noticed that the numbers of dinoflagellates recorded in the food are very small. There seems to be no reason why these should not form part of the food of the young stages as diatoms and tintinnids do and their scarcity is probably due to the fact that their period of abundance in the Scottish plankton falls later in the year.

Summary.

1. The food of post-larval haddock taken on the Scottish spawning grounds in 1934 and 1935 has been examined.
2. About 70 % of the food consists of copepod nauplii and these with adults, copepodids and ova account for almost 90 %. The remainder consists of early stages of euphausids, larval molluscs and micro-plankton organisms.
3. The fish had been feeding well. Empty stomachs were remarkably few and they occurred chiefly in the 3.5 mm. and 4 mm. sizes.
4. Comparison of the average numbers of nauplii in the stomachs and the counts of nauplii in the corresponding plankton samples indicates that the number of nauplii in the environment under normal conditions is more than sufficient to provide for the requirements of the fish.
5. The uniformity of the food shows that selection is made even by the very young stages.
6. The temporary predominance of a particular copepod species in the plankton may also be evident in the stomach contents.

Table I.

1934. Numbers of Organisms in successive Sizes of Post-larval Haddock.

Haddock: Size in mm.	3.5	4	4.5	5	5.5	6	7	8	9	10	11	12	13	14	15	16	17	Totals	%		
No. of Specimens	3	16	11	11	2	9	11	7	8	6	5	3	2	—	3	—	1	98			
Copepods																					
Pseudocalanus	—	—	—	—	—	—	—	—	1	2	—	2	—	—	9	—	3	**17**	0·76		
Temora	—	—	—	—	—	—	—	—	—	—	—	2	1	—	2	—	—	**5**	0·22		
Oithona	—	—	—	—	—	—	1	—	2	—	3	5	3	—	8	—	4	**26**	1·17		
Other Copepods	—	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—	—	**2**	0·09	2·24	
Copepodids																					
Calanus	—	—	—	—	—	—	1	4	1	1	6	38	2	—	28	—	31	**112**	5·04		
Pseudocalanus	—	—	—	—	—	—	—	1	5	5	8	2	—	—	—	—	10	**31**	1·39		
Temora	—	—	—	—	—	—	—	—	1	1	—	6	—	—	11	—	—	**19**	0·85		
Acartia	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	**2**	0·09		
Oithona	—	—	3	—	1	—	1	11	3	1	5	3	2	—	2	—	—	**32**	1·44		86·49 %
Other Copepodids	—	—	—	—	1	—	1	1	1	7	—	—	2	—	2	—	—	**15**	0·67	9·48	
Nauplii																					
Calonoid	—	16	33	67	20	75	141	122	127	166	82	343	57	—	139	—	44	**1432**	64·39		
Oithona	1	2	9	9	3	5	12	6	5	3	1	2	1	—	—	—	—	**59**	2·65		
Other Nauplii	—	1	1	—	—	8	—	2	4	—	—	2	4	—	—	—	—	**22**	0·99	68·03	
Ova																					
Calanus	1	7	8	15	2	11	25	5	3	3	13	8	3	—	1	—	—	**105**	4·72		
Pseudocalanus	—	—	—	1	—	—	—	—	—	20	—	4	—	—	5	—	—	**30**	1·35		
Unidentified	—	1	2	3	1	—	—	1	3	2	—	—	—	—	—	—	2	**15**	0·67	6·74	
Euphausids																					
Juvenes	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	3	**4**	0·18	0·18	
Limacina juvs.	—	—	—	4	1	—	—	6	—	—	—	2	9	—	—	—	—	**22**	0·99		
Lamellibranch juvs.	—	—	—	1	1	—	—	—	2	—	—	—	—	—	—	—	1	**5**	0·18	1·17	
Stenosemella	12	85	55	32	—	—	—	—	—	1	—	—	—	—	—	—	—	**185**	8·32	8·32	
Coscinodiscus spp.	—	3	—	4	1	1	—	3	1	—	—	—	—	—	—	—	—	**13**	0·58		
Chaetoceros spp.	—	21	6	1	2	—	—	—	—	—	—	—	—	—	—	—	—	**30**	1·35		
Rhizosolenia spp.	—	1	1	—	—	—	—	—	1	—	—	—	—	—	—	—	—	**3**	0·14		
Other Diatoms	—	21	5	2	—	1	—	1	—	1	—	—	—	—	—	—	—	**31**	1·39		
Peridinium depress.	—	—	—	—	1	—	—	—	—	—	2	—	2	—	—	—	—	**5**	0·22		
Other Dinoflagellat.	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**3**	0·14	3·82	
																		2225		99·98	

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Table IA.

1934. The Food of Post-larval Haddock in the Months and Areas examined.

	March				April			May			June			
Number of Fish examined	9	10	7	26	12	9	21	25	15	40	3	8	11	98
Size in mm.	Central 4.0—4.5	North 3.5—5.3	West 4.0—5.0	Totals	Central 4.0—9.0	West 3.0—7.0	Totals	Central 4.0—17.0	North 5.0—12.0	Totals	Central 5.0—9.0	West 6.0—15.0	Totals	Totals
Copepods														
Pseudocalanus	—	—	—	—	—	—	—	7	3	**10**	—	7	**7**	17
Temora	—	—	—	—	—	—	—	5	—	**5**	—	—	—	5
Acartia	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Oithona	—	—	—	—	—	—	—	17	6	**23**	—	3	**3**	26
Other Copepods	—	—	—	—	—	—	—	1	1	**2**	—	—	—	2
Copepodids														
Calanus	—	—	—	—	3	—	**3**	97	8	**105**	—	4	**4**	112
Pseudocalanus	—	—	—	—	—	—	—	11	10	**21**	—	10	**10**	31
Temora	—	—	—	—	—	—	—	18	1	**19**	—	—	—	19
Acartia	—	—	—	—	—	—	—	2	—	**2**	—	—	—	2
Oithona	—	1	3	**4**	13	—	**13**	10	5	**15**	—	—	—	32
Other Copepodids	—	1	—	**1**	2	—	**2**	9	—	**9**	—	3	**3**	15
Nauplii														
Calanoid	3	30	7	**40**	15	97	**112**	602	311	**913**	49	318	**367**	1432
Oithona	—	11	6	**17**	13	4	**17**	1	23	**24**	—	1	**1**	59
Other Nauplii	1	—	—	**1**	12	3	**15**	6	—	**6**	—	—	—	22
Ova														
Calanus	2	10	5	**17**	6	21	**27**	24	35	**59**	—	2	**2**	105
Pseudocalanus	—	—	1	**1**	—	—	—	24	—	**24**	—	5	**5**	30
Undetermined	—	2	2	**4**	3	2	**5**	6	—	**6**	—	—	—	15
Euphausids														
Juvenes	—	—	—	—	—	—	—	4	—	**4**	—	—	—	4
Ova	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Limacina	—	2	—	**2**	9	—	**9**	11	—	**11**	—	—	—	22
Lamellibranch juvs.	—	1	—	**1**	—	—	—	1	2	**3**	1	—	**1**	5
Stenosemella	9	33	68	**110**	39	35	**74**	1	—	**1**	—	—	—	185
Other Tintinnids	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Coscinodiscus spp.	1	1	3	**5**	8	—	**8**	—	—	—	—	—	—	13
Chaetoceros spp.	27	2	1	**30**	—	—	—	—	—	—	—	—	—	30
Rhizosolenia styliformis	2	—	—	**2**	—	—	—	1	—	**1**	—	—	—	3
Other Diatoms	23	3	1	**27**	2	1	**3**	1	—	**1**	—	—	—	31
Peridinium depressum	—	1	—	**1**	—	—	—	4	—	**4**	—	—	—	5
Other Dinoflagellates	1	2	—	**3**	—	—	—	—	—	—	—	—	—	3

Table II.

1935. Number of Organisms in successive Sizes of Post-larval Haddock.

Haddock: Size in mm.	3.5	4	4.5	5	5.5	6	7	8	9	10	11	12	13	14	15	16	18	19	23	31	Total			
No. of Specimens	18	39	38	31	9	10	12	10	15	8	6	6	2	4	3	2	2	1	1	1	218			
Copepods																								
Pseudocalanus	—	—	—	—	—	—	—	—	3	—	—	2	1	12	6	8	3	2	21	—	**58**	1·45		
Temora	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	**2**	0·05		
Acartia	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	**2**	0·05		
Oithona	—	—	—	—	—	1	—	4	3	1	1	8	3	57	2	9	3	50	—	—	**142**	3·56		
Other Copepods .. .	—	—	—	—	—	—	—	—	—	—	—	1	1	3	1	—	3	1	—	1	**11**	0·27	5·38	
Copepodids																								
Calanus............	—	—	—	1	—	—	6	2	8	1	5	17	—	2	8	2	12	21	—	8	**93**	2·33		
Pseudocalanus	—	—	—	—	—	—	1	7	6	2	31	3	7	4	6	4	3	3	1	—	**78**	1·96		
Temora	—	—	1	—	2	—	—	1	3	—	8	—	—	20	1	—	—	—	—	—	**36**	0·90		
Acartia	—	—	—	—	—	—	—	—	3	—	1	—	—	1	1	16	6	24	—	1	**53**	1·33		
Oithona	—	—	—	5	5	8	17	11	28	5	4	1	—	—	—	—	4	—	—	—	**88**	2·21		
Other Copepodids...	—	—	—	—	1	—	1	—	—	—	4	—	—	—	—	—	—	2	—	—	**8**	0·20	8·93	92.23 %
Nauplii																								
Calanoid	9	65	160	233	151	94	157	218	264	101	101	157	139	129	25	74	5	140	2	—	**2224**	55·79		
Oithona	2	65	100	152	45	25	74	11	43	—	1	1	1	4	2	—	—	—	—	—	**526**	13·20		
Other Nauplii	—	1	—	1	5	8	—	—	8	—	—	—	—	—	—	—	—	—	—	—	**23**	0·58	69·57	
Ova																								
Calanus............	7	18	30	24	3	3	4	25	47	8	146	2	5	8	—	—	—	—	—	1	**331**	8·30		
Pseudocalanus	—	—	—	—	—	—	—	—	30	—	5	—	48	130	54	200	8	—	240	—	***715**			
Unidentified........	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	**2**	0·05	8·35	
Euphausids																								
Juvenes............	—	—	—	—	—	—	1	—	2	—	7	1	—	5	—	3	1	8	—	—	**28**	0·70		
Ova	—	—	—	—	—	—	—	2	1	—	—	—	—	1	—	—	—	—	—	—	**4**	0·10	0·80	
Limacina juvs.	—	6	16	18	10	11	17	9	14	11	1	—	—	—	—	2	—	—	—	—	**115**	2·88		
Lamellibranch juvs..	—	1	2	—	5	—	1	—	—	—	—	—	—	—	—	1	—	—	—	—	**10**	0·25	3·13	
Stenosemella	3	5	47	18	15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**88**	2·21		
Other Tintinnids....	4	8	6	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**19**	0·48	2·69	
Coscinodiscus spp....	2	17	9	5	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**34**	0·85		
Chaetoceros spp......	—	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**3**	0·08		
Other Diatoms	—	4	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**5**	0·13		
Peridinium depressum	—	2	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	**3**	0·08	1·14	
																					3986		99·99	

* Ova of *Pseudocalanus* omitted from Total because probably ingested as ovisecs.

Table IIA.

1935. Food of Post-larval Haddock in the Months and Areas examined.

	April					May				
Number of Fish examined	7	14	76	19	116	13	38	51	102	218
Size in mm.	Central 3.5—5	Central 5.5—12	North 3.5—5	North 5.5—12	Totals	Central 3.5—14.5	West 3.5—5	West 5.5—31	Totals	Totals
Copepods										
Pseudocalanus	—	1	—	1	**2**	7	—	49	**56**	58
Temora	—	—	—	—	—	1	—	1	**2**	2
Acartia	—	—	—	—	—	—	—	2	**2**	2
Oithona	—	1	—	3	**4**	4	—	134	**138**	142
Other Copepods	—	—	—	—	—	2	—	9	**11**	11
Copepodids										
Calanus	1	16	—	—	**17**	5	—	71	**76**	93
Pseudocalanus	—	—	—	5	**5**	12	—	61	**73**	78
Temora	—	10	—	—	**10**	23	—	3	**26**	36
Acartia	—	—	—	—	—	—	—	53	**53**	53
Oithona	1	3	4	59	**67**	—	—	21	**21**	88
Other Copepodids	—	6	—	—	**6**	—	—	2	**2**	8
Nauplii										
Calanoid	75	507	129	86	**797**	205	235	987	**1427**	2224
Oithona	3	25	304	162	**494**	9	10	13	**32**	526
Other Nauplii	—	2	—	21	**23**	—	—	—	—	23
Ova										
Calanus	11	12	21	7	**51**	16	34	230	**280**	331
Pseudocalanus	—	—	—	30	**30**	102	—	583	**685**	715
Undetermined	—	—	—	—	—	1	1	—	**2**	2
Euphausids										
Juvenes	—	9	—	—	**9**	—	—	19	**19**	28
Ova	—	1	—	1	**2**	—	—	2	**2**	4
Limacina	—	—	39	49	**88**	—	1	26	**27**	115
Lamellibranch juvs.	—	6	3	—	**9**	—	—	1	**1**	10
Stenosemella	—	—	67	15	**82**	3	3	—	**6**	88
Other Tintinnids	1	—	7	—	**8**	7	4	—	**11**	19
Coscinodiscus spp.	—	—	33	1	**34**	—	—	—	—	34
Chaetoceros spp.	—	—	1	—	**1**	—	2	—	**2**	3
Other Diatoms	—	—	4	1	**5**	—	—	—	—	5
Peridinium depressum	—	—	2	1	**3**	—	—	—	—	3
Other Dinoflagellates	—	—	—	—	—	—	—	—	—	—