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EDITOR'S NOTE

To conform with previous numbers in this volume, the date of Vol. 11, No. 3 has been made December, 1956. However, the date of issue is February, 1959.

Dr. Shaw's article "A *Deightoniella* disease of *Saccharum* species" was accepted for publication in February, 1958.

from 16 per cent. of the body weight for plant feeders to 2.1 per cent. for active fish eating types.. Food per meal for line caught fish is estimated at double the average quantity found in those stomachs with food in them, based on troll caught southern bluefin tuna. This species of 4.5 kg. average size was found to increase by 13 gm. per day for a food consumption of thirteen times the amount; small horsemackerel may compete with sardines on the New South Wales coast but at a size over 120 mm. in length they eat almost exclusively *Nyctiphanes australis*.

I. INTRODUCTION.

Although food of fishes has been of great interest to biologists for many years, quantitative analyses of the amount of food consumed and relative energy values have only recently been made. Scott (1901) compiled one of the most voluminous records of fish foods ever attempted while McHugh (1952)

mullet *Mugil cephalus* L. (diatoms), butterfish *Coridodax pullus* (Foster) and blackfish *Girella tricuspidata* (Q. and G). higher algae, etc. Horsemackerel *Trachurus declivis* (Jenyns and pilchard *Sardinops neopilchardus* (Steindachner), pelagic filter feeders. Bluecod *Paraperais colias* (Foster), omnivorous bottom feeder. Souhern bluefin tuna*Thunnus maccoyi* (Castlenau), pelagic predator. An examination has been made of the protein content of thirteen different types of fish food.

II. TYPES OF FEEDING AND THE FOOD CONSUMED.

In Table I, the weight of food in the stomachs of different species of fish of various weights is given and expressed also as a percentage of the body weights. The method of obtaining these data has varied according to the different methods of capture and different methods of feeding.

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TABLE 1.

STOMACH CONTENTS AS A PERCENTAGE OF THE TOTAL WEIGHT AND THE EQUIVALENT PROTEIN REQUIREMENTS OF 100GM. OF EACH SPECIES.

Species of Fish	Food	Average weight of fish—gm.	Average weight of stomach contents—gm.	Percentage stomach of total weight	Equivalent protein food requirements of 100 gm. live weight of each species (gm.)	Remarks
Mugil cephalus	Diatoms	1,079	173.2	16	....	Beach seine, Dargaville Beach, New Zealand.
Girella tricuspidata	Algae Poisedonia	426	56.8	13	.14	Beach seine, Port Hacking, New South Wales.
Corridodax pullus	Algae	2,300	426.0	18	.072	Mesh net, Cook Strait, New Zealand.
Parapercis colias	Salpa miscellaneous	1,045	102.2	10 90	.26	Handlines, Cook Strait, New Zealand.
Sardinops neopilchardus	Copepods Chaetognatha	35	1.5	4.3	.36	Ex. Tuna stomachs, off Albany, Western Australia.
Trachurus declivis	Apogonops Euphausids	850 679	25.5 27.0	4.1 3.9	.52 .27	Trawl net, off Port Hacking. Ring net off Eden.
Kishinoella tonggol	Pilchards	12,190	267.0	2.1	.27	Beach seine, Port Hacking, New South Wales.
Thunnus maccoyii	Pilchards	4,487	106.8	2.4	.31	Troll lines, off Albany, Western Australia.

(1) *Plant eating types.*

(a) *Phytoplankton feeders.*—Stomachs of *Mugil cephalus* were obtained in beach netting on the west coast of New Zealand where great quantities of phytoplankton are accumulated inshore, and mullet feed freely so that the stomachs and intestines are full. As the stomachs of mullet are small, contents of the first half of the alimentary canal were included as in this part no actual digestion appeared to have taken place. Six stomachs were taken of a small shoal and all appeared to be equally full of the diatom *Chaetoceros armatus* Westerndorp (See Chidambaram and Kuriyan 1952, Haitt 1944). These quantities of food are the greatest found in mullet, which often have mixed diatom and sand. In some species small quantities of decaying vegetation are found, probably consumed only under conditions of extreme shortage of food supply.*

(*b*) *Weed browsing feeders.*—The Zoöstera in the stomachs of *Girella tricuspidata* (blackfish) contained a much higher proportion of *Bryozoa* and other animals than stems collected at random by hand from the sea, and the fish obviously seek out the grass beds with a greater percentage of animals attached. This selective feeding was even more marked in the case of *Ulva latuca* where the fish grazed the fronds closely but not so as to kill the plant. Enclosed in the heart is a high proportion of small crustacea and the method of feeding indicates that the fish take the leaves as far as the crustaceans can conceal themselves. A great many blackfish are taken in which there is little food, the three recorded contained the greatest quantity found in a number of fish examined taken with hand lines and beach nets. *Coridodax pullus* (butterfish) feed among brown sea weeds and feed, usually on *Macrocysis* where it prefers the basal spore-bearing fronds, but also eats well developed but young surface leaves excluding floats and stems. The leaves are merely broken up and swallowed in pieces up to one inch square without being chewed. The surface leaves are not usually encrusted with the calcareous growths which are favoured by the *Girella* but the spore bearing basal leaves probably contain a higher percentage of protein than those on the surface. In mesh nets butterfish in their struggles usually regurgitate their food but four fish recently meshed had the stomachs full and the leaves still had the slime covering them as if taken freshly from the sea.

(2) *Bottom Feeding Carnivores*

A number of carnivorous species of fish have been found with algae in their stomachs and the inference that there is a large group of omnivorous species was shown to be incorrect only by a careful examination. It is probable that the only true omnivorous fish are the phytoplankton and algae feeders which consume small quantities of microscopic animals ecologically associated with plants.

In all these species of fish, which are sometimes found with small quantities of algae in the stomachs, it is probable that the reason for eating algae is its effect on the alimentary canal; in the feeding of blue cod in New Zealand algae is consumed only after alimentary upsets caused by shortage of pelagic foodstuffs as clupeoids and other fish and crustaceans such as mysids and whale feed (*Munida*), etc. At these periods, cod are forced to subsist on sea and heart urchins, shellfish and other hard foods which leave the alimentary canal inflamed as the spiny urchins and sharp shells up to one inch in diameter are swallowed whole..

A different feeding at first believed to be of the subsistence type is found when pelagic jellyfish *Ctenophora*, *Schyphozoa* and *Salpa* swarm. Cod consume great numbers and are fat when feeding on these types of food, the high protein content of *Salpa* on the dry basis shows the considerable food value. In blue cod stomachs, where the food was entirely of *Salpa*, the weight of the stomachs in fish varying from .57 to 1.37 kg., ranged from 6.0 to 7.2 per cent. of the total weight.

As a large part of digestion took place in the small intestine, an examination was made of the contents of that organ to the part where the *Salpa* were more than half

* In the estuary near the west coast where these mullet were feeding, was a thriving mullet fishery at the end of the last century. It declined as few mullet are now taken there. A possible reason, from the evidence of the plankton, is that the estuary changed with the depletion of timber stocks, which caused silting and the production at least in recent years of the spiny diatom *Rhizolenia* which is not usually eaten by fishes.

TABLE 2.

PROTEIN CONTENT OF MISCELLANEOUS FOODSTUFFS OF FISHES

(From formalin preserved material.)

No.	Date	Locality	Organisms	Displacement or settled vol. c.c.	Weight wet grams.	Weight dried grams.	Per cent loss in weight	N2 Per cent in dry weight (av.)	Per cent. Protein Average	
									Wet weight	Dry weight
1.	12.5.1951	Limestone Head, S-W Australia	Copepoda	46	8.41	0.81	91	9.5	5.3	59
2.	12.5.1951	Michaelmas Island, S-W Australia	Copepoda	45	10.08	1.09	89	8.4	5.7	52
3.	19.5.1951	Two People Bay, S-W Australia	Sagitta and Copepoda	71	10.18	1.31	87	11.1	8.8	69
4.	20.5.1951	Cape Knob	Copepoda	73	11.85	1.51	87	10.3	8.3	64
5.	24.5.1951	Bremer Bay	Copepoda	42	6.01	0.98	85	10.0	9.3	62
6.	25.5.1951	Doubtful Island	Copepoda and fish larvae	29	3.65	0.61	83	8.4	8.8	52
7.	5.6.1951	½ mile east of Bold Island	Copepoda	48	9.04	0.57	94	8.9	3.4	56
8.	12.6.1951	Off Cape Riche	Copepoda	21	4.93	0.33	93	8.8	3.8	55
9.	14.6.1951	Off Mississippi Bay	Copepoda	15	1.44	0.19	87	8.7	6.8	54
10.	17.6.1951	Bremer Bay	Copepoda	46	5.26	0.70	87	9.3	7.5	58
11.	24.6.1951	100 miles south of Albany	(Aggregate) Salpa maxima	82	11.71	0.48	96	10.2	2.5	63
12.	25.6.1951	20 miles south of Albany	Euphausids and Copepoda	49	8.63	0.96	89	10.7	7.0	64
13.	27.6.1951	Off Albany	Sardinops neopilchardus	14	15.3	2.44	84	12.9	12.9	81
14.	20.11.1952	Sydney Harbour	Metapenqeus macleayi shoot prawn	5	5.8	0.81	86	12.2	10.6	76
15.	7.9.1952	Off Eden	Euphausids (Trachurus stomach)	20 ‡	14.4	1.58	89	6.1	3.7	38
16.	20.10.1952	Port Hacking	Zoostera (blackfish stomach)	20	....	....	92	3.3	1.7	21
17.	16.12.1952	Port Hacking	Ulva lactuca (blackfish feed)	16	7.9 *	0.49	93	2.2	0.9	13
18.	14.12.1952	Port Hacking	Poisodonia (Ribbon weed)	10	9.1	0.73	92	2.3	1.1	14
19.	14.12.1952	Port Hacking	Burley weed (for blackfish)	17	....	....	94	1.6	0.9	10
20.	14.12.1952	Port Hacking	Eklonia	13	....	....	91	2.1	1.2	13
21.	15.2.1952	Port Sorrell, Tasmania	Macrocystis floating fronds	.... †	....	....	89	0.7	0.4	4

* 0.6 gm. Cumacea removed. † Air dried with potash adhering. ‡ Part digested.

digested; this was a stage where the muscular tissue could still be distinguished in most specimens and where the nucleus of the *Salpa*, the last organ to be affected had started to disintegrate; including with the stomach the contents of the alimentary canal to the point at which digestion was half completed, the stomach contents ranged from 8.2 to 10.9 per cent. of the total weight. Many specimens were examined but in no case where the fish were feeding freely on *Salpa* was digestion taking place in the stomach, so that the inclusion of the part of the intestine is justified as representing an extension of the stomach.

Many records describing "jellyfish" being consumed as food have been made. It has not usually been conceded, however, that they are of great importance except perhaps as food for *Mola*. About New Zealand, jellyfish often extend over many miles of the sea and it is possible that the fish have adapted themselves to using small *Aurelia*, *Ctenophora* and *Salpa* as food. The latter species is paricularly important, and in addition to the blue cod in more northern waters, the snapper *Pagrosomus auratus* (Foster), the most important commercial species in New Zealand, feeds almost exclusively on these forms, for some months each year.

(3) *Pelagic Carnivores.*

(*a*) *Tuna.*—In a record of northern bluefin tuna (*Kishinoella Tonggol* Blkr.) caught at Port Hacking in April, 1941, detailed observations on the stomachs of twenty showed the average number of pilchards per meal was nine, their average weight being 267 grams; weight of fish was 12.04 kg. The stomach content being 2 per cent. (Table 2) of the total weight of the fish. In this instance the number of pilchards in the stomachs varied from three to twenty, or from 61 to 565 grams, and the weight of the tuna from 11 to 13½ kg. These fish were captured in a similar gorged condition to shoals of salmon in both southern New South Wales and Western Australia. The fish lie up on occasions for some days and are then usually easily captured.

During a period of six weeks from May to the end of June, 1951, small regular catches of southern bluefin tuna *Thunnus maccoyii* (Castleneau) were obtained in south Western Australia. Of 142 tuna examined, 55 had a total of 123 pilchards in their stomachs in the proportions given in Table 3.

TABLE 3. SHOWING NUMBER OF TUNA WITH FROM ONE TO NINE PILCHARDS IN THEIR STOMACHS.

No. of Pilchard	1	2	3	4	5	6	7	8	9
No. of Tuna	18	22	4	7	....	3	....	....	1

Of these different numbers, the fish with nine pilchards in the stomach may be considered as exceptional—gourmandising—but the other records suggest a pattern of feeding.

If it is assumed that the artificial lure used to catch these tuna is a pilchard, it might be expected that about six pilchards was a full meal and that hungry fish starting their meal would be taken in greater proportion than fish with full or nearly full stomachs. In theory one would hope to obtain equal numbers of fish with none, one, two to five pilchards in the stomach, but the very hungry fish were taken in greater abundance. However, omitting the empty fish, the average number of pilchards in the stomach gives a good approximation to the amount of a half meal and this method may be used for any method of line fishing to determine the amount of food consumed per meal. In the case of the northern bluefin tuna the similarity of the results to the net catch of northern bluefin is confirmation of this theory. It is not possible, however, to state that tuna feed mainly once per day but it is certain that this is the case for a number of species, the exception being when fish become over-full through gourmandising and may not feed for several days. Data in Table 4 gives the average daily increase in weight of tuna caught with troll lines off the coast of south-west Australia.. The fish varied in weight from 2.7 to 8 kg. and are considered all to belong to Group 1. Two exceptionally large fish at nine kg. were not included and ten small fish about one kg. in weight were also omitted. It is not known if the extreme large

TABLE 4. AVERAGE DAILY INCREASE IN WEIGHT OF SOUTHERN BLUEFIN TUNA, MARCH TO JUNE, 1951.

Date of Collection	March 22-26	April 4-15	May 18-25	June 3-9	June 17-19
Average date from calculations	March 24	April 10	May 21	June 6	June 18
Number of fish	35	149	101	77	42
Average weight (gm.)	4,232	4,518	4,961	5,055	5,339
Increase from March 24 (gm.)	....	286.8	673	823.5	110.6
Longest period of days (from March 24)	....	16	57	73	85
Average daily increase (gm.)	....	17.9	11.8	11.3	13.0

and small sized fish are respectively early and late spawning, or if they belong to Groups 0 and 2.

Fishing was concentrated in four periods, the average weight being given for each and over the largest period interval the average weight increase per day. The increase per day of 13.5 grams over the three months is consistent for the four intervals between samples. (See Aust. Nat. Res. Council 1944 for nutrient allowances for domestic animals. Davies 1930, 1931*a* and 1931*b* for growth of plaice in captivity.) A possible explanation of the increase in average weight is that larger fish entered the shoal from an outside source. This, however, is not probable as the length frequency distribution showed only a gradual change.

Assuming the food in the stomach to represent a half daily requirement, the average quantity of food required to produce an increase in weight of the fish is 181 grams, or approximately one thirteenth the food requirements are related to increase in weight. This is a much more efficient process than one would expect in the sea, where the activity in feeding is considerable, and for comparison the food requirements of domestic animals, in which the increase in weight is usually considered to be approximately a fifth of the food intake measured on a dry basis.

The energy expended in feeding varies for active predators but the south-west Australia tuna were never seen feeding very actively, and although fishing was sometimes brisk, the fish on no occasion made sportive leaps which sometimes characterize the movements of tuna in other localities. For comparison also, the feeding activity of Spanish mackerel (*Scomberomorus commerson* Lacepede) in north-eastern Australia and New Guinea may be instanced. This species when feeding has been observed to make leaps of 30-40 feet in the air and the energy requirements to make such a leap are estimated at a minimum of 250 gramme calories..

Fish in feeding on other than jelly-like animals usually fill their stomachs and cease feeding, exceptions are rapacious types which allegedly consume up to 60 pounds weight of other fish to increase their own body weight by a single pound.

In the case of northern bluefin tuna, it was seen that in feeding the stomach filled and then no more is taken until digestion is completed. But in the case of southern bluefin tuna, this does not always appear to be the case, nor can it be definitely said that the tuna feed only once per day, or every two days. However, it is probable that the fish feed once a day; the manner in which tuna in south-west Australia are caught all day long from daylight till dark indicates that although the shoal of tuna feeds to some extent continuously, the proportion of empty stomachs suggests that there is a long period of digestion during which no food is consumed.

(*b*) *Starvation conditions, etc.*—In the water of New Guinea one common tuna species, the yellowfin (*Neothynnus macropterus* J. and E.) is frequently found with *Squilla* larvae in the stomach, and it is considered that tuna feeding on this type of food is virtually at starvation level. Nothing comparable has been found in the southern bluefin tuna in Australian waters, but on the east Australian coast southern bluefin were taken in 1953 with a great variety of demersal fish all of moderate size, in their stomachs, including the snake eel (*Opisurus serpens* L.) and the Nannyai (*Trachichthodes affinis* Regan), while several years previously the stomachs contained for a considerable period, post larval *Cheilodactylidae*. There appears to be little doubt that the catching power of tuna seeking out their prey is very great and the survival of the species will not be jeopardised by a shortage of any one particular type. On the New South Wales coast the usual food of the bluefin tuna is horsemackerel.

(4) *Pelagic Filter Feeders.*

The food of sardines and horsemackerel shows that comparable quantities are consumed by each species on a weight basis. The feeding habits of sardines in south-west Australia have been treated previously (Rapson, 1953) and for comparison horsemackerel is now considered.

Table 5 gives the percentage of various organisms in stomachs of horsemackerel in four size groups and the food consumed progressively changes until the fish reach a size exceeding 120 mm. in length. Even at a size of less than 40 mm. long, a small number of *Nyctiphanes* six and nine mm. long is consumed, the number of abnormally large organisms in the stomach decreases, and only in the largest group are full-sized *Nyctiphanes* found.

From early June in New South Wales adult *Nyctiphanes* shoal and in calm water weather come to the surface where they are preyed upon by a number of species of fish and birds. The horsemackerel are able under these conditions to surround the shoals of *Nyctiphanes* and fill their stomachs in a relatively short time. The amount consumed per meal shows that a dense shoal of horsemackerel comprising 30 tons of fish consumes nearly four tons of feed. The surface migration of euphausids is latest in Tasmanian waters, and the surface shoaling may not start until January.

In periods of cool weather, horsemackerel remain in the mid-water zone where they are seldom captured by fishing methods now in use. In exceptional conditions, small quantities are taken in trawl nets on the bottom where, however, they are usually resting or a small proportion feeding on the demersal forage fish *Apogonops*. This forage species is an important food off the New South Wales coast and flathead (*Platycephalus*) feed on it from below, while *Trachurus* prey on it from above. The relatively small quantity of *Apogonops* consumed by *Trachurus* leads to the assumption that only the small percentage of fish in a shoal feeding on *Nyctiphanes*, which does not obtain sufficient food continues to feed when the greater part of the shoal is resting.

Stomachs of pilchards (130-180 mm. long) in south-west Australia contained 97 per cent. by number of small copepods. This compares

Table 5. PERCENTAGE OF VARIOUS ORGANISMS IN STOMACHS OF *TRACHURUS DECLIVIS* OF DIFFERENT SIZES.

Number of Trachurus	Standard length	Organisms in the Stomach			
		Copepods 0.5-2.5 in length.	Other Crustacea etc. 3-9 mm. in length.	9 mm. in length. Nyphiphanes over	Fish.
9	25-40	95	5	....	....
27	41-70	57	30	13	....
22	71-120	39	46	15	....
36	120--360	1	2	96	1

favourably with the contents of *Trachurus* stomachs where the average quantity of copepods is 64 per cent.

The dominant position which horsemackerel hold on the New South Wales coast is probably related to the greater supply of the larger food *Nyctiphanes,* which for approximately six months each year is found near the surface between southern New South Wales and Tasmania.

Several important findings were made in the examination of *Trachurus* stomachs :—

(1) With rare exceptions in individual stomachs, fish are found to feed and the food then is digested over a considerable period, varying as far as can be judged from a minimum of some hours to one or more days. A small shoal of *Trachurus* was found in which most of the fish had in their stomachs the remains of two meals. The organisms in the stomachs were all very small, less than 0.5 mm. in length, and the largest of the fish had in their stomachs the remains of only one meal. It is assumed that they were unable to catch or filter microscopic organisms of this size. The shoal may have been interrupted in feeding, but this is contrary to the findings with pilchard shoals, in which the shoal continued to feed while being preyed upon by tuna. At the time this particular shoal was taken considerable numbers of *Scyphoa* were to be found, and the water was remarkably barren of plankton. The explanation suggested is that the small fish were at subsistence level and the larger fish in the shoal at starvation point.

(2) *Trachurus* are reported by Lettaconnoux 1951 and other writers to consume large quantities of *Scyphozoa*; a careful examination of the stomachs mentioned above showed that with two exceptions the stomachs did not contain scyphozoan or other similar remains and in the two cases the gelatinous matrix which appeared to be part of the tentacle had minute crustacea embedded in it. . . . .

In ring-net caught fish, it was expected that the greatest quantity of food would be found in the largest fish. Such, however, did not prove to be the case and small fish often had a relatively great quantity of krill in the stomach. An examination of the gill rakers shows that fish over $2\frac{1}{2}$ pounds in weight usually have the long gill rakers bent over in the roof of the mouth which reduces the effective use of these organs considerably. Further evidence of a slackening in feeding activity or in the ability to obtain food was found in a small catch of horsemackerel obtained in trolling for tuna in March and April, 1949. The tuna stomachs contained small fish. These horsemackerel which were feeding among tuna shoals took artificial lures representing fish four to five inches long; their stomachs were empty or contained a few krill. (See California Co-op Sardine Research 1950.) This inability of the older fish to get food may be one of the reasons for the short life span of this species. The age on the Australian coast seldom exceeds eight years.

Although horsemackerel remain in dense shoals for six months in the spring and summer, during the remainder of the year the shoals are somewhat dispersed. The shoaling observed is primarily for feeding, during which period the fish actually spawn and later become somewhat dispersed entering inshore waters.

As shoals in Australian waters are usually more limited in size than most important fish species in the northern hemisphere, observations may be more easily interpreted in terms of shoal behaviour (see Sette, 1949) than for northern hemisphere species, where shoals are large. As feeding is closely related to shoal behaviour the following observations are given :—

Horsemackerel and sardines form shoals for protection, feeding, and spawning; shoals, however, become dispersed under certain feeding conditions when each fish hunts as an individual.

Size of a shoal is limited mainly by the quantity of food available, not in one particular shoal of the forage species but in the average which permits the predator species to obtain food with sufficient ease. Correct water surface conditions (including temperature) and sometimes food are necessary to bring shoals of horsemackerel to the surface. Abnormal cold will drive the shoals to the bottom even in deep water.

As all horsemackerel which were taken in the ring-net contained large quantities of krill in the stomachs, it is assumed that this fish when feeding intensively become less wary. This, in fact, appears to be the case for a number of species, e.g., southern and northern bluefin tunas, salmon and sardines.

One aspect concerning the behaviour of fish shoals, which is quite as difficult of approach as the quantity of food consumed by fish, is the problem of competition for food among fish (see Shorygum 1939, 1946).

III. CHEMICAL ANALYSES.

In Table 2, analyses are given of seven different animals eaten by many species of fish and six plant foods used by a relatively small number of species. Vinogradov (1938) gives the nitrogen content of the other classes of marine organisms, used extensively for food. Protein calculated from his tables for Kiel Bay and other places are as follows: Peridinians varied in protein content from 19.2 to 44.9 per cent. and a single sample of *Ceratium* gave 26.12 per cent.; *Rhizosolenia, Thalassiothrix, Chaetoceros, Skeletonema,* and *Coscinodiscus* 14.1 to 27.8 per cent., the lowest figure being the only analysis of 14 which contained *Coscinodiscus*, the highest contained *Thalassiothrix*; other writers, see Juday (1943), have given analyses for various marine plants. On the basis of dry weight, food protein value can be stated in descending values of protein as follows: Pilchards or fish and prawns then *Sagitta, Copepoda, Euphausia* and *Salpa* approximately equal, followed by peridinians diatoms then *Zoostera, Poisodonia* and *Macrocystis*. There is considerable evidence that weed eaters prefer those parts which harbour the greatest quantities of marine animals. The species which has been observed to feed regularly on *Macrocystis* the butterfish, *Coridodax pullus* in New Zealand prefers the basal spore bearing fronds which probably contain a higher protein content than the floating leaves.

On the basis of wet weights the *Sagitta* and *Salpa* show a lower protein content than those foodstuffs with a comparable protein content determined on the dry basis. They are, however, appreciably higher in protein than vegetable foods. Rapson (1953) shows how pilchards seek *Sagitta* for food and the records of fish consuming jellyfish, Bigelow (1924), Powell (1937), Rapson (unpublished) indicated that although these organisms contain a large quantity of water they are valuable foods. With the exception of *Poisodonia* (which was, however, encrusted with *Brachyura*) the plant samples taken from the sea had a lower protein content than the actual stomach contents of fishes feeding on them, suggesting that the animals living in or on the plant communities may contribute substantially to the food of herbivores. The great range in protein value from 0.4 per cent. to 12.9 per cent. on the wet basis * shows a similarity to the variety of foods consumed by the group mamalia, but is found in a single species of fish or mammal only in unusual circumstances..

Nikolskii (1950) says a fundamental difference between the fertility of soil and the so-called "fish productivity" consists in that in agriculture the first and second links are the economically valuable product, whereas in the sea the economic product is at least the third, and more often the fourth and fifth. This may often be the case, but the smaller quantities of food, rich in protein, which are required by carnivores suggests that the complex food chains may not, in the ultimate production of fish, be less economic than the simple plant feeding of herbivorous mammals. In the sea under natural conditions it is difficult to estimate growth in weight for a given weight of food consumed. The average weight of feed consumed per meal as a percentage of the total weight, however, is a guide to the food value of different foodstuffs (see Chidambaran and others 1952, Venktaraman and Chari 1952, Juday 1943, Clarke and Bishop 1948 for analyses other than protein).

IV. CONCLUSIONS.

Although some fish are found gorged with food, the average quantity consumed per meal varies from approximately 16 per cent. for plant feeders to less than 5 per cent. for fish feeders. For the better type of fish, growth is of the order of one thirteenth of the weight of food consumed estimated on the wet basis. This compares favourably with domestic animals where on the dry basis the increase is only one fifth of the weight of food consumed.

The competition for food in the sea is a problem even more difficult of solution than the food requirements of fish in their natural

* The formalin preserved material is approximately 10 per cent. more concentrated than the living substance.

state. Fish are adapted so that their gill rakers take food of varying size from small species with 150 gill rakers to larger types as tuna with only a few. Yet all species seem able to adapt themselves to an extremely wide range in size of food organisms.

Fish experience periods of subsistence level feeding and starvation conditions but are probably more adaptable to their environment in this respect than warm blooded land animals.

Some little known animals are important in the food of fish and a study of chemical composition is of value in gaining information on the habits of fish and may ultimately prove useful in fishing techniques.

V. ACKNOWLEDGMENTS.

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