DEPARTMENT OF NAVAL SERVICE

CONTRIBUTIONS

TO

CANADIAN BIOLOGY

BEING STUDIES FROM THE

BIOLOGICAL STATIONS OF CANADA

1918-1920

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CONTENTS

PREFACE.

By Professor Edward E. Prince, LL.D., M.A., D.Sc., F.R.S.C., Dominion Commissioner of Fisheries; Chairman of the Biological Board; Chairman of the Canadian Arctic Expedition Committee; Member of the Advisory Board on Wild Life Protection, Ottawa; Chairman of the Food Refrigeration Committee, Canadian Research Council; Vice-President of the International Fisheries Congress, Washington, D.C., 1907. etc.

The present volume of Contributions to Canadian Biology is composed of a series of separate reports by trained scientists who have taken advantage of the facilities generously provided by the Dominion Government at the Atlantic Biological Station, St. Andrews, N.B., and the Pacific Station, Departure Bay, near Nanaimo, B.C. The subjects treated cover a wide range, but they all have, like marine research in general, a very important practical bearing upon fisheries and fish resources of Canada.

It may be pointed out that the problems which occupy the attention of the staffs of technical investigators at both stations consist either of questions which the Department of Naval Service finds it urgently necessary to have exact and adequate information upon, or of problems determined by the Biological Board as of importance in the general advancement of knowledge relating to fish life in our seas, or they are lines of investigation which members of the scientific staff have selected as likely to yield valuable technical and practical results.

Of departmental problems which have arisen in connection with the conservation of the British Columbia salmon fisheries, and especially in the devising of wise regulations, as well as the effective restoration of the supply by fish-culture, the problem of the rate of growth, which Dr. McLean Fraser has still further advanced, in the first report, is of signal interest. It carries to a further stage the work which he summarized in a previous report, and which he has treated in a number of scattered memoirs and papers.

The second report in the series, by Dr. Fraser, deals with the effects which seem to be associated with severe weather as they influence organisms on which fish directly and indirectly depend for food. The observations were made in the winter and spring of 1915-16, and they show that marine animals in certain instances shifted into deeper water owing to the cool temperature, and fish and other forms had to follow them, and thus change their local habitat. Not only was much life actually destroyed; but higher forms such as migratory fishes had the incubation of the eggs delayed, and the fry migrated later than usual.

The third report, also by Dr. Fraser, embodies systematic observations, for five years, 1914-19, on the temperature and specific gravity variations at the sea's surface near Nanaimo, B.C.

Miss Fritz's report, forming the fourth in order, gives the results of patient and laborious work in the culture of Diatoms, which form a staple food of the minute crustaceans called Copepods by which young fishes and a multitude of other organisms are sustained.

The fifth report on Plankton Diatoms near St. Andrews, also by Miss Fritz, is a study of material obtained from October, 1916, to October, 1917, and includes eighty-two species. Their relative abundance and scarcity over extensive areas, and at various depths, are detailed and the numbers at various specified stations are given in detail. Counts up to many millions were made, thus in spring (on May 1), 8,750,000 examples of five species were obtained, and again on August 2 of one species no less than 7,000,000 frustules were noted (*Ch. debile*).

Professor W. A. Clemens' account of the Mutton Fish (*Zoarces*) is a very thorough study of a species, which is really an excellent food-fish though not generally recognized as such. The research was a joint one, in which Mrs. Lucy Smith Clemens collaborated, and it has much scientific as well as practical value.

Dr. Huntsman's two valuable reports (seven and eight) embody studies of Plankton material collected during Dr. Hjort's fisheries investigations, 1914-15, and treat respectively of the peculiar transparent annelids, the Tomopteridae; and the floating Tunicates, the Thaliacea; and demonstrates their varying abundance at different seasons of the year, and the causes of their distribution.

Dr. Gross's paper, Report IX on the Putrefaction of Fish is of much practical as well as scientific value, and demonstrates very different rates of deterioration as characterizing the various species studied. Hence some fish are better adapted for transportation, and for prolonged handling in the markets, than others. This is a new field of investigation and demands more attention owing to its vital importance to fish marketing. Dr. Wilfrid Sadler's report (X) on the causes of "Swelled Canned Sardines" is of similar interest and value. The cause is found to be in the presence of gas-producing bacteria, of which he determined eight varieties, and their source of origin may be due to the intestinal contents of the fish, or to lack of cleanliness in the factory workers, the latter being in the author's opinion the less likely source.

Professor Philip Cox's list of Cape Breton and Magdalen Islands fishes (XI) collected in 1917, is an interesting addition to our maritime faunistic knowledge, and the synopsis of Canadian Diatoms (XII), by Drs. L. W. Bailey and A. H. MacKay, is a compilation long needed, and embodying extensive researches by the authors. These are reports numbers eleven and twelve.

Professor J. W. Mavor's paper (XIII) on the utilization of dogfish and other shark-like species, occurring in our Atlantic waters, forms the thirteenth report of the present series, and summarizes all the most important phases of this subject. Now known by the trade-name of "grayfish," they have come into demand in many markets, and it is important to have, in accessible form, information as to the nature and habits of these fish, the character of the flesh, etc., and its chemical composition, especially its food value, palatability, and other points which are of public importance. Dr. Mavor adds some notes on the use of these fish for oil, glue, fertilizer, and other purposes. Dr. Baumann's' report on the analysis of grayfish and Dr. A. B. Macallum's note on the urea content of the flesh form appendices A and B to the report.

The fourteenth report of the volume is Dr. McLean Fraser's "Key to the Hydroids of Eastern Canada," illustrated with 109 beautiful figures. It is the first of a proposed series of guides to the marine animals of Canadian waters. These will supply a keenly-felt want amongst all who are interested in the resources of our seas. No handy guides are available for students and the general public which would enable them to recognize and name specimens when obtained. Even scientific workers deplore the lack of such guides and Dr. Fraser's report is a notable beginning.

The fifteenth report describes a new genus, and three new species of minute filamentous Algæ of the Order Hormogoneæ, by Mr. A. Brooker Klugh, who collected them in the Miramichi river and estuary in 1918, and is preparing a full report on the microscopic flora of the region.

The last (the sixteenth) report by Dr. A. P. Knight deals with the "Histology of the Flexor Tendon in the Crushing Claw of the Lobster," with nine figures ,and is a study of the minute structure of the larger of the two oval keeled plates to which the claw muscles, for opening and closing, are attached. Each plate, which has a laminated structure shows a central core, and network of crossing fibres in the outer portions. These laminae appear, under low powers, to be of two kinds, thirty-two dark coloured in section, and fifty-seven white; but in young lobsters the laminae are fewer. Under a high power, the latter seem to be more uniform, resembling the finest lawn in appearance. When fresh the texture is soft like cartilage; but hard and brittle after boiling.

I.

Further Studies on the Growth Rate in Pacific Salmon.

BY

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Curator of the Pacific Biological Station, Departure Bay, B.C.

INTRODUCTION.

Having completed and submitted my report on salmon material collected in 1916, I secured further material in 1917 and the present report is therefore a continuation of the preceding researches. All of the Pacific salmon again receive attention. In some respects the material was better for examination than that from the preceding year. Practically all of the scales were in good condition and as the material was obtained from a greater number of localities it gave a better chance for comparison. For this diversity of material I am indebted to the managers and employees of the canneries at Quathiaski, Lasqueti island and Nanaimo. The weight of the fish was taken in each case and that permitted the working out of a length-weight ratio for each species in each locality. The methods used were the same throughout as with the 1916 material.

On March 24 and 25, 1915, one thousand spring salmon fry and one thousand coho fry were marked at the Cowichan Lake hatchery. The information gained from these, although not very extensive, was quite satisfactory. On October 11, 1917, one of the cohos was caught in Cowichan bay, near the mouth of the river up which evidently it would have gone to spawn if it had not been caught. It weighed 9¼ pounds. The scale corresponded perfectly with the scales of those that have all along been taken as three-year fish. It must have gone down the Cowichan river as a yearling and evidently it was on its way to ascend the same river to spawn.

On January 9, 1918, one of the marked spring salmon, 26 inches long, weighing 8½ pounds, was caught in Departure bay, near the north shore, not far from the Biological Station. Its scales indicated a three-year spring of the sea type. It was in no sense mature and hence there was nothing to indicate the river it would have ascended. The fact that is was caught in Departure bay corroborates, as far as it goes, the opinion expressed previously that some spring salmon that have passed into the strait of Georgia from the rivers that empty into it do not go out to the open sea but instead wander about in the inner waters in search of food.

The five species are considered in much the same way as in the previous paper although the same amount of detail was not considered necessary. On the other hand, the possibility of comparing each species in the two years has somewhat enlarged the field.

Spring Salmon.

As in previous years, it was not possible to get many spring salmon that could be definitely assigned to any particular river-system. Some Fraser river fish were obtained but as, in general, these were on the cannery floor with others caught elsewhere, they could not be separated with certainty. Specimens obtained at Quathiaski cannery and from the Lasqueti island cannery are included, but as they were few in number and as the areas from which they were received, approach or overlap the Nanaimo cannery area, it was scarcely worth while to consider them separately. As these fish feed in the Strait of Georgia and adjacent waters throughout the period of their marine life and as they wander about in this area, it follows that only when spring salmon are caught in the rivers or as they are entering the rivers, can one have any assurance in this area as to the river system to which they belong.

The total number examined was 527, of which 412, or 78·2 per cent were of the sea type and 115, or 21·8 per cent of the stream type. Of the sea type, 35 were in their fifth year (8·5 per cent), 142 in the fourth year (34·5 per cent), 203 in the third year (49·2 per cent) and 32 in the second year (7·8 per cent). Of the stream type, 4 were in their sixth year (3·5 per cent), 26 in the fifth year (22·6 per cent), 50 in the fourth year (43·5 per cent) and 35 in the third year (30·4 per cent). (As in previous years many of the fish were immature and hence these percentages give no indication of the relative numbers that mature in each year).

In both types the females outnumbered the males as indicated in the following table:—

SEA TYPE.

Year—Class.	Total No.	Male.	Per cent.	Female.	Per cent.
5	35	14	40·0	21	60·0
4	142	47	33·1	95	66·9
3	203	87	42·9	116	57·1
2	32	30	93·8	2	6·2
	412	178	43·2	234	56·8

STREAM TYPE.

Year—Class.	Total No.	Male.	Per cent.	Female.	Per cent.
6	4	4	100·0	....	
5	26	9	34·6	17	65·4
4	50	23	46·0	27	54·0
3	35	20	57·1	15	42·9
	115	56	48·7	59	51·3

Although the data are not suitable for determining definitely the relative growth of male and female fish it may be worth while to give the lengths of each type and year to indicate the limits of each. The lengths are given in inches.

SEA TYPE.

Two year Class.

Length	14	14·5	15	15·5	16	16·5	17	17·5	18	18·5	19	19·5	20
Number—Male	1	2	3	3	6		2	6	3	2	1		1
Female				1	1								

Aveəƨer length, male, 16·6; female, 15·7; total, 16·6.

Three year Class.

Length	19	19·5	20	20·5	21	21·5	22	22·5	23	23·5	24	24·5	25	25·5	26	26·5	27	27·5	28
Number—Male	1			2	3	1	10	8	17	2	6	4	8	5	4	2	12	1	1
Female		1		1	4	5	15	12	15	14	15	8	6	9	3	1	6	1	

Average length, male 24·0; female 23·6; total 23·8.

Four year Class.

Length	26	26·5	27	27·5	28	28·5	29	29·5	30	30·5	31	31·5	32	32·5	33	33·5	34	34·5	35
Number—Male			1		3	3	4	1	4	7	5	5	5	2	3	1	3		
Female	2		5	6	9	6	13	7	8	8	5	6	2	4	4	2	5	2	1

Average length, male 30·8; female, 30·0; total, 30·3.

Five year Class.

Length	32	32·5	33	33·5	34	34·5	35	35·5	36	36·5	37	37·5	38	38·5	39	39·5	40	40·5	41
Number—Male	1						2		1	1	3	1	2		1		1		1
Female	1			1			2	3	3	2	2	1	2	1	2				

Average length, male, 37·0; female, 36·2; total, 36·6.

STREAM TYPE.

Three year Class.

Length	17	17·5	18	18·5	19	19·5	20	20·5	21	21·5	22	22·5
Number—Male	2	3	2	2	3	2	2	2	1	1		
Female			3				2	3	6			1

Average length, male, 18·9; female, 20·3; total, 19·5.

Four year Class.

Length	22	22·5	23	23·5	24	24·5	25	25·5	26	26·5	27	27·5	28	28·5	29	29·5
Number—Male	1	2	1		1		3	1	3	1	3	1	1	2	1	2
Female				1	3	1	4		3	1	8	2	3		1	

Average length, male 26·1; female 26·2; total 26·2.

Five year Class.

Length	28·5	29	29·5	30	30·5	31	31·5	32	32·5	33	33·5	34	34·5	35	35·5	36	36·5	37
Number—Male	1	2						1	1			1	1		1			1
Female		2			1	1	1	3	2				1	1	1			2

Average length, male, 32·4; female, 32·4; total, 32·4.

Six-year Class.

Length	35	37	39	40·5
Number—Male	1	1	1	1

Average length, 37·9,

As the period of collection of these salmon extended over three months this may have increased the normal spread between limits for each year but as the period of rapid growth was well over before the first collecting was done this would not make so much difference as if it had been done earlier. In any case the conditions were similar for male and female and hence there should be the same ratio in length as if they had all been taken at the same time. In the sea type in every year class the male average is distinctly greater than the female average. In the stream type the two averages are very similar, but what difference there is is in favour of the female.

The rate of growth as calculated by years is shown in the following table:—

TABLE OF GROWTH.

SEA TYPE.

Year—Class.	No.	Growth during—Years. 1st	2nd	3rd	4th	5th
2	32	10·9	5·6	....	....	
3	203	10·7	8·8	4·3	....	
4	142	10·8	9·0	6·8	3·6	
5	35	10·6	9·1	7·8	6·0	3·0

Year—Class.	No.	Length at end of—Years. 1st	2nd	3rd	4th	5th
2	32	10·9	16·6	....	....	
3	203	10·7	19·5	23·8	....	
4	142	10·8	19·8	26·6	30·3	
5	35	10·6	19·7	27·5	33·5	36·6

STREAM TYPE.

Year—Class.	No.	Growth during—Years. 1st	2nd	3rd	4th	5th	6th
3	35	3·7	10·2	5·6	....	....	
4	50	3·8	10·1	8·4	3·9	....	
5	26	3·8	10·5	8·8	6·2	3·1	
6	4	3·8	10·1	8·9	7·3	5·3	2·5

Year—Class.	No.	Length at end of—Years. 1st	2nd	3rd	4th	5th	6th
3	35	3·7	13·9	19·5	....	....	
4	50	3·8	13·9	22·3	26·2	....	
5	26	3·8	14·3	23·1	29·3	32·4	
6	6	3·8	13·9	22·8	30·1	35·4	37·9

length for the incompleted year is recorded. It is evident that while the period of most rapid growth was over when the collection started, there must still have been time for a noticeable increase before the growth of the year was complete. As the

In both types the averages for each year class are very similar. In these tables the range of growth in the different years is much the same as in previous years and the curve of growth similar, little is to be gained by introducing these data for the year 1917.

The weights of all these fish were taken and hence it was possible to get the approximate ratio of weight to length. As the absolute weights would be of little use for comparison, the average weight of all the specimens of a certain length in each type and year class, male and female, was taken and from these a table was prepared to show the ratio of weight to length. As in many cases, especially towards the extreme of range, the number of specimens for any one length is very small, sometimes only one, too small for getting a proper average, the figures show much irregularity and allowance must be made for this as the figures were put in the table just as they were worked out. The number of specimens for any length in any group can be obtained by referring to the previous tables.

TABLE SHOWING RELATION OF WEIGHT TO LENGTH.

SEA TYPE.

Length.	Two year.		Three year.		Four year.		Five year.	
	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.
14·	1·5							
14·5	2·0							
15·	2·0							
15·5	2·2	2·0						
16·	2·7	2·6						
16·5								
17·	3·0							
17·5	3·3							
18·	3·5							
18·5	3·7							
19·	4·0		4·0					
19·5				4·0				
20·	4·5							
20·5			4·2	4·2				
21·			4·3	4·9				
21·5			5·0	5·5				
22·			5·6	5·8				
22·5			6·4	6·4				
23·			7·0	6·6				
23·5			6·5	6·7				
24·			7·8	7·2				
24·5			8·4	7·7				
25·			9·1	8·2				
25·5			9·3	9·5				
26·			9·6	9·9		10·0		
26·5			11·2	11·5				
27·			12·0	12·7	12·5	10·9		
27·5			12·0	12·5		12·9		
28·			13·5		13·2	13·7		
28·5					13·9	13·9		
29·					13·6	14·3		
29·5					16·5	15·0		
30·					16·6	15·1		
30·5					17·4	15·8		
31·					18·0	17·9		
31·5					18·2	20·3		
32·					19·9	21·0	18·7	19·0
32·5					20·4	22·4		
33·					22·2	21·5		
33·5					26·5	22·3		25·0
34·6					23·7	24·5		25·5
34·5						26·2		
35						29·5	28·0	27·1
35·5								29·5
36·							29·0	30·6
36·5							33·5	32·5
37·							30·6	34·5
37·5							33·0	33·5
38·							34·9	36·2
38·5								35·0
39·							41·0	36·0
39·5							43·0	
41·								39·5

STREAM TYPE.

Length.	Three year.		Four year.		Five year.		Six year.
	Male.	Female.	Male.	Female.	Male.	Female.	Male.
17·	2·9						
17·5	3·3						
18·	3·4	3·2					
18·5	4·1						
19·	3·8						
19·5	4·2						
20·	4·4	4·0					
20·5	4·6	4·9					
21·	5·5	4·8					
21·5	5·5						
22·			6·2				
22·5		5·5	6·0				
23·							
23·5				6·5			
24·			8·0	7·4			
24·5				7·7			
25·			9·2	8·2			
25·5			10·5				
26·			11·1	8·9			
26·5			11·7	11·0			
27·			10·9	10·7			
27·5			11·7	12·0			
28·			11·0	11·7			
28·5			13·1		15·0		
29·			16·5	13·7	17·1	15·5	
29·5			17·8			14·0	
30·							
30·5						16·0	
31·						18·7	
31·5						21·0	
32·					24·5	21·0	
32·5					23·0	21·0	
33·							
33·5							
34·					20·0		
34·5					25·0	28·0	
35·						27·0	26·0
35·5					30·0	27·0	
36·							
36·5							
37·					33·2	34·5	32·5
39·					35·0		
40·5					38·5		

There is nothing in this table to indicate that there is any sustained difference in weight ratio in sex, age or type. It would seem rather that with species in this area, an area where conditions should be much similar for all individuals, although there may be much variation, there is a constant average weight for any length. There is a large enough number of cases where the average is sufficiently exact to show that the weight varies as the cube of the length. Although this is what should be expected it is a satisfaction to have such evidence since it is an assurance that the length of the fish is a safe basis for comparison. This variation can be followed throughout the five species as is shown for the other species in the tables that accompany the report on each.

In comparing the spring salmon collection of 1917 with that of 1916 and that of 1915, there seems to be very little difference in the rate of growth in any year of the different year classes. In no case is there much variation in growth for the same year in the different year classes in any collection and the year class that gives the highest average in one collection does not always give the highest average in the other collections. Since the collection in each year was a composite one from a wide area, including the entrance to several rivers, it would be too much to expect that there would be exactly the same average even in the same year class. There is no indication that any one year class has had more rapid growth throughout than any other year class. This is true of both the sea and the stream type of fish.

In the 1917 collection there was a larger number of larger and older fish than in the other collections, largely due to the presence of the Fraser river and Quathiaski fish. These may have come in from the open ocean and possibly if they could have been kept separate they would have shown a decided difference in growth. All of the six year fish of the stream type and most of the five year fish of each type were among these.

The sex ratio is changed somewhat. Whereas, in the 1916 collection, there was a slight majority of males in both types of fish, in the 1917 collection there is a majority of females in both types, that majority being quite pronounced in the sea type.

The percentage of sea type fish, which was practically the same (65 per cent) for 1915 and 1916 was greatly increased (over 78 per cent) in 1917. No cause is suggested for such an increase. For those over three years the percentage is much the same in 1917 as in previous years, but in the three year class the stream type fish were a much smaller percentage. This may be the condition of that class as a class, or since it is the latest class of which any considerable number were taken, it may indicate a step towards the elimination of the stream type fish to bring the spring salmon in the same class as the humpback and dog salmon in that respect.

Sockeye.

During the summer of 1917, sockeye were obtained at Quathiaski cannery from Deepwater bay near Seymour narrows, at the Lasqueti Island cannery from the mouth of Sauch-en-auch creek, at the entrance to Jervis inlet, and at the Nanaimo cannery from the strait of Fuca off Victoria and from the Fraser river. In all 1,670 were examined, of which the great majority, 1,468, or 87·9 per cent, were four-year fish of the stream type that had gone to sea in the second year; 510 were from Deepwater bay, 407 from near Victoria, 596 from the Fraser river, and 153 from Sauch-en-auch creek. They were distributed among the different types as follows:—

—	Deepwater Bay.		Victoria.		Fraser River.		Sauch-en-auc. Creek.	
	No.	%	No.	%	No.	%	No.	%
Two-year stream	5	1·0	2	0·5	7	1·2	1	0·6
One-year stream	470	92·2	387	95·1	524	87·9	150	95·6
Sea	35	6·8	18	4·4	65	10·9	6	3·8

They were distributed in year-classes as follows:—

	Five-year.	%	Four-year.	%	Three-year.	%
Deepwater bay—						
Two-year stream	5	100·0	......	......	......	
One-year stream	29	6·2	441	93·8	......	
Sea	......	......	35	100·0	......	
Total	34	6·7	476	93·3	......	
Victoria—						
Two-year stream	2	100·0	......	......	......	
One-year stream	1	0·3	386	99·7	......	
Sea	......	......	18	100·0	......	
Total	3	0·7	404	99·3	......	
Fraser river—						
Two-year stream	7	100·0	......	......	......	
One-year stream	24	4·6	500	95·4	......	
Sea	......	......	65	100·0	......	
Total	31	5·2	565	94·8	......	
Sauch-en-auch creek—						
Two-year stream	1	100·0	......	......	......	
One-year stream	9	6·0	141	94·0	......	
Sea	......	......	5	83·3	1	16·7
Total	10	6·4	146	93·0	1	0·6

The sexes were distributed as follows:—

		Total.	Male.	%	Female.	%
Deepwater bay—						
Two-year stream	Five-year	5	3	60·0	2	40·0
One-year stream	Five-year	29	20	69·0	9	31·0
	Four-year	441	205	46·5	236	53·5
Sea	Four-year	35	25	71·4	10	28·6
Total		510	253	49·6	257	50·4
Victoria—						
Two-year stream	Five-year	2	1	50·0	1	50·0
One-year stream	Five-year	1	1	100·0	....	
	Four-year	386	167	43·3	219	56·7
Sea	Four-year	18	12	66·7	6	33·3
Total		407	181	44·5	226	55·5
Fraser river—						
Two-year stream	Five-year	7	6	85·7	1	14·3
One-year stream	Five-year	24	12	50·0	12	50·0
	Four-year	500	222	44·4	278	55·6
Sea	Four-year	65	42	64·6	23	35·4
Total		596	282	47·3	314	52·7
Sauch-en-auch creek—						
Two-year stream	Five-year	1	....	....	1	100·0
One-year stream	Five-year	9	6	66·7	3	33·3
	Four-year	141	54	38·3	87	61·7
Sea	Four-year	5	4	80·0	1	20·0
	Three-year	1	1	100·0	....	
Total		157	65	41·4	92	58·6

The females were in the majority in every locality, but very markedly so at Sauch-en-auch creek. This majority is obtained in the four-year class of the stream type.

Relative lengths of males and females are shown in the following table:—

Deepwater Bay.

Two-year stream, Five-year class.

Length	22	22·5	23
Number—Male	1	1	1
Female		2	

Average length, male 22·5; female, 22·5; total, 22·5.

One-year stream, Five-year class.

Length	22	22·5	23	23·5	24	24·5	25
Number—Male		2	7	6		3	2
Female	1	1	6	1			

Average length, male, 23·5; females, 22·9; total, 23·3.

Four-year class.

Length	19	19·5	20	20·5	21	21·5	22	22·5	23	23·5
Number—Male	1	2	2	10	37	26	54	46	24	3
Female	2	3	12	25	76	49	50	16	3	

Average length, male, 21·9; female, 21·3; total, 21·6.

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Sea, Four-year class.

Length	19·5	20	20·5	21	21·5	22	22·5	23	23·5	24
Number—Male	1			2	1	6	4	9	1	1
Female				1	2	3	3	1	1	

Average length, male, 22·4; female, 22·1; total, 22·3.

Victoria.

Two-year stream, Five-year class.

1 male, 24; 1 female, 22·5; average, 23·3.

One-year stream, Five-year class.

1 male, 24.

One-year stream, Four-year class.

Length	19·5	20	20·5	21	21·5	22	22·5	23	23·5
Number—Male		3	5	23	37	50	34	13	2
Female	2	7	20	66	63	41	20		

Average length, male, 21·9; female, 21·4; total, 21·6.

VICTORIA.—*Concluded*

Sea, Four-year class.

Length	21	21·5	22	22·5	23	23·5
Number—Male	1	....	2	4	3	2
Female		1	1	2	2	

Average length, male, 22·6; female, 22·4; total, 22·5.

FRASER RIVER.

Two-year stream, Five-year class.

Length	21·5	22	22·5	23	23·5
Number—Male				1	5
Femals	1				

Average length, male, 23·4; female, 21·5; total, 23·1.

One-year stream, Five-year class.

Length	22	22·5	23	23·5	24	24·5	25	25·5
Number—Male		1	2	2	1	2	3	1
Female	2	1	4	2	3			

Average length, male, 24·1; female, 23·1; total, 23·6.

Four-year class.

Length	20	20·5	21	21·5	22	22·5	23	23·5
Number—Male	1	3	27	48	52	66	19	6
Female	1	9	49	81	94	32	11	1

Average length, male, 22·0; female, 21·7; total, 21·8.

Sea, Four-year class.

Length	21	21·5	22	22·5	23	23·5	24..
Number—Male	1	2	4	12	11	9	
male		2	7	9	3	2	3

Average length, male,22·8; female, 22·4; total, 22·7.

SAUCH-EN-AUCH CREEK.

Two-year stream, Five-year class.

1 female, 18·5.

One-year stream, Five-year class.

Length	20·5	21	21·5	22	22·5	23
Number—Male	1....		1	1	1	2
Female		2	1			

Average length, male, 22·1; female, 21·2; total, 21·8.

Four-year class.

Length	17	17·5	18	18·5	19	19·5	20	20·5	21	21·5	22
Number—Male			1	2	6	16	14	4	7	1	3
Female	2	1	12	18	22	19	6	4	3		

Average length, male, 19·9; female, 19·0; total, 19·4.

Sea, Four-year class.

Length	18·5	19	19·5	20	20·5	21	21·5
Number—Male					1	2	1
Female	1						

Average length, male, 21·0; female, 18·5; total, 20·5.

Three-year class.

1 male, 17·5.

The male average is greater than the female average throughout.

For the purpose of easy comparison the tables showing annual growth are arranged to group the localities for each type and year class. The tables are in pairs, the first of the pair showing the growth year by year and the second showing the length at the end of each year.

TABLES SHOWING RATE OF GROWTH.

Two-year stream, Five-year class.

—	1st	2nd	3rd	4th	5th
Deepwater bay	3·4	3·1	6·5	6·5	2·9
Victoria	3·5	3·3	7·6	5·9	3·0
Fraser river	3·6	3·1	7·7	6·1	2·7
Sauch-en-auch creek	3·7	3·1	5·8	4·1	1·8
Deepwater bay	3·4	6·5	13·1	19·6	22·5
Victoria	3·5	6·8	14·4	20·3	22·3
Fraser river	3·6	6·6	14·3	20·4	23·1
Sauch-en-auch creek	3·7	6·8	12·6	16·7	18·5

One-year stream, Five-year class.

Deepwater bay	3·3	7·7	6·4	3·8	2·0
Victoria	3·2	6·3	6·4	5·3	2·8
Fraser river	3·6	7·2	6·6	4·1	2·2
Sauch-en-auch creek	3·6	6·8	5·6	3·8	2·0
Deepwater bay	3·3	11·1	17·5	21·3	23·3
Victoria	3·2	9·5	15·9	21·2	24·0
Fraser river	3·6	10·7	17·3	21·4	23·6
Sauch-en-auch creek	3·6	10·4	16·0	19·8	21·8

One-year stream, Four-year class.

—	1st	2nd	3rd	4th
Deepwater bay	3·6	8·1	6·8	3·0
Victoria	3·7	8·0	6·7	3·1
Fraser river	3·7	8·0	6·9	3·2
Sauch-en-auch creek	3·6	7·2	6·1	2·5
Deepwater bay	3·6	11·7	18·5	21·6
Victoria	3·7	11·7	18·5	21·6
Fraser river	3·7	11·8	18·6	21·8
Sauch-en-auch creek	3·6	10·8	16·9	19·4

Sea, Four-year class.

Deepwater bay	5·2	7·6	6·5	3·0
Victoria	5·2	7·6	6·5	3·1
Fraser river	5·2	7·7	6·6	3·1
Sauch-en-auch creek	5·2	7·1	5·8	2·4
Deepwater bay	5·2	12·8	19·3	22·3
Victoria	5·2	12·9	19·4	22·5
Fraser river	5·2	13·0	19·6	22·7
Sauch-en-auch creek	5·2	12·3	18·1	20·5

Sea, Three-year class.

Sauch-en-auch creek	6·9	7·5	3·1
Sauch-en-auch creek	6·9	14·4	17·5

Although the figures are available to present growth frequency curves, it is scarcely necessary to include them as there is not enough dissimilarity as compared with the 1916 figures.

The table to show the ratio of weight to length in the sockeye is subject to the same limitation as that given for the spring salmon.

RATIO OF WEIGHT TO LENGTH IN SOCKEYE.

Length.	17	17·5	18	18·5	19	19·5	20	20·5	21	21·5	22	22·5	23	23·5	24	24·5	25	25·5
Two-year stream, Five-year—																		
Deepwater bay—Male											5·5	5·7	6·0					
Female												6·1						
Victoria—Male															7·0			
Female												6·7						
Fraser river—Male													5·2	6·5				
Female										5·5								
Sauch-en-auch creek—Male																		
Female				3·5														
One-year stream, Five-year—																		
Deepwater bay—Male												5·9	6·5	6·8		7·2	8·0	
Female											5·5	6·0	6·8	7·0				
Victoria—Male															7·0			
Female																		
Fraser river—Male												6·2	6·0	6·6	6·7	7·0	8·2	8·5
Female										5·7	6·0	6·6	7·1	7·8				
Sauch-en-auch creek—Male								4·5		4·5	5·0	5·7	6·1					
Female									5·0	4·7								
One-year stream, Four-year—																		
Deepwater bay—Male					4·3	4·5	4·5	4·7	5·1	5·4	5·8	6·1	6·5	6·7				
Female					4·4	4·5	4·5	4·7	5·2	5·4	5·9	6·0	6·2					
Victoria—Male							4·8	4·8	5·1	5·4	5·8	6·1	6·7	6·7				
Female						4·1	4·4	4·7	5·1	5·4	5·7	6·0						
Fraser river—Male							5·0	4·5	4·9	5·1	5·5	5·9	6·2	6·3				
Female							4·7	4·9	5·0	5·2	5·4	5·8	6·1	6·3				
Sauch-en-auch creek—Male			2·9	3·1	3·6	3·8	4·1	4·5	4·7	5·0	5·2							
Female	2·2	3·7	3·1	3·4	3·6	4·1	4·1	4·3	5·0									
Sea, Four-year—																		
Deepwater bay—Male						4·2			5·2	5·4	5·7	6·1	6·5	6·8	7·7			
Female									5·5	5·4	5·7	6·4	6·0					
Victoria—Male									5·0		5·5	6·0	6·3	6·8				
Female										5·5	5·2	5·8	6·0					
Fraser river—Male									4·5	5·2	5·9	6·4	6·7	7·5				
Female										5·4	5·6	5·9	6·5	6·2				
Sauch-en-auch creek—Male								4·0	5·1	4·7								
Female				3·2														
Sea, Three-year—																		
Sauch-en-auch creek—Male		2·7																

All of these data serve as a basis for a comparison of the sockeye from the four different localities and of all of these with those of the preceding year. Taking in the first place, those from the different localities in 1917, the striking similarity throughout of the fish from Deepwater bay, Victoria and Fraser river, as distinct from those from Sauch-en-auch creek is a very noticeable feature. There are some points in common to all. In each the four year class of the one year stream type is very decidedly predominant. All of the other classes in this and the other types being poorly represented but yet there are representatives of the two year stream type and of the sea type in all localities. In each locality, in all fish of the stream type the increase in length during the first year at sea is greater than that of any of the following years but in the sea type, the first year growth is not so great as the second. It is in the growth examined more in detail that the resemblance in the fish from the first three localities is so marked and the difference between these and the fish from Sauch-en-auch creek becomes evident.

It has long been recognized that the route taken by at least a large number of the Fraser river fish passes through the strait of Fuca and on through Haro and Rosario straits and the connecting channels and therefore it is not surprising that the fish caught off Victoria should be similar to those caught in the Fraser river, but the possibility that some of the Fraser river sockeye should come by way of Queen Charlotte sound and Johnstone strait was not generally suspected. Professor Prince, Dominion Commissioner of Fisheries, had publicly expressed the opinion, based on observations made on a scientific cruise upon the Canadian Fishery cruiser *Quadra*, that large numbers of sockeye salmon approached the Fraser river from the north (see *Colonist*, Victoria, B.C., August 26, 1897, p. 4). In his report of 1913, Mr. Babcock called attention to the opinion of Mr. W. E. Anderson, salmon canner of Quathiaski, that the fish caught at Deepwater bay, in the years of the big run on the Fraser river, were Fraser river fish. In 1915, Dr. C. H. Gilbert examined 198 fish from Deepwater bay and found they were similar in length and in scale characteristics to those from the Fraser river. Hence he concluded that this run by the northern route was not confined to the years of the big run on the Fraser river. Thus Professor Prince's expert view has been fully confirmed. Since 1917 was a year in the quadrennial series, known as the years of the big run, although there was not the usual large run on the Fraser, the examination of the collection from Deepwater bay does not show anything for the off years, but it does show that for that year at least the identity of the Deepwater bay fish can scarcely be doubted. Taking the growth year by year, the similarity is so marked that it would scarcely be possible to get two batches of such large numbers on different days from either locality to give better agreement in any respect.

It is fortunate that with the fish from these three localities that show unmistaken identity, it is possible to compare the fish that enter Sauch-en-auch creek, since these, also entering the strait of Georgia, show a decided departure in type, or rather in absolute rate of growth, as the rate of growth for each year, relative to that of the preceding year, is much similar to that of the Fraser river type.

In general appearance the Sauch-en-auch sockeye seem quite different to the Fraser river fish but doubtless much of this is due to the smaller size. A collection of undersized Fraser river fish might have much the same appearance. Although they are small, the flesh in the can, is not readily distinguished from that of the Fraser river sockeye. According to Mr. W. E. Anderson of Quathiaski, the sockeye that are caught in Loughborough inlet and Philips arm, are of the same type. It would appear therefore, that the fish that pass from Johnstone strait through Discovery passage, are of the Fraser river type, while those that are diverted from this course to pass through Chancellor channel are of somewhat similar type but they are of an undersized race, that do not get as far south as the Fraser river. Instead they pass up Loughborough inlet and Philips arm while some of them get as far south as Sauch-en-auch creek. According to Mr. Anderson, in earlier years the Indians had a narrow portion of this pass entirely staked so that all larger fish were caught and only the smaller ones got through. This may account for the small race of fish, for even if this selection went on for only four years, and it may have done so for a much longer period, there would be a possibility at least, that the majority of the large sized fish of the run would be eliminated. Since, occasionally, a larger fish is found among the others, there is all the greater probability for such an explanation. There were three of those in the four year class of the one year stream type in the collection from Sauch-en-auch creek, each 22 inches long, the average growth of which in the four years, was 3.7, 8.0, 7.2, and 3.1 inches respectively, very closely coinciding with the average from the other three localities.

If this run of sockeye, passing through Chancellor channel or other adjacent channels, was originally of the Fraser river type, a cause for the diversion of this run from the main Fraser river run in the first place is not readily surmised or a reason for their passage up these inlets and creeks instead of meeting with the others to move up the Fraser river, although, to be sure, at the south end of the strait of Georgia, the run divides to pass through Haro and Rosario straits and the intervening channels, and some pass up the smaller rivers into the State of Washington.

In making comparison of the 1917 sockeye with those of 1916, a direct basis can only be obtained in the Fraser river sockeye of that year, since none of the 1917 sockeye were of the same general type as the Rivers inlet sockeye, and the Rivers inlet sockeye were compared with the Fraser river fish in the previous paper.

Comparing the Fraser river sockeye in the two year, is is evident that there are the same three types—the two year stream, the one year stream and the sea, but the six year class of the first type and the five and three year classes of the last type were not represented in the 1917 collection. The one year stream type predominated even more largely than in 1916 on account of the lack of fish in the two year stream type, as the percentage of sea type fish was much the same. In the one year stream type, the four year fish made up even a larger percentage (95.4) of the whole number than in 1916 (82.9). There was little difference in the percentage of males and females in the two years, the females being slightly in the majority in each case.

With the exception of the two year stream fish, the average length was slightly less in all classes and types in 1917 than in 1916, the average difference being 0·5 inches. The growth in the first year was so consistently higher in the 1917 collection that it would seem that the fish must have come from different parts of the Fraser river watershed in the two years. This difference is more than made up in the 1916 lot by the more rapid growth in the second and third years. Which collection is more typical it is hard to say but possibly since those caught in the Fraser river in 1917 agree with those caught off Victoria and in Discovery passage, they are more likely to be typical. Judging from the size of the yearlings this is likely to be the case.

Looking at these figures there may be something in the contention that the fish of what has been the largest year of the four year cycle, are smaller than in the other years.

Coho.

The coho of the 1917 run, 1,417 in number, were obtained from localities within the strait of Georgia and adjacent waters, and although they are considered in four distinct lots, most of them were caught before they were mature enough to indicate to what river or creek they would have returned if they had been allowed to proceed to the spawning grounds. Most of those obtained at the Quathiaski cannery (407) were caught around Cape Mudge and from this point to Heriot bay. The Lasqueti cannery specimens (417) were caught in the vicinity of Lasqueti and Texada islands. The Fraser river specimens (89) obtained at the Nanaimo cannery had become definitely localized on the way to the spawning grounds, but the remaining 504 obtained at this cannery were widely distributed from Lasqueti island, Qualicum, Northwest bay, Winchelsea islands, all the way to Gabriola pass and Cowichan gap (Porlier pass). They were therefore a cosmopolitan lot but they could not well be kept distinct, although differences were plainly to be seen at times, since the one day's catch was all put together on the cannery floor. Even although there is not the same definiteness in delimitation as in the case of the sockeye, there is still enough to make it worth while to draw comparison.

All of the 1917 coho examined had gone down to the sea some time during the second year and were in their third year when they were caught. In some cases where the migration had been delayed until late in the second summer, the scale had much the appearance of one from a fish that had spent over two years in fresh water, but as the central portion of these scales corresponded with the complete scales of cohos in their second year, caught in fresh water as late as the end of June, the conclusion that they could be fish in the fourth year, having spent over two years in fresh water can scarcely be justified.

In all cases the females were more numerous than the males, the Quathiaski fish showing the greatest difference, as the following table indicates:—

—	Total.	Male.	%	Female.	%
Quathiaski	407	159	39·1	248	60·9
Lasqueti	417	195	46·8	222	53·2
Fraser river	89	43	48·3	46	51·7
Nanaimo	504	234	46·4	270	53·6
Total	1,417	631	44·5	786	55·5

The length shows much variation.

QUATHIASKI.

Length	17·5	18	18·5	19	19·5	20	20·5	21	21·5	22	22·5	23	23·5	24	24·5	25	25
Number—Male			2	3	...	6	12	16	15	34	29	22	9	8	1	2	
Female	1	...	1	2	5	4	16	52	39	67	33	13	7	5	2	...	1

Average length: male, 22·0; female, 21·7; total, 21·8.

LASQUETI.

Length	15·5	17·5	18	18·5	19	19·5	20	20·5	21	21·5	22	22·5	23	23·5	24	24·5	25
Number—Male	1	4	4	3	8	13	6	9	31	20	37	34	16	9	3	...	1
Female		1	2	3	1	2	6	15	37	33	44	40	27	6	3	2	

Average length: male, 21·4; female, 21·8; total, 21·6.

FRASER RIVER.

Length	18	18·5	19	19·5	20	20·5	21	21·5	22	22·5	23	23·5	24	24·5	25	25·5	26	26·5	27	27·5
Number—Male	1	1	1	1	1	1	3	3	3	1	7	3	4	5	3	1	2	1	...	1
Female								3	5	2	10	11	5	...	6	...	2	1	1	

Average length: male, 23·0; female, 23·6; total, 23·3.

NANAIMO.

Length	18·5	19	19·5	20	20·5	21	21·5	22	22·5	23	23·5	24	24·5	25	25·5	26	26·5	27	27·5	28	28·5	29
Number—Male	1	4	5	6	7	18	25	41	35	26	18	11	6	8	2	3	3	2	3	4	3	3
Female	2	2	3	8	11	21	42	54	47	31	13	11	5	3	3	8	...	1	2	2	...	1

Average length: male, 22·7; female, 22·4; total, 22·5.

SUMMARY OF AVERAGES.

—	Quathiaski.	Lasqueti.	Fraser river.	Nanaimo.
Male	22·0	21·4	23·0	22·7
Female	21·7	21·8	23·6	22·4
Total	21·8	21·6	23·3	22·5

TABLE OF GROWTH.

—	Growth in—Years.		
	1st	2nd	3rd
Quathiaski	3·5	10·5	7·9
Lasqueti	3·5	10·4	7·7
Fraser river	3·7	10·8	8·8
Nanaimo	3·6	10·7	8·3
—	Length at the end of—Years.		
	1st	2nd	3rd
Quathiaski	3·5	13·9	21·8
Lasqueti	3·5	13·9	21·6
Fraser river	3·7	14·5	23·3
Nanaimo	3·6	14·3	22·5

LENGTH—WEIGHT RATIO.

Length.	15·5	16	16·5	17	17·5	18	18·5	19	19·5	20	20·5	21	21·5	22
Quathiaski—Male	...	...	...	...	...	...	3·6	4·0	...	4·5	4·8	5·2	5·5	6·0
Female	...	...	...	...	3·5	...	3·5	3·9	4·3	4·6	4·7	5·1	5·4	5·7
Lasqueti—Male	2·5	...	...	...	...	3·6	3·8	3·9	4·2	4·5	4·9	5·1	5·5	5·8
Female	...	...	...	...	3·0	3·0	3·4	4·0	4·2	4·4	4·6	4·9	5·3	5·7
Fraser river—Male	...	...	...	...	...	3·5	4·5	4·7	3·7	5·0	4·5	5·2	5·2	5·3
Female	...	...	...	...	...	...	...	...	...	...	...	...	5·0	5·2
Nanaimo——Male	...	...	...	...	...	...	3·7	3·8	4·4	4·4	4·6	4·7	5·3	5·4
Female	...	...	...	...	...	...	3·3	3·6	3·7	3·8	4·3	4·7	5·0	5·4

LENGTH—WEIGHT RATIO.—*Concluded.*

Length.	22·5	23	23·5	24	24·5	25	25·5	26	26·5	27	27·5	28	28·5	29
Quathiaski—Male	6·2	6·6	7·0	7·4	8·2	9·5	......	......	......	......	......	......	......	......
Female	6·1	6·4	7·0	7·5	8·6	......	9·0	......	......	......	......	......	......	......
Lasqueti—Male	6·3	6·9	7·3	8·5	......	9·7	......	......	......	......	......	......	......	......
Female	6·1	6·7	7·1	8·3	8·6	......	......	......	......	......	......	......	......	......
Fraser river—Male	6·5	6·5	6·5	7·5	7·8	7·5	10·2	9·5	11·2	......	10·5	......	......	......
Female	6·0	6·4	6·7	7·8	......	8·8	......	10·2	10·5	11·0	......	......	......	......
Nanaimo—Male	5·9	6·2	6·6	6·9	7·7	8·6	9·2	9·7	10·8	11·5	11·9	13·2	13·8	14·4
Female	5·7	6·1	6·4	7·2	7·5	8·8	9·5	10·3	......	12·0	11·8	14·2	......	13·7

In comparing the cohos of 1917 according to the groups into which they have been placed, those from Quathiaski and those from Lasqueti have practically the same rate of growth throughout the three years, while those from Nanaimo and still more those from the Fraser river, have greater growth in each year than these. In all probability some of the Fraser river coho, if not all of them, had been out to the open sea, and some of the late caught Nanaimo fish may have been, or may have been living in the deeper water of the strait, since in 1917, as in previous years, most of the larger fish were caught late in the season. Since these fish have greater growth in each year, it seems that in the case of the coho, as in the case of the spring salmon, those that go out to the open sea get better feed and are larger fish than those that remain within the confines of the strait throughout their marine life. On the other hand the data available for 1917 indicate that there is comparatively little difference in the fish that remain in the inner waters, no matter what river or creek they pass up to spawn, or at any rate that the fish from the various rivers and creeks roam about the strait, so that a cosmopolitan lot is likely to be caught in any one locality unless this locality is at the mouth of a river or creek, where the members of an individual race have congregated before the final migration begins. The relatively small number of males in the fish from Quathiaski is unusual in the cohos as far as observation has gone. All the others more nearly retain the equilibrium, although the males are in the majority in every instance. Seldom anywhere among the Pacific salmon has the average length of the female been found to be greater than that of the male as it was in the case of the coho from Lasqueti and from the Fraser river. In the ratio of weight to length there is no indication of any definite difference between male and female or between those in the different groups.

The Nanaimo group may be compared with those of 1916 and 1915. The first year's growth corresponds exactly with the growth of those caught in 1916, and is somewhat greater than in those caught in 1915. The second year's growth is the least of the three years, 1915 and 1916 being nearly equal. The greatest difference is shown in the third year's growth, that of 1917 being considerably greater than that of 1916 but much less than that of 1915. Since there is the greatest difference here the total length varies in much the same proportion as the third year's growth.

The catch of coho in the strait is getting less year by year. One might suppose that there might be more food more easily procured for those that remain and that these should grow larger. Since they do not do so, there must be other limitations to growth than those depending on the amount of available food.

Humpback.

Of the 925 humpbacks examined from the 1917 run, 181 were caught in Deep-water bay, 231 in the Fraser river and 513 near Pender island in the vicinity of Haro strait. The first lot was obtained at the Quathiaski cannery, July 24 and 25, and the other two at the Nanaimo cannery, August 15 to August 30. As many would have been taken from the Fraser river as from Pender island if it had not been that after the first few were caught the scales were too badly disintegrated at the margin to make growth calculation possible. All of the scales used for calculation were in good condition.

All of these humpbacks were of the sea type in their second year. The sex percentage shows a wide divergence. Only those from the Fraser river were approximately equal in numbers. At Deepwater bay the males were almost twice as numerous as the females and off Pender island the females were nearly three times as numerous as the males. The Deepwater bay fish were the first of the season but the others were caught well in mid season.

Sex Distribution.

—	Total.	Male.	%	Female.	%
Deepwater bay	181	118	65·2	63	34·8
Fraser river	231	111	48·0	120	52·0
Pender island	513	136	26·5	377	73·5

Length—frequency

Length	13	13·5	14	14·5	15	15·5	16	16·5	17	17·5	18	18·5	19	19·5
Deepwater bay—Male	1						1	1	4	3	8	13	11	9
Female							1			1	5	8	6	11
Fraser river—Male												1		3
Female												1	1	5
Pender island—Male													1	4
Female													4	4

Length	20	20·5	21	21·5	22	22·5	23	23·5	24	24·5	25	25·5
Deepwater bay—Male	12	8	13	5	6	3	5	6	5	4		
Female	6	3	12	1	6	1	2					
Fraser river—Male	7	10	13	24	11	13	8	10	6	3	1	
Female	10	15	30	27	14	14	3					
Penber island—Male	9	16	25	23	22	17	8	6	3	1	1	
Female	21	54	108	88	65	27	3	3				

Deepwater bay, average length: male, 20·3; female, 19·9; total, 20·2.
Fraser river, average length, male, 21·9; female, 21·2; total, 21·5.
Pender island, average length: male, 21·6; female, 21·3; total, 21·4.

The average length of the male is greater in each instance than that of the female.

The average growth for each year is as follows:—

Deepwater bay, 1st year, 11·7; 2nd year, 8·4.
Fraser river, 1st year, 12·2; 2nd year, 9·3.
Pender island, 1st year, 12·1; 2nd year, 9·3.

Length—Weight Ratio.

Length	13	16	16·5	17	17·5	18	18·5	19	19·5	20	20·5	21	21·5
Deepwater bay—Male	1·5	2·0	2·5	3·0	3·2	3·4	3·7	4·0	4·4	4·6	5·3	5·6	5·9
Female		2·5			3·0	3·3	3·6	3·9	4·3	4·8	4·9	5·3	5·7
Fraser river—Male							3·5		4·2	4·4	4·9	5·1	5·3
Female							4·0	4·5	4·4	4·7	4·9	5·1	5·3
Pender island—Male								3·5	4·6	4·9	5·0	5·3	5·5
Female								4·3	4·6	4·9	5·0	5·8	5·6

Length	22	22·5	23	23·5	24	24·5	25	25·5
Deepwater bay—Male	6·5	6·9	7·6	7·7	8·3	8·6		
Female	6·1	6·5	6·7					
Fraser river—Male	5·7	6·0	6·5	6·8	7·3	7·8	8·5	8·7
Female	5·5	5·9	6·3					
Pender island—Male	5·8	6·2	6·4	6·8	7·5	8·0	8·0	
Female	5·8	6·2	6·4	6·7				

In comparing the humpbacks from the three localities it can be observed at once that those from near Pender island correspond almost exactly with those from the Fraser river, while those from Deepwater bay differ materially from these in total length as well as in the growth in each year. In each case the range of length is much greater in the males than in the females, most noticably so in the case of the Deepwater bay fish, where the male range extends both below and above the female range. The under size of these fish is indicated in the number of small fish as well as in the average length. One male was but 13 inches long and there were 63 fish (34.8 per cent of the whole number) less than 19.5 inches long, while in the fish from the other two localities there were but 8 under 19.5 inches (1.1 per cent of the whole number). The range in length in both the males and the females is almost the same in the Fraser river and in the Pender island fish. If the fish examined were typical, it is apparent that those humpbacks that keep near the Vancouver island shore at the south east extremity, and pass up through Haro strait, or through the channels to the west of this, are on the way to the Fraser river, even if some of the others that pass in through the strait of Fuca, enter some of the Washington rivers and streams, unless all of those coming in through the strait of Fuca are similar, and this is not at all probable. Those from Deepwater bay, on the other hand, are surely so different that they constitute a different race. Although they were caught in the net at the same time as the sockeye that evidently were on the way to the Fraser river, they must have parted company later, probably going up some of the Vancouver island streams.

A direct comparison of the 1917 humpbacks with those of 1916 is not possible, since there was no common point of collecting. The Rivers inlet humpbacks obtained in 1916 were but slightly larger than the Fraser river or Pender island fish of 1917 but apparently the Rivers inlet fish of 1917 were much larger than those caught in 1916. Mr. F. Burke, of the Wallace Fisheries, was kind enough to give me some canning figures from their canneries, going back for some years. Pinks have been caught at the Strathcona cannery in Rivers inlet since 1912, and the number of fish to the case in each year was as follows: 1912, 18.6; 1913, 17.9; 1914, 16.9; 1915, 16.14; 1916, 16.5; 1917, 12.15. This indicates that the 1917 run consisted of much larger fish than the 1916 run or any other in the last six years. It is possible that in the earlier years the fish were not cut so closely as later but this could not account for the great change from 1916 to 1917.

This superiority of size was not evident all along the coast as on the Skeena, for instance, the 1917 pinks were much smaller than usual. Even if the number of fish to the case is not a very definite guide to the actual size of the fish, it is some indication at least, and since, by measurement, the Rivers inlet fish of 1916 were larger than the Fraser river fish of 1917, the Rivers inlet fish of 1917 must have been very much larger.

The humpbacks caught in Deepwater bay in 1917 are, in type, much like those caught in the strait of Georgia between Cape Lazo and Comox in 1916, although they are somewhat larger. In all probability the Comox fish came through Discovery passage and thus used the same route as those caught in Deepwater bay. They were bound for the Courtenay river. The 1917 fish may have been en route to some of the adjacent rivers, the Oyster river for instance, or they may have been Courtenay river fish, larger in 1917 than in 1916, or they may have been a mixture of the two, which might account for the wide range of length already referred to. The more rapid growth in the first year and the less rapid growth in the second year of the 1917 fish would apparently indicate that they were not all Courtenay river fish.

Dog Salmon.

In 1916 dog salmon were obtained from Qualicum and from Nanaimo, but mixed with those from the Nanaimo were a few from the neighbourhood of Crofton and Chemainus. In the 1917 collection it was possible to keep those from the three localities better separated than in 1916 and hence although they were all obtained at the Nanaimo cannery, they will be considered as Qualicum, Nanaimo and Chemainus fish respectively. There were 1,024 altogether, 139 from Chemainus, 379 from Nanaimo and 506 from Qualicum. The number and percentage of the different year classes in each group are shown in the following table: All of them were of the sea type.

—	Total. No.	Five-year.		Four-year.		Three-year.		Two-year.	
		No.	%	No.	%	No.	%	No.	%
Chemainus	139	....	....	13	9·4	126	90·6	....	
Nanaimo	379	1	0·3	112	29·5	266	70·2	....	
Qualicum	506	3	0·6	315	62·3	187	36·9	1	0·2

The males and females are nearly equal in number except in those from Qualicum where the males predominate in each year class.

Sex Distribution.

CHEMAINUS.

	Total.	Male.	%	Female.	%
Four-year	13	4	30·8	9	69·2
Three-year	126	65	51·6	61	48·4
Total	139	69	49·6	70	50·4

NANAIMO.

Five-year	1	1	100·0		
Four-year	112	59	52·7	53	47·3
Three-year	266	116	43·6	150	56·4
Total	379	176	46·4	203	53·6

QUALICUM.

Five-year	3	3	100·0		
Four-year	315	232	73·7	83	26·3
Three-year	187	94	50·3	93	49·7
Two-year	1	1	100·0		
Total	506	330	65·2	176	34·8

Tables of Length Frequency.

CHEMAINUS.

Length	26	26·5	27	27·5	28	28·5	29	29·5
Four-year—Male				1		2		1
Female	1		2	1	1	1	3	

Average length: male, 28·5; female, 27·9; total, 28·1.

Length	21·5	22	22·5	23	23·5	24	24·5	25	25·5	26	26·5	27	28·5
Three-year—Male			2	3	7	7	8	13	4	9	10	1	1
Female	1	1	4	8	6	12	8	4	8	6	2	1	

Average length: male, 26·0; female, 25·3; total, 25·6.

NANAIMO.

Five-year—1 male, 31 inches.

Length	26	26·5	27	27·5	28	28·5	29	29·5	30	30·5	31	31·5
Four-year—Male				1	12	12	11	6	11	3	2	1
Female	2		5	14	17	9	4	2				

Average length: male, 29·1; female, 27·9; total, 28·5.

Length	22	22·5	23	23·5	24	24·5	25	25·5	26	26·5	272	7·5	28	28·5
Three-year—Male			2		2	4	6	11	12	22	22	21	11	3
Female	1		1	2	5	12	16	25	29	30	17	10	2	

Average length: male, 26·6; female, 25·9; total, 26·2.

TABLES OF LENGTH FREQUENCY.—*Concluded.*

QUALICUM.

Length	30	32·5
Five-year—male	2	1

Average length, 30·8.

Length	26	26·5	27	27·5	28	28·5	29	29·5	30	30·5	31	31·5	32	32·5	33
Four-year—Male	1		4	15	31	34	41	38	43	12	11	1			1
Female		5	6	30	14	14	9	4			1				

Average length: male, 29·1; female, 28·0; total, 28·8.

Length		22·5	23	23·5	24	24·5	25	25·5	26	26·5	27	27·5	28	28·5
Three-year—Male	18				1	1	1	7	10	19	21	15	5	3
Female	11		1	1		2	5	13	15	19	11	8		

Average length: male, 26·6; female, 25·9; total, 26·2.

Two-year—1 male, 21 inches.

SUMMARY OF AVERAGE LENGTHS.

—	5th Year.		4th Year.		3rd Year.		2nd Year.	
	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.
Chemainus			28·5	27·9	26·0	25·0		
Nanaimo	31·0		29·1	27·9	26·6	25·9		
Qualicum	30·8		29·1	28·0	26·6	25·9	21·0	

TABLES OF GROWTH.

—	Class.	Growth during—Years.				
		1st	2nd	3rd	4th	5th
Chemainus	3-year	12·3	8·4	4·9		
	4-year	11·9	7·9	5·0	3·2	
Nanaimo	3-year	12·1	8·7	5·3		
	4-year	11·5	8·2	5·3	3·6	
	5-year	9·8	7·5	5·8	4·8	3·1
Qualicum	2-year	12·0	9·0			
	3-year	11·9	8·8	5·5		
	4-year	11·7	8·1	5·3	3·6	
	5-year	10·8	7·8	5·5	4·1	2·6

—	Class.	Length at end of—Years.				
		1st	2nd	3rd	4th	5th
Chemainus	3-year	12·3	20·7	25·6		
	4-year	11·9	19·8	24·8	28·1	
Nanaimo	3-year	12·1	20·8	26·2		
	4-year	11·5	19·7	25·0	28·5	
	5-year	9·8	17·3	23·1	27·9	31·0
Qualicum	2-year	12·0	21·0			
	3-year	11·9	20·7	26·2		
	4-year	11·7	19·9	25·2	28·8	
	5-year	10·8	18·6	24·1	28·2	30·8

LENGTH-WEIGHT RATIO.

Length	21	21·5	22	22·5	23	23·5	24	24·5	25	25·5	26	26·5	27
Chemainus—Three-year—Male						6·5	6·5	7·1	7·6	8·2	8·6	8·9	9·7
Female		4·0			5·5	6·5	6·5	7·3	8·1	8·2	8·4	9·3	9·6
Four-year—Male													
Female											10·0		10·0
Nanaimo—Three-year—Male					6·3		7·7	7·9	8·0	9·3	9·5	9·6	10·6
Female			5·0		6·0	6·3	7·2	7·8	8·3	9·1	9·3	9·9	10·4
Four-year—Male													
Female											10·0		10·1
Five-year—Male													
Qualicum—Two-year—Male	5·5												
Three-year—Male						6·5	8·0	8·0	8·4	8·8	10·0	10·3	10·6
Female				5·5	5·5		7·5	8·2	8·6	9·0	9·5	10·2	10·7
Four-year—Male											11·0		10·4
Female												10·8	10·8
Five-year—Male													

Length-weight Ratio.—*Concluded.*

Length	27·5	28	28·5	29	29·5	30	30·5	31	31·5	32·5	33
Chemainus—Three-year—Male	10·0	10·0	11·0								
Female	10·8	11·0									
Four-year—Male	10·5		11·2		13·5						
Female	10·0	10·5	10·5	11·3							
Nanaimo—Three-year—Male	11·3	12·5	12·8								
Female	11·1	12·7									
Four-year—Male	10 0	12·0	12·3	13·2	13·6	15·1	16·3	17·0	15·0		
Female	11·2	11·8	12·6	14·0	13·5						
Five-year—Male								16·5			
Qualicum—Two-year—Male											
Three-year—Male	11·1	12·2	12·7								
Female	11·3										
Four-year—Male	11·4	12·4	13·0	13·5	14·3	14·8	16·0	17·2	16·5		18·0
Female	11·9	12·4	12·5	13·2	14·2			15·5			
Five-year—Male						15·2				17·5	

The three localities from which these dog salmon were taken are but little distant from another and the differences are not so marked as in different groups examined in the other species; nevertheless, there are some points that are worth considering. There is greater similarity between the Nanaimo and Qualicum fish than there is between either of these and the Chemainus fish, but even here there are some points of difference. There is a great dissimilarity in the numbers in the different year classes. Chemainus supplied no five year specimens and very few four year, the three year class being nearly ten times as large. Nanaimo and Qualicum have the five year class merely represented, but in the former the three year class is 2·4 times the size of the four year, while in the latter the four year class is 1·7 times the three year and there is one representative of the two year class.

With regard to the proportion of the sexes, Chemainus shows the less usual condition of having a greater percentage of females in the higher year than in the lower, but as the four year class is so poorly represented this is not of great significance. There is little difference in the general proportion. From Nanaimo the preponderance of females in the third year is more than euough to offset the preponderance of the males in the smaller four year class, but even here the difference is not excessive. From Qualicum, the large excess of males in the large four year class makes a heavy general excess as in the smaller three year class the numbers are nearly equal.

The Nanaimo and Qualicum rate of growth corresponds almost exactly, year by year. The Chemainus rate is different. There is a greater growth in the first year but less in each succeeding year. Thus at the end of the first year the length is greater than in either of the others, at the end of the second year it is equal to and in later years less than those.

The weight of the Chemainus fish in proportion to the length is somewhat less than that of either the Nanaimo or Qualicum fish and these show but little difference. Judging from the figures of the one year, one should conclude that the earlier spawning fish are the largest of the year class.

The Chemainus fish come in much earlier than the others and probably come from the open sea by way of the south end of Vancouver island while those from Qualicum and Nanaimo evidently come from the north.

In comparing the 1917 dog salmon with those taken in 1916 only those from Nanaimo and Qualicum can be considered. The proportion of the four and the three-year fish is almost the same in the two years with the Qualicum fish but in the Nanaimo fish, the three-year class from being in a small minority in 1916 changed over to a large majority in 1917. The excess of males in the four year Qualicum fish, which was great in 1916, became greater in 1917 but in the three-year class, the excess of males, which was not great in 1916, became practically eliminated in 1917. In the Nanaimo fish, the excess of males of the four-year class in 1916 was somewhat reduced in 1917, but the excess of females in the three-year class was much the same in both years.

The 1917 fish were larger on the average than the 1916 fish in both year classes and in both sexes. This difference is due almost entirely to the greater growth in each of the first two years. When, however, the four-year class of 1917 is compared with the three-year class of 1916 (both of them spawned in 1913) no such difference appears. Looking at the question from this standpoint, it would appear that those of the 1913 class that spawned in their third year were not larger at that time than those that remained over to spawn in the fourth year but rather that the 1913 class, as a class, consisted of larger fish than the 1912 class. If that continues to hold good, then, the 1914 class must consist of still larger fish. It is scarcely possible though that each succeeding year class will consist of larger and larger fish. It might be possible that increase and decrease work in cycles on account of the conditions of getting food supply, or other matters on which growth depends, getting gradually better or worse, but it would take examination for a series of years before that could be determined.

Summary and Conclusions.

Among the 1917 salmon there were the three different types according to the time of migration to the sea, as in 1916. A larger percentage of spring salmon were of the sea type (78·2 per cent as compared with 65·4 per cent). In all localities from which sockeye were obtained, those of the one-year stream type made up almost the whole number, although in each case the two-year stream type and the sea type were represented. Only 15 of the former (less than 1 per cent) and 124 of the latter (7·5 per cent) were found altogether, the largest number in each case from the Fraser river. The cohos were all of the one-year stream type, and the humpbacks and dogs all of the sea type.

The spring salmon of either type did not differ materially in rate of growth from those of previous years. There has not been anything thus far to indicate that any one-year class has had more rapid growth than any other. Four six-year fish of the stream type were obtained. The sex ratio changed from a slight predominance of males to an excess of females (especially pronounced in the sea type).

The three types of fish were represented in the sockeye from each locality. Those of the two-year stream type were all in their fifth year and those of the sea type all in their fourth year with the exception of a three-year-old from Sauch-en-auch creek. The fish of the one-year stream type were nearly all in the fourth year, the percentage ranging from 93·8 at Deepwater bay to 99·7 off Victoria. The remainder were in the fifth year.

In every feature the sockeye, collectively and individually, from Deepwater bay, off Victoria and from the Fraser river, were similar. Those from Sauch-en-auch creek were similar in general type to these others but were smaller and showed less average growth in length in each year. They agreed so well with the smaller fish from the other localities that it is credible that the race had become smaller through continued elimination of the larger members. The route that these fish take must be the same at the beginning as it is for those that pass through Deepwater bay, but evidently they turn aside from Johnstone strait through Chancellor channel and through some of the passages nearer the mainland, while the direct route through Discovery passage and on to the Fraser river is taken by the others.

The average length of the 1917 sockeye was somewhat less than that for 1916, hence it may be that the fish of the quadrennial run are somewhat smaller than those of other years in the cycle. As there is also a greater predominance of four-year fish, the number to the case of canned salmon is greater than in other years.

Since all the sockeye were of the same general type one should scarcely expect to find any material difference in the weight-length ratio, nor did any such appear.

As in other years, all the coho were of the one-year stream type. Although they were obtained from four different localities, Quathiaski, Lasqueti, Nanaimo and Fraser river, there were no indications of four races of fish. There may readily be two, one that stays in the strait of Georgia and neighbouring waters throughout the whole of the marine life, and another, a race of larger fish that goes out to the open ocean and comes back only as spawning time approaches. The Quathiaski and Lasqueti fish were made up largely or entirely of the former, the Fraser river fish largely or entirely of the latter, and those from Nanaimo included some of each. There seems to be little difference in the first two years' growth in the different year classes; the variation occurs in the growth during the third year. Of the fish brought into Nanaimo, the 1917 fish were larger than the 1916 but smaller than the 1915. The weight-length ratio shows no material difference in the different localities.

All the humpbacks were of the sea type in the second year. Those from Deepwater bay were evidently different from those from near Pender island and those from the Fraser river, but these show no material difference. Those caught in Deepwater bay were similar in type but somewhat larger than those obtained from near Comox in 1916. Evidently they do not go to the Fraser river but rather to some of the rivers or streams of the Vancouver island east coast.

All of the dog salmon were of the sea type but those from Chemainus, Nanaimo and Qualicum varied much in the percentages of the different year classes. There were very few of the five-year or the two-year class. Chemainus had less than 10 per cent in the fourth year, Nanaimo nearly 30 per cent, and Qualicum over 62 per cent. Qualicum and Nanaimo fish were similar in rate of growth, but the Chemainus fish are smaller, not only in absolute measurement, but also in length-weight ratio. The two former apparently come in from the open ocean around the north end of the island and the latter around the south end. Where comparison was possible, the 1917 fish were larger than the 1916 fish. To judge from the different year classes represented in one year's catch, it would appear that the larger fish of the class spawned in the third year, but when the catches of 1917 and 1916 were compared this was not borne out, this appearance being due to the fact that the fish of the 1913 class were larger throughout than those of the 1912 class, but if this is the reason, the fish of the 1914 class must be still larger.

II.

Some Apparent Effects of Severe Weather on the Marine Organisms in the vicinity of Departure Bay, B. C.

BY

C. McLean Fraser.

From a fisheries standpoint, the first effect of the severe winter and spring of 1915-16, almost unparalleled in British Columbia records, was the loss of so many human lives and the serious destruction of boats, gear, etc., in the storms of the North Pacific, which were so bad that those who did manage to make port, did so after so much stress and strain, that, even to men inured to the hardships of the wintry sea, it was a new and most unwelcome experience. In such a winter a close season for halibut would be worthy of consideration from a humanitarian point of view.

Another effect, also of much importance from a commercial standpoint, was the loss of oysters both on dyked and undyked lands, due to the low temperature reached when they were uncovered or covered with ice at low tide. The Puget Sound region, I understand, suffered extensively in this regard and other areas to a less extent.

Besides these special cases, it is possible that there was a wide-spread effect on the whole life of the sea, and particularly in such an area as the strait of Georgia, which is nearly landlocked and hence more subject to changes than the waters of the open ocean. This effect was produced by the severe weather in three ways. In the first place, on account of the continued low temperature, the surface waters became colder than usual and this had an effect on the organisms that come near the surface. In the second place, some of the low temperatures were coincident with low tides and shore forms suffered thereby. In the third place, as the streams were also affected by the cold weather, anadromous forms may have been influenced.

To consider these in the order mentioned, the first is the effect of lowering the surface temperature of the water in the sea. The daily range of air temperature has little noticeable effect on the temperature of the sea water and hence the maximum and minimum daily temperatures need not be considered. The average temperature over a longer period of time has a more direct bearing, hence it is well here to compare the average temperatures by the month in the fall, winter and spring of 1915-16, with those of the preceding season. The following table shows a comparison from October until May, both inclusive.

AIR TEMPERATURE.

	1914-15.		1915-16.	
	°C	°F	°C	°F
October	13·3	55·9	10·0	50·0
November	6·1	43·0	4·4	40·0
December	2·4	36·4	3·7	38·6
January	2·9	37·3	−2·2	28·0
February	5·0	41·0	2·7	36·8
March	7·9	46·2	4·7	40·4
April	10·7	51·2	8·1	46·5
May	12·8	55·0	11·1	51·9

The average temperature for the whole eight months was 2·3°C (4·2°F) lower in 1915-16 than in 1914-15.

No record has been made of the maximum and minimum temperatures of the surface water daily and hence the average in the same sense in which it is applied in connection with the air temperatures is not obtainable, but as there is so much less daily variation in the water temperature this is not of so much moment. The water temperature was taken at or near eight o'clock each morning at the landing float of the Station wharf, Departure bay, and from these records, average, maximum and minimum figures for the months above referred to, were obtained.

WATER TEMPERATURE.

CENTIGRADE.

—	Year.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April.	May.
Average	1914–15	11·1	9·0	7·2	7·0	7·4	8·6	10·5	12·5
	1915–16	11·0	7·6	6·1	4·4	5·0	5·6	7·6	11·1
Maximum	1914–15	12·7	10·5	8·6	8·7	8·6	10·3	11·9	13·9
	1915–16	14·0	10·0	7·7	7·2	6·5	6·7	10·2	13·1
Minimum	1914–15	10·0	7·3	6·3	5·6	6·5	7·5	9·0	9·9
	1915–16	8·2	4·5	4·0	1·2	0·2	3·5	6·5	8·0

FAHRENHEIT.

—	Year.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April.	May.
Average	1914–15	52·0	48·2	45·0	44·6	45·3	47·5	50·9	54·5
	1915–16	51·8	45·7	43·0	39·9	41·0	42·1	45·7	52·0
Maximum	1914–15	54·9	50·9	47·5	47·7	47·5	50·5	53·4	57·0
	1915–16	57·2	50·0	45·9	45·0	43·7	44·1	50·4	55·6
Minimum	1914–15	50·0	45·1	43·3	42·1	43·7	45·5	48·2	49·8
	1915–16	46·8	40·1	39·2	34·2	32·4	38·3	43·7	46·4

This shows that the surface water although not going to the same extremes as the air temperature, is yet very materially dependent upon it. In fact, taking the two seasons into consideration, there is almost as great a difference in the average water temperature for the eight months, viz., 1·9°C (3·4F) as there was in the average air temperature.

It is not probable that this difference in temperature is so great as to be beyond the power of accommodation in the larger species, food fishes for example, but these all, directly or indirectly, live on much more minute forms that are more readily affected by changes that act as stimuli, than are the larger forms. During the months of December, January and February, the greater portion of the minute animal food consists of crustaceans, copepods predominating. On account of the rough seas or of the cold surface waters or from the fact that the diatoms on which they feed are influenced by these, copepods were extremely scarce during the past season and hence many larger forms remained at depth as well. During the winter of 1914-15 there was scarcely a day that the fishermen, using a troll and spoon, and fishing near the surface, were unsuccessful in obtaining spring salmon. In 1915-16, when they did venture out, very few salmon were to be obtained and those that were caught, were caught at depth.

In the Nanaimo district herring are usually caught with purse seines and in such a method of fishing it is necessary to be able to see the schools of fish near the surface before the net can be cast successfully. Last season the seine fishing was a failure until very late as no herring could be seen. Doubtless they were there as usual as the gill net fishermen at Pender harbour on the other side of the strait found a good supply during the surface scarcity. When the herring did come into shallow water towards the end of February and early in March, the copepods were plentiful again. The herring spawning season was somewhat later than it was the previous year but not very much so, and possibly the weather had nothing to do with it.

Usually towards the end of February or early in March the water becomes thoroughly stocked with larvæ of all kinds, crustacean, molluscan, ascidian, etc., and these help much to replenish the larder for many of the larger as well as the smaller fish. The numbers were not lacking this year but they were much later appearing at the surface. Many annelids and crustaceans come to the surface to spawn and in some cases at least the spawning was delayed. One especially notable case might be mentioned. At a certain time in the spring, certain crustaceans, known as schizopods, come to the surface in such countless numbers that large areas of the surface water may be pink from their presence. The two-year-old coho, in the strait of Georgia commonly called the "blueback," have a decided preference for these and naturally they follow them to the surface and often in their haste go beyond them into the air. At this time they may be hooked in large numbers. The schizopod rise was much later than usual this year and in consequence the "blueback" run was also later in the season.

These are special instances but it is not at all likely that they are isolated cases. Many other species large and small would naturally be similarly affected.

Apparently there has been no special difference in the salinity of the water in the two seasons. The snow melted but slowly at the head waters of the large rivers and in consequence these rivers were lower than usual in the early summer, but on the other hand on account of the greater amount of snow on the lower levels the small streams have kept up their flow better than they did last year at least.

In the littoral zone, the greatest harm in any one night was probably produced on January 3–4, as on that night, according to the tide tables, the tide went to –0·3 foot at 22·07 and the minimum temperature of the air during the night was –9·0°C (15·8°F). With such a long run out, even half-tide shore forms, would be exposed to the cold for a long period. It is quite possible, however, that the cumulative effect of the continued cold from January 15 to January 19, with quite low tides, would be even greater than the effect during that one night. For these four nights we had the following:

January 15–16	—Low tide, 2·6 ft.	at 20·50;	minimum temperature,	–11·3°C,	11·6°F.
16–17	" 2·2	" 21·30;	"	– 8·9	15·9
17–18	" 1·8	" 22·06;	"	– 7·2	19·0
18–19	" 1·7	" 22·40;	"	– 6·9	19·6

These records are for Sand Heads, at the mouth of the Fraser river. The time is nearly the same at Departure bay but the change of tides is about one and a third times that at Sand Heads. That does not affect the question materially as there would be the same relative change.

The forms that inhabit the littoral zone may be divided into three classes. First there are those that move freely, such as certain flat fishes, that go in and out with the tide. These would not suffer with the cold at low tide. Secondly, there are those that move less freely and are thus left on the shore when the tide goes out but they are able to huddle together to retain moisture as the starfish do or keep under cover of seaweed or rocks as many of the crustaceans do. These might suffer but not very seriously, since that which would protect them from being dried out would also protect them from the cold. Thirdly there are the sessile forms, that throughout a great portion of their life-history remain firmly attached to rocks, logs, etc. They are left behind when the tide recedes and have no means of getting shelter or of retaining any very large amount of moisture. It is to this class that the oyster belongs and such as these are the worst sufferers. Reference has already been made to the oyster loss, a loss which was felt commercially. The destruction in some cases was more widespread than in the case of the oyster, but the loss in money value was not so noticeable.

On sandstone everywhere and sometimes on other rock as well, from nearly high tide mark to low tide mark, barnacles have established themselves. Those high up on shore are used to extremes as some of them get moisture and food only at the highest tides, but even those much lower down would be exposed for a long time at such low tide as that on January 3. These suffered from the abnormally low temperature and without doubt many of them died. But as human beings do not eat barnacles, what difference does it make if they were killed off? Human beings may not eat them in quantity, but other animals do. Many fish eat mature barnacles. the various species of viviparous perch and rock cod live on them continually when they are available in localities suitably situated. In other seasons perch and rock cod could be seen around the piles and near the sheer rocks at almost all times of the year, but this year scarcely one was visible until well on towards spring. They had to go to deeper water to find other supplies of food and these as well as those previously referred to, may not have had enough food for the normal growth during that period, or if they had they may have deprived some of the regular inhabitants of the deeper water of their share.

Starfish live extensively on barnacles and no one who has not seen starfish in certain areas along this coast can realize how abundant they are. This year they had fewer barnacles to supply them with food and hence they attacked clams, cockles and other shellfish to a greater extent. Thus while the shellfish may have been deep enough in the sand or mud to be protected from the frost, they suffered indirectly as the numerous dead shells on various beaches testify. The starfish was not alone in this work of distruction, the boring mollusc, *Thais*, probably accounted for a greater number of shell fish than usual, for it too depends on the barnacle to some extent for its food supply.

Some of the small fish, commonly called "bullheads," although that name is applied to a host of species, feed on barnacles as do a number of the crabs. These in turn serve as food for larger fish such as the various flounders, the ling cod (*Ophiodon*) and the tomcod (*Hexagrammus*). All of these therefore, had to seek their food supply in deeper water, with less success in all probability. Certainly they were not to be found in their usual haunts.

But this is not all. When the adult barnacles were chilled to death, the eggs from these would also die and quite probably in many cases where the adult was able to survive, the embryos would fail to do so. When the embryos are hatched out they are little shield-shaped creatures with three legs straggling out at each side. Later they grow a bivalve shell and become somewhat changed in shape. In these two larval stages, the nauplius and the cypris, the barnacle is free swimming and it forms an important part of the food supply of freely moving forms, different to those that eat the adult barnacle.

These barnacle larvæ ordinarily are found in plenty during the latter part of January and from that on until April or even May. This year they were very scarce during the first part of this period. Although the plankton was examined often, it was not until April 6 that they appeared in large numbers. It would seem therefore, that those far advanced in development, during the cold weather, suffered much more than those in the earlier stages.

The herring devour these larvæ in great numbers, for which purpose they move along in schools parallel to the shore in close proximity to the barnacle zone. Here then is another reason for their late appearance in shallow water last season. Even when they did come in they had to feed on copepods for a time or on their own spawn when it was deposited, but the later larvæ kept them supplied when they appeared so that they stayed in the shallow water later than usual. The young herring immediately after the yolk is absorbed begin to feed on these larvæ, but as it is only the later lot that they make use of, they were probably put to no inconvenience.

The sand launces feed on the barnacle larvæ as the herring do, but they are by no means so plentiful as the herring around Nanaimo. The salmon fry feed on these larvæ extensively, probably because they are plentiful, as they will eat almost anything that can be swallowed, but, as is mentioned later, the salmon fry appeared in the sea much later than usual this year and they did not suffer from any lack.

It is quite possible that serpulids and other annelids as well as many other clinging and boring forms would suffer, but little observation has been made on these. The anemones, many of which are entirely exposed at low tide, seemed to come through the cold all right. Finally the effect on anadromous forms is to be considered. The water in the rivers and lakes answers to the change of air temperature more readily than the water in the sea as the volume is comparatively small. The lowering of the temperature of the fresh water would have an effect on the food supply similar to the effect in sea water, and as the change would be greater the effect would probably be more marked. We are not here concerned with the food supply of fresh water fishes and of the anadromous forms that live through the winter in fresh water we have no definite information. The most important anadromous forms are the Pacific salmon, but the fresh water food supply does not affect the adults, since these die in the fall or early winter. Of the young forms, apparently all of the coho, most of the sockeye and some of the spring salmon remain a year or more in fresh water and these small fish would come under the influence of this cold weather. At present I have no data to compare these with those that were hatched out the year previous. The low temperature certainly did delay the hatching out of the eggs. At many hatcheries the time of hatching was as much as a month longer than usual and in some cases there was a corresponding loss in the number of healthy fry for liberation. As in nature, the eggs, deep down in the gravel, are fairly well protected, and one might have supposed that the difference would not be so great as in those hatched in the hatcheries, but apparently it must have been. The dog salmon fry are very plentiful near the Station for two or three months after they come down to salt water in the spring. In 1914 the first were noticed on March 4, in 1915, on March 7, and in 1916 none were noticed until April 8, and they did not become plentiful until much later. Judging from the numbers that did appear one should not think that a greater number than usual had been lost. If they had come down early in March they might have had a difficult task to get a sufficient supply of food. The cohos (in their second year) and the humpbacks were later than usual, but I have not exact dates for comparison. Probably all the species were affected in much the same way.

If it is the case that the fry that get the earliest start, other things being equal, makes the greatest growth during the first year, and ultimately becomes the largest fish, it will be interesting to compare the growth of the fry that hatched out in 1916 with those in other years, but while the conditions might be much similar among the fish of the same year group, it might be so different in different years as to shut out any such comparison. In the older fish, in which the scales are already formed, there should be a greater winter check for the winter of 1915-1916. Since the year's growth in all these older fish would be off to a bad start this year, this should be shown on the scales.

Summary.

The weather on the British Columbia coast during the winter and spring of 1915-1916 was much more severe than usual, affecting not only the atmospheric conditions but also those of the sea, lakes and rivers.

On account of the cooling of the surface water and possibly the disturbance by storms, marine forms had to go deeper for a food supply and in consequence many of them have not been able to get the normal amount for food requirements.

On account of low temperatures at low tides, some forms of commercial value were destroyed and the destruction of others made a great difference in the food supply of many marine species. The low temperature in the rivers and streams caused a retardation in the hatching out of embryos and hence the fry of anadromous forms got a later start than usual.

III.

Temperature and Specific Gravity Variations in the Surface Waters of Departure Bay, B.C.

BY

C. McLEAN FRASER.

An earlier paper provided some preliminary notes on the variations in temperature and density in coast waters, based on observations made during the summer of 1914[1]. In continuation of one phase of the work then begun, the daily record of the temperature and the specific gravity of the surface water at the station landing float in Departure bay, has since been kept. This paper deals with the record for five years ending May 31, 1919.

It is fully realized that temperature readings taken once a day and specific gravity readings taken with an hydrometer do not give sufficiently accurate data for getting any light on such problems as diurnal migration but in a location such as this where there is so much variation during the year, certain general conditions of value may be deduced which at least may form the basis for more accurate observations by one who may put his whole time on the work. It is true also that in the waters of a sheltered bay the conditions are somewhat special, but, although they cannot be considered as truly oceanic, by any means, they are typical of hundreds of situations along the north Pacific coast, where there are such extensive areas protected in a similar way, while at the same time they are directly connected with the open ocean and hence share to some extent the oceanic conditions.

In considering the temperature records, it will be noted that there is a definite relation between the temperature of the surface water and that of the air. Since the readings were taken but once a day, there is nothing to show coincidence throughout the day, but although the water does not show the variation in temperature during the twenty-four hours that the air does, it is probable that there is a certain amount of coincidence. As the water readings were taken at a definite time of the day, at or near 8 a.m., and the air records were not taken at a definite time, since only the maximum and minimum temperatures were recorded, there are no records exactly comparable. Since the water varies comparatively little during the day, the mean of the maximum and minimum temperatures each day shows a better parallelism with the water temperature from day to day than either the maximum or the minimum temperature does, hence the mean readings are considered here and it is these that are given in the table of air temperature.

While there are many small fluctuations in each record that are not found in the other, practically all the larger fluctuations are common to both, although the water variation is not so extreme as the air variation. Thus when graphs are made of the daily readings, many differences show up, whereas, when averages are taken for more extended periods (the periods taken for the graph appearing in the plate are of ten days), the correlation is very distinctly marked.

The curves for the different years are similar in a general way but each has its own special features and these may have much to do with changing conditions from year to year for the inhabitants of the sea. This is noticeably true in the hatching out of

[1] Fraser, C. M., and Cameron, A. T. Variations in density and temperature in the coastal waters of British Columbia, Contr. to Can. Biol. for 1914-1915, 1916, p. 133-143.

embryos, where a comparatively slight variation in temperature may make considerable difference in the time of hatching, e.g., in the spring of 1916, when the waters were colder than usual, many larval forms were much later in appearing and some at least were killed during development. A lack of larvæ in smaller species is sure to mean a lack of food supply in larger species and hence the whole fauna of the sea may be more or less affected.

In the spring and fall the water temperatures and the mean air temperatures practically coincide. In the winter the water does not keep up with the air in its extremes of cold and in the summer with its extremes of heat. This is particularly true if the change to the extreme is sudden and if the extreme is of short duration.

As to the minor fluctuations in the water temperature that do not necessarily coincide with air fluctuations, the main cause is evidently the variation in the amount of fresh water present. Taking this by itself it may be said in general that an influx of fresh water tends to raise the temperature in the summer and lower it in winter. The raising or lowering may accentuate or may counteract to some extent the fluctuations corresponding to those present in the air temperature records.

The causes for the fluctuations in the specific gravity are not so easily placed. A study of the five years' records shows certain of the predominating factors. The specific gravity is high every year in the spring, about April, and in the fall, about October, and drops low in the winter, about January, and in the summer, about June, but varying somewhat in each case from year to year.

In the previous paper it was indicated that the low salinity in the summer was due largely to the waters of the large mainland rivers, the Fraser in particular. This has been fully borne out by the more extended records. Mr. C. C. Worsfold, District Engineer of the Department of Public Works, New Westminster, has been kind enough to give me a copy of the records of the height of the water in the Fraser river at Mission bridge, about forty miles above the mouth of the river, during the months of May, June and July for these years. The records are kept for these months only as these cover the flood period of the river, but they are sufficient to show the coincidence in time of the high water and the low specific gravity of the water in Departure bay, the change in Departure bay naturally taking place a little later than the time when flood appears at the Mission bridge.

The main driving force to take the fresh water across the strait is the flood from the river itself. When the river is in flood a large volume of water is being continually emptied into the strait, forced onward by the hundreds of miles of water following it up. The fresh water, particularly while it is going with a strong current, mixes little with the more saline water below, so that its effect in reducing salinity is felt but a few fathoms down, scarcely five fathoms down where the current enters the strait, but somewhat deeper than that when the strength of the current is reduced. At times the muddy water of the Fraser appears to be carried right across the strait of Georgia to Gabriola, Valdez and Galiano islands, without, on the surface, becoming materially mixed with the saline water of the strait, while logs, sticks and other debris, carried with the current, give some idea of its rate of flow. The ebb and the flow of the tide have some effect on the current, swerving it somewhat southward or northward, as the case may be. As the flow spreads out over a wider and wider area, the rate of flow diminishes, and the water brought down mixes to a greater degree with the waters of the strait. When the main current strikes the shore of the islands across the strait, is is deflected northward or southward and the effect is gradually extended for a great distance from the mouth of the river. The degree of extent is evidently affected somewhat by weather conditions. More or less still weather is conducive to extension at the surface, while a strong wind, particularly if it is strong enough to cause the waves to break, disturbs the surface, causing a greater mixing with the deeper water and hence tends to hinder the spread. In many cases when the layer of fresh water is very superficial, much of the fresh water seems to be carried along by the wind in somewhat the same way as a floating object is carried.

As Departure bay is somewhat northward of the direct flow of the river, light southeast winds favour the influx of Fraser River water, while northwest winds hinder its progress. In the summer the northwest winds are usually the strong winds and hence their influence is commonly strongly marked. As the trend of Departure bay is at a definite angle to the general trend of the coast, the wind in the bay is not always in the same direction as the wind outside in the strait. Practically speaking, the wind in the bay is always in one of two directions, either into the bay or out of the bay. When the wind is blowing out of the bay the specific gravity of the surface water may be greater than that of the strait near by; when it is blowing into the bay the reverse may be the case or the difference may not be noticeable.

An attempt was made to connect up the fluctuations in specific gravity with the variations in barometer but the path of cyclonic centres varies so much in this locality that it was impossible to trace any relationship, although the periodicity in the fall and rise of specific gravity corresponds more or less regularly to the cyclonic and anticyclonic periodicity.

The effect of the Fraser river and the other large rivers of the mainland gradually wanes after the height of the flood in late June until by the end of September it has practically disappeared as far as Departure bay is concerned. For a longer or shorter time at this period the specific gravity is constantly high, before the winter fluctuations begin. These winter fluctuations are largely dependent on the height of the water in the local streams and rivers and hence on the rainfall. The graph that has been made for the precipitation, taking ten-day periods as in the other cases, shows very definitely the relationship between the specific gravity of the water and the precipitation.

In the daily readings fluctuations take place apart from the general rainfall effect, and, as in the summer, this is largely due to the strength and direction of the wind. A southeast wind may drive in fresh water from the Nanaimo river, to send the surface specific gravity away down and in a few hours the wind may change to the northwest and the wind blowing out of the bay may cause the specific gravity to rise again.

As the time of greatest rainfall varies from year to year so does the time of lowest specific gravity, but ordinarily the effect of winter rain is well over by the end of March. Hence during April there is constant high specific gravity as during October. In May the effect of the mainland rivers begin to show and the cycle is complete.

There is no doubt that the variations in time and degree of the various phases of the cycle, both as to temperature and to specific gravity or salinity, have much to do with the time of migrations of many, perhaps all, marine animals that come within their influence, and the fuller the data on these factors, the more fully the migrations may be explained. Data on migrations are accummulating from year to year. A paper was recently published calling attention to some points that have been observed[2] but in this paper attention was not directed to migration of fishes and from an economic point of view, these are of the greatest importance.

Although the conclusions from these records are very general, they are sufficient to show what might be expected from more accurate and more extended work in the same field.

Summary.

The temperature of the surface water in Departure bay is subject to much the same fluctuations as the mean air temperature but does not go to the same extremes. It is affected by influxes of fresh water, which tend to raise the temperature in the summer and lower it in winter.

The specific gravity is at its highest in the spring and in the fall. In the summer it is lowered by the influx of water from the Fraser and other mainland rivers, being

[3] Fraser, C. M. Migration of marine animals. Trans. Royal Soc. Can., 1918. Sec. iv, p. 139. 143.

most affected when the water in the rivers is highest, usually towards the last of June. Daily fluctuations are largely due to weather changes, more particularly on the direction and velocity of the wind. In the winter the specific gravity is lowered by the flow from the local rivers and streams, depending definitely on the precipitation. Local weather conditions produce fluctuations here as well.

The variations in the time and the degree of the different phases of the yearly cycle, both as to temperature and to specific gravity, from year to year, evidently have much to do with migration, time of spawning, etc., of many marine animals.

Explanation of Tables.

Table I gives the daily mean air temperature records in Centigrade degrees.

Table II gives the daily records of the surface water temperature taken at the station landing float, Departure bay.

Table. III gives the specific gravity records taken at the same time and place as the temperature records in Table II and reduced to 10°C. Maximum density of water taken as 10,000.

The plate includes graphs taken with a ten-day period as a unit, for the five years beginning June 1, 1914, and ending May 31, 1919.

The upper figure gives the air temperature graph in continuous line and the water temperature graph in dotted line.

The second figure gives the graph of the specific gravity records.

The third figure gives the graph of the precipitation in inches.

The fourth figure (discontinuous) gives a graph of the records of the height of the Fraser river during May, June and July of each year, measured in feet above a zero mark on Mission bridge.

TABLE I.

1914.

—	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec
1	......	......	......	......	......	20·0	21·3	18·4	16·0	7·3	9·8	4·5
2	......	......	......	......	......	13·9	22·7	20·9	13·8	10·3	7·9	3·9
3	......	......	......	......	......	11·4	20·8	18·4	12·9	8·4	6·9	5·6
4	......	......	......	......	......	11·2	17·5	18·2	15·1	9·9	7·1	4·7
5	......	......	......	......	......	11·7	16·7	18·5	13·2	10·1	6·9	3·1
6	......	......	......	......	......	12·8	16·8	15·9	12·3	10·8	4·6	2·9
7	......	......	......	......	......	11·2	17·9	14·2	12·9	10·2	5·2	4·7
8	......	......	......	......	......	12·3	16·9	16·9	11·1	10·8	9·8	3·9
9	......	......	......	......	......	12·8	19·1	16·9	11·4	12·8	7·5	4·6
10	......	......	......	......	......	13·6	19·1	18·3	13·8	11·4	8·2	2·1
11	......	......	......	......	......	15·8	22·5	21·2	11·6	9·3	6·3	0·2
12	......	......	......	......	......	16·9	21·8	21·2	11·6	10·8	3·8	0·1
13	......	......	......	......	......	16·7	18·6	21·6	12·3	11·7	4·0	−0·3
14	......	......	......	......	......	17·8	16·6	20·9	11·6	14·7	3·2	−0·3
15	......	......	......	......	......	21·1	19·2	17·9	11·3	14·2	2·4	1·4
16	......	......	......	......	......	18·7	20·7	15·2	10·7	12·0	1·8	−0·4
17	......	......	......	......	......	17·3	23·3	15·2	11·1	10·3	5·1	0·0
18	......	......	......	......	......	17·4	23·0	16·5	12·5	10·2	3·6	−0·5
19	......	......	......	......	......	15·5	21·3	20·2	12·3	9·1	6·2	1·7
20	......	......	......	......	......	12·9	16·3	18·9	11·9	9·8	7·5	−0·3
21	......	......	......	......	......	11·3	13·2	15·7	12·4	8·8	8·4	0·0
22	......	......	......	......	......	12·4	17·2	17·0	12·8	8·1	7·7	2·3
23	......	......	......	......	......	13·4	18·6	19·6	12·1	11·2	7·0	3·2
24	......	......	......	......	......	12·2	15·4	20·3	13·8	8·6	9·8	3·4
25	......	......	......	......	......	15·1	16·4	19·6	14·2	9·9	9·1	2·4
26	......	......	......	......	......	15·6	15·3	18·2	12·7	11·8	4·9	4·6
27	......	......	......	......	......	15·8	14·9	16·5	9·5	10·1	7·1	4·0
28	......	......	......	......	......	16·6	17·1	16·7	10·7	9·2	5·2	3·7
29	......	......	......	......	......	20·6	17·4	15·6	12·3	9·7	2·2	3·2
30	......	......	......	......	......	21·9	17·7	16·4	10·7	11·8	4·1	5·1
31	......	......	......	......	......	......	17·6	17·4	......	8·2	......	3·0

TABLE I.—*Continued.*

1915.

—	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1.	5·7	6·1	7·7	10·6	10·6	13·1	26·1	17·2	16·7	12·8	5·8	2·8
2.	4·8	4·2	4·7	11·9	16·2	15·1	25·4	18·7	15·4	12·5	7·5	6·4
3.	4·9	4·6	5·9	10·1	16·3	15·3	20·7	15·9	18·6	11·5	8·4	7·0
4.	1·9	2·8	7·2	9·2	16·3	19·4	18·5	17·4	17·8	9·2	8·0	5·9
5.	4·1	4·4	5·0	8·7	16·3	21·6	16·5	16·4	14·9	11·2	5·1	4·6
6.	5·3	6·7	8·6	10·1	15·4	19·7	16·4	17·6	14·1	10·2	4·4	5·1
7.	5·5	7·8	5·8	10·0	13·8	14·7	14·8	18·5	12·5	9·4	4·8	4·8
8.	5·6	6·3	5·0	7·3	11·9	15·4	18·9	18·6	12·8	10·6	5·9	4·2
9.	2·5	7·3	4·2	9·0	11·1	14·2	15·8	19·1	13·6	10·9	5·2	2·6
10.	4·8	4·7	5·0	9·2	12·2	14·6	15·7	19·5	15·5	11·1	3·3	3·9
11.	5·3	4·9	5·8	10·2	13·4	14·3	14·7	17·3	14·1	11·3	2·9	5·7
12.	2·2	4·6	7·6	11·1	13·5	13·6	13·6	20·9	13·7	11·1	2·2	5·1
13.	2·9	2·8	8·1	10·2	12·4	15·8	12·4	21·3	11·8	10·1	2·4	5·1
14.	3·3	3·6	9·5	8·7	10·9	16·4	17·1	19·3	14·7	9·6	2·8	3·1
15.	3·4	5·3	9·2	11·7	10·7	18·3	15·3	17·5	15·7	9·3	6·2	2·7
16.	1·2	4·5	8·5	13·8	11·6	18·7	15·8	16·6	17·2	9·4	4·4	3·7
17.	2·5	4·2	9·3	15·2	13·2	13·5	14·9	19·3	16·3	11·7	8·6	1·2
18.	2·2	3·3	7·1	14·3	13·9	13·4	16·8	21·1	17·4	9·2	6·1	3·6
19.	2·1	2·0	7·3	12·8	12·5	14·3	19·8	24·5	16·4	7·8	4·1	5·2
20.	2·4	5·6	9·3	10·5	12·7	14·9	22·0	26·8	17·2	10·4	2·7	4·9
21.	0·6	3·7	10·6	11·0	12·6	15·0	21·3	26·7	15·1	10·4	4·3	7·1
22.	−0·7	6·4	12·2	11·2	11·6	17·0	21·0	24·2	14·4	9·8	4·6	3·8
23.	1·7	5·8	10·8	13·0	11·3	15·0	21·2	20·2	14·2	9·1	4·3	2·9
24.	1·1	7·4	10·7	10·3	12·1	14·7	21·4	18·3	11·9	6·9	3·7	2·2
25.	0·2	4·7	9·7	12·1	12·0	13·4	19·5	17·1	12·4	9·8	4·3	2·3
26.	0·4	3·9	6·6	11·6	11·6	14·8	17·5	16·8	11·8	11·9	5·3	3·1
27.	0·7	7·1	7·7	10·7	12·5	16·6	17·1	18·0	11·8	9·0	2·1	3·4
28.	1·1	6·4	9·0	10·8	11·4	18·2	17·7	18·6	11·4	10·8	2·1	2·7
29.	3·0	....	10·3	8·8	11·5	22·2	19·4	17·2	11·7	8·6	3·3	1·5
30.	3·9	....	8·4	6·9	11·2	23·9	19·3	18·8	13·8	6·5	2·2	−1·6
31.	5·2	....	8·4	....	13·4	....	17·7	13·4	....	8·8	....	−1·0

TABLE I.—*Continued.*

1916.

—	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1.	0·1	−3·3	3·3	10·7	12·1	11·7	14·7	14·2	16·5	7·5	5·7	3·1
2.	−2·4	−0·3	2·1	10·6	13·2	12·8	16·6	14·6	16·1	7·5	7·5	5·8
3.	−2·9	−1·7	2·9	9·1	14·3	13·4	15·1	13·9	16·2	7·1	6·7	3·4
4.	−4·1	−1·0	2·3	8·9	11·2	13·4	12·7	16·8	14·8	7·2	5·9	1·5
5.	−3·0	−0·7	1·2	8·5	9·3	10·7	13·2	16·6	15·9	7·9	4·7	0·4
6.	−0·3	0·4	1·9	6·6	8·7	11·4	14·8	17·8	14·5	10·9	6·7	−0·4
7.	2·1	0·2	3·9	9·6	5·7	11·6	16·9	18·9	14·2	9·8	5·2	0·0
8.	1·9	−1·1	6·1	7·8	7·1	13·9	16·1	18·7	13·2	9·8	6·9	2·6
9.	1·7	0·8	7·8	8·4	5·0	11·6	16·4	17·0	11·9	10·7	7·4	2·6
10.	−4·5	3·7	8·6	7·9	6·4	13·9	15·3	18·4	11·8	9·6	5·3	1·2
11.	−6·7	1·9	8·8	7·4	8·4	17·2	17·7	16·3	13·3	10·8	0·9	3·1
12.	−4·7	3·4	6·3	5·5	11·1	19·1	17·9	19·2	14·3	9·6	0·3	3·5
13.	−5·0	3·3	4·0	9·3	12·8	19·6	13·9	17·6	15·3	9·8	0·4	3·6
14.	−7·2	4·7	1·9	7·3	11·4	20·0	15·2	16·6	15·1	9·0	1·6	2·8
15.	−5·8	4·4	4·2	6·8	12·8	22·6	14·7	15·3	15·0	9·6	2·6	1·2
16.	−5·0	4·0	7·2	8·6	14·5	23·2	16·0	14·6	15·5	8·9	1·7	2·8
17.	−2·9	4·1	4·6	6·5	11·4	23·0	15·1	13·5	14·4	10·7	1·7	3·7
18.	−1·9	3·1	3·2	7·5	11·9	20·0	15·1	13·3	13·7	9·1	5·0	5·6
19.	−2·8	2·8	3·6	5·0	9·9	12·5	15·0	13·5	13·7	7·9	2·8	3·1
20.	0·9	3·7	7·1	6·9	11·2	14·6	14·8	14·8	13·8	8·2	4·3	1·6
21.	−0·9	4·1	4·3	5·9	10·5	13·2	11·9	16·7	15·6	10·2	3·3	2·2
22.	3·2	3·6	4·2	7·0	8·6	12·7	15·4	18·7	15·4	8·0	5·9	1·2
23.	−1·3	5·1	4·0	6·1	10·6	15·0	15·3	22·7	11·4	6·0	2·8	1·1
24.	−6·2	4·3	2·8	8·8	16·9	16·2	15·7	24·8	11·8	4·7	3·1	1·4
25.	−3·3	6·1	4·4	7·9	16·9	14·2	11·7	22·2	11·2	8·8	5·2	−2·2
26.	−5·0	9·3	4·7	8·1	12·4	15·8	12·6	21·0	13·8	8·7	3·4	−0·9
27.	−4·1	5·2	5·1	9·9	12·6	14·8	13·3	20·2	11·9	7·9	5·3	−0·8
28.	−6·4	4·2	4·7	9·9	11·1	14·0	14·9	17·4	14·3	6·1	3·7	0·7
29.	−6·1	2·8	4·7	9·9	11·4	14·6	15·2	16·4	12·1	6·4	5·3	−2·6
30.	−4·6	....	6·6	9·3	12·8	15·3	18·4	16·3	10·4	5·4	2·6	0·5
31.	−8·3	....	9·4	....	11·4	....	16·4	17·3	....	7·7	....	1·8

TABLE I.—*Continued*

1917.

—	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec
1	3·0	−1·9	0·7	3·3	7·9	10·7	16·2	18·3	19·3	9·8	9·8	2·5
2	3·6	2·0	0·4	4·0	8·6	9·6	16·7	21·6	19·2	15·2	7·7	2·2
3	2·9	3·3	2·3	4·8	8·7	10·7	16·2	20·0	15·6	15·2	11·6	2·2
4	4·1	4·8	3·4	6·3	8·0	13·5	17·3	20·1	14·7	16·1	6·9	2·3
5	5·3	4·9	4·9	6·3	18·7	11·7	17·6	19·6	16·3	14·9	11·3	1·1
6	4·1	4·6	2·9	4·7	10·3	12·2	14·2	16·0	15·3	12·0	9·2	3·8
7	4·3	4·3	2·7	6·9	11·6	12·6	14·7	16·4	14·8	12·9	4·7	3·1
8	6·2	3·7	3·7	7·5	11·8	12·0	17·2	17·3	15·4	13·2	6·4	5·5
9	5·5	2·7	5·2	7·6	13·2	11·3	16·1	17·1	13·7	11·4	10·4	4·8
10	5·7	5·4	3·7	6·2	11·2	9·9	16·7	16·3	13·1	12·5	8·7	2·6
11	4·1	7·3	3·1	5·9	9·7	11·2	18·8	22·1	14·3	10·6	10·1	3·9
12	1·2	5·8	3·1	7·4	11·9	12·2	21·7	22·4	13·1	10·9	10·6	0·8
13	1·0	4·8	2·9	8·3	10·5	15·2	21·0	19·1	10·1	9·7	10·1	3·1
14	0·3	4·7	2·9	7·1	10·3	15·4	22·4	18·4	12·4	10·6	5·2	6·7
15	−0·6	5·2	1·9	6·8	9·0	17·7	20·2	20·3	16·7	8·9	5·3	6·2
16	0·5	5·2	3·4	6·9	8·5	15·3	20·5	23·3	15·4	7·9	7·9	7·3
17	−0·3	4·0	3·7	6·9	9·3	13·5	21·2	22·0	14·0	6·4	7·9	3·8
18	0·2	1·3	4·1	6·6	9·6	13·4	20·4	18·9	15·5	7·2	9·4	6·1
19	0·7	0·9	2·9	5·8	11·6	12·9	20·3	15·6	13·5	8·1	7·8	3·9
20	1·8	−0·3	2·6	5·0	11·8	13·8	19·1	18·6	13·4	6·8	10·3	2·8
21	2·2	−0·4	4·3	6·8	10·9	13·3	17·3	17·9	13·3	9·3	11·4	1·4
22	2·9	−1·4	4·3	6·7	12·5	12·3	15·6	19·4	12·5	7·2	10·8	0·7
23	2·7	−1·2	6·6	6·5	12·6	11·2	15·8	20·8	12·9	9·2	11·3	−1·2
24	3·2	−2·1	4·3	7·1	14·6	12·9	18·9	20·3	9·6	9·6	8·9	−1·6
25	5·6	−1·0	2·8	8·6	14·3	13·8	17·6	20·7	11·6	8·2	4·9	−2·0
26	3·1	−0·8	3·1	11·5	13·9	15·4	22·2	19·4	14·7	5·8	3·4	1·6
27	2·9	0·4	5·1	12·4	14·2	15·9	17·1	17·4	10·5	7·3	7·4	2·9
28	1·1	0·3	5·6	10·8	14·8	11·9	15·1	17·5	11·8	4·9	3·8	3·9
29	−3·8	....	4·6	10·1	16·7	12·5	11·1	19·9	11·1	6·9	4·8	6·2
30	−5·2	....	2·2	9·2	12·7	14·4	12·3	18·9	13·3	6·6	3·7	8·0
31	−6·8	....	2·1	....	12·3	....	15·7	20·2	....	10·6	....	9·8

TABLE I—*Continued.*

1918.

—	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	9·8	0·0	4·0	6·7	10·6	10·6	18·7	18·3	21·2	13·9	10·4	5·2
2	10·8	3·0	4·8	6·5	11·8	10·2	16·4	17·7	18·7	12·3	6·3	6·6
3	9·0	6·3	2·5	5·9	13·4	11·9	18·7	16·3	18·8	13·5	7·7	3·5
4	7·0	7·9	2·1	5·9	12·4	16·3	19·9	18·7	18·6	14·1	8·5	4·8
5	6·3	7·4	1·7	6·2	10·6	15·9	19·6	18·9	18·4	12·8	7·6	4·7
6	7·7	7·1	0·3	8·4	10·8	18·7	15·3	16·2	19·4	10·4	3·9	6·2
7	6·9	5·4	2·8	10·1	10·4	16·1	17·0	16·3	17·3	8·8	6·2	7·6
8	6·2	6·8	1·7	10·7	15·1	16·3	19·1	16·7	16·7	12·1	6·6	6·4
9	2·2	8·4	2·8	11·2	15·0	17·3	19·4	13·7	14·3	−8·8	6·4	4·1
10	0·9	6·2	2·3	8·8	12·6	15·9	14·4	15·9	14·9	12·1	7·4	4·0
11	2·6	2·8	2·3	8·6	13·6	18·2	14·1	16·5	17·3	14·6	6·9	3·7
12	2·7	3·3	3·2	7·3	12·7	19·6	14·7	16·3	18·3	10·8	7·9	2·7
13	1·9	1·6	2·4	4·9	11·4	18·5	15·7	17·8	19·2	10·2	7·4	7·6
14	4·3	1·2	6·3	6·9	15·4	14·1	16·1	17·0	21·7	8·3	5·0	7·0
15	2·7	0·5	5·8	4·0	11·4	13·8	15·7	15·1	18·3	9·9	6·4	3·6
16	4·0	1·7	8·4	8·3	12·1	16·3	20·1	16·3	18·4	10·4	5·4	3·8
17	6·9	0·8	7·3	6·3	10·9	16·6	23·8	16·3	17·7	10·8	7·3	1·7
18	5·9	−1·7	5·6	8·1	9·2	13·8	23·9	15·2	17·4	10·7	7·7	4·9
19	3·6	−2·2	6·3	12·7	8·7	18·2	19·3	15·7	17·0	12·1	8·0	4·5
20	1·4	−2·2	4·8	16·1	9·3	21·5	15·6	17·1	15·5	11·9	7·5	4·4
21	3·5	1·0	7·4	15·3	10·8	20·1	17·2	16·1	13·6	8·5	4·6	2·7
22	4·9	−0·4	5·9	12·1	8·8	19·2	19·1	17·3	12·7	8·3	7·2	1·4
23	5·1	3·1	4·0	9·7	10·6	19·1	19·4	17·5	10·6	7·1	6·4	1·7
24	5·6	2·8	9·3	10·0	10·9	17·4	17·7	16·8	13·4	7·4	4·7	1·4
25	5·6	3·0	7·3	12·2	11·5	16·8	15·7	21·4	15·0	7·4	4·6	1·1
26	2·5	3·2	7·3	10·2	13·7	18·2	17·2	18·4	19·4	8·1	3·7	2·1
27	3·5	2·0	6·2	13·0	18·2	16·6	17·2	15·8	21·1	11·1	2·7	4·7
28	5·4	4·7	9·1	12·4	14·2	17·5	16·8	18·7	18·7	9·6	5·3	5·8
29	2·5	....	8·7	10·7	15·6	18·8	17·2	19·2	17·4	9·3	6·2	4·8
30	−1·6	....	9·3	10·7	14·1	20·8	19·9	22·9	15·6	7·6	6·7	1·7
31	−3·0	....	7·8	....	10·9	....	18·5	22·9	....	8·3	....	2·4

TABLE I—*Concluded.*

1919.

—	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1·4	1·7	0·1	10·8	11·2	...	...	...	...	...	...	...
2	2·0	2·2	3·9	9·6	9·3	...	...	...	...	...	...	...
3	2·7	2·3	4·4	9·8	10·6	...	...	...	...	...	...	...
4	2·8	3·9	5·2	8·1	10·1	...	...	...	...	...	...	...
5	3·5	3·5	3·6	7·3	11·2	...	...	...	...	...	...	...
6	4·2	2·2	4·7	7·8	10·7	...	...	...	...	...	...	...
7	2·1	1·7	3·1	8·1	11·7	...	...	...	...	...	...	...
8	3·1	5·6	5·5	5·4	12·6	...	...	...	...	...	...	...
9	3·8	8·6	3·1	7·4	10·7	...	...	...	...	...	...	...
10	6·8	6·6	5·0	8·6	8·2	...	...	...	...	...	...	...
11	4·6	4·6	4·8	5·6	11·3	...	...	...	...	...	...	...
12	5·7	1·7	3·6	8·3	9·3	...	...	...	...	...	...	...
13	7·4	3·8	2·6	7·0	10·6	...	...	...	...	...	...	...
14	7·4	4·8	4·3	6·1	11·2	...	...	...	...	...	...	...
15	6·4	5·4	4·9	6·5	11·1	...	...	...	...	...	...	...
16	5·2	7·4	3·9	8·7	10·4	...	...	...	...	...	...	...
17	6·8	6·2	6·9	10·7	7·8	...	...	...	...	...	...	...
18	6·5	2·8	7·3	10·0	11·3	...	...	...	...	...	...	...
19	3·6	3·7	6·7	10·1	11·7	...	...	...	...	...	...	...
20	4·0	4·3	5·7	7·6	12·6	...	...	...	...	...	...	...
21	5·5	1·9	8·6	7·9	15·9	...	...	...	...	...	...	...
22	6·6	2·8	7·8	7·6	11·9	...	...	...	...	...	...	...
23	4·6	2·4	7·3	9·9	11·3	...	...	...	...	...	...	...
24	2·9	0·8	6·8	10·4	11·2	...	...	...	...	...	...	...
25	5·7	2·2	6·2	10·2	13·8	...	...	...	...	...	...	...
26	4·1	3·7	6·3	9·2	10·0	...	...	...	...	...	...	...
27	5·1	2·2	7·4	9·4	12·3	...	...	...	...	...	...	...
28	6·0	1·6	9·3	11·1	11·7	...	...	...	...	...	...	...
29	4·3	...	11·7	9·9	8·8	...	...	...	...	...	...	...
30	4·0	...	8·2	10·9	11·9	...	...	...	...	...	...	...
31	2·7	...	7·4	...	11·4	...	...	...	...	...	...	...

TABLE II

1914.

—	Jan.	Feb.	Mar.	April.	May	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	...	...	...	...	...	15·5	19·3	17·2	15·8	11·8	10·6	7·4
2	...	...	...	...	...	15·9	18·4	17·1	16·4	11·5	10·5	8·7
3	...	...	...	...	...	15·7	...	17·2	16·6	11·1	10·4	7·6
4	...	...	...	...	...	15·1	...	17·4	16·0	11·6	10·0	8·6
5	...	...	...	...	...	...	19·5	17·2	15·9	11·8	9·9	7·7
6	...	...	...	...	...	14·2	18·4	17·3	15·7	11·7	9·7	7·5
7	...	...	...	...	...	14·1	...	16·2	15·0	12·3	8·7	7·8
8	...	...	...	...	...	14·5	...	16·1	16·3	12·3	9·3	6·8
9	...	...	...	...	...	13·7	...	17·5	13·2	12·7	9·7	7·9
10	...	...	...	...	...	14·1	19·7	17·4	13·6	12·2	9·2	7·0
11	...	...	...	...	...	16·0	20·9	17·3	...	11·6	9·8	6·3
12	...	...	...	...	...	16·3	20·5	17·8	13·2	11·4	9·1	7·4
13	...	...	...	...	...	15·6	21·1	17·9	14·1	10·8	8·3	7·1
14	...	...	...	...	...	14·5	19·6	17·8	13·9	10·9	8·5	7·2
15	...	...	...	...	...	17·9	15·9	...	13·2	11·6	7·4	7·4
16	...	...	...	...	...	18·5	17·8	18·9	12·8	11·2	8·3	7·7
17	...	...	...	...	...	18·8	19·3	17·3	12·5	10·5	9·0	6·3
18	...	...	...	...	...	17·1	18·6	18·0	12·7	10·4	8·2	6·4
19	...	...	...	...	...	16·6	19·4	...	11·7	10·0	8·3	6·7
20	...	...	...	...	...	16·6	18·6	17·8	11·2	10·0	8·9	6·6
21	...	...	...	...	...	15·9	17·8	17·7	11·1	10·2	9·2	6·6
22	...	...	...	...	...	16·2	19·4	16·0	11·9	10·3	9·4	6·4
23	...	...	...	...	...	16·6	17·3	16·7	12·8	10·8	8·8	7·1
24	...	...	...	...	...	15·6	21·0	17·0	13·5	10·5	8·9	7·3
25	...	...	...	...	...	17·4	17·5	17·8	13·4	10·3	8·9	7·1
26	...	...	...	...	...	...	15·4	17·4	13·5	10·7	9·1	7·2
27	...	...	...	...	...	17·5	15·8	18·2	12·6	11·0	8·8	6·9
28	...	...	...	...	...	17·5	16·2	17·2	11·8	10·9	8·8	7·1
29	...	...	...	...	...	17·9	16·8	16·4	11·7	10·8	8·6	6·6
30	...	...	...	...	...	18·4	17·1	16·0	11·6	11·1	7·3	6·7
31	...	...	...	...	...	...	17·4	15·8	...	10·9	...	7·1

TABLE II—*Continued.*

1915.

—	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	7·9	6·9	8·4	9·4	10·7	12·5	16·8	17·5	15·2	14·0	10·0	5·3
2	8·1	7·9	7·7	9·8	11·0	13·5	17·1	17·1	14·7	12·8	9·8	5·7
3	8·7	7·4	7·7	9·1	11·5	14·2	17·3	16·2	16·3	11·5	9·8	7·4
4	7·3	6·8	7·5	9·3	11·6	14·6	18·0	15·8	18·1	11·7	9·8	7·0
5	6·5	7·3	7·8	9·4	13·3	14·5	18·0	16·6	17·3	11·8	8·4	6·9
6	6·3	7·2	7·7	10·3	13·0	14·5	15·1	18·9	16·4	12·0	8·9	5·7
7	6·8	7·9	8·2	10·4	13·9	13·6	15·1	18·7	16·7	12·0	9·0	6·8
8	7·4	8·6	7·8	9·0	13·3	14·1	16·1	18·3	15·5	12·0	8·7	6·2
9	7·8	8·4	7·9	9·8	12·8	14·6	15·1	18·0	15·2	12·1	7·9	5·4
10	7·1	8·1	8·2	10·7	12·2	14·3	16·0	17·3	15·4	11·8	8·1	5·9
11	7·2	7·3	8·2	9·9	11·8	14·5	16·8	17·0	15·4	11·8	7·8	5·8
12	8·2	7·3	8·2	10·3	11·6	15·1	15·2	17·9	15·4	11·9	8·0	6·3
13	7·6	7·8	8·5	10·3	12·0	13·1	14·7	18·8	15·5	11·5	7·2	7·2
14	7·8	6·6	8·7	9·8	12·1	14·4	16·5	19·0	15·6	10·2	8·0	7·7
15	7·3	6·7	8·5	10·9	12·6	14·5	16·1	19·0	14·9	10·8	7·9	7·5
16	7·2	7·7	8·2	11·3	13·1	15·7	16·6	18·0	15·2	10·7	7·5	6·4
17	7·1	8·5	8·2	11·7	13·4	16·0	17·3	18·0	15·1	9·8	7·4	7·2
18	7·2	7·7	8·1	11·9	13·7	16·0	17·3	18·6	15·5	11·2	7·9	5·7
19	6·6	7·4	8·6	11·7	13·5	15·7	18·2	18·8	15·7	11·0	7·5	5·5
20	6·7	6·8	8·1	10·6	13·2	15·7	19·0	19·0	15·3	10·9	6·1	5·2
21	5·7	7·3	9·1	10·6	12·2	15·3	19·7	19·3	15·7	11·5	6·9	7·7
22	6·3	7·0	9·7	11·1	12·6	16·4	19·0	19·5	15·6	10·1	7·9	6·7
23	6·7	7·3	9·4	10·8	12·2	17·0	19·0	19·2	15·4	9·7	7·5	6·6
24	5·6	7·1	9·7	11·8	12·1	16·6	18·5	18·2	14·9	9·8	4·5	4·5
25	6·9	7·1	9·7	11·3	12·7	13·3	18·6	17·1	15·0	9·5	5·8	6·3
26	6·2	7·1	9·3	11·1	12·4	15·9	18·2	17·5	14·8	10·0	7·3	5·7
27	6·9	7·7	10·0	11·0	12·4	16·5	18·2	17·4	14·4	9·8	5·8	5·0
28	6·7	8·6	10·1	10·8	9·9	16·4	17·2	17·5	14·2	10·2	5·4	6·3
29	6·9	....	10·3	10·6	12·4	16·5	17·0	17·6	14·2	10·4	5·9	6·1
30	6·7	....	9·7	10·6	13·5	16·8	17·7	18·1	14·0	8·2	4·6	4·2
31	6·9	....	9·0	....	13·8	....	17·9	16·1	....	10·0	....	4·0

TABLE II—*Continued.*

1916.

—	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3·0	4·0	6·1	6·7	11·1	12·0	15·4	15·5	14·5	11·2	7·4	6·1
2	5·5	0·2	4·1	7·0	11·5	12·8	15·3	14·0	13·8	11·8	7·2	6·3
3	6·9	4·8	3·5	8·1	11·7	13·8	15·0	16·6	14·6	10·9	7·7	6·6
4	4·8	3·7	5·7	8·2	12·0	12·0	15·8	16·9	15·8	10·5	7·1	6·2
5	4·6	4·0	5·3	7·8	10·5	12·7	16·1	17·4	15·1	10·5	7·0	5·6
6	3·8	3·8	6·0	7·2	10·7	12·8	15·4	17·3	16·6	10·8	7·3	5·5
7	4·7	5·8	5·7	7·8	8·5	13·1	16·2	17·3	16·5	10·6	8·5	5·7
8	5·0	5·2	5·9	8·0	8·2	13·2	15·5	17·5	12·8	12·0	8·2	5·5
9	6·0	4·8	5·7	7·8	8·5	13·4	15·8	17·5	14·8	10·5	8·4	5·3
10	7·2	4·6	6·1	7·1	8·0	13·8	15·5	17·8	15·8	11·3	8·5	6·3
11	5·1	5·6	6·4	7·2	9·8	13·4	15·5	17·5	15·5	10·5	6·4	6·0
12	4·8	4·5	5·5	7·0	9·8	13·6	15·5	19·1	14·3	10·5	5·5	5·3
13	5·6	5·0	5·4	7·0	10·1	13·6	15·2	18·6	15·5	10·5	6·1	5·9
14	5·0	5·1	4·9	6·8	10·8	13·5	15·3	14·3	14·4	10·5	6·5	5·7
15	4·2	6·5	5·2	7·5	11·8	13·7	13·5	15·3	14·4	10·5	5·8	4·6
16	4·3	6·0	5·7	6·6	12·1	14·5	13·1	15·8	15·3	10·4	5·5	6·6
17	4·2	5·1	6·1	6·9	12·8	14·5	15·5	16·6	14·3	9·5	6·8	5·5
18	4·2	5·0	5·0	7·8	12·4	14·8	14·4	15·8	15·7	9·4	6·6	5·9
19	4·1	5·4	5·4	6·7	11·5	15·3	15·5	17·8	15·4	9·4	7·1	6·2
20	3·5	5·3	5·6	6·5	10·8	13·3	13·2	16·3	15·5	9·5	7·1	6·2
21	4·1	4·7	5·2	7·1	10·5	13·8	14·3	17·3	15·6	10·3	7·0	5·3
22	4·3	5·0	5·0	6·8	10·6	13·8	14·0	18·9	14·8	9·5	7·5	5·9
23	5·0	5·2	5·4	6·9	10·9	14·1	14·8	20·5	15·1	9·3	6·4	3·5
24	4·4	5·1	4·8	6·9	11·7	15·0	14·8	18·9	15·0	9·0	7·0	6·2
25	2·8	5·2	5·8	7·1	12·0	14·8	14·7	19·5	12·5	9·0	6·5	5·1
26	4·3	5·2	5·8	8·0	13·1	14·8	13·7	20·2	12·5	9·3	8·2	3·7
27	2·0	5·1	6·2	8·8	12·2	14·4	15·4	19·2	12·0	9·3	6·5	3·8
28	5·1	6·1	6·2	8·8	11·9	15·5	16·4	19·5	11·5	9·0	6·9	5·7
29	3·0	5·2	5·8	9·9	12·0	15·6	16·6	18·0	11·6	8·7	6·7	4·4
30	2·9	....	6·4	10·2	12·8	13·0	16·4	16·2	11·6	8·8	6·1	4·5
31	1·2	....	6·7	....	12·5	....	17·0	14·3	....	7·6	....	5·0

TABLE II—*Continued.*

1917.

—	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5·3	3·4	5·8	5·6	8·3	12·8	15·4	15·7	15·7	11·2	8·7	8·1
2	5·3	3·4	5·5	5·5	8·8	12·6	16·6	16·0	15·9	11·1	8·7	7·7
3	5·6	5·0	5·0	6·8	9·2	12·7	17·6	16·1	16·6	11·5	9·0	7·1
4	6·0	4·5	5·1	6·3	9·5	12·2	15·0	16·7	16·5	11·5	8·4	6·7
5	5·7	6·0	6·2	6·5	9·7	13·0	15·6	16·7	14·2	11·3	8·4	5·9
6	5·6	5·8	5·5	5·8	9·5	13·5	13·7	16·5	14·0	12·2	8·4	7·1
7	5·5	6·0	5·3	6·0	8·8	12·8	14·9	15·5	14·0	12·5	8·0	6·1
8	5·4	5·2	5·5	6·6	9·9	14·0	16·3	15·7	14·0	13·1	7·8	6·5
9	6·5	4·2	5·5	6·7	10·5	11·0	16·6	16·5	13·8	12·0	8·2	8·1
10	6·1	4·9	5·0	6·6	11·3	12·7	16·4	17·0	14·5	12·2	8·0	7·1
11	6·3	5·7	5·5	6·5	10·4	12·4	17·5	17·9	14·6	12·2	8·3	7·0
12	5·3	5·4	5·4	6·2	9·5	12·4	17·5	17·8	14·5	12·4	8·4	6·7
13	4·5	5·7	5·1	6·2	10·0	12·6	18·1	17·9	10·1	11·6	9·4	6·6
14	4·3	5·6	4·5	6·5	9·7	14·8	17·6	17·9	10·9	11·6	9·5	6·7
15	3·8	5·7	5·5	6·6	10·7	15·0	17·5	18·3	11·8	11·5	8·8	7·0
16	4·3	5·5	5·5	6·8	9·7	15·1	17·2	18·4	10·7	11·2	7·0	7·8
17	4·5	5·5	5·5	7·1	10·3	15·0	16·6	18·8	12·3	11·5	7·7	6·7
18	4·2	4·8	5·6	7·6	10·5	14·5	17·2	20·0	13·1	10·8	9·1	6·6
19	4·0	4·6	5·4	7·0	10·5	15·2	16·9	18·7	13·1	11·1	8·5	7·2
20	5·6	5·1	5·5	7·0	11·1	15·7	17·8	16·1	13·1	10·4	9·1	6·4
21	6·0	3·6	5·7	6·2	11·5	14·0	17·0	12·2	12·8	10·4	9·3	6·3
22	5·0	2·8	6·0	7·0	11·6	11·7	14·7	15·5	12·3	10·0	9·6	5·7
23	5·6	5·5	5·7	7·2	11·2	12·1	14·5	16·4	13·2	10·1	9·1	5·5
24	5·7	5·1	6·0	8·0	11·1	12·2	16·0	16·6	13·1	9·5	9·5	5·0
25	5·2	5·1	5·8	7·9	11·2	13·2	16·9	16·4	13·0	9·5	8·7	5·7
26	6·0	5·0	5·5	8·5	11·8	14·6	17·5	16·4	13·0	9·8	7·0	5·6
27	5·8	5·1	5·5	8·5	11·9	15·7	17·9	16·6	10·0	9·0	8·6	5·3
28	6·0	4·9	5·9	8·7	13·0	15·7	17·4	17·6	10·1	8·6	8·3	4·9
29	4·9	....	5·5	9·0	12·5	15·9	14·5	17·2	10·4	8·6	7·4	5·4
30	5·4	....	5·4	8·5	13·7	15·5	14·4	15·6	11·0	9·4	7·7	6·2
31	4·0	....	6·0	....	14·0	....	14·1	15·5	....	8·7	....	6·1

TABLE II—*Continued.*

1918.

—	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	6·8	3·9	5·6	6·0	9·8	12·5	15·0	16·6	16·9	13·8	9·6	8·3
2	7·0	4·5	6·1	6·2	10·7	12·2	15·2	18·4	17·0	13·9	9·5	8·6
3	6·9	5·5	6·8	6·1	10·8	13·5	14·8	17·6	17·0	13·6	9·5	7·5
4	7·1	5·7	6·0	6·9	10·5	12·8	15·0	14·9	17·9	13·7	9·7	6·9
5	7·5	5·5	5·6	7·9	10·0	14·1	15·0	15·0	17·9	13·3	9·7	5·7
6	6·5	6·0	5·9	7·8	9·3	15·0	15·8	17·0	18·4	10·2	9·0	6·9
7	6·6	6·2	5·6	8·6	10·4	14·7	13·0	18·4	18·0	10·2	8·8	7·1
8	6·7	5·2	5·0	8·7	10·7	13·8	14·8	17·4	17·9	10·2	9·2	7·0
9	5·6	5·7	4·6	7·8	11·2	12·4	15·9	18·1	17·4	12·3	9·3	6·6
10	5·4	5·6	4·8	7·0	11·5	12·4	16·2	17·0	16·6	12·3	9·0	7·8
11	5·8	6·1	5·6	7·5	12·0	11·2	14·8	15·7	15·8	12·1	8·3	6·0
12	5·6	6·6	5·1	7·4	12·2	14·4	14·4	16·3	16·7	10·5	8·9	7·0
13	6·2	5·7	5·3	6·5	12·2	15·6	15·7	16·1	17·2	10·0	8·4	7·5
14	6·3	5·1	5·6	7·7	12·0	13·1	16·8	16·6	16·6	11·0	8·0	7·3
15	5·5	4·2	5·1	6·5	12·6	13·2	17·8	17·0	17·2	11·2	8·0	5·5
16	5·5	4·2	5·9	6·4	12·2	15·3	18·1	16·7	17·2	11·8	7·2	5·1
17	5·8	4·7	5·7	7·5	12·3	15·2	18·5	15·8	17·2	11·4	8·1	5·0
18	6·2	5·0	5·6	7·3	11·0	13·4	18·7	15·1	17·2	11·9	8·6	6·5
19	5·0	4·6	5·1	8·2	11·5	14·0	18·1	15·4	17·0	11·4	9·0	7·0
20	4·1	3·9	6·4	8·6	10·8	15·2	16·2	15·7	17·0	11·0	9·0	8·2
21	5·0	5·0	5·7	8·8	11·6	15·7	15·9	15·0	16·2	11·0	8·3	8·2
22	4·7	4·5	6·1	8·9	12·5	15·7	16·4	15·5	16·1	11·2	6·9	7·1
23	5·5	4·9	5·1	9·6	11·2	16·2	17·5	14·5	16·1	10·6	7·6	7·3
24	5·7	4·7	5·9	8·5	12·1	16·9	17·8	15·2	15·8	10·3	7·7	7·4
25	5·6	4·9	6·5	8·4	11·4	14·5	15·0	15·2	15·5	10·6	6·7	7·2
26	5·0	4·9	5·4	9·3	11·7	15·0	14·6	18·6	14·8	10·3	8·2	5·9
27	5·3	5·5	6·0	9·6	12·6	15·7	16·1	18·8	14·6	10·1	7·6	7·7
28	5·2	4·8	5·8	9·1	14·0	15·4	16·3	17·7	13·8	10·5	7·8	7·9
29	5·5	....	7·3	9·8	13·1	15·4	16·3	17·6	14·4	10·0	8·2	8·6
30	3·7	....	6·5	10·8	13·2	14·5	16·6	16·5	14·9	10·0	7·6	7·5
31	3·8	....	6·5	....	13·4	....	17·2	16·5	....	9·1	....	6·2

TABLE II—*Continued.*

1919.

—	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	7·3	2·5	6·2	8·4	10·7							
2	6·9	4·2	5·0	7·6	11·2							
3	5·5	4·9	6·3	9·1	10·8							
4	5·3	6·4	6·4	8·5	10·7							
5	7·4	6·2	7·2	8·2	10·6							
6	6·5	6·8	6·7	7·8	11·1							
7	6·2	5·5	6·1	8·6	12·0							
8	5·5	6·0	6·2	8·0	12·8							
9	6·3	8·2	6·5	7·5	11·4							
10	6·5	6·5	6·2	8·2	11·3							
11	5·9	6·1	6·7	7·8	11·7							
12	6·8	5·5	6·2	7·3	11·3							
13	7·9	5·8	6·5	7·8	11·0							
14	7·8	6·3	7·0	7·7	11·2							
15	7·5	6·2	6·1	7·2	11·2							
16	7·0	6·9	7·1	8·3	11·2							
17	7·2	7·0	6·9	9·2	10·7							
18	7·5	6·3	7·5	9·8	10·3							
19	7·8	6·0	6·5	9·6	10·4							
20	5·3	6·8	7·2	7·8	11·0							
21	6·9	6·2	6·8	8·7	13·0							
22	7·1	6·4	6·1	9·3	14·0							
23	7·3	6·1	6·7	8·5	13·0							
24	5·9	5·2	6·9	10·6	12·6							
25	7·0	5·0	6·5	10·1	12·1							
26	7·2	7·0	6·6	9·8	10·0							
27	6·5	6·5	7·2	10·6	10·0							
28	7·0	5·9	8·0	11·2	10·3							
29	6·0		7·9	10·7	12·1							
20	4·5		9·2	10·3	12·8							
31	6·5		8·7		12·1							

TABLE III.

1914.

—	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1						10,184	10,140	10,190	10,186	10,197	10,165	10,152
2						10,182	10,155	10,197	10,196	10,196	10,125	10,175
3						10,191		10,198	10,192	10,208	10,114	10,168
4						10,190		10,204	10,203	10,206	10,204	10,202
5							10,177	10,182	10,207	10,202	10,204	10,191
6						10,217	10,189	10,211	10,207	10,217	10,090	10,188
7						10,209		10,209	10,207	10,204	10,159	10,176
8						10,207		10,209	10,216	10,206	10,151	10,181
9						10,216		10,180	10,219	10,208	10,192	10,198
10						10,215	10,185	10,176	10,219	10,206	10,124	10,201
11						10,216	10,158	10,180		10,212	10,038	10,197
12						10,169	10,157	10,187	10,208	10,217	10,151	10,203
13						10,166	10,161	10,190	10,185	10,185	10,179	10,203
14						10,205	10,165	10,192	10,184	10,103	10,181	10,205
15						10,175	10,208		10,188	10,096	10,166	10,205
16						10,168	10,187	10,196	10,193	10,146	10,177	10,207
17						10,174	10,179	10,202	10,190	10,192	10,179	10,207
18						10,188	10,173	10,193	10,197	10,141	10,171	10,210
19						10,183	10,180		10,205	10,120	10,177	10,206
20						10,188	10,195	10,182	10,209	10,185	10,124	10,206
21						10,192	10,197	10,188	10,208	10,086	10,065	10,208
22						10,213	10,199	10,215	10,207	10,143	10,132	10,204
23						10,212	10,204	10,201	10,183	10,163	10,176	10,205
24						10,205	10,216	10,195	10,186	10,164	10,156	10,205
25						10,174	10,214	10,188	10,193	10,135	10,136	10,208
26						10,208	10,210	10,195	10,198	10,129	10,138	10,208
27						10,207	10,217	10,200	10,198	10,153	10,109	10,182
28						10,200	10,199	10,203	10,207	10,181	10,205	10,208
29						10,137	10,189	10,206	10,209	10,184	10,156	10,195
30						10,144	10,185	10,208	10,218	10,186	10,173	10,204
31							10,184	10,201		10,184		10,208

TABLE III—*Continued.*

1915.

—	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	10,199	10,206	10,212	10,187	10,214	10,196	10,193	10,219	10,197	10,217	10,196	10,130
2	10,209	10,207	10,212	10,174	10,214	10,196	10,201	10,224	10,206	10,219	10,202	10,148
3	10,209	10,185	10,177	10,102	10,212	10,197	10,206	10,227	10,185	10,217	10,192	10,160
4	10,198	10,206	10,212	10,113	10,215	10,195	10,206	10,233	10,156	10,214	10,191	10,158
5	10,186	10,206	10,197	10,109	10,216	10,196	10,213	10,227	10,177	10,216	10,211	10,130
6	10,175	10,191	10,204	10,114	10,216	10,201	10,223	10,177	10,182	10,214	10,212	10,130
7	10,188	10,176	10,207	10,159	10,217	10,209	10,223	10,156	10,193	10,214	10,212	10,143
8	10,180	10,162	10,212	10,189	10,216	10,216	10,224	10,173	10,209	10,214	10,209	10,108
9	10,209	10,207	10,212	10,198	10,216	10,216	10,229	10,185	10,189	10,214	10,212	10,180
10	10,205	10,182	10,212	10,205	10,215	10,213	10,213	10,184	10,174	10,218	10,211	10,122
11	10,188	10,123	10,212	10,213	10,200	10,216	10,195	10,184	10,164	10,218	10,211	10,106
12	10,202	10,186	10,212	10,178	10,215	10,216	10,203	10,186	10,175	10,216	10,214	10,140
13	10,150	10,207	10,212	10,188	10,215	10,216	10,219	10,157	10,183	10,215	10,207	10,129
14	10,185	10,166	10,209	10,213	10,199	10,218	10,188	10,163	10,188	10,216	10,204	10,213
15	10,206	10,201	10,204	10,214	10,197	10,219	10,203	10,161	10,202	10,217	10,214	10,213
16	10,203	10,206	10,185	10,205	10,175	10,196	10,191	10,182	10,201	10,217	10,208	10,179
17	10,138	10,207	10,179	10,215	10,162	10,182	10,166	10,200	10,196	10,216	10,209	10,211
18	10,196	10,207	10,212	10,215	10,163	10,193	10,155	10,183	10,170	10,217	10,188	10,201
19	10,206	10,206	10,212	10,215	10,183	10,193	10,150	10,165	10,180	10,217	10,207	10,185
20	10,206	10,206	10,198	10,214	10,193	10,194	10,152	10,164	10,190	10,217	10,159	10,149
21	10,205	10,206	10,192	10,214	10,215	10,205	10,151	10,176	10,197	10,217	10,186	10,161
22	10,205	10,206	10,193	10,214	10,212	10,205	10,168	10,183	10,199	10,216	10,208	10,136
23	10,206	10,198	10,212	10,214	10,203	10,193	10,189	10,189	10,201	10,218	10,209	10,206
24	10,205	10,182	10,213	10,215	10,215	10,204	10,200	10,159	10,204	10,170	10,159	10,141
25	10,206	10,206	10,213	10,214	10,216	10,216	10,202	10,205	10,210	10,216	10,207	10,209
26	10,205	10,206	10,212	10,214	10,201	10,146	10,205	10,186	10,214	10,210	10,208	10,209
27	10,206	10,109	10,210	10,214	10,215	10,156	10,208	10,179	10,215	10,216	10,210	10,141
28	10,206	10,204	10,216	10,214	10,217	10,165	10,222	10,182	10,217	10,183	10,124	10,209
29	10,206	....	10,188	10,214	10,181	10,176	10,224	10,177	10,217	10,137	10,140	10,209
30	10,206	....	10,182	10,214	10,176	10,180	10,215	10,159	10,213	10,167	10,151	10,147
31	10,206	....	10,158	....	10,178	....	10,225	10,202	....	10,216	....	10,206

TABLE III—*Concluded.*

1916.

—	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	10,191	10,209	10,209	10,211	10,193	10,199	10,133	10,183	10,210	10,212	10,210	10,207
2	10,189	10,154	10,193	10,209	10,188	10,211	10,080	10,191	10,211	10,214	10,210	10,208
3	10,210	10,209	10,156	10,167	10,209	10,220	10,114	10,122	10,178	10,213	10,209	10,209
4	10,210	10,191	10,211	10,213	10,193	10,214	10,123	10,113	10,145	10,212	10,208	10,208
5	10,210	10,209	10,211	10,208	10,136	10,187	10,124	10,116	10,153	10,212	10,209	10,208
6	10,210	10,207	10,211	10,192	10,179	10,181	10,141	10,136	10,150	10,212	10,208	10,209
7	10,209	10,209	10,209	10,210	10,211	10,199	10,142	10,155	10,155	10,213	10,211	10,208
8	10,198	10,211	10,211	10,181	10,194	10,211	10,146	10,165	10,196	10,214	10,210	10,208
9	10,210	10,203	10,170	10,183	10,211	10,207	10,156	10,176	10,173	10,212	10,211	10,209
10	10,214	10,209	10,124	10,194	10,211	10,203	10,170	10,176	10,178	10,213	10,211	10,210
11	10,176	10,209	10,168	10,212	10,173	10,215	10,182	10,136	10,180	10,213	10,209	10,208
12	10,211	10,124	10,177	10,173	10,198	10,215	10,188	10,139	10,188	10,212	10,210	10,208
13	10,213	10,158	10,211	10,177	10,202	10,214	10,153	10,157	10,193	10,212	10,210	10,209
14	10,213	10,123	10,187	10,212	10,187	10,216	10,139	10,191	10,189	10,212	10,209	10,210
15	10,213	10,167	10,125	10,202	10,194	10,214	10,163	10,193	10,191	10,212	10,208	10,209
16	10,213	10,132	10,164	10,145	10,205	10,217	10,184	10,184	10,193	10,212	10,209	10,209
17	10,213	10,105	10,211	10,198	10,209	10,218	10,175	10,169	10,195	10,213	10,210	10,209
18	10,213	10,099	10,209	10,201	10,160	10,214	10,139	10,153	10,201	10,213	10,210	10,194
19	10,213	10,104	10,197	10,206	10,188	10,203	10,175	10,164	10,197	10,213	10,210	10,209
20	10,210	10,115	10,188	10,198	10,187	10,212	10,185	10,168	10,193	10,213	10,209	10,209
21	10,209	10,120	10,201	10,190	10,206	10,198	10,120	10,170	10,196	10,212	10,210	10,208
22	10,211	10,091	10,193	10,203	10,211	10,200	10,125	10,164	10,202	10,212	10,210	10,210
23	10,211	10,207	10,187	10,206	10,211	10,212	10,166	10,155	10,205	10,212	10,209	10,208
24	10,211	10,209	10,175	10,183	10,202	10,200	10,166	10,155	10,197	10,212	10,210	10,210
25	10,212	10,143	10,180	10,191	10,204	10,200	10,157	10,155	10,214	10,211	10,211	10,208
26	10,211	10,207	10,179	10,193	10,198	10,193	10,163	10,157	10,215	10,211	10,211	10,178
27	10,181	10,209	10,211	10,191	10,212	10,155	10,168	10,162	10,215	10,211	10,209	10,209
28	10,213	10,209	10,180	10,195	10,214	10,119	10,127	10,174	10,213	10,211	10,210	10,210
29	10,199	10,209	10,211	10,201	10,206	10,141	10,163	10,184	10,212	10,211	10,210	10,209
30	10,196	....	10,199	10,201	10,189	10,189	10,154	10,194	10,213	10,211	10,209	10,206
31	10,169	....	10,205	....	10,189	....	10,144	10,204	....	10,212	....	10,201

TABLE III—*Continued.*

1917.

—	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	10,210	10,210	10,210	10,209	10,102	10,205	10,168	10,183	10,209	10,211	10,214	10,210
2	10,201	10,210	10,210	10,209	10,152	10,141	10,164	10,137	10,208	10,211	10,213	10,210
3	10,198	10,210	10,209	10,210	10,205	10,131	10,112	10,157	10,213	10,211	10,213	10,206
4	10,190	10,189	10,209	10,207	10,211	10,151	10,169	10,161	10,214	10,211	10,213	10,199
5	10,205	10,191	10,210	10,199	10,159	10,174	10,175	10,186	10,215	10,174	10,213	10,189
6	10,208	10,210	10,210	10,181	10,145	10,171	10,201	10,189	10,213	10,199	10,213	10,208
7	10,173	10,126	10,209	10,169	10,186	10,159	10,142	10,197	10,215	10,209	10,211	10,197
8	10,169	10,058	10,210	10,178	10,187	10,179	10,112	10,200	10,216	10,210	10,208	10,193
9	10,210	10,106	10,210	10,212	10,211	10,177	10,112	10,175	10,216	10,209	10,210	10,211
10	10,095	10,188	10,210	10,179	10,172	10,149	10,122	10,175	10,175	10,211	10,209	10,210
11	10,209	10,210	10,210	10,191	10,105	10,156	10,139	10,172	10,169	10,207	10,210	10,209
12	10,189	10,161	10,210	10,167	10,138	10,144	10,150	10,173	10,165	10,208	10,208	10,210
13	10,210	10,209	10,208	10,189	10,189	10,163	10,149	10,175	10,197	10,212	10,208	10,209
14	10,209	10,171	10,209	10,209	10,213	10,179	10,151	10,177	10,212	10,210	10,208	10,210
15	10,209	10,207	10,209	10,210	10,191	10,166	10,166	10,179	10,213	10,212	10,208	10,200
16	10,209	10,210	10,210	10,158	10,121	10,132	10,192	10,183	10,213	10,211	10,210	10,209
17	10,209	10,210	10,210	10,210	10,121	10,170	10,148	10,188	10,210	10,211	10,211	10,138
18	10,210	10,148	10,210	10,211	10,202	10,174	10,180	10,188	10,200	10,211	10,211	10,120
19	10,209	10,209	10,198	10,188	10,212	10,184	10,186	10,194	10,205	10,211	10,209	10,155
20	10,210	10,209	10,192	10,200	10,213	10,135	10,174	10,196	10,195	10,211	10,211	10,118
21	10,210	10,208	10,210	10,193	10,209	10,175	10,179	10,214	10,211	10,212	10,209	10,135
22	10,209	10,210	10,210	10,174	10,210	10,212	10,196	10,200	10,210	10,212	10,112	10,189
23	10,210	10,210	10,208	10,211	10,212	10,213	10,198	10,150	10,213	10,212	10,099	10,203
24	10,210	10,210	10,210	10,211	10,213	10,154	10,178	10,174	10,213	10,211	10,179	10,208
25	10,209	10,210	10,210	10,113	10,213	10,097	10,166	10,181	10,213	10,212	10,211	10,208
26	10,210	10,210	10,209	10,212	10,190	10,101	10,173	10,192	10,213	10,212	10,210	10,208
27	10,209	10,210	10,209	10,210	10,212	10,103	10,173	10,184	10,212	10,213	10,211	10,154
28	10,210	10,210	10,210	10,209	10,215	10,113	10,179	10,190	10,212	10,213	10,211	10,164
29	10,210	....	10,210	10,202	10,214	10,137	10,194	10,165	10,212	10,213	10,209	10,133
30	10,210	....	10,210	10,187	10,204	10,159	10,194	10,206	10,212	10,213	10,211	10,041
31	10,210	....	10,210	....	10,206	....	10,184	10,202	....	10,213	....	10,119

TABLE III—*Continued.*

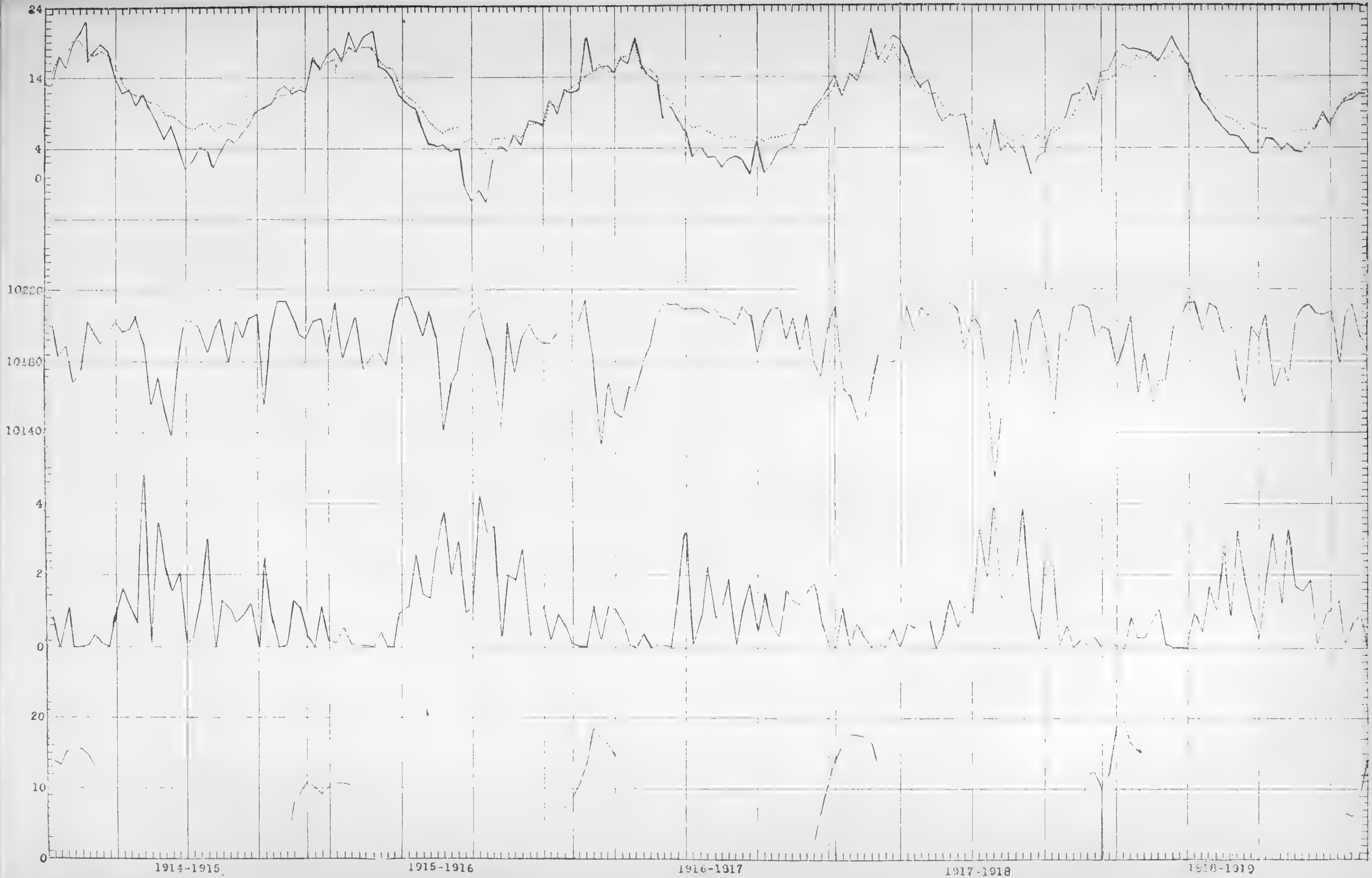
1918.

—	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	10,127	10,208	10,209	10,208	10,212	10,182	10,198	10,188	10,199	10,218	10,209	10,210
2	10,069	10,207	10,209	10,209	10,212	10,191	10,206	10,131	10,201	10,217	10,212	10,211
3	10,111	10,207	10,209	10,207	10,212	10,197	10,212	10,137	10,202	10,217	10,212	10,165
4	10,109	10,193	10,209	10,209	10,212	10,186	10,212	10,153	10,202	10,216	10,212	10,138
5	10,109	10,104	10,208	10,210	10,212	10,192	10,210	10,200	10,201	10,215	10,209	10,130
6	10,112	10,129	10,209	10,210	10,211	10,196	10,205	10,155	10,197	10,213	10,210	10,133
7	10,125	10,195	10,209	10,200	10,212	10,194	10,211	10,155	10,199	10,213	10,207	10,151
8	10,096	10,138	10,207	10,176	10,212	10,205	10,214	10,160	10,200	10,203	10,210	10,173
9	10,157	10,135	10,207	10,186	10,212	10,210	10,208	10,157	10,210	10,199	10,211	10,173
10	10,099	10,107	10,209	10,158	10,212	10,213	10,173	10,176	10,216	10,205	10,211	10,205
11	10,095	10,124	10,210	10,175	10,213	10,213	10,195	10,194	10,220	10,214	10,195	10,125
12	10,201	10,206	10,209	10,184	10,214	10,153	10,202	10,149	10,196	10,213	10,201	10,206
13	10,208	10,194	10,209	10,210	10,212	10,150	10,209	10,152	10,196	10,213	10,185	10,176
14	10,200	10,207	10,208	10,211	10,214	10,186	10,110	10,153	10,195	10,209	10,210	10,151
15	10,198	10,200	10,195	10,210	10,197	10,187	10,124	10,160	10,203	10,156	10,187	10,132
16	10,123	10,153	10,178	10,210	10,214	10,173	10,125	10,160	10,203	10,190	10,169	10,073
17	10,154	10,207	10,114	10,212	10,214	10,170	10,132	10,174	10,203	10,184	10,181	10,153
18	10,124	10,209	10,149	10,212	10,212	10,176	10,173	10,190	10,207	10,191	10,193	10,174
19	10,182	10,208	10,112	10,211	10,206	10,200	10,161	10,181	10,210	10,207	10,211	10,188
20	10,091	10,209	10,173	10,212	10,193	10,166	10,185	10,165	10,215	10,214	10,209	10,210
21	10,149	10,209	10,165	10,212	10,170	10,167	10,200	10,170	10,206	10,213	10,210	10,211
22	10,129	10,209	10,158	10,211	10,175	10,178	10,188	10,175	10,214	10,212	10,182	10,209
23	10,187	10,209	10,159	10,206	10,175	10,181	10,126	10,195	10,215	10,212	10,191	10,209
24	10,191	10,209	10,133	10,211	10,212	10,187	10,145	10,201	10,219	10,212	10,209	10,210
25	10,205	10,209	10,133	10,211	10,189	10,213	10,188	10,153	10,217	10,213	10,160	10,209
26	10,206	10,209	10,144	10,211	10,198	10,210	10,205	10,137	10,209	10,212	10,211	10,175
27	10,207	10,210	10,155	10,212	10,210	10,183	10,182	10,148	10,216	10,212	10,211	10,192
28	10,201	10,209	10,126	10,211	10,199	10,190	10,205	10,167	10,212	10,211	10,212	10,211
29	10,207	....	10,164	10,212	10,200	10,190	10,204	10,173	10,212	10,212	10,205	10,211
30	10,199	....	10,209	10,213	10,200	10,203	10,193	10,195	10,211	10,212	10,209	10,210
31	10,207	....	10,207	....	10,185	....	10,132	10,198	....	10,210	....	10,195

TABLE III—*Concluded.*

1919.

—	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	10,201	10,177	10,211	10,198	10,212	....	....	....	....	....	....	
2	10,208	10,120	10,166	10,179	10,212	....	....	....	....	....	....	
3	10,167	10,182	10,225	10,193	10,213	....	....	....	....	....	....	
4	10,164	10,202	10,230	10,227	10,213	....	....	....	....	....	....	
5	10,161	10,218	10,231	10,222	10,213	....	....	....	....	....	....	
6	10,199	10,223	10,196	10,232	10,212	....	....	....	....	....	....	
7	10,207	10,218	10,210	10,217	10,213	....	....	....	....	....	....	
8	10,220	10,185	10,220	10,222	10,214	....	....	....	....	....	....	
9	10,205	10,163	10,230	10,150	10,212	....	....	....	....	....	....	
10	10,200	10,144	10,202	10,195	10,211	....	....	....	....	....	....	
11	10,174	10,119	10,219	10,227	10,205	....	....	....	....	....	....	
12	10,197	10,149	10,186	10,183	10,212	....	....	....	....	....	....	
13	10,224	10,177	10,218	10,232	10,213	....	....	....	....	....	....	
14	10,207	10,172	10,226	10,227	10,214	....	....	....	....	....	....	
15	10,219	10,129	10,211	10,221	10,212	....	....	....	....	....	....	
16	10,204	10,196	10,212	10,210	10,214	....	....	....	....	....	....	
17	10,181	10,219	10,202	10,197	10,214	....	....	....	....	....	....	
18	10,172	10,210	10,219	10,198	10,213	....	....	....	....	....	....	
19	10,136	10,156	10,225	10,197	10,213	....	....	....	....	....	....	
20	10,133	10,219	10,145	10,179	10,212	....	....	....	....	....	....	
21	10,180	10,196	10,219	10,195	10,179	....	....	....	....	....	....	
22	10,187	10,214	10,218	10,193	10,176	....	....	....	....	....	....	
23	10,197	10,230	10,219	10,170	10,181	....	....	....	....	....	....	
24	10,145	10,186	10,231	10,191	10,150	....	....	....	....	....	....	
25	10,213	10,205	10,220	10,128	10,184	....	....	....	....	....	....	
26	10,121	10,206	10,174	10,138	10,213	....	....	....	....	....	....	
27	10,148	10,211	10,201	10,209	10,211	....	....	....	....	....	....	
28	10,172	10,218	10,198	10,177	10,213	....	....	....	....	....	....	
29	10,221	....	10,220	10,187	10,185	....	....	....	....	....	....	
30	10,153	....	10,222	10,212	10,175	....	....	....	....	....	....	
31	10,211	....	10,179	....	10,194	....	....	....	....	....	....	


24
14
4
0
10220
10180
10140
4
2
0
20
10
0
1914-1915
1915-1916
1916-1917
1917-1918
1918-1919

IV.

Plankton Diatoms, their Distribution and Bathymetric Range in St. Andrews Waters.

BY

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(With three plates.)

INTRODUCTION.

If a bottle of water be drawn from the sea and examined with the naked eye nothing presents itself but the clear, sparkling liquid; but if this same sample be centrifuged for half an hour and the residue examined under the microscope, it will be found that many organisms of unparalleled beauty have been extracted. Chief among these are the diatoms, unicellular plants, exquisite in beauty of symmetry and design. The object of the investigations recorded in the following pages is to add some facts to the present knowledge of these interesting forms.

Collections of material were made throughout the year from October, 1916 to October, 1917, at various points in Passamaquoddy bay and the adjoining waters of the the bay of Fundy. Careful examination of these has revealed the presence of eighty-two species, representative of twenty-six genera. Material collected during the different months was found to vary greatly. Attention was, therefore, given to the seasonal distribution and relative abundance of the many forms. Ordinary tows were taken at the surface and at a depth of from five to six metres, but, during the summer of 1917, a series of samples was drawn from certain stations at various definitely recorded depths, and the contents examined in order to ascertain the bathymetric range of species.

Eighty-two species were found, and figures are furnished of those which are rare, or, owing to their similarity, difficult to classify. The system of classification used is that introduced by W. L. Smith and followed by Van Heurck (1) and by the Challenger Report (3).

I desire to take this opportunity of expressing my thanks to Dr. A. Willey, under whose guidance the problem was commenced; to Dr. A. G. Huntsman, Director of the Biological Station, and to his assistants, for their careful attention to the collection of material; and to Prof. C. M. Derick for assistance and suggestions, which she has kindly given.

Locality and Collection of Material.

Passamaquoddy bay is situated at the south west corner of New Brunswick, where it serves as a boundary between that province and the state of Maine. Into it empty the waters of the St. Croix river; and its waters are in turn mingled with those of the bay of Fundy by the ever-changing tides which sometimes reach a height of twenty-four feet. A group of islands, of which the largest are Deer and Campo Bello, form a partial barrier, through which the tides flow swiftly and with force.

Collections were made with more or less regularity throughout the year at each of the seven stations marked on the appended map: Prince Stations 1, 3, 4, 5, 6, 9, and 10. Particular attention was given to tows taken at Station 6, which it will be noted is at the mouth of the St. Croix river and directly opposite to the Atlantic Biological Station. Here material was obtained with great regularity: at first twice a week and later, when it was ascertained that changes in the content were not rapid, weekly. All collections made were taken in a net of No. 20 silk bolting cloth. The same net was used on all occasions, and was towed for twenty minutes behind a boat, the speed of which was kept as uniform as possible for all the tows. Culture material was immediately emptied into a large jar of water; material for examination was preserved in two to three per cent formalin.

Seasonal Distribution and Relative Abundance.

Station 6.—Tows, as recorded above, were taken twice a week at the surface and at a depth of from 5 to 6 metres during the months of October and November. Later weekly collections were deemed sufficient, and during the winter, material was gathered even less frequently. Owing to a misunderstanding only surface tows were made for a few weeks after the first of May. Enough has been obtained, however, to give an accurate idea of the monthly possibilities. Tables I to IV give a record of representative five-metre tows throughout the year at Station 6; and from these the gradual increase and disappearance or general constancy of the different forms can be traced. Since, with the counting apparatus employed, it was possible to use only a

TABLE I.

Station 6. October—December. 5m. Tows.

—	October.					November.		December.			
	6	12	16	24	27	7	15	4	13	19	27
Navicula				2,000			666		300		
P. fasciola	3,000	2,000	50	50	50	2,000	1,333	800	300	600	
Pl. angulatum	3,000	2,000	50		1,333	2,000	666	500	2,000	1,400	200
Pl. strigosum	3,000						1,333	200	400		400
Pl. Balticum							666	200	200		
Pl. formosum								200	100		200
Asterionella					5,333				200		
Synedra		4,000	2,000					100	300		
Tabellaria							50	600	4,500		
Rhabdonema									100		
Surirella								100	200	200	200
N. seriata	12,000	72,000	2,000	18,000	50						
N. closterium		2,000						50			
N. bilobata										200	
N. sigma										200	
Thal. nitzschioides	600	8,000							1,500		
Thal. longissima	522,000	92,000	8,000	2,000	50	2,000	2,000	100	800	1,000	
R. shrubsolei	141,000	188,000	156,000	72,000	10,666	2,000	666		100		
R. obtusa	15,000	20,000	2,000	50			666				
R. hebetata	12,000	2,000	2,000	2,000				100	100		
R. faeröensis		2,000	400			4,000					
Corethron		2,000									
Ditylium	99,000	82,000	38,000	48,000	9,333	12,000	3,333	50	200		
Ch. sp	3,000		2,000	6,000	1,333	4,000	50	100	100	200	
Ch. debile		14,000	50		2,666	50			1,000	1,800	
Ch. sociale	108,000	126,000	10,000								
Ch. Willei		16,000									
Ch. diadema		16,000	32,000	16,000		6,000		800			
Ch. laciniosum	3,000	12,000	16,000	50	50	50			400		
Ch. constrictum				50					400		
Ch. decipiens	3,000	8,000	2,000	50	50	50					
Ch. criophilum		4,000									
Skeletonema									2,500		
Mel. Borreri								50			
Mel. hyperborea								50			
Mel. sulcata			8,000	4,000	1,333	6,000	4,000	1,100	5,400	6,600	2,800
Mel. crenulata										800	
Thalassiosira			50	4,000							
Cerataulina	9,000		6,000			6,000					
Bid. aurita						3,000			400	1,200	600
Bid. mobiliensis											200
Actinoptychus	3,000		50		50	2,000	666	200	400	800	800
Coscinodiscus	3,000	10,000	10,000	10,000	1,333	6,000	4,666	700	4,100	3,000	2,000

TABLE II.

Station 6. January—March. 5m. Tows.

—	January. 8	January. 13	January. 24	February. 9	February. 23	March. 8	March. 15	March. 23	March. 28
Navicula					100	100			
Pl. fasciola	400		100		100	200	100	600	300
Pl. angulatum	100		500	50	100		200	100	
Pl. strigosum	400	400	600	2,200	800	1,200	400	1,400	400
Pl. Balticum			100	200	100	100		100	100
Pl. formosum	100			100	100		100		100
Pl. elongatum				500					
Achnanthes						700		100	
Fragilaria				200					
Tabellaria				2,000			1,500	3,500	3,500
Grammatophora				400					
Rhabdonema	300		100	100	100		300	300	
Surirella			100	100		100			..
Campylodiscus			100	100			100		100
N. sigma	100			100					
Thal. nitzschioides	400	400	2,200	2,100	2,100	4,200	600	400	600
R. hebetata		100	600	100	100	300	200	300	100
Ch. debile				600		700	400	3,300	4,400
Ch. diadema	1,500		800	1,200	1,100	300			
Ch. laciniosum	600			800		300		500	4,200
Ch. decipiens	200		500	50					
Skeletonema	700	500	2,500	3,800		3,000	500	1,700	900
M. Borreri } *M. hyperborea* }					400	200	200	100	
M. sulcata	1,500	1,100	2,200	2,400	300	2,200	900		300
M. crenulata						400			
Thalassiosira				300	200	500	500	17,000	309,500
Biddulphia	400	100	1,100	200	1,500	9,900	20,300	19,300	18,900
Actinoptychus	200		200	100	100		100	200	100
Coscinodiscus	3,800	700	3,100	400	1,100	1,900	2,200	1,000	1,800

TABLE III.

Station 6.—April–July. 5m. Tows.

—	April. 7.	April. 14	April. 20	May. 1	June. 21	June. 25	July. 3	July. 11	July. 17	July. 23
Navicula	500					333	1,000			250
Pl. fasciola	2,500	2,000	1,666	50	3,333	333	500	1,000	750	250
Pl. angulatum	500		1,666		2,666	333	500	2,000	50	250
Pl. strigosum	5,750	2,500	1,666			333		1,000		
Pl. formosum	250	50					500			
Asterionella		50		50	8,000	7,666	2,500			
Synedra		1,000				333				
Fragilaria					6,666	2,666				
Tabellaria	13,750	50								
Grammatophora					2,666					
Rhabdonema	250					50				
Surirella					50					
Campylodiscus	500									
N. seriata							2,500	2,000	50	
N. closterium									750	50
Thal. nitzschioides	2,250	2,000	5,000		2,000	1,333	3,500	29,000	5,250	
R. hebetata	500	50		50	1,333	666	500			50
Ch. debile	30,000	36,500	255,000	40,000	418,000	106,333	3,420,000	3,600,000	4,267,900	622,000
Ch. sociale	36,750		95,000	207,500	8,666	50				
Ch. diadema	6,500	9,500	13,333	46,250	16,000		40,000	11,000	96,000	
Ch. laciniosum	12,250	15,000	8,333	23,750	10,000	15,333	73,000	102,000	75,750	5,000
Ch. constrictum									4,500	
Ch. decipiens					3,333	12,000	5,500	3,000	50	50
Ch. contortum									27,000	1,500
Ch. convolutum									15,000	
Skeletonema	17,500	10,500	41,666	6,250			7,500	240,000	48,750	50
M. Borreri } *M. hyperborea* }	750	21,666								
M. sulcata	7,500			50	6,000	1,666	50	50		50
M. crenulata					50	5,666				
Thalassiosira	769,500	952,500	3,770,000	8,750,000	722,000	138,666	1,760,000	39,000	1,500	1,500
Leptocylindrus							7,500		12,000	1,500
Eucampia							50			
Biddulphia	59,750	48,500	305,000	83,750			500			
Actinoptychus		500								
Coscinodiscus	1,500	2,000	3,333	1,250		1,000		2,000		250

TABLE IV.

Station 6.—August-Oct. 5m. Tows.

—	August.					September.			Oct.
	2	8	14	20	28	6	13	20	5
Navicula	1,000			1,000			66		
Pl. fasciola	2,000				28		133	400	666
Pl. angulatum	1,000	250			28		66		333
Pl. strigosum							66	200	1,000
Pl. Balticum		50					66		
Pl. formosum		250							333
Asterionella							933	600	
Fragilaria				6,000					
Tabellaria						750			
Rhabdonema							66		333
N. seriata	8,000	500	16,666	11,000			1,133	1,600	21,333
N. closterium	3,000		1,666	1,000	28		400		333
Thal. nitzschioides	9,000	500	19,666	27,000	428		133	400	666
Thal. longissima					143	50		200	666
Bacillaria									1,000
R. hebetata	50	250	3,666	1,000	171	150	466	1,800	4,000
R. obtusa					28		66	406	3,333
R. faeröensis	7,000		666		28				
Ditylium								800	1,666
Ch. sp.	1,000	250					66	200	333
Ch. debile	7,000,000	6,625	440,000	810,000	455		866	1,000	
Ch. sociale	4,000		16,666	121,000	114	280,000		160,000	
Ch. Willei							466	1,200	
Ch. diadema		50			714		8,466	160,000	3,000
Ch. laciniosum	54,000	500	40,333	118,000	143	50	6,400	5,200	1,666
Ch. constrictum	7,000	1,750					133	800	
Ch. decipiens		50	5,666	46,000	55		200	400	11,000
Ch. contortum	2,400			6,000				800	
Ch. danicum					228	50	666	2,000	333
Ch. convolutum		50		1,000			200	400	
Skeletonema	61,000	750	2,666		428	300	1,466	1,200	13,666
M. sulcata	17,000	1,500	50	5,000	55		2,466	800	7,333
Thalassiosira	6,000	1,150	2,666	9,000	371		200	2,400	6,666
Leptocylindrus	3,000		2,333	40,000	85	50	2,000	11,200	333
Cerataulina		375	3,666	4,000					
Bid. aurita									333
Coscinodiscus		50	666	1,000	55		266	200	12,333

16mm. objective, I was unable to determine with accuracy species which are distinguished by minute details of structure, such as some of the Coscinodisci. In the tables I have, therefore, grouped together the Thalassiosirae and the allied species *Coscinosira polychorda;* and have included under their respective generic names all the Naviculae, Asterionellae, Surirellae, Campylodisci and Coscinodisci.

After the material of each tow had been examined and all the species recorded, a careful estimate of the numbers present was made in the following manner. The volume of water, in which the organisms had been preserved, was increased to from 50 to 500cc. according as the amount of material was slight or abundant. In each case the final volume was recorded. Counting was done by means of a Rafter cell as recommended by Moore (12). This consists of an ordinary glass microscope slide, on which is fastened a rectangular rim of metal 5 cm. x 2 cm. and 1 mm. in depth. This, therefore, when filled and covered with a slip contains 1 c.c. of liquid. To facilitate counting, a disc, on which was ruled a square, 1 mm. in area, was used in the eyepiece. The material was well stirred to insure a thorough mixing and to prevent the accumulation of heavy forms at the bottom. While still in motion 1 c.c. was quickly drawn off and placed in the cell. At least forty squares were counted in each preparation and several slides were used from each collection. From the forty or more squares counted the contents of each c.c. was reckoned; an average of the contents of the several cells was then taken and this multiplied by the number of c.c. in the prepared material is an estimate of the number of individuals present.

It will be noted that both in numbers and diversity of form the genus Chaetoceras stands far in the lead. In September eleven species are recorded. The ranks are then gradually thinned until during the winter only four species, *Ch. debile, diadema, laciniosum* and *decipiens* are found; and these are but scantily represented. The addition of *Ch. sociale* in the spring adds greatly to the numbers; and from July onwards the remaining forms appear. The great predominance of *Ch. debile,* which on August 2 gives the record count of 7,000,000 frustules, is to be noted. The graceful spiral chains of this species are a characteristic feature of summer gatherings. But the maximum for diversity of form is, as recorded above, in September.

The allied genera, Corethron, Ditylium and Rhizosolenia, also attain their maxima in the autumn. *Corethron criophilum* appears only occasionally; but the beautifully modelled *Ditylium Brightwelii* is a dominant plankton form from the end of September until the first of December. In the autumn four species of Rhizosolenia are abundant, but throughout the winter and until the following August only R. hebitata is found. McMurrich (13) has recorded a distinct spring maximum for *R. setigera* in 1915, but this was not repeated in 1917.

Another dominant autumn form is *Thalassiothrix longissima,* which attains a sudden maximum in October, but holds its position of prominence for but a brief period. Its allied species *T. nitzschioides* is present in varying, but never great numbers throughout the year.

A prevalence of free living, compact forms is to be noted in winter. Pleurosigma, but scantily represented during the autumn, presents six species in February. The only one, however, which can be said to be characteristic of any season is *P. strigosum,* which abounds from February until April. December brings in Rhabdonema and Surirella, and January the Campylodisci; *Actinoptychus undulatus* and the Coscinodisci persist and the latter presents an increase in the number of species. The majority of the more delicate forms, Leptocylindrus, Cerataulina, etc., fail; but filamentous forms are not entirely lacking, for *Skeletonema costatum* and *Melosira* are taken in practically every collection.

The prevailing spring forms are Biddulphia and Thalassiosira. The former is introduced in December and occurs in small numbers during the winter. It then gradually increases and attains a distinct maximum in the middle of March, after which its numbers decrease; and it is rarely found after May. For *B. sinensis* a similar maximum has been recorded by Ostenfeld (16) in the North sea, but it there prevailed throughout the summer and reached its height in November. Thalassiosira appears in February. Five species *T. gravida, nordenskioldii, hyalina, condensata and Coscinosira polychorda,* are grouped together in the tables. These dominate the plankton during April and May and on May 1 give the enormous total of 8,750,000 frustules.

It is seen that in general the autumn plankton is characterized by the presence of slender, elongated forms such as Thalassiothrix and Rhizosolenia, together with numerous species of Chaetoceras. The winter presents the solid, compact forms, while in spring and summer the long, graceful chains of Thalassiosira and Chaetoceras prevail. Other species appear occasionally, or are present in small numbers throughout the year, but at no time does any other form a characteristic, seasonal feature.

Station 3.—Station 3 is situated in the bay of Fundy, eleven miles southeast of Swallow Tail Light, Grand Manan. The results of monthly collections from the first of January to the end of July are recorded in Table V.

TABLE V.

Station 3.—January-July. 5m. Tows.

—	January 3.	February 8.	April 9.	May 4.	June 15.	July 4.	July 31.
Navicula						50	
Pl. angulatum	50						
Pl. strigosum	50	300	50				
Asterionella				1,800		200	1,400
N. seriata							600
N. closterium							1,000
Thal. nitzschioides	600		4,300	3,900		100	
R. shrubsolei		50					
R. hebetata	150	50	500	2,600	50	50	200
Corethron							200
Ch. debile			1,200	88,400		1,700	10,200
Ch. sociale				80,000			4,000,000
Ch. Willei							2,000
Ch. diadema	350	150	6,100	6,100	350	1,650	4,400
Ch. laciniosum				3,500		200	6,200
Ch. decipiens	150			500	200	1,450	6,800
Ch. danicum	50		100	100			
Ch. atlanticum			500	200			800
Ch. convolutum			200	800		100	20,000
Skeletonema			8,200	4,400			10,000
M. sulcata			200				
Thalassiosira			250,000	880,000	50	4,300	
Leptocylindrus						100	
Bid. aurita	100	50	1,200	500			
Bid. mobiliensis	50						
Actinoptychus	50	50					
Coscinodiscus	1,600	550	200	2,200	2,200	200	700

A comparison with the previous tables, immediately reveals the similarity of the flora to that of Station 6; but the more exposed waters of the bay of Fundy are clearly not so favourable to diatom production, for at all seasons the number, both of species and individuals, is greatly reduced. One new species, *Chaetoceras atlanticum,* is the only addition to the former records; and *Ch. danicum* is found to persist throughout the year.

Other stations.—The remaining stations lie in the order 10, 4, 9, 1 in the channel leading from the Biological Station toward the bay of Fundy; and Station 5 is in the bay of Fundy, midway between the northern end of Campo Bello and The Wolves. As only surface tows were taken at these points, the results recorded in Tables VI and VII do not bear comparison with those of the former tables. They serve in themselves, however, as a means of comparing the floras of the different localities. Two seasons, October and May, are presented. As the result of an accident the October material of Station 5 was lost before a count was made; the species found are, therefore, merely marked in the table, and I may add that I have recorded that the diatoms present were few.

As would be expected from the force of the constantly changing tides, it is the predominant forms which prevail over the whole area. No form attains its maximum at one particular point. Thus in May *Chatoceras debile, Ch. sociale and Thalassiosira* are always present in large numbers; and in the autumn the prevailing species *Thalassiothrix longissima, Rhizosolenia shrubsolei* and *Ditylium Brightwelii* are taken at every point. The constantly persistent forms, *Chaetoceras diadema* and *Coscinodiscus* appear uniformly at all stations at both seasons, while the less abundant forms are occasionally obtained at the various points Two species, *Isthmia nervosa* and *Isthmia enervis,* obtained at Station 1, are the only additions to the previous lists.

In brief we may conclude that with respect to seasonal distribution the members of the phytoplankton may be included in three groups: firstly, those species which

TABLE VI.

5m. Tows in May from Stations 6, 10, 4, 9, 1, 5, 3.

—	6	10	4	9	1	5	3
Navicula	400						
Pl. fasciola	400	800		200	200		
Pl. angulatum	400			200		250	
Pl. strigosum	50			200		250	
Pl. formosum	200						
Achnanthes	100						
Asterionella				400			1,800
Synedra	1,000						
Grammatophora				800			
Rhabdonema				400			
Thal. nitzschioides	3,000	2,000		400	800	1,750	3,900
Bacillaria					200		
R. hebetata	1,200	800	800		300	250	2,600
R. faeröensis	400	800					
Ch. debile	101,000	254,000	112,000	23,000	22,700	23,000	88,400
Ch. sociale	33,000	2,000	60,000	39,600	23,300	7,500	80,000
Ch. Willei		2,000					
Ch. diadema	19,000	50,800	12,000	9,400	5,600	5,500	6,100
Ch. laciniosum	10,000	11,200	1,600				3,500
Ch. decipiens		800					500
Ch. contortum		800					
Ch. danicum							100
Ch. atlanticum				600			200
Ch. convolutum	50						800
Skeletonema	50			11,200	4,300	10,000	4,400
M. sulcata	2,000					1,000	
Thalassiosira	81,500,000	6,000,000	8,400,000	2,900,000	570,000	266,000	880,000
Bacterosira				3,200			
Bid. aurita				5,600	2,200	22,500	500
Actinoptychus					100		
Coscinodiscus	400	800	2,400	200		750	2,200

TABLE VII.

5m. Tows of October from Stations 6, 10, 4, 9, 1, 5, 3.

—	6	10	4	9	1	5
Pl. fasciola	2,000	100			600	
Pl. angulatum		100				*
Pl. strigosum		100			300	
Pl. formosum				50	600	
Tabellaria					30,000	*
Rhabdonema					300	*
Surirella					600	
Campylodiscus		100			300	*
N. seriata	50	8,800	1,800	2,850	2,400	
N. closterium	2,000					
Thal. nitzschioides		300				
Thal. longissima	2,000	300	400	1,700	4,800	*
Bacillaria				100		
R. shrubsolei	66,000	80,000	30,000	7,340	4,200	*
R. obtusa	1,400	1,000	200	150		
R. alata		100		50	600	
R. hebetata	8,000	700	200	250		
R. faeröensis					900	
Ditylium	24,000	30,000	20,000	8,000	14,400	*
Ch. sp		100	200			
Ch. sociale	124,000					
Ch. debile	16,000	2,100				
Ch. Willei		200				
Ch. diadema	6,000	13,600	600	4,100	13,200	*
Ch. laciniosum	10,000	1,200				
Ch. constrictum			800			
Ch. contortum		500				
Ch. decipiens	50	300	600	100	1,200	*
Ch. danicum		400	600			
Ch. convolutum				150		
Ch. criophilum	50					
Skeletonema		200		250		
M. sulcata	50	300		250	1,800	*
Cerataulina		500	400			
Bid. aurita		100				*
Bid. mobiliensis		100				*
Isthmia					600	*
Actinoptychus	2,000	100			600	*
Coscinodiscus	10,000	1,000	400	250	4,800	*

*Pr

persist in considerable abundance over the whole area throughtout the year; secondly, those which occur occasionally at all seasons; and thirdly, those which attain a marked predominance at one season and then either entirely disappear or occur at rare intervals.

Bathymetric Range.

Station 6. A comparison between surface and 5 metre tows. To ascertain the more favourable depth for the gathering of material a comparison was made between the numbers obtained in monthly tows at the surface and at a depth of 5 metres. Each species was considered separately and each presented the same irregularity of distribution. Most frequently, however, the greater numbers came from the lower level, for out of 183 comparisons made, the five metre collections proved the greater in 103 cases. No species showed a preference for the surface water, nor did any fail to appear in them. A synopsis of the results for eleven of the most abundant genera will be found in Table VIII.

TABLE VIII.

Comparison of Surface and 5m. Tows. Station 6.

—		Oct. 6	Dec. 4	Dec. 27	Jan. 24	Mar. 15	April 14	June 21	July 11	Aug. 8	Sept. 6
Pleurosigma	S	2,000	1,350	450	4,300	450	250	300	4,000	....	200
	5m	9,000	1,900	800	1,300	800	4,550	6,000	4,000	550	
Thalassiothrix	S	200,000	400	....	50	400	400	50	8,000	800	500
	5m	528,000	100	....	2,200	600	2,000	2,000	29,000	50	50
Rhizosolenia	S	24,000	50	....	....	200	....	50	4,000	....	650
	5m	168,000	100	....	600	200	50	1,300	....	250	150
Dityliun	S	24,000	....	....	....	....	....	....	....	....	50
	5m	99,000	50	....	....	....	....	....	....	....	
Chaetoceras	S	156,000	900	400	2,200	850	9,800	37,400	1,842,000	1,000	8,200
	5m	216,050	800	800	500	400	61,000	455,900	3,716,000	9,225	100
Skeletonema	S	....	....	1,800	1,000	1,000	1,400	....	274,000	300	
	5m	....	....	....	2,500	500	10,500	....	240,000	750	300
Melosira	S	50	2,400	3,800	700	650	100	1,875	2,000	200	300
	5m	50	1,150	2,800	2,200	1,100	....	6,050	50	1,500	
Thalassiosira	S	....	....	....	....	800	98,000	53,750	106,000	....	....
	5m	....	....	....	....	500	952,500	722,000	39,000	1,125	
Biddulphia	S	....	....	200	100	22,800	11,000	....	....	....	
	5m	....	....	600	1,100	20,300	48,500	....	....	....	
Actinoptychus	S	2,000	400	600	600	200	50	....	....	....	
	5m	3,000	200	800	200	100	500	....	....	....	
Coscinodiscus	S	10,000	2,000	1,800	1,800	400	400	250	2,000	....	350
	5m	3,000	700	2,000	3,100	2,200	2,000	....	2,000	50	

Stations 3 and 6.—Station 3 offers the best conditions for a study of the bathymetric range, since at that point the water has a depth of 175 metres; at Station 6 it ranges from 26 to 30 metres. At the former station eleven samples were taken on July 31, at intervals of 10 or 25 metres. Later an estimate was made in the following manner of the average diatom content of 50 c.c. at each level. From each of the eleven samples, four volumes of 50 c.c. each were centrifuged for half an hour, it having been previously ascertained that that period sufficed for the extraction of all the plankton organims. The water was then siphoned off leaving the residue in 2 c.c. The organisms were again counted in the Rafter cell, but in this case the cover slip was divided into forty squares, each measuring 25 sq. mm. The frustules of each species were counted in 10 squares in each of the two slides made from a preparation; and the average of these multiplied by 80 gives the total content of the 50 c.c. The average results obtained from the four similar 50 c.c. samples drawn from each will be found in Table IX.

TABLE IX.

Bathymetric Range. Station 3. July 31.

—	0	10	20	30	40	50	75	100	125	150	175
Navicula						8				8	24
Synedra						8					8
N. seriata	1,144	1,912	16	40		8	8	16	8		
N. closterium	144	456	8				8				
Thal. nitzschioides		24	24	8		16			8	8	
R. hebetata									8	8	8
Corethron								8			
Ch. debile	280			72		16					
Ch. diadema										8	8
Ch. laciniosum	240	40		88							
Ch. decipiens	8	32									
Ch. convolutum		32		32							
Skeletonema	976	4,584	16		16	88		32			72
M. sulcata						48		8	104		512
Thalassiosira	160	3,288	456	176	88	56	24	8			
Leptocylindrus			24					160			
Bid. aurita			16								
Coscinodiscus		24				8					8

These show a distinct maximum at 10 metres, and then a rapid decrease. Below 20 metres the decrease is gradual and somewhat irregular until at 150 metres few diatoms are found. At the bottom, however, a decided increase will be noted due to an abundance of Melosira sulcata. The latter is the only form which is found to increase with descent.

Records similar to the above were made for Station 6 on July 27 and August 15 and are listed in Tables X and XI.

TABLE X.

Bathymetric Range. Station 6. July 27.

—	0	7	12	17	22	27
Navicula	48	8	16	16	32	
Pl. fasciola	24					
Pl. angulatum		8	16	32		
N. seriata	64			16	24	
N. closterium	8	8				
Thal. nitzschioides	128	80	40	32	88	
R. hebetata	104	24			8	
Ch. debile	800	1,640	2,952	3,392	3,416	1,944
Ch. laciniosum	32	32	88			
Ch. convolutum						16
Skeletonema		304	112	456	368	40
M. sulcata	56	360	176	56	104	72
Thalassiosira	8	88	48	32	104	
Leptocylindrus					112	
Actinoptychus					8	
Coscinodiscus			8			

In the former a maximum was obtained at 22 metres, below which a marked decrease was evident. In the latter we find an exception to results previously recorded for the surface waters were found to contain a distinct maximum, chiefly due to the great abundance of *Skeletonema costatum* and *Chaetoceras sociale,* forms of extreme delicacy.

TABLE XI.

Bathymetric Range. Station 6. August 15.

—	0	5	10	17	22	27
Navicula	32	24	24	....	24	16
Pl. fasciola	8	....	8	....	....	
Asterionella	....	16	....	....	40	32
Synedra	....	....	....	....	....	8
N. seriata	4,496	4,088	3,232	3,200	1,904	2,240
N. closterium	184	256	200	208	112	112
Thal. nitzschioides	120	160	160	104	56	88
R. hebetata	....	80	8	8	....	16
R. faerôensis	56	....	....	....	....	
Ch. sp.?	....	72	8	24	8	
Ch. debile	2,728	2,200	1,024	608	2,640	3,552
Ch. sociale	8,136	1,184	2,360	2,604	608	432
Ch. diadema	....	....	....	80	....	
Ch. laciniosum	848	440	264	256	392	54
Ch. decipiens	32	136	....	40	....	
Skeletonema	5,384	2,076	3,288	5,240	1,864	1,736
M. hyperborea	....	176	....	8	216	24
Thalassiosira	136	32	80	96	304	32
Leptocylindrus	....	848	520	136	744	344
Cerataulina	48	48	40	40	48	72
Coscinodiscus	....	24	....	....	....	

I regret that time did not permit a more thorough examination of the conditions at Station 3. From the results obtained it appears that the most favourable level is from 10-20 metres, and that below that depth a rapid decrease may be expected. One form, *Melosira sulcata,* which is not uncommon in surface waters, has been found on one occasion to be greatly increased at lower depths. Diatoms are by no means rare at a depth of 175 metres.

Cultures.

To ascertain whether other diatoms were present at any level in such small numbers that their presence was undetected by centrifuging, or were perhaps present in the form of spores, too minute for observation (3), cultures were started from water obtained at each level from Station 6. To this end a beaker of one litre volume was half filled with water drawn from each level. The water was treated by Miquel's method (18) as improved by Allen (9). This treatment is dealt with in a later paper on Culture Methods. The six cultures were then placed in the most favourable situation for growth. No strictly plankton forms others than those listed in the tables, developed; but Schizonema Grevillei, roped in long beautiful strands, appeared in abundance in every beaker; and Melosira Borreri produced several normal chains in the water from 7 metres. It may then be concluded that other forms were lacking for, although the specific differences are such that diverse conditions are necessary for obtaining permanent cultures of the many forms, I have found that the method here employed has given a greater or less initial growth for all the plankton diatoms so treated.

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Distribution of Diatoms. PLATE I.

Clara W. Fritz.

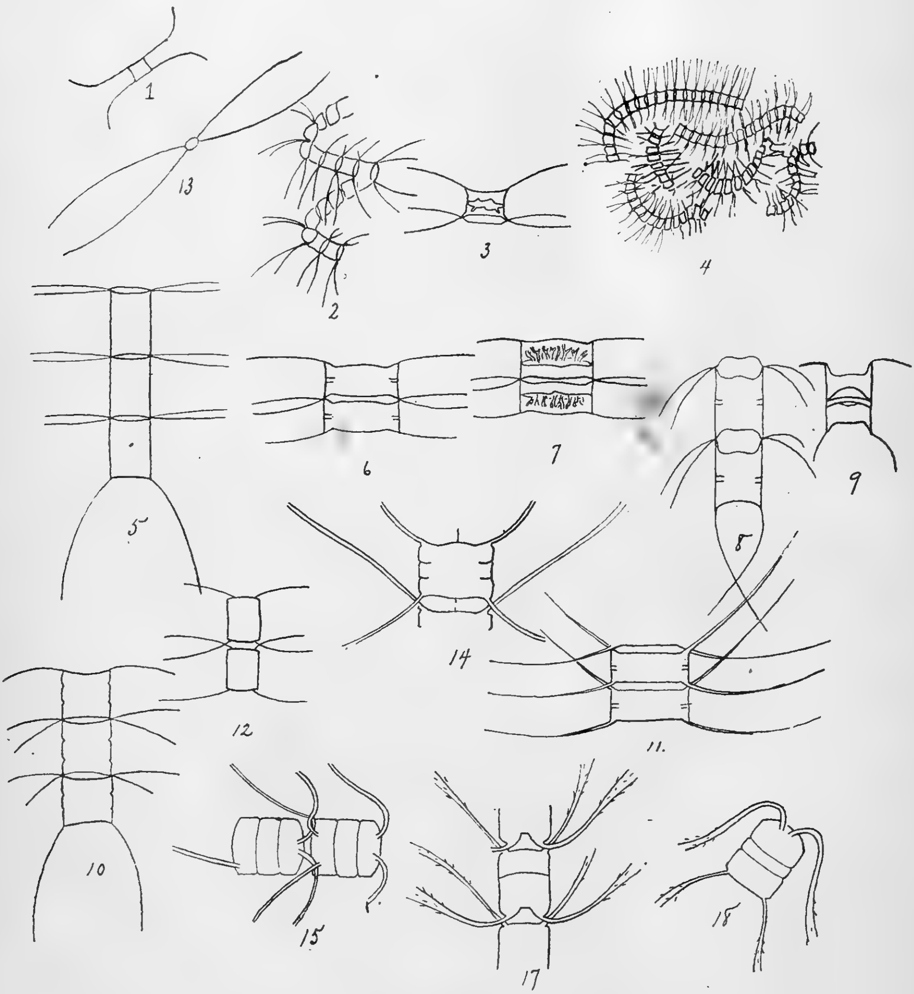

PLATE I.

Chaetoceras, Ehr.

1. *Ch.* Sp.?
2. " *debile* Cleve.
3. " " with spores.
4. " *sociale* Lauder.
5. " *Willei* Gran.
6. " *diadema* Ehr.
7. " " with spores.
8. " *laciniosum* Schutt.
9. " " with spores.
10. *Ch. constrictum* Gran.
11. " *decipiens* Cleve.
12. " *contortum* Schutt.
13. " *danicum* Cleve.
14. " *atlanticum* Cleve.
15. " *convolutum* Castr.
17. " *criophilum* Castr.
18. " *peruvianum* Brightw.

Distribution of Diatoms. Clara W. Fritz. PLATE II.

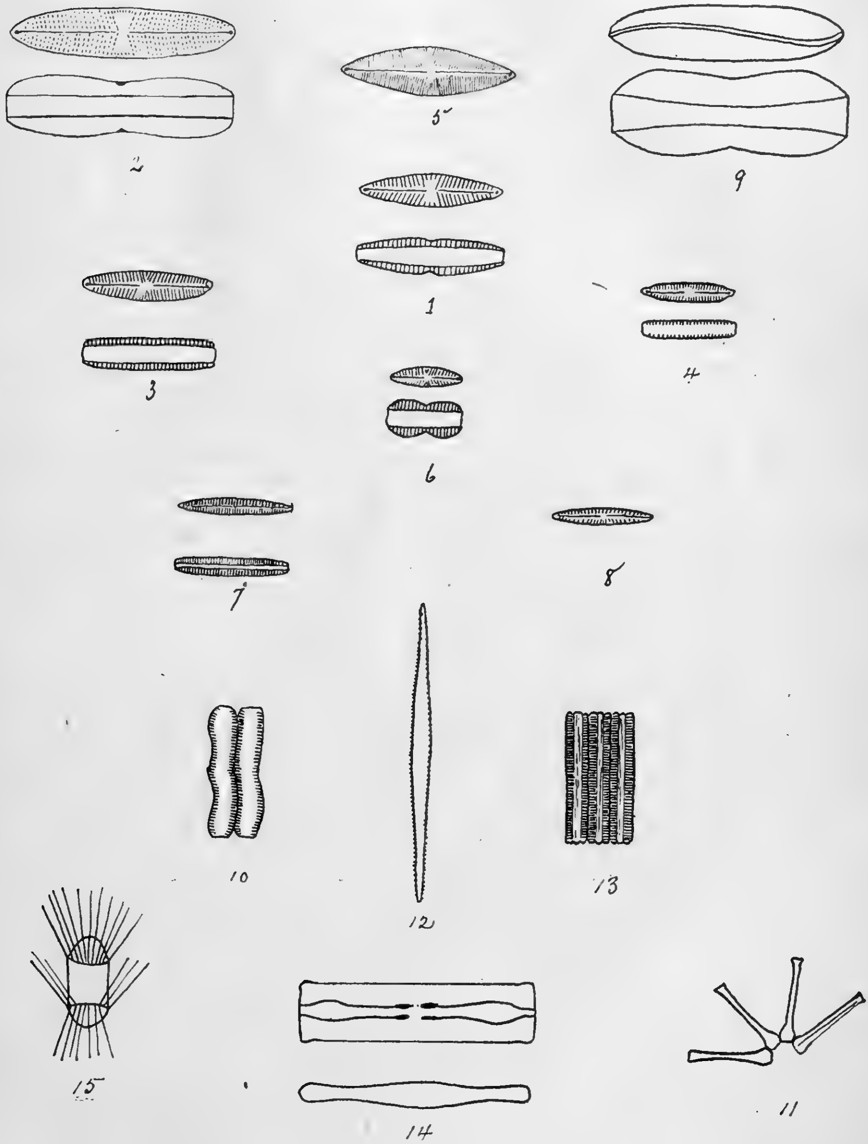

PLATE II.

1. *Navicula distans* W.S.
2. " *aspera* Ehr.
3. " *digito-radiata* Greg.
4. " *Rhynchocephala* Kütz.
5. " *brevis* Greg.
6. " *retusa* Breb.
7. " *sp.?*
8. " *sp.?*
9. *Scoliopleura latestriata* Grun.
10. *Achnanthes brevipes* Ag.
11. *Asterionella Bleakeleyi* W.S.
12. *Synedra affinis* Kütz.
13. *Fragilaria islandica* Grun.
14. *Grammatophora marina* Kütz.
15. *Corethron criophilum* Castr.

Distribution of Diatoms. PLATE III.

Clara W. Fritz.

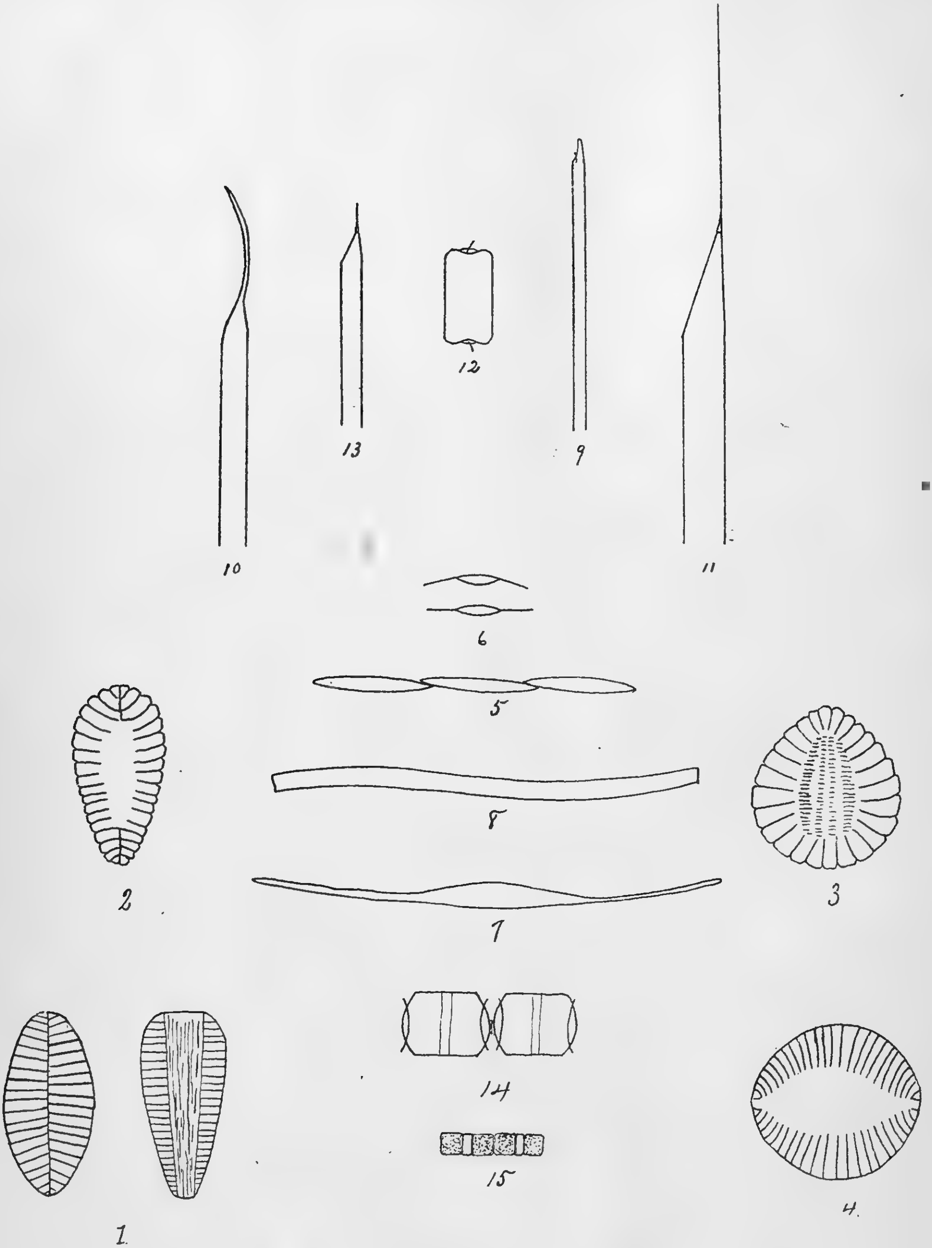

PLATE III.

1. *Surirella gemma* Ehr.
2. " *ovalis* Breb.
3. *Campylodiscus Thuretii* Breb.
4. " *hibernicus* Ehr.?
5. *Nitzschia seriata* Cleve.
6. " *closterium* W.S.
7. " *longissima Grun.*
8. " *sigma* W.S.
9. *Rhizosolenia obtusa* Hensen.
10. " *alata* Brightw.
11. " *hebetata semispina* Hensen.
12. " *faeröensis* Ostenf.
13. " *shrubsolei* Cleve.
14. *Melosira hyperborea* Grun.
15. " *crenulata* Bail. (?)

V.

Experimental Cultures of Diatoms occurring near St. Andrews, N.B.

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INTRODUCTION.

In the summer of 1916 cultures were set up at the Atlantic Biological Station with the object of providing food for marine copepods. The particular species sought was *Nitzschia closterium,* but owing to its rare occurrence it was found necessary to make trial of other forms. I have since found, however, that when present Nitzschia closterium grows with great luxuriance, will in a mixed culture rapidly replace many forms and is persistent.

The results of the work of 1916 have already been recorded, and as the nutrients used by Allen and Nelson (9) were found beneficial, they were again employed.

Solution A. Dissolve 20.2 potassium nitrate in 100 c.c. distilled water.

Solution B. Dissolve 4 g. sodium phosphate in 40 c.c. distilled water. Add 2 c. c. pure concentrated hydrochloric acid, then 2 c. c. ferric chloride dissolved by gentle heating. Add 4 g. calcium chloride dissolved in 40 c.c. distilled water.

These solutions were used in the proportion of 2 c. c. of A and 1 c. c. of B per litre of sea water. The precipitate thrown down by B, containing most of the iron, a little phosphorus and some calcium, was allowed to settle and then removed. The sea water used was first raised to 70°C. and maintained at that temperature for 30 minutes in order that all plant life might be destroyed.

Mixed Cultures.

Plankton was collected on July 4, 1917. The collection contained nineteen species, of which the prevailing forms were *Chaetoceras debile* and *Thalassiosira nordenskioldii.* In the hope of more effectively isolating individual species than in previous work a method of subdivision in test tubes was employed. A tube of prepared sea water was inoculated with two drops of plankton and divided into six test tubes. The contents of each was then added to an erlenmeyer flask of 125 c. c. volume, which had been half filled with prepared sea water. Three series were arranged and with each a control in untreated, sterilized sea water was run. The sets were placed in: (1) a window receiving afternoon sun, (2) a window receiving no sun; (3) flasks covered with cheesecloth.

No development was obtained in the untreated water except in one flask in position 2; and this was very slight and disappeared in ten days. In position 1, three flasks produced each a mixed culture of *Thalassiosira nordenskioldii* and *Skeletonema costatum.* These were at their height on July 18, after which one became exhausted and the other two presented *Nitzschia closterium* and *Melosira hyperborea.* On August 6 these forms were showing rapid increase and on August 25 when the work was closed at the Biological Station were in excellent condition. New flasks were inoculated from these and formed the source of material for winter studies.

In position 2, five mixed cultures were obtained and one pure culture referred to later. *Thalassiosira nordenskioldii* was always the dominant form, but was accompanied by *Skeletonema costatum, Chaetoceras debile* and *Melosira hyperborea,* singly or in combination. All forms except *Melosira* lost their vitality in a few weeks. One culture was swamped by *Nitzschia closterium* and another by *Chaetoceras* sp.?, a small, delicate form, found singly or in pairs, of which the compressed frustules were rectangular in zonal view and furnished with delicate setae. The others became exhausted. The initial mixed growth obtained in this position showed a decided superiority to that of position 1, but it lasted not more than a week longer, and the final development of *Nitzschia* and *Melosira* was superior in position 1. In position 3, no growth was obtained.

It is noticeable that although *Chaetoceras debile* was one of the dominant plankton forms it developed in but one culture and then to but a slight extent. Another series started on July 11 from plankton in which *Ch. debile* was even more abundant gave a similar result. Two other species of *Chaetoceras* also, *diadema* and *laciniosum,* were more abundant than *Skeletonema costatum* but gave much less growth. Although chains of all three could be found for several weeks with the aid of a microscope no visible growth was obtained.

In considering the results from the three positions it may be said that the majority of forms thrive best in strong, diffuse light, but that some forms, *Nitzschia* and *Melosira,* are uninjured by direct sunlight. Subsequent work, however, has shown that even they are unable to persist, when the light is too intense. The majority of plankton forms show also an aversion to crowding and die out after a slight increase. This may be due to the exhaustion of some essential nutrient and suggests that interesting developments may be met along such lines; or the exhaustion may be due to the influence of the products of metabolism. The power of living in a crowded area is decidedly greater in some forms than in others, among the least persistent being the members of the genus *Chaetoceras.*

A mixed culture maintained during the autumn gave a very considerable development of several species. *Skeletonema costatum* was the prevailing form, but *Asterionella japonica* was remarkably abundant and healthy. One colony was seen to cantain eighty-five frustules, and the colonies were numerous. This culture was started on August 25, and its position was changed several times before it was finally placed on September 9 in a permanent position opposite to a bright, south window. Until the latter date little development was noted, but later it continued to increase until November 13, when the maximum development was obtained. *Chaetoceras sociale, Nitzschia bilobata, Coscinodiscus subbulliens* and *Thalassiothrix nitzschioides* were present in numbers.

Pure Cultures.

In position 2 (a window receiving no sun) one very luxuriant, pure culture of *Thalassiosira nordenskioldii* was obtained. By a pure culture is intended one quite free from other organisms. It reached its maximum in two weeks and remained in excellent condition until the end of July, when the chains began to break up. When at its height the water was filled with a brown cloud of suspended chains. Several flasks were inoculated from this, and for some time showed excellent growth; but after the middle of August its vitality seemed lost, for no further cultures could be started from the original and those already started rapidly deteriorated, so that by August 25 very few healthy frustules could be found. The original was retained but showed no subsequent revival.

Later a pure culture of *Skeletonema costatum* was obtained in addition to those of *Nitzschia closterium* and *Melosira hyperborea* already mentioned. Only the two latter forms, however, proved persistent. In all cases, except where a culture was swamped by the development of *Nitzschia,* or some navicular form, the most profuse growth was obtained in the pure cultures. In these, at the end of two weeks, diatoms were present in such numbers that the water was visibly filled with clouds of their chains.

Summary.

The following plankton species may be recorded as developing to a greater or less extent in culture vessels of prepared sea water:—

Pleurosigma fasciola,
Asterionella japonica,
Tabellaria sp.?
Nitzschia closterium,
Nitzschia seriata,
Nitzschia bilobata,
Thalassiothrix nitzschioides,
Skeletonema costatum,
Melosira hyperborea,
Chaetoceras debile.
Chaetoceras diadema.
Chaetoceras laciniosum.
Chaetoceras contortum.
Chaetoceras decipiens.
Chaetoceras convolutum.
Biddulphia aurita,
Coscinodiscus subbulliens,
Coscinodiscus radiatus,
Nitzschia closterium.

Nitzschia closterium.

As I previously stated *Nitzschia closterium* has been found capable of developing in great luxuriance, and of replacing, under artificial conditions, a variety of forms. Its optimum temperature is from 18°—20° C.; but it will endure a range of 0°—23° C. without loss of vitality. A preference for bright light is revealed by a comparison between two cultures, which were grown for two months, the one opposite a bright window and just out of the direct sunlight and the other in a northern exposure. In the former the frustules attained an average length of 59 μ, contained rich, dark brown chromatophores, and were very active; in the latter the average length was 35 μ, the form irregular, the chromatophores greenish and the movement sluggish. These two cultures were grown in flasks lightly plugged with cotton, but the best growth obtained was an uncovered beaker culture, developed later under optimum conditions of light and heat. In this the frustules attained a length of 112 μ and showed a tendency to form chain-like colonies. In one chain nine frustules were counted and these moved over one another actively, with a motion similar to that of *Schizonema Grevillei.* This would seem to indicate that the free access to a considerable air surface is beneficial. In less favourable conditions the frustules are frequently grouped in irregular masses of coleoderm. As regards size and habit of growth it may be concluded that the environment may exert a very considerable influence.

Melosira hyperborea, Grun.

Cultures of *Melosira hyperborea,* set up from material developed from the plankton collection of July 4, were maintained from September 14, 1917, to March 22, 1918, and dealt with the following conditions: (1) air and light, (2) salinity, (3) temperature, (4) development in artificial sea water.

I. *Air and Light.*—Since it has been previously ascertained that *Melosira* required the addition of nutrient salts, all cultures were grown in sterilized treated sea water. Cultures were set up on September 14, in open flasks and in others plugged with cotton and placed: (1) in north window, (2) in south window, (3) opposite south window just beyond the direct rays of the sun, (4) in dark. The following table briefly summarizes the results.—

—		Condition.			
		September 21.	October 6.	October 28.	November
North	1. Open		Excellent	Good	Fair.
	2. Closed		Good	Poor	Dead.
South	1. Open	Good	Good	Good	Life.
	2. Closed	Slight	Life	Life	Few living.
Opposite South	1. Open		Excellent	*Best of series*	Excellent.
	2. Closed		Good	Good	Good.

From the above it may be judged that the most favourable development may be expected in strong, diffuse light and with access to the air. It may be added, however, that the difference between the flasks in position 3 was one of quantity and not of quality. Both contained long, beautifully formed chains, without any signs of disintegration; and a later trial showed that if the plug were removed every few days to permit a change of air, the growth could be maintained. To prevent the entrance of foreign substances and undue evaporation the latter plan was then adopted.

In several of these cultures the terminal frustules frequently enlarged to form large globular cells. The outer valve was cast off and the contents of the whole frustules issued, but remained closely bound to the inner valve, and encased in a firm, transparent wall. These cells were filled with dark, dense contents. Later they divided to form long, regular, broad chains. These sporangial frustules and consequent broad chains were most abundant in the flasks placed in the south window, and particularly so in that which was closed; a few appeared in the north window, and an even smaller number were noted in position 3. A further consideration of these will be given in a later section.

The cultures placed in the dark showed a very considerable development. Growth was not profuse but after two months many chains were still in good condition. At that date it was noted that no sporangial cells had developed, that the chromatophores were decidedly greener than those in the light and that the divisions were often irregular and the frustules distorted. The material was then divided and part removed to favourable light conditions. There it revived to a considerable extent, but the chains displayed much more malformation then in normal cultures. The portion left in the dark continued to live and on January 12 a few enlarged end cells were noted. On March 15, six months after the culture was set up, living cells were still to be found, although they were not abundant. Most of the chains were empty and it is worthy of note that fully half of them had developed from the sporangia noted on January 12, for they were on an average 36 μ in width.

A culture in which broad chains were particularly numerous produced, when removed from the south window, a fairly healthy, normal colony, in which no broad chains were found after two months development. It may then be inferred that in an actively growing culture the older cells are dissolved and thus retard the exhaustion of food material by the growing cells. In the colony exhausted by life in the dark dissolution did not take place and the empty cases remained.

II. *Salinity.*—To test the development with respect to the concentration of salts a series of cultures was set up in treated sea water, strengthened by evaporation, or diluted by the addition of tap water. The latter was used owing to the lack of distilled water and I am indebted to Prof. Alex. Vachon for the following analysis of its contents. The sample analysed contained 0.0225 g. of residue per thousand, which was composed of a trace of chlorides, a little calcium carbonate and fine sand. The series was set up on November 25 and gave the following results:—

Concentration.	December 9.	January 27.
Tap water	Fair	Deteriorated.
Tap + Miquel sol	Dead	
10% Sea	Good	Deteriorated.
25% "	"	Improved.
40% "	Excellent	Excellent.
50% "	"	"
60% "	"	"
75% "	"	"
90% "	"	"
100% "	"	"
125% "	"	Fair.
150% "		"
175% "		Poor.
200% "		Little life.

It is seen at once that *Melosira hyperborea* will endure a great diminution of salts and can live for some time even in tap water in which salts are practically lacking. The addition of Miquel nutrients, however, instead of acting favourably proved fatal in a short time.

The above table has reference merely to the state of the chains examined microscopically and not to the increase in size of the colony. With a reduction to lower than 40 per cent little development occurred; but in from 40 to 100 per cent the colonies were practically equal in size as well as uniform in quality. Increased concentration acted as a check to growth and caused disintegration in proportion to the degree of concentration. The latter caused also much malformation due to thickening of the walls, inward curving of the zone and irregular divisions.

III. *Temperature.*—A healthy, normal colony was divided into sections as nearly equal in size as possible and each was placed in a separate flask, half filled with treated sea water. The temperature of each was then slowly lowered or raised over steam to the required degree. To prevent contamination the thermometer was in each case kept in a second flask, one of which had been prepared for each of the series. When the desired temperature was reached it was maintained for three minutes and then allowed to return to normal. The series was set up on February 3, and gave the results tabulated below:—

Temperature.	March 3.		March 15.
	Area of Surfaces.	Condition.	
60°C		Dead	
50°		"	
45°		"	
40°	27 sq. mm	Fair	Improved.
35°	54 "	Excellent	Excellent.
30°	48 "	"	"
25°	40 "	"	"
20°	45 "	"	"
15°	32 "	"	"
10°	25 "	"	"
5°	24 "	"	"
0°	54 "	"	"
5°	Scattered	Best of Series.	Best of Series.
Frozen	15 sq. mm	Poor	Disintegrated.

It was noted in preliminary work that some frustules seemed capable of resisting a temperature of 50° C, but it was evident from the development of the series that their vitality was so impaired that subsequent growth was inhibited. That which was raised to 40° revived and after six weeks presented a colony 90 per cent of the frustules of which were in excellent condition. An increase or decrease of 20° was found to be no hindrance to development; but I regret that time did not permit of ascertaining the length of time to which the organism might be submitted to the changed condition. One variation due to change of temperature, which was noted, was the great ease with which the frustules could be separated. This indicates a change in the mucilaginous substance by which the frustules are bound together.

The flask lowered to –5°, which is recorded above as showing the best development, was accidentally overturned and the contents scattered through the flask. It was found that the chains in this were remarkably good, practically no disintegrated frustules occurring. From this it may be inferred that in other flasks some disintegration may have been due to crowding.

On March 3 many sporangial cells, similar to those found in the experiments on light, were noted in all the flasks, even in the unheated controls. In the -5° flask some had already divided. On March 15 all the cultures contained beautiful, long, broad chains; and on March 22 they were still in the process of division. The broadest chains noted had attained a diameter of 39 μ, and in advanced cutures all gradations were found down to a diameter of 10 μ. The sporangial formation was clearly not due to the stimulus of temperature, since is was also noted in the controls. In the latter, however, it was least pronounced, and it is probable that a change in condition induced the profuse development. The same may be said regarding light. Darkness did not prevent, but merely delayed the appearance of sporangia; optimum conditions produced them in small numbers; while excess of light acted as a strong stimulus. It may be inferred that they are a normal means of increasing vitality, which may be stimulated by abnormal conditions.

IV. *Artificial Sea Water.*—An artificial sea water based on the analysis of Dittmar (14) was employed. Gram molecular solutions of the salts to be used were made up and combined in the following proportions: 480.8 c.c. Na Cl, 10.28 c.c. K Cl, 10.86 c.c. $CaCl_2$; 26.70 c.c. $MgCl_2$; 29.06 c.c. Mg So_4; 2 c.c. Na H Co_3. The total was then diluted with distilled water to a volume of one litre.

Cultures were set up on September 14. Allen (10) has recorded that for the growth of *Thalassiosira gravida* in water of a similar composition the presence of a small quantity, 1 per cent to 4 per cent, of natural sea water is essential. To ascertain whether a similar condition was necessary in the case of *Melosira hyperborea,* all trace of the natural was removed by passing the material through several changes of artificial before finally transferring it to the prepared flask. Two cultures were started, one in artificial sea water, and one in artificial plus Miquel nutrients in the proportion previously employed. These were examined at intervals, and twice during the winter the medium was renewed. Its concentration was maintained by the addition of distilled water.

Very fair growth resulted, and though it did not equal in quantity that obtained in natural sea water, the material was uniformly healthy. The growth in untreated water was only 25 per cent of that obtained in the treated, but it also was normal in quality. It is worthy of note that in neither culture did sporangial cells appear. It therefore is concluded that the substance whose presence is essential to the development of *Thalassiosira gravida* is unnecessary to the growth of *Melosira hyperborea.* And this seems to support the conclusion that the exhaustion of the mixed cultures recorded above may be due to the loss of some essential nutrient, which the initial growth of some species exhausts; while the persistence of *Melosira* is permitted by its lack of dependence on that substance.

SUMMARY.

Melosira hyperborea can endure a great variety of light conditions, but the optimum development will be obtained in strong diffuse light. Its growth is regulated to some extent by the solution of gases from the air. It can endure a range of forty degrees of temperature, and a diminution to forty per cent of natural sea water. It can even exist for a time in tap water. Miquel solutions act as a stimulus to growth in all cases except when added to tap water; they then rapidly prove fatal. Increased concentration of natural sea water is detrimental. Excellent, persistent cultures may be obtained in artificial sea water. A comparison with the work of Allen on *Thalassiosira gravida* points to fundamental, specific differences in the nutrient requirements of plankton diatoms.

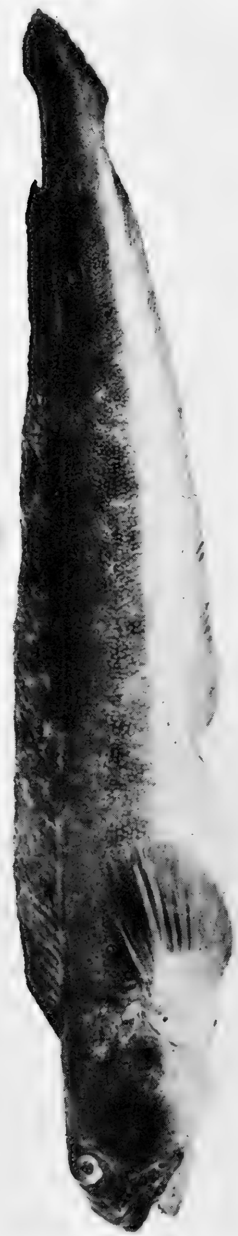

Fig. 1—Muttonfish sixteen and a half inches long from Bay of Fundy

79550—to face p. 69.

VI.

Contribution to the Biology of the Muttonfish, *Zoarces anguillaris.*

BY

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1. INTRODUCTION.

During the summer of 1918 at the St. Andrews Biological Station, St. Andrews, N.B., the writers commenced a study of the life-history of the muttonfish, or eelpout, (*Zoarces anguillaris* Peck). The primary object was to obtain some definite information in regard to the life-history and abundance of the fish relative to the possibility of placing it on the market and the results of that phase of the study have been published (Clemens, 1920).* There remain considerable scientific data which are presented here.

The writers are much indebted to Dr. A. G. Huntsman, Biologist to the Biological Board of Canada, for suggesting the study and for kind advice and assistance.

2. HISTORICAL.

Zoarces anguillaris was described by Peck (1804). Besides giving a detailed description, Peck states that the fish is taken on the haddock grounds, chiefly in the months of March and April, and that it feeds principally on echini and asteriæ. Since that time reports of capture have been numerous, but no study of the life-history has hitherto been undertaken. Storer (1839) gives a list of stomach contents, and again (1867) describes the fish in detail with the addition of a good illustration. He also gives a further list of stomach contents and states that the fish is occasionally taken at all seasons of the year but more frequently in the spring and summer. Goode (1884) states that it is frequently taken north of Cape Cod in winter with hook and line and that it spawns in July and August in the deep waters of Massachusetts bay. Nichols (1916) reports that it was taken throughout the year 1915 off New York and was especially abundant in June.

3. DISTRIBUTION ALONG THE ATLANTIC COAST.

The muttonfish occurs commonly along the Atlantic coast of Canada and northern United States, entering the bays and also the rivers for some distance. The extremes of its range reported at the present time are Bradore (?) Bay, Labrador, and Fort

* Issued in Bulletin No. IV in the Series "Histories of New Food Fishes. Biological Board of Canada, Ottawa, July, 1920.

Macon, North Carolina. The following are the records of distribution as far as we have been able to ascertain. An asterisk is used to indicate those publications which have not been examined.

Name.	Date.	Publication.	Locality.
Bean, Tarleton H	1880	Check-list of Duplicates of N.A. Fishes, etc Proc. U.S. Nat. Mus. 3 (82)	*Maine*—Eastport and Portland *Massachusetts*—Gloucester, Provincetown and Massachusetts bay.
Bean, Tarleton H	1903	Cat. of the Fishes of N.Y. N.Y. State Mus. Bull. 60, Zool. 9 (674)	*New York.* *Massachusetts*—Sandy Hook.
Bell, Robert, Jr	1859	On the Natural History of the Gulf of St. Lawrence Canad. Nat. and Geol. 4 (208).	*Quebec*—Marcouin.
Bigelow, Henry B	1914	Explorations in the Gulf of Maine Bull. Mus. Comp. Zool. 58 (31).	*Maine*—Off Halfway Rock.
Cornish, George A	1907	Notes on the Fishes of Canso Contrib. Canad. Biol. Ottawa, (81).	*Nova Scotia*—Canso
Cornish, George A	1912	Notes on the Fauna of Tignish, P.E.I Contrib. Canad. Biol. Ottawa, (79).	*Prince Edward Island*—Tignish.
Cox, Philip	1896	Cat. of the Marine and Freshwater Fishes of N.B Bull. Nat. Hist. Soc. N.B. 3 (40).	*New Brunswick*—Miramichi bay.
DeKay, James E	1842	N.Y. Fauna: Fishes. Albany (155)	*New York.*
Fortin, Pierre	1865	List of Fishes found in the Gulf of St. Lawrence Sessional Papers Canada, 25 (65).	All parts of the gulf of St Lawrence.
Fowler, H. W	1906	The Fishes of New Jersey Rept, N.J. State Mus. Trenton (407).	*New Jersey.*
Gill, Theodore	1863	Desc. of the Genera of Gadoid and Brotuloid Fishes of Western N.A. Proc. Acad. Nat. Sci. Phil. (258).	*New York* and *New England Coast.*
Gill, Theodore	1878	Cat. of the Fishes of the East Coast N.A Smith. Misc. Coll. 14	*Massachusetts* — Massachusetts bay. *Maine*—Eastport.
Goode, G. B. and Bean, T. H	1879	Cat. of the Fishes, Essex Co. Mass. etc Bull. Essex Inst. 11 (1).	*Massachusetts*—Mass. bay and contiguous deep waters.
Goode, George B	1884	The Fisheries and Fishing Industries of the U.S. Washington	*Massachusetts* — Massachusetts bay. *Maine.*
Gunther, Albert	1861	Cat. of the Acanthopterygian Fishes, British Museum, 3 (296)	*Massachusetts*—Boston.
Halkett, A	1906	Report of the Can. Fisheries Museum Sessional Papers Canada (362).	Gulf of St. Lawrence.
Halkett, A	1907	Report of the Can. Fisheries Museum 40th Ann. Report Dept. Marine & Fisheries (340).	*Quebec*—Paspebiac, Gaspe bay, Bay Chaleur, gulf of St. St. Lawrence.
*Holmes, Ezekiel	1862	Report on the Fisheries of Maine, etc Nat. Hist. and Geol. Maine (2) 11.	*Maine.*
Jones, J. Mathew	1879	List of the Fishes of Nova Scotia Proc. and Trans. N.S. Inst. of N.S. 5 (90).	*Nova Scotia*—Halifax.
Jordan, D. S. and Gilbert, Chas. H	1882	Synopsis of the Fishes of N.A Bull. 16, U.S. Nat. Mus. 24 (784).	*Deleware* to *Labrador.*
Jordan, D. S. and Evermann, B	1898	The Fishes of North and Middle America Bull. 47, U.S. Nat. Mus. part 111 (2457).	*Deleware* to *Labrador*—rather common north of Cape Cod.
Jordan, David S	1914	A Manual of the Vertebrate Animals of North. U.S. Chicago (160).	*Deleware* to *Labrador*—common north.
Kendall, William Converse	1908	Fauna of New England: List of Fishes Occ. Paper—Bost. Soc. Nat. Hist. No. 7 (135)	*Maine*—Eastern river, Eastport, Bucksport, Portland, Casco bay. *New Hampshire* *Massachusetts*—Mass. bay, Provincetown, N. Truro, Cape Ann, Annisquam, Gloucester Nantucket Shoals, Gayhead, Cuttyhunk. *Rhode Island*—Black island, Narragansett bay. *Connecticut*—Middleground.
Kendall, W. C	1909	The Fishes of Labrador Proc. Portland Soc. Nat. Hist. 2 (207).	*Labrador*—Bradore bay?
Kendall, W. C	1914	The Fishes of Maine Proc. Portland Soc. Nat. Hist. 3	*New Hampshire*—Piscataqua river. *Maine* — Eastern river, Eastport, Bucksport, Casco bay, Portland, Small point, Whaleboat and Eagle islands
*Mitchill	1815	 Trans. Lit. & Phil. Soc. N.Y. 1 (374).	*New York.*
*Nichols, John Treadwell	1913	Fishes within Fifty Miles of New York City Proc. Linn. Soc. N.Y. Nos. 20–23.	*New York*—Off New York City.

Name.	Date.	Publication.	Locality.
Nichols, J. T.	1916	Seasonal Annotations on 2 Long Island Fishes. Copeia No. 27 (10).	*New York*—Off New York city. Cholera Bay.
Nichols, J. T. and Gregory, W. K.	1918	Fishes of the vicinity of New York City. Handbook No. 7, Am. Mus. Nat. Hist. (91).	*New York*—Off New York.
Peck, William D.	1804	Description of Four Remarkable Fishes, etc. Mem. Am. Acad. Ar ts and Sci. 2 (46).	*New Hampshire*—Near Piscata qua river.
Schmitt, Joseph	1904	Monographie de l'Ile d'Anticosti. Paris (286).	*Anticosti island*—(Gulf of St. Lawrence).
Smith, Hugh M.	1897	Fishes found in the vicinity of Woods Hole. Bull. U.S. Fish Comm. (106).	*Massachusetts*— Gayhead, Cuttyhunk, Vineyard sound, Massachusetts bay.
Storer, David Humphreys.	1839	A Report on the Fishes of Mass. Bost. Jour. Nat. Hist. 2 (289).	*Massachusetts.*
Storer, D. H.	1846	A Synopsis of the Fishes of North America. Mem. Am. Acad. Arts and Sci. N. Ser. 2 (375).	*New Hampshire: Maine; Massachusetts, New York.*
Storer, D. H.	1867	A History of the Fishes of Mass. Mem. Am. Acad. Arts and Sci. N. Ser. 5 (263).	*Massachusetts.*
Storer, H. R.	1857	Observations on the Fishes of Nova Scotia and Labrador. Bost. Journ. Nat. Hist. 6 (247).	*Labrador*—(Bradore?)
Whiteaves, Joseph F.	1886	Colonial & Indian Exhibition Catalogue. Ottawa (1-42).	Atlantic Coast of Canada. Gulf of St. Lawrence.
Williamson, Wm. D.	1832	The History of the State of Maine, 1 (150).	*Maine*—Eastern river and other localities.
Yarrow, H. C.	1877	Notes on the Natural History of Fort Macon, N.C. Proc. Acad. Nat. Sci. Phila. (206).	*North Carolina*—Fort Macon.

4. LOCAL DISTRIBUTION AND MIGRATION.

The map (fig. 2) below shows the distribution of the muttonfish in its northern range.

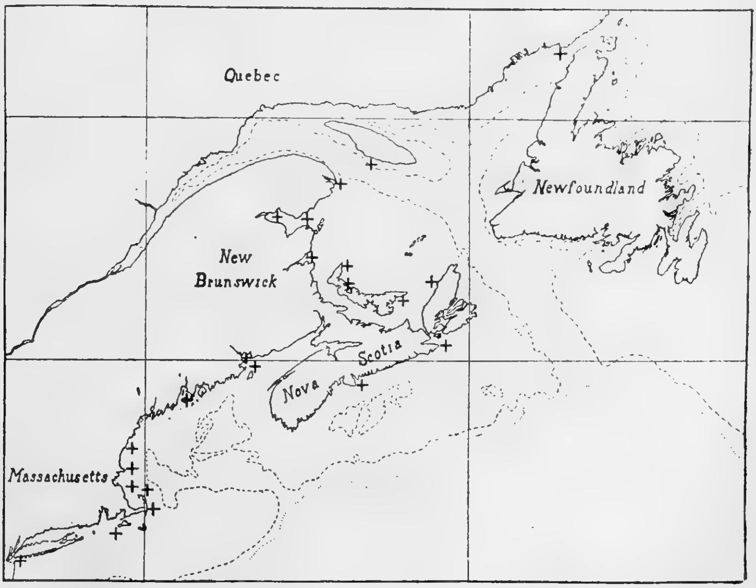

Fig. 2—Atlantic Coast with the localities from which the muttonfish has been reported shown by crosses.

Our knowledge of the habits, activities, migrations, breeding habits, etc., of the muttonfish is limited. Specimens kept in a large laboratory tank in 1918, remained coiled up in the darkest parts, but when disturbed swam swiftly and with power. The character of the food and the absence of swim bladders indicate that they are bottom dwellers. During the summer months they are comparatively abundant in Passamaquoddy bay and in the lower portions of the St. Croix river. A few were taken in 1918 at a point about six miles up the St. Croix river and outward in the Bay of Fundy at the Wolves islands. In the course of the study specimens have been examined from the following localities: St. Croix river, Passamaquoddy bay, Bay of Fundy, including localities near the island of Grand Manan, Campobello island and the Wolves islands, St. Mary's bay, N.S., Miramichi bay (near Loggieville), Cheticamp (Cape Breton island) and gulf of St. Lawrence. They are most commonly taken by means of set lines but are also taken on hand lines, in herring traps, seines, lobster traps and various kinds of trawls. Young specimens are occasionally found around rocks and in seaweed along the shore during ebb tide. They occur on practically every variety of bottom in this region and at depths up to 55 metres. The following are the set line and shrimp trawl records for the Passamaquoddy bay region, with the addition of one record off Cape Breton island and another in Miramichi bay.

SET LINE RECORDS.

Date.	Locality.	Sets.	Bait.	No. Zoarces per 3,000 hooks.
1917, July 21 to Sept. 1	Off Cheticamp (Cape Breton Island)	3	Squid and Mussel	6
1917, June 29 to Aug. 24	St. Croix river	2	Clam	22
1917, Oct. 9	St. Croix river	1	Herring	14
1917, Sept. 25	Passamaquoddy bay	1	Herring	105
1918, June 18 to June 27	Miramichi bay	5	Gaspereaux	9
1918, May 31 to Aug. 19	St. Croix river	19	Clam	30
1918, June 28 to Aug. 13	St. Croix river	10	Herring	12
1918, July 18	Passamaquoddy bay	1	Herring	6
1918, July 19	Wolves islands, Bay of Fundy	1	Herring	1
1919, Jan. 7 to May 16	Passamaquoddy bay	10	Herring	0
1919, Jan. 13 to April 7	Bay of Fundy (outside Passamaquoddy bay)	4	Herring	0
1919, July 22 to Sept. 9	St. Croix river	4	Clam	41
1919, May 22 to Aug. 19	St. Croix river	5	Herring	6

SHRIMP TRAWL RECORDS.

Date.	Locality.	Depth in metres.	Number of Zoarces.
1917, Nov. 15	Passamaquoddy bay	25–30	2
1918, April 9	Bay of Fundy	93	1
1919, Jan.–May (14 hauls)	Passamaquoddy bay	various depths	0
1919, April 21	Bay of Fundy	?	1 (2·5 cm)
1919, June 13	Passamaquoddy bay	30	10
1919, July 15	"	30	8
1919, Aug. 28	"	25–30	4

The outstanding points in these records are:—

1. That the muttonfish is apparently absent from the St. Croix river and Passamaquoddy bay during at least four months of the year, from January to April.

2. The proportionately large capture in Passamaquoddy bay on September 25, 1917, may indicate a migration from the rivers into the bay prior to further migration into the Bay of Fundy.

3. The capture of a specimen on April 9, 1918, in the Bay of Fundy at a depth of 93 metres may be additional evidence of winter spent in the outer waters.

4. Where comparison is possible, clams (*Mya arenaria*) appear to be a better bait than herring (*Clupea harengus*). This agrees with the results of the food study, which shows that molluscs form a very important part of the food, whereas fish are seldom eaten.

5. AGE ESTIMATION AND RATE OF GROWTH.

An estimation of the age and rate of growth of the muttonfish has been made from a study of the otoliths. The scales are very small and show no uniformity in annual growth areas. The vertebræ were found to be very unsatisfactory in the older fish because of the difficulty of distinguishing the rings toward the margins. However, in the younger specimens they were a valuable check on the otolith counts. The otoliths are comparatively small and regular in form and show clearly alternate light and dark areas. Final counts of the bands were made with the low power objective of the compound microscope upon ear-stones cleared and mounted in glycerine. No grinding down of the stones was necessary. In all, otoliths from ninety-one specimens have been examined. The method of computation has been somewhat the same as

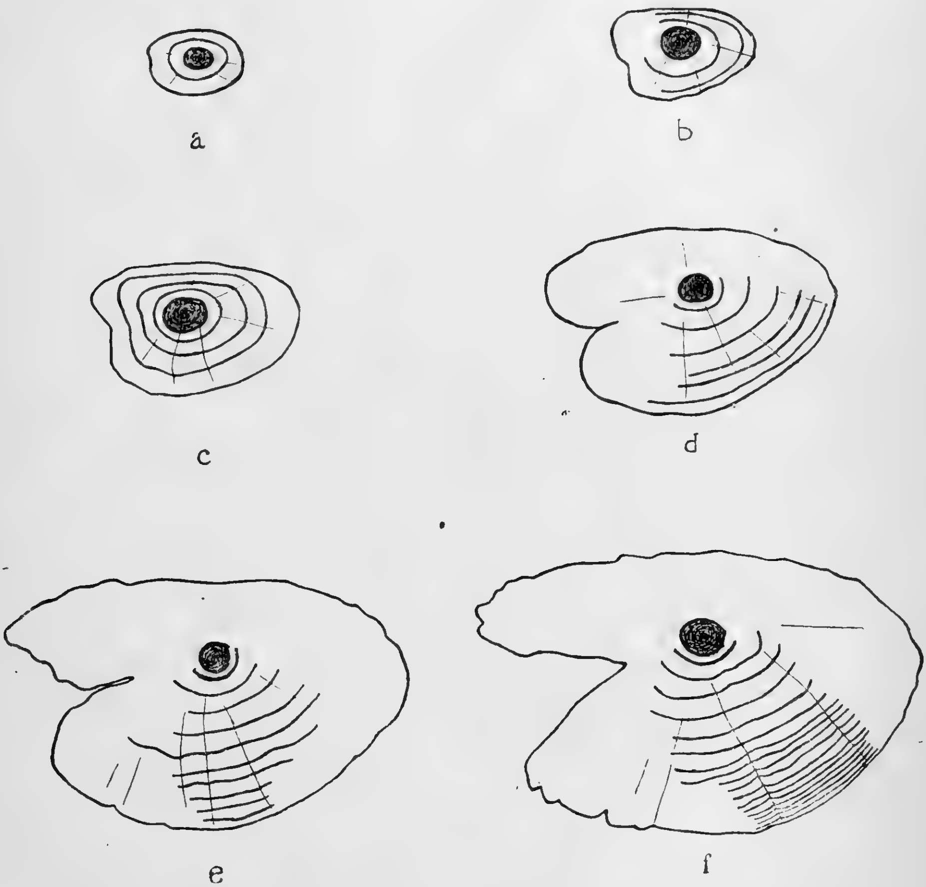

Fig. 3. Muttonfish otoliths drawn to the same scale.
(*a*) No. 119: 1·1 x ·7 mm. Fish in first summer, 9·0 cm. in length.
(*b*) No. 124: 1·5 x ·8 mm. " " second summer, 12·6 cm. in length.
(*c*) No. 41: 2·2 x 1·4 mm. " " third summer, 21·0 cm. in length.
(*d*) No. 98: 3·2 x 2 mm. " " sixth summer, 33·5 cm. in length.
(*e*) No. 31: 4·2 x 2·5 mm. " " tenth summer, 51·5 cm. in length.
(*f*) No. 33: 4·7 x 3·0 mm. " " seventeenth summer, 61·5 cm. in length.

that used by Fryd (1901) for *Zoarces viviparus*. He assumes that during the winter a comparatively small amount of material is added to the otolith and this shows as a narrow opaque band or line. During the summer a comparatively large amount is added, which shows as a broad and much less opaque area. The dark centre or kernel is considered as the embroyonic beginning and the narrow light band immediately outside as representing the period in the body of the mother prior to birth, since the fish is ovoviviparous. The first dark band represents the remaining part of the winter period following birth, and the next broad light area, the first summer. From this on the dark and light areas represent the succeeding winters and summers respectively. The otoliths of *Zoarces anguillaris* agree with the description given for those of *Zoarces viviparus,* but there is no evidence as yet to show that the muttonfish is ovoviviparous. Drawings have been made of six otoliths to illustrate the method of calculation and also to show the changes in shape of the otolith with increasing age (fig. 3). For example, the otolith of fig. 3 (*a*) was taken on July 16, 1919, from a specimen 9 cm. in length. It is exactly similar to others taken during the summer from specimens 7·5, 8·0 and 8·3 cm. in length. It seems extremely probable that these muttonfish were in their first year because *Zoarces viviparus* grows much more rapidly than this, (Fryd loc. cit.), and in Canadian waters, pollock, cod, haddock and hake attain considerably greater lengths in their first years. Moreover, specimens 2·5 and 3·7 cm. have been taken in April and a growth of 1·5 cm. per month during the months May, June and July would not be excessive. Unfortunately these small specimens were preserved in strong formalin and the otoliths disintegrated. The otoliths from the four larger specimens show one winter ring. As will be shown later, the reproductive period undoubtedly occurs in the autumn, and therefore the first light area on the otolith probably represents a short period of very rapid growth in the autumn before the onset of winter conditions.

It should be stated here that in dealing with the otoliths many difficulties occurred. Bands are often indistinct; secondary lines tend to confuse the counts; the lines towards the margins become crowded together. It is a method of age estimation, not absolute determination. The difficulties are much the same as those met with in the scales of fish. Lea (1919) expresses the same opinion in his work with the scales of herring (*Clupea harengus*). "That errors and uncertainty are unavoidable in investigations of this kind will be admitted by all who have had any experience of such work. The material may be handled with the highest possible degree of care and attention, so as to warrant the hope that a repetition of the determinations must give exactly the same results, yet on going through the whole once more, discrepancies will nevertheless be found. As a matter of fact, we are hardly justified in using the term "age-determination" when dealing with scales; "estimate" would be more correct, for there will always be found, whatever may be the material under consideration, a greater or less number of individuals whose scales must be classed as doubtful, and where the decision must be based more or less upon personal judgment."

No. of Specimens.	Age.	Length.	Estimated average growth limits in each year.	Increase in length per year in cm.
7	1st year	3·7–10 cm.	1–10 cm.	10
3	2nd "	12·0–14·7 cm.	10–16 cm.	6
7	3rd "	17·5–21·0 cm.	16–21 cm.	5
5	4th "	21·8–26·2 cm.	21–26 cm.	5
4	5th "	25·5.30·9 cm.	26–31 cm.	5
7	6th "	31·3–34·7 cm.	31–35 cm.	4
2	7th "	34·3–35·2 cm.	35–39 cm.	4
6	8th "	37·5–47·0 cm.	39–43 cm.	4
10	9th "	41·0–50·0 cm.	43–46 cm.	3
21	10th "	43·4–53·7 cm.	46–49 cm.	3
5	11th "	45·5–56·0 cm.	49–52 cm.	3
2	12th "	56·5–57·0 cm.	52–55 cm.	3
1	13th "	59·8 cm.	55–58 cm.	3
1	14th "	59·0 cm.	58–60 cm.	2
2	15th "	59·0 cm.	60–62 cm.	2
4	16th "	60·0–73·0 cm.	62–64 cm.	2
3	17th "	61·5–68·0 cm.	64–66 cm.	2
0	18th "		66–68 cm.	2
1	19th "	67·5 cm.	68–69 cm.	1
0	20th "		69–70 cm.	1

The first column shows the number of muttonfish of each age.

The second column gives the age as estimated by the otoliths.

The third column shows the smallest and greatest lengths found for each age.

The fourth column gives the estimated average lengths for each year. For example, it is estimated that on the average a muttonfish is 10 cm. long at the end of the first year, 16 cm. long at the end of the second year, 21 cm. at the end of the third year, etc.

The fifth column gives the probable average growth in cm. for each year.

The rate of growth is shown in fig. 4. The curve represents the estimated average lengths for each year. Since the majority of the young fish were taken in early summer, they would not have reached their growth limits for that year and therefore fall to the left of the curve.

6. REPRODUCTION.

It is impossible to distinguish the sexes externally except possibly in older specimens where the head of the male appears slightly larger and heavier than that of the female. Females in the environs of the St. Andrew's Biological Station from May 31 to October 15, 1918, contained eggs from less than 1 mm. to 5 mm. in diameter. A female 62 cm. in length, weighing 3 pounds 12 ounces, and probably 17 years of age, contained 1,805 eggs 5 mm. in diameter. Seventy-nine specimens were opened, and the diameters of the eggs in the ovary and the lengths of the testes were measured. The results are given in the following two tables:—

EGGS IN OVARIES—DIAMETER.

	0–1 mm.	1–2 mm.	2–3 mm.	3–4 mm.	4–5 mm.
May	71 cm.				
June		51 cm. 54·5 cm.	58·5		
July	21·0 26·5 27·0 40·5 41·0 54·5 61·5	33 59	57 60·5 64·8	47 48 56	49·5 56·5 57·0 62·0
August	37·5 40·5 43 45 45 45·5 50				
September	44·0				

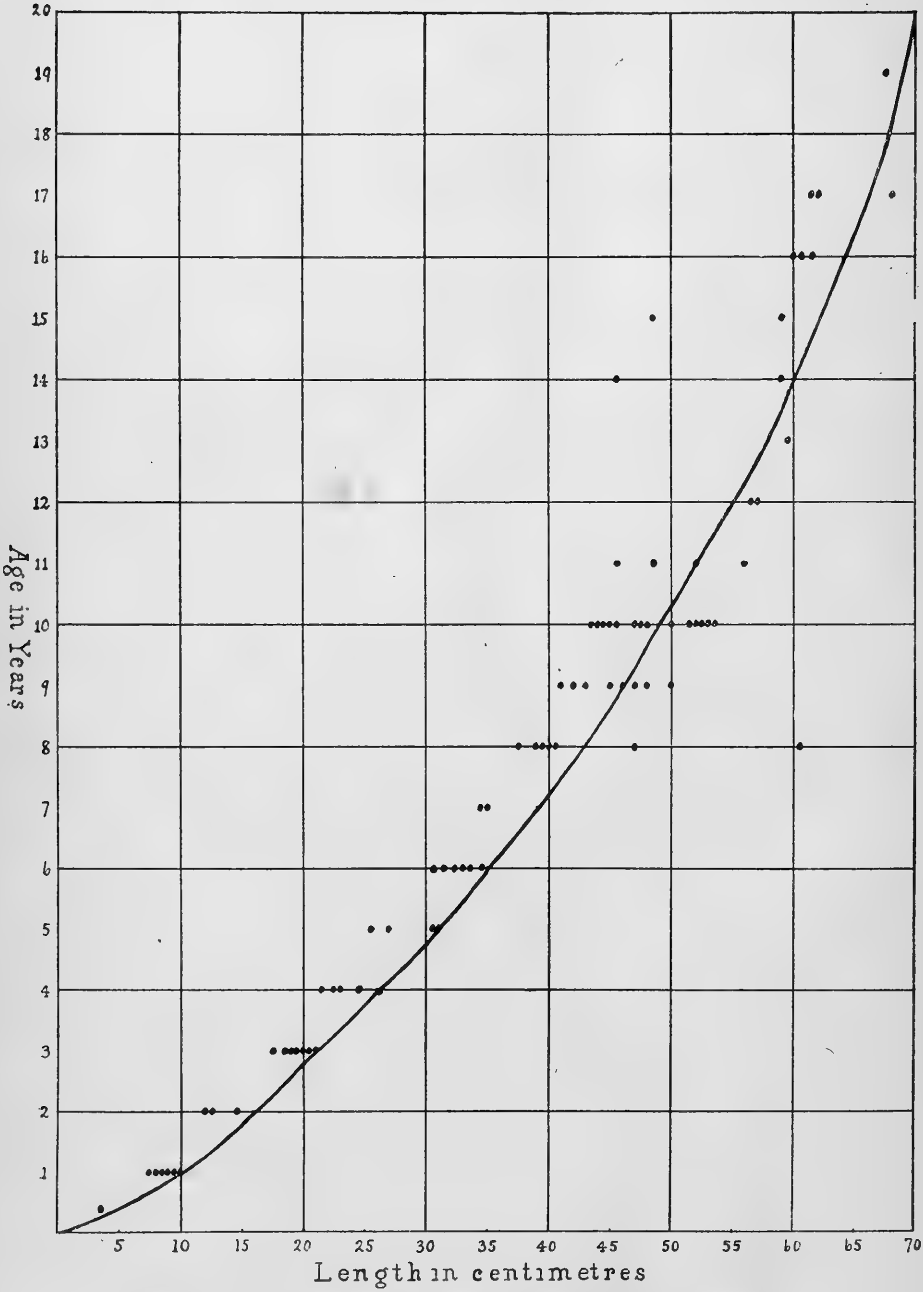

Fig. 4. Curve showing the rate of growth of the muttonfish.

TESTES—LENGTH.

	1–2 cm.		2–3 cm.		3–4 cm.		4–5 cm.		5–6 cm.	
	Testes	Fish	Testes	Fish	Testes	Fish	Testes	Fish	Testes	Fish
April			2·3	47·0	3·5	60·0				
May			2·2 2·6	43·0 54·5						
June	1·6 cm.	cm. 34·0	2·5 2·5 2·9	49·5 50·5 66·0	3·2	49·5				
July	6 mm. 1·9 cm.	20·5 45·5	2·4 2·8	40·0 61·5	3·0 3·2 3·2 3·4 3·4 3·5 3·5	51·5 54·5 60·0 45·5 51·5 56·0 62·0	4·0 4·0 4·0 4·0 4·1 4·5 4·6	45·0 52·0 53·0 53·0 63·5 67·5 59·0	5·0 5·8	53·5 83·0
Average for July		33·0		50·5		54·5		57·0		68·0
August	1·6	42·0	2·0 2·5 2·6 2·7 2·9	43·5 44·5 43·5 39·0 47·5	3·0 3·5 3·6 3·9	46·0 48·5 44·0 52·0	4·0 4·0 4·2 4·2	48·0 50·0 47·0 48·0		
Average for August		42·0		43·0		47·5		48·0		
September	1·4	36·0								
October	1·4	33·5	2·0 2·2	43·0 47·5	3·0	60·5				

Examination of the tables shows—

(1) that as a rule the larger females contained the larger eggs and that no specimens with large eggs were taken later than July;

(2) similarly the larger males contained the larger testes and the larger males tended to disappear in August.

These results are then evidence—

(1) that a fall migration occurs and corroborates the set line and shrimp trawl records;

(2) that the reproductive period occurs in the fall of the year since the sexually mature fish disappear early in August and since no "spent" males or females were taken from May to October, 1918. Two captures tend to substantiate this. On April 15, 1919, a muttonfish 3·7 cm. in length was found in the stomach of a sculpin (*Myoxocephalus octodecimspinosus*) taken in a seine in St. Andrew's bay. Also on April 21, 1919, an imperfect specimen 2·5 cm. in length was taken in a shrimp trawl in the Bay of Fundy. As previously stated there is no doubt but that these small specimens were produced during late fall or early winter. This would coincide with the period given for *Zoarces viviparus* (McIntosh, 1885, and Van Bambeke, 1888);

(3) that the fish do not become sexually mature until they have attained a length of about 40 to 45 cm. According to the age estimations the fish would be about eight years of age;

(4) that reproduction may not occur every year in some, possibly in all individuals. In late July there were large females containing small eggs and large males with small testes. Also there were taken occasional large specimens later than July with small eggs and small testes. For example, a female 61·5 cm. in length taken on July 10, 1918, had eggs only 1 mm. in diameter; another 59 cm., taken July 26, 1918, had eggs only 1·5 mm. in diameter; and another 50 cm., on August 21, 1918, had eggs 1 mm. in diameter. It is doubtful if these eggs would have matured that season.

Whether *Zoarces anguillaris* resembles *Zoarces viviparus* in being ovoviviparous has not been determined. Goode (loc. cit.) states that the fish spawns in July and August in the deep waters of Massachusetts bay, but gives no evidence in support of his statement.

McIntosh (loc. cit.) states that *Zoarces viviparus* in Scottish waters may liberate young up to the lengh of 4·5 cm. Van Bambeke (loc. cit.) states that females of this species from 30-39 cm. in length contain from 200-400 young. Fryd (loc. cit.) gives about 100 young for specimens 30 cm. in length, and 205 for a specimen 37·7 cm. in length. Bridges (1904) gives the number of young produced as 20—300 or more according to the size of the female and adds that the eggs hatch in about 20 days, and the young are not born until about four months after fertilization when they are about 1½ inches long. It is apparent that a much smaller number of eggs mature in *Zoarces viviparus* than in *Zoarces anguillaris.* If the muttonfish is ovoviviparous it is not probable that it would retain 1,800 young until they attain a length of 4·5 cm. They would probably only be about 1 or 1·5 cm. in length when liberated since the young reach a length of only 2·5 to 3·7 cm. by April. It is unlikely that this short period would have any relation to the first light area surrounding the "nucleus" of the otolith.

7. RELATION OF TEMPERATURE TO THE PERIODS OF MIGRATION AND REPRODUCTION.

The extremes of temperature for the bottom waters of the St. Croix river, Passamaquoddy bay and the Bay of Fundy in 1916 and 1917 are shown in the following table. The writers are indebted to Professor A. Vachon, Laval University, for these records.

Locality.	Date.	Lowest Temperature.	Date.	Highest Temperature.	Depth.
St. Croix river	Mar. 15, 1917	—·03	Sept. 6, 1917	10·48	30 m.
"	" 28, 1918	—·27	" 19, 1918	10·94	30 m.
Passamaquoddy bay	Feb. 23, 1917	—·10	" 6, 1917	10·02	30 m.
"	Mar. 21, 1918	—·74			
Bay of Fundy	Feb. 28, 1917	+·49	Sept. 22, 1917	9·23	90 m.
"	Mar. 20, 1918	+·70	" 9, 1918	9·78	90 m.

The sexually mature muttonfish leave the St. Croix river and Passamaquoddy bay about the end of July, and the remainder probably have left by the end of October. The height of the outward migration therefore occurs at the period of highest temperature. The inward migration probably begins early in April, which is the time when the temperature of the water in the St. Croix river and Passamaquoddy bay goes above 0° C. Fertilization of the eggs probably occurs in September which is the period of highest bottom temperature. There is thus a coincidence between the temperature extremes and the migration periods, but whether or not there is a causal relation it is impossible to decide at the present time.

8. RELATION OF WEIGHT TO AGE, LENGTH AND SEX.

The following table shows the relation of the weight to the age and length and gives the probable average increase in weight for each year.

Age in years	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Number of specimens	5	3	2	5	2	4	9	17	5	2	1	1	2	4	3	....	1
Calculated average wgt. in oz	1·3	1·8	4	6	6·2	14·2	18	25·3	28·2	35	44·5	44	49	54·2	59	....	73
Estimated average increase in wgt. in oz.	....	1	2	2	3	4	5	6	6	5	5	5	5	5	5	5	5
Estimated average weight in oz	1	2	4	6	9	13	18	24	30	35	40	45	50	55	60	65	70
Estimated average length in cm	21	26	31	35	39	43	46	49	52	55	58	60	62	64	66	68	69

Figure 5 below is a graph showing more clearly the relation of weight to length.

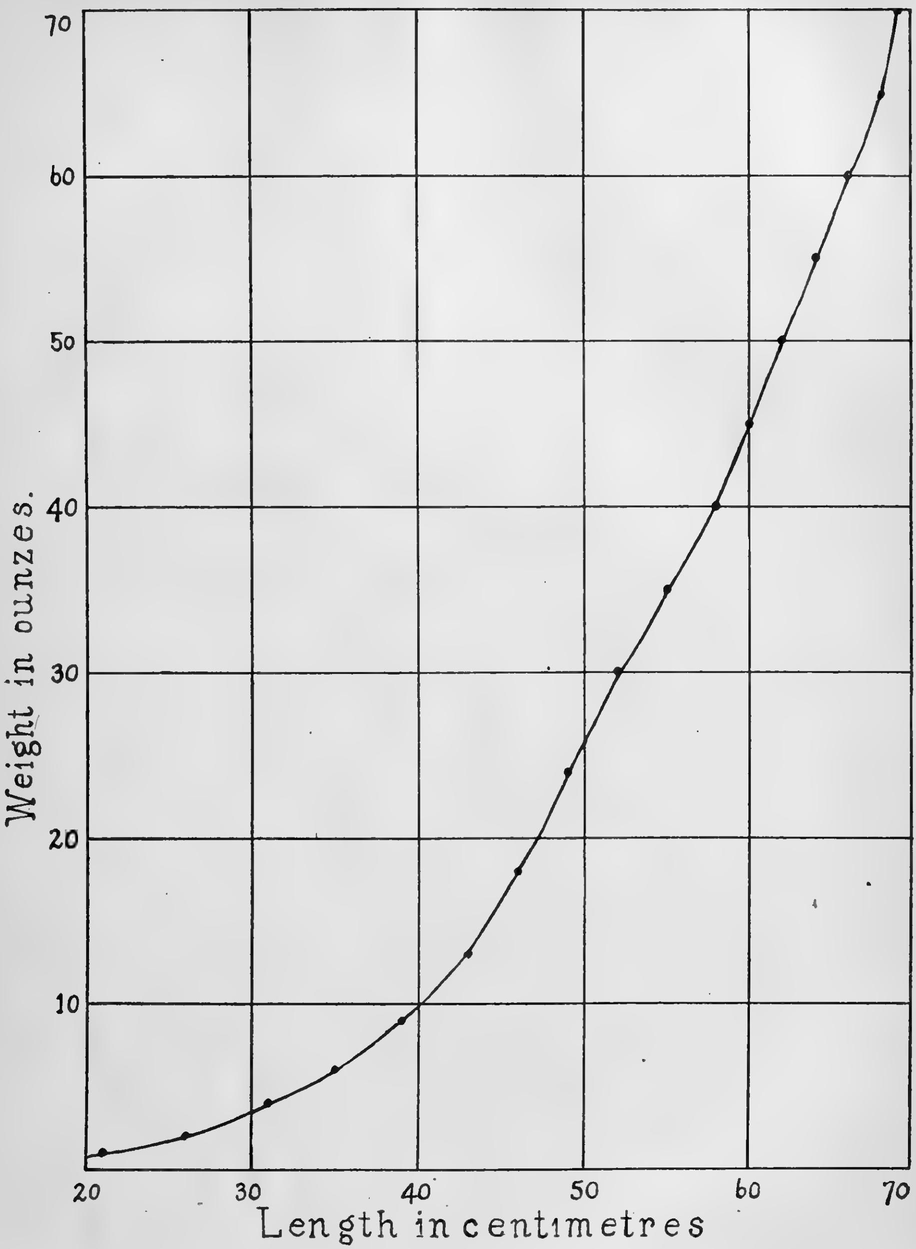

Fig. 5. Curve showing the relation of the length of the muttonfish to the weight.

These results indicate that the muttonfish is not a heavy fish in relation to its length and that the increase in weight in any year is not great.

There is no difference in weight between the sexes. The average weight of fourteen males in the tenth year of age, average length 49·4 cm. was 1 pound, 9 ounces. The average weight of four females in the tenth year, average length 49·2 cm., was 1 pound, 9 ounces. Similarly in the ninth year the average weights of the two sexes were almost identical.

9. FOOD.

The contents of the alimentary tracts of seventy-five muttonfish were examined to obtain some data in regard to the food of the species. The records show that the muttonfish draws upon Molluscs, Echinoderms and Crustaceans almost exclusively for its food. Of the 75 specimens examined, 59 had eaten Mollusca, 47 Echinodermata, and 40 Crustacea, percentages of 79, 63, and 53, respectively.

The relative abundance of the chief forms found in the digestive tracts of the 75 specimens is shown in the following table:—

Name.	No. of Zoarces in which found.	Percentage.	Greatest No. found in a single specimen.
Whelk—*Buccinum undatum*	16	21	18
Blackmussel—*Mytilus edulis*	12	16	122
Modiolaria, various species	11	15	65
Periwinkle—*Littorina litorea*	9	12	33
Scallops—*Pecten* sp	8	11	8
Sea-urchin—*Stronglyocentrotus droebachiensis*	44	59	51
Brittle stars—*Ophiopholis aculeata*	9	12	7
Barnacle—*Balanus balanoides*	14	19	very numerous.
Tunicates	12	16	8
Polynoids	10	13	4

Two specimens had each eaten a small fish, one was a small smelt, (*Osmerus mordax*); the other could not be identified. The following forms were kindly identified by Dr. A. G. Huntsman, Curator of the St. Andrews Biological Station.

ANNULATA—
- *Polynoids.*
- *Phascolosoma* sp?
- *Cistenides granulata* (Malmgren).

CRUSTACEA—
- *Pagurus kröyeri* (Stimpson).
- *Pagurus acadianus* (Benedict).
- *Erichthonius rubricornis* (Stimpson).
- *Aeginella longicornis* (Kröyer).
- *Nymphon grossipes* (L).
- *Jaera marina* (Fabr.).
- *Gammarus locusta* (L).
- *Balanus balanoides* (L).
- *Pycnogonum littorale* (Ström).
- *Leptocheirus pinguis* (Stimpson).
- *Unciola irrorata* (Say).
- *Crago septemspinosus* (Say).

MOLLUSCA—
- *Modiolaria discors* (L).
- *Modiola modiolus* (L).
- *Buccinum undatum* (L).
- *Margarita undulata* (Sowerby).
- *Pecten magellanicus* (Gmelin).
- *Aporrhais occidentalis* (Beck).
- *Cardium pinnulatum* (Conrad).
- *Velutina undata* (Brown).

MOLLUSCA—*Continued.*
- *Velutina laevigata* (Gould).
- *Yoldia sapotilla* (Gould).
- *Cyclocardia borealis* (Conrad).
- *Polynices groenlandica* (Müller).
- *Nucula tenuis* (Montagu).
- *Crenella glandula* (Totten).
- *Crenella decussata* (Montagu).
- *Lyonsia hyalina* (Conrad).
- *Littorina litorea* (L).
- *Astarte undata* (Gould).
- *Saxicava arctica* (L).
- *Mya arenaria* (L).
- *Acmaea testudinalis* (L).
- *Solenomya velum* (Say).
- *Corophium bonellii* (M. E.).

ECHINODERMATA—
- *Strongylocentrotus droebachiensis* (Müller).
- *Ophiopholis aculeata* (L).
- *Echinarachnius parma* (Lamarck).

CHORDATA—
- *Ascidiopsis prunum* (Müller).
- *Caesira retortiformis* (Verrill).
- *Tetradidemnum albidum* (Verrill).

Storer (1839) lists the following as stomach contents:—

Buccinum undatum.
Fusus corneus.
Fusus pleurotomarius.
Turbo inflatus.
Natica triserata.
Natica consolidata.
Bulla tritacea.
Tellina sordida.

Storer (1867) lists these additional forms—

Turbo obscurus.
Fusus turricula.
Trichotropis borealis.
Nucula minuta.
Turritella erosa.
Venus gemma.
Pecten islandicus.
Pectinaria sp.

The results of the food study show that the muttonfish is a bottom feeder but is not a scavenger.

10. LIST OF ASSOCIATES FROM SET LINE RECORDS.

Considerable information regarding the common associates of the muttonfish in the St. Croix river is obtained from the set line records as shown in the following table, in addition to that afforded by the study of the food. The records were obtained between May 31 and August 19, 1918. The area covered was from the mouth of the river to about 10 miles upstream at depths from 10 to 30 metres. An average of 250 hooks was used at a set and the line usually set for an hour either at high or low water slack. Clams (*Mya arenaria*) and herring (*Clupea harengus*) were used for bait as shown in the table:—

—		Clam bait, 19 sets.	Herring bait, 10 sets.
Anemones		4	6
Crabs	*Cancer* sp?	2	1
Horse mussel,	*Modiola modiolus* (L)	6	5
Whelk,	*Buccinum undatum* (L)	18	1
Round whelk,	*Polynices heros* (Say)	3	3
Common starfish,	*Asterias vulgaris* (Verrill)	670	92
Sea urchins,	*Strongylocentrotus droebachiensis* (Müller)	175	42
Basket stars,	*Gorgonocephalus agassizi* (Stimpson)	37	44
Crossaster,	*Crossaster papposus*	1	2
Blood star,	*Henricia sanguinolenta* (Müller)	..	1
Brittle stars,	*Ophiopholis aculeata* (L)	2	10
Sea-cucumber,	*Cucumaria frondosa* (Gunnerus)	1	1
Sea pear,	*Boltenia ovifera*	5	18
Sea peach,	*Tethyum pyriforme*	31	9
Sea potato,	*Ascidiopsis prunum* (Müller)	1	1
Tobacco box,	*Raja erinacea* (Mitchill)	16	113
Spiny skate,	*Raja radiata* (Donavan)	5	9
Barn door skate,	*Raja laevis* (Mitchill)	2	7
Dogfish,	*Acanthias vulgaris* (L)	..	1
Haddock,	*Melanogrammus aeglefinus* (L)	29	2
Hake,	*Urophycis tenuis* (Mitchill)	..	2
Cod,	*Gadus morrhua* (L)	..	2
Tomcod,	*Microgadus tomcod* (Walbaum)	..	5
Rosefish,	*Sebastes marinus* (L)	..	4
Sculpin,	*Myoxocephalus octodecimspinosus* (Mitchill)	37	48
Sea raven,	*Hemitripterus americanus* (Gmelin)	2	1
Flounder,	*Pseudopleuronectes americanus* (Walbaum)	13	2
Halibut,	*Hippoglossus hippoglossus* (L)	..	1
Eelpout or Muttonfish,	*Zoarces anguillaris* (Peck)	41	9

11. ENEMIES.

Only three fish have been found to have eaten the muttonfish, a sculpin (*Myoxocephalus octodecimspinosus*), a sea raven (*Hemitripterus americanus*), and a skate (*Raja laevis*). The first had eaten a small specimen, 3·7 cm. in length. The other two had eaten the muttonfish after the latter had taken the hook of the set line.

12. PARASITES.

Considerable parasitism by nematode and platyhelminth worms occurs in the alimentary tract, and by nematodes in the body muscles. Of 44 specimens examined for intestinal parasites, 45 per cent contained nematodes and 35 per cent tapeworms. The nematodes were kindly identified by Mr. Maurice C. Hall, of the Bureau of Animal Industry, Washington, D.C., as *Kathleena* sp. and *Echinorhynchus* sp., both probably undescribed species. The tapeworms have been kindly identified by Dr. A. R. Cooper, University of Illinois Medical School, Chicago, Ill., as *Bothrimonus intermedius* Cooper.

Of 41 specimens examined for body-muscle parasites from July 26 to October 15, 1918, 60 per cent were parasited. These were also identified by Mr. Hall as *Kathleena* sp. ?, probably undescribed species. Similar nematode worms have been found in the body muscles of flounders (*Pseudopleuronectes americanus*) and cod (*Gadus morrhua*) taken in the same region. Possibly this parasitism may be only local or only occur to any extent in certain years.

13. SUMMARY.

The important points brought out in this study of the muttonfish (*Zoarces*) in the Passamaquoddy bay region are:—

1. That it leaves the rivers and bays in the fall of the year for the outer deeper waters of the Atlantic, and returns about the end of April of the following year.
2. That the reproductive period occurs in the autumn.
3. That the fish is comparatively slow of growth, reaching a length of about 70 cm. and a weight of 69 ounces at 20 years of age.
4. That it is a bottom feeder, feeding almost entirely upon Mollusca, Echinodermata and Crustacea.

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VII.

Eastern Canadian Plankton.—The Distribution of the Tomopteridæ obtained during the Canadian Fisheries Expedition, 1914-1915.

BY

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The Tomopterids form the bulk of the pelagic Annelids of the expedition. Several specimens of species belonging to other groups were obtained, but these were in such poor condition that their identification was not attempted.

The Tomopterids have proven to be so rare in our material that the method of capture must be considered to a large extent unsuitable for a determination of their distribution. The four species obtained may be distinguished by means of the following table:—

Key to the species of Tomopteris.

A_1. Rosettes present on the parapodia. Tail present. (Subgenus *Johnstonella.*)
- B_1. Rosettes on the trunk of each of the first two pairs of parapodia and on the fins of the remainder. *T. duccii.*
- B_2. Rosettes on the ventral ramus of the first two pairs of parapodia and on all the fins. *T. catharina.*

A_2. Rosettes absent. Tail lacking. (Subgenus *Tomopteris.*)
- C_1. Both hyaline and chromophile glands at apex of fin of ventral ramus of parapodium. *T. septentrionalis.*
- C_2. Hyaline gland apical, chromophile gland inferior in fin of ventral ramus of parapodium. *T. planktonis.*

Tomopteris (Johnstonella) duccii Rosa.
1907. Rosa, p. 177.
1908. Rosa, p. 273.

The single specimen obtained showed the following characters, which agree so closely with those of *T. duccii,* as described by Rosa, as to leave no doubt of its belonging to that species.

Length: trunk, 8 mm.; tail, ca. 6 mm.

Width: the greatest is about 4 mm.

The prostomium has a convex anterior border. The horns are about 1 mm. long. The first cirri are decidedly shorter than the horns, while the second cirri are 6 mm. long.

The eyes are distinct, brownish in colour, and elongated longitudinally. The ciliated epaulettes are narrow and tongue-like, extending back considerably behind the cerebral ganglion.

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*This article and the following one were completed too late to be included in the report of the expedition (Canadian Fisheries Expedition, 1914-1915, Department of the Naval Service, Ottawa, 1919). For an account of the cruises undertaken, methods used, etc., see the introduction by Dr. Johan Hjort, the leader of the expedition, in that report.

The stations of C.G.S. "Acadia" and C.G.S. "Princess" are shown in figure 1, the dates for the two cruises of each being indicated. The stations taken by C.G.S. "Thirty-three" were all in the Gulf St. Lawrence, while those of the Biological vessel "Prince" were taken in the Bay of Fundy in September of that year (1915).

The parapodia are 18 in number, the last two being rudimentary. There are none on the tail, which is very slender.

A rosette is present in the middle of the lower side of the trunk of each of the first two parapodia of the right side, but none can be seen in those of the left side. A rosette is present in the fin just inside and close to the tip of both rami of all the parapodia with the exception of the first two pairs. A spine projects from a slight notch in the ventral part of the fin of the ventral ramus of each parapodium, but is indistinct in the first ones. An hyaline gland is closely applied to the outer side of the spine in all the parapodia. A chromophile gland is placed just inside the spine on the parapodia, beginning with the fifth pair.

The single specimen was obtained at "Acadia" Station 75, in the vertical haul from a depth of 325 metres. This species has heretofore been known only from two specimens reported by Rosa from the Pacific coast of Mexico. It is very evidently a tropical form, and is the only Tomopterid obtained on the expedition that is restricted to the southern oceanic water of the Gulf Stream.

Tomopteris (Johnstonella) catharina (Gosse).

1900. Apstein, p. 38 (as *T. helgolandica*)
1905. Reibisch, p. 8 (as *T. helgolandica*)
1907. Wright, p. 12 (as *T. mariana*)
1908. Rosa, p. 283
1911. Southern, p. 8 (as *T. helgolandica*)
1911. Malaquin et Carin, p. 11 (as *T helgolandica*)

Up to 6 cm. in length. This is the largest, as well as the most common, *Tomopteris* of the region.

It is described as possessing the first pair of setigerous tentacles. All the individuals that I have examined, have been without them but none smaller than 11 mm. has been available. This is in rather striking contrast with the condition in European individuals, in which it is usually present unless in rather large specimens.

Wright obtained off Canso a young Tomopterid, which he indentified with the *Tomopteris mariana* of Greef as described by Apstein, evidently relying upon the presence of a rosette in the basal joint of each of the first two pairs of parapodia. An individual, 1.2 mm. in length, from "Acadia" Station 81 on the St. Pierre bank showed the same condition, but closer inspection revealed the fact that the rosette in reality was in the base of the ventral ramus. I believe, therefore, that these belong to *T. catharina*. This diagnosis is confirmed by their occurrence only on the St. Pierre bank, where adults of the species were most abundant.

Individuals with eggs free in the coelome were obtained on both cruises, at "Acadia" Stations 19, 21, 80, 81 and 83, and at "Princess" Station 45.

DISTRIBUTION.*

C.G.S. *Acadia*.

Station No.	10	11	12	13	19	21	23	24	25	26
Depth of Haul (m.)	0 (T)	0 (T)	100–0 (V)	70–0 (V.)	0 (T)	0 (T)	70–0 (V)	100–0 (V)	120–0 (V)	100–0(V)
Length (mm.)	20	20–32	32 & 37	20 & 30	18–37	20–40	28	18–27	Ca. 22	Ca. 20
Number	1	6	2	2	11	24	1	6	5	3

Station No.	26	27	34	35	36	50	80	80	81
Depth of Haul (m.)	0 (T)	0 (T)	100–0 (V)	125–25 (C)	100–15 (C)	145–0 (V)	145–0 (V)	55–0 (V)	55–0 (V)
Length (mm.)	18–30	20–40	15–30	15–40	25–30	42	30–45	Ca. 30	juv.
Number	3	19	5	5	3	1	4	1	1 x 10

Station No.	81	83	83	83	84		84	86
Depth of Haul (m.)	Ca. 20–10 (T)	160–0 (V)	55–0 (V)	Ca. 20–10 (T)	Ca. 20–10 (T)		55–0 (V)	Ca. 20–10 (T)
Length (mm.)	30–47	30–40	30–60	25–40	juv.	20–30	juv.	25
Number	6	13	7	many	several	6	1 x 5	1

* In the tables of distribution the following abbreviations are employed,—T for "Tow"; V for "Vertical haul from a certain depth to the surface"; and C for "Vertical haul between certain depths, net being closed before bringing to the surface."

DISTRIBUTION—*Continued.*

C.G.S. *Princess.*

Station No.	20	21	42	45	45
Depth of Haul (m.)	100–0 (V)	100–0 (V)	100–0 (V)	30–0 (V)	Ca. 40–0 (T)
Length (mm.)	25	30	35	ca. 25	30–40.
Number	1	1	1	1	3

	C.G.S. *Thirty-three.*	Motor-boat *Prince.*
Station No.	64	3
Depth of Haul (m.)	80–0 (T)	180–0 (V)
Length (mm.)	20–35	30
Number	10	1

Vertical.—This species was found at the surface and down to a considerable depth. The data indicate a daily migration to and from the surface. With one exception ("Acadia" Station 86) it was obtained in the near-surface tows only between 6 p.m. and 6 a.m. It occurred in the vertical hauls and was absent from the near-surface tows at eleven stations, taken between 6 a.m. and 6 p.m. For the Irish coast Southern (1911, p. 12) records it from the surface to below 1,000 fathoms, but fails to find any correlation between its vertical distribution and the hour of the day.

Horizontal.—On the May-June cruises, the largest numbers were obtained at "Acadia" Stations 19 and 21 on the Green bank off the south coast of Newfoundland. On the July-August cruises, the only station at which the species was found in any abundance was "Acadia" Station 83, which was off St. Pierre island, near Newfoundland. The centre of abundance of the species is, therefore, the Newfoundland banks. This is in agreement with the finding of the species in greatest abundance on the Grand Banks of Newfoundland by the Plankton-Expedition, as recorded by Apstein (1900, p. 45).

From its centre of abundance on the banks off Newfoundland *T. catharina* is distributed toward the northwest and toward the southwest and decreases in abundance in each direction. On the May-June cruises it extended to the northwest along the southern coast of Newfoundland into the gulf through Cabot strait, keeping to the north side of the strait. Only a single specimen was obtained at each of "Princess" Stations 20 and 21 just inside the strait and not one was obtained at any of the remaining stations in the gulf. This seems to have been the extent of its distribution inside the gulf at that time. It indicates that very little of the coastal water is passing westward along the southern coast of Newfoundland into the gulf. If the current flowing into the gulf through Cabot strait off cape Ray had any strong component from the water covering the banks off the south east part of Newfoundland, this species would undoubtedly be well distributed inside the gulf.

It is abundant at the mouth of the Laurentian channel and extends from that region toward the southwest in a broad band along the edge of the continental shelf, as found at "Acadia" Stations 10-13. At first sight it would appear that *T. catharina* is being carried by a current from the Newfoundland banks across the mouth of the Laurentian channel to the southwest. It may be otherwise. Its presence in moderate abundance at "Acadia" Station 34, places it in the outer part of the outflowing Cape Breton current, which it enters from the north. In the outer part of this current it would be carried to the mouth of the Laurentian channel and then to the southwest along the side of the continent.

In the area of distribution outlined above (See fig. 1), the species was lacking at only two stations. At both of these stations, "Acadia" Stations 20 and 22, only surface hauls were made, and at the latter station the haul was made during the day, when it would not be expected at the surface.

On the July-August cruises certain differences in the distribution are to be noticed. Except on the Newfoundland banks, only solitary specimens were obtained in the vertical hauls and these were at widely separated points. It is again present just inside Cabot strait on the north at "Princess" Station 45 off cape Anguille and at

"Thirty-three" Station 64 in St. George bay. It has almost disappeared from the Laurentian channel outside the strait. One individual was obtained at "Acadia" Station 86 in the middle of the channel.

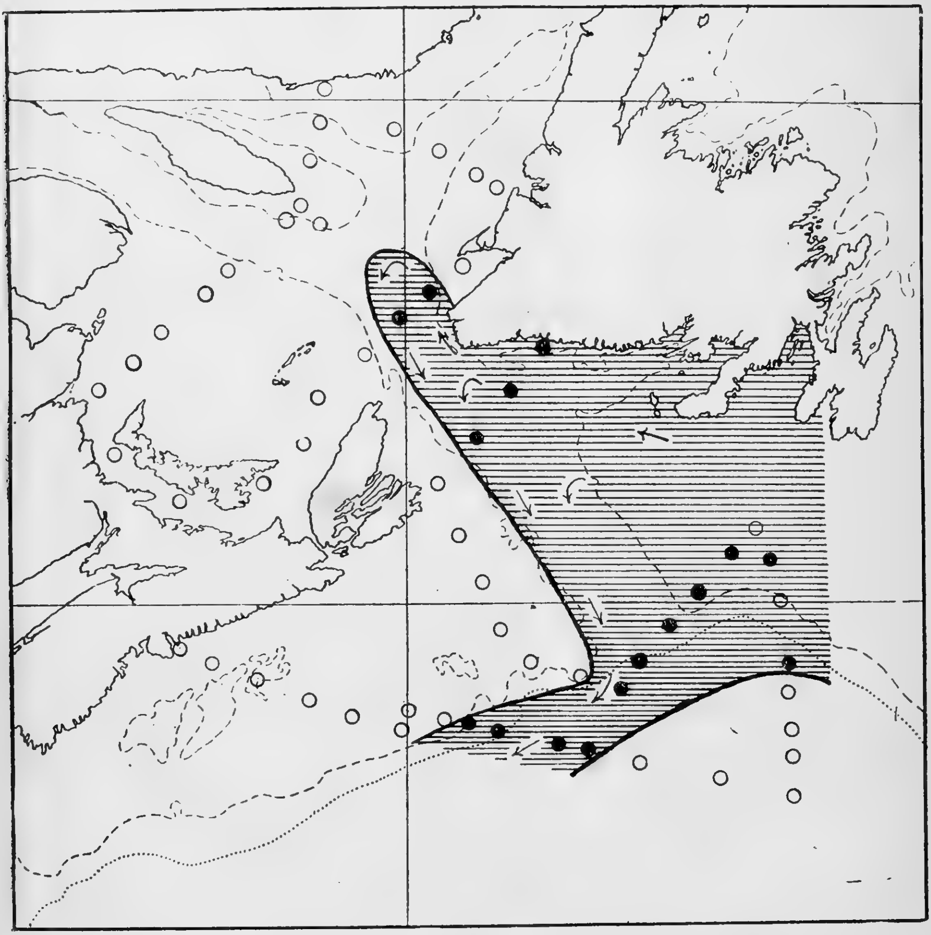

FIG. 1. Distribution of *T. catharina* in May-June, 1915. Arrows indicate supposed directions of drift.

In the northern part of the gulf a single individual was taken at "Princess" Station 42. It might be thought that this had been carried in through Cabot strait. If this were so, it would be expected also at "Princess" Stations 43 and 44, and none were obtained. It is as likely that it has entered the gulf through the strait of Belle Isle. Captain Chalifour of the *Princess* informed me that in July, 1915, he met extensive ice floes well inside the strait of Belle Isle. These will have been driven in by northeast winds. If the *Tomopteris* had in that way been brought into the Esquiman channel, the current which Dawson has demonstrated on the northwest side of the channel, would carry it direct to "Princess" Station 42. Certain arctic medusae show a similar distribution in the northern part of the gulf; for example, *Mertensia*, *Catablema* and *Aeginopsis*.

A single specimen was taken on the Scotian bank off Halifax at "Acadia" Station 50. This had probably been brought to this point by the coastal tongue outside Sable Island bank, which was so distinct in the May-June cruise.

It is evident that the pressing in of the Gulf Stream, which is characteristic of the summer condition, has been accompanied by an obliteration of the stream of individuals of this species, which on the first cruise was passing out of the Laurentian channel around the Breton bank and southwestward along the edge of the continent (see fig. 2). This indicates the smallness of the contribution given by the water covering the Newfoundland bank to the mass of water passing southwestward over the Breton and Scotian banks.

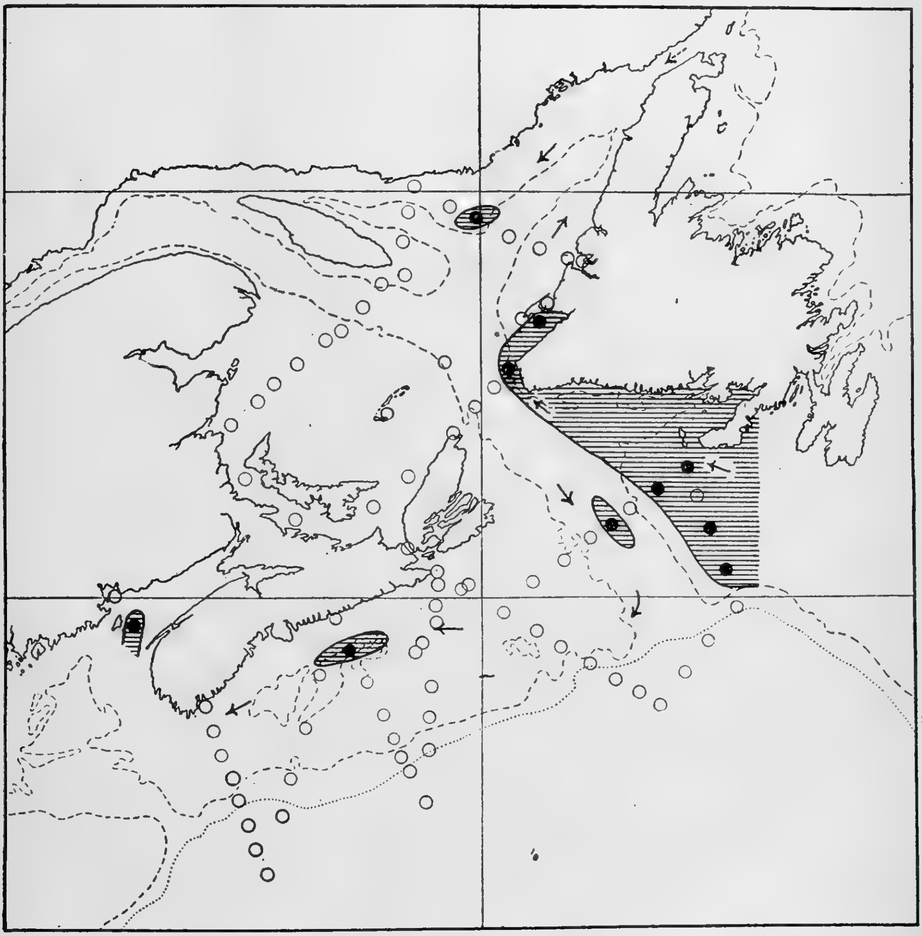

FIG. 2. Distribution of *T. catharina* in July-September, 1915. Arrows indicate directions of currents affecting the distribution.

Another individual was taken in September at "Prince" Station 3 in the bay of Fundy. We have taken it in previous years even farther north in the bay, namely, inside Campobello island near Eastport. Bigelow (1914, p. 121 and 1915, p. 301) found it at many points in the gulf of Maine in 1912 and 1913 and also south of cape Cod as far as New York. Whether it breeds as far south as the gulf of Maine or whether the individuals occurring there have all been brought from the Newfoundland banks is a subject for investigation. Our failure to find the larvæ at any point except near Newfoundland is perhaps significant. Wright's capture of one at Canso proves, however, that they may survive that far to the south at least occasionally. Its virtual absence from the cold coastal water of the St. Lawrence gulf and the Breton and

Scotian banks is an argument against its successful breeding south of Newfoundland. It is perhaps to be considered an Arctic coastal species, which will survive for a long time in boreal or temperate water.

Our records and also those of Bigelow show that it lives in water having a salinity of between 32⁰/oo and 33⁰/oo. On the European coast its conditions of life appear to be quite different. Southern (1911, p. 12) states that on the Irish coast it was not taken in water of lower salinity than 34⁰/oo and that it was taken at all depths down to below 1,000 fathoms. There is no indication that it ever on our coast occurs in water of as high a salinity as 34⁰/oo, or that it ever goes into the deep water. Its distribution on the European coast is,—the North sea, around the British isles, for some distance out into the Atlantic, and as far south as Portugal (Apstein, 1900, and Malaquin et Carin, 1911). It is therefore, in no sense an estuarial species, although carried well into bays and estuaries where the tides are heavy as in the bay of Fundy and in the Irish channel. Its southern limit on the American side of the Atlantic would seem to be the fortieth parallel. On the European side it goes even farther south, namely, to Gibraltar, and is found in the Mediterranean region confined to the Adriatic (Rosa, 1912, p. 5). Whether the tropical records for this species are to be depended upon or not, is open to question. In view of the difference, as noted above, between American and European specimens in regard to the first pair of cirri, a critical comparison of extensive series of specimens from the different regions is much to be desired.

Tomopteris (Tomopteris) septentrionalis. Quatr. ex. Steenstrup.

1900. Apstein, p. 41.
1905. Reibisch, p. 9.
1908. Rosa, p. 297.
1911. Southern, p. 20
1911. Malaquin et Carin, p. 14.

The length ranges from 2 to 11 mm.

DISTRIBUTION.

C.G.S. *Acadia.*

Station No.	16	26	51	51	51	74	75	75
Depth of Haul (m.)	200–0 (V)	100–0 (V)	125–55 (C)	125–0 (V)	0 (T)	325–0 (V)	325–0 (V)	55–0 (V)
Length (mm.)	4–11	4 & 11	8	11	9–11	4 & 5	2 & 3	3–9
Number	7+	2	1	1	6	2	2	5

This species is an oceanic form, and occurs typically in the Atlantic north of 50° N. latitude (see Apstein, 1900). It is abundant some distance off the Irish coast (Southern, 1911), and extends south to the coast of Africa and even into the Mediterranean (Malaquin et Carin, 1911). Rosa (1908) has recorded it from the south Pacific off Chile and considers it to be a "bipolar" species.

It was found in our waters in too small numbers to be classed as a typical inhabitant. It may be that our hauls were on the whole too shallow for it. With one exception the records indicate that it belongs to our northern oceanic water, being brought from the Labrador current, where it is abundant, around the Grand banks. Its presence at "Acadia" Station 51 on the Breton bank off Halifax is in harmony with the presence in that region of other northern oceanic species. Its occurrence only in the most northerly Gulf Stream Stations, "Acadia" Stations 74 and 75, indicates that it enters the Gulf Stream towards the north.

Tomopteris (Tomopteris) planktonis, Apstein.

1900. Apstein, p. 42.
1905. Reibisch, p. 9.
1908. Rosa, p. 301.
1911. Malaquin et Carin, p. 14.

The length ranges from 3 to 6 mm.

DISTRIBUTION.

C.G.S. *Acadia.*

Station No.	16	26	50	75	87
Depth of Haul (m.)	200–0 (V)	100–0 (V)	145–0 (V)	325–0 (V)	290–0 (V)
Length (mm.)	3–5	6	6	3	3
Number	4+	1	1 x 5	4	1

Unlike the preceding, this species occurred only in the deep vertical hauls, and never in the shallow tows. It has a somewhat similar horizontal distribution to that of the preceding one, but is found at the equator as well as in the north, according to Apstein (1900). Malaquin et Carin report it from a number of points from the Canaries to north of the Azores and Rosa (1912, p. 8) has reported it from the Adriatic. On our coast it occurred with the preceding species or at neighbouring stations. In addition, the record at "Acadia" Station 87 shows that it extends in the northern oceanic water for some distance up the Laurentian channel. It is thus confined to the northern oceanic water and the northern part of the Gulf Stream.

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VIII.

Eastern Canadian Plankton.—The Distribution of Floating Tunicates (Thaliacea) obtained during the Canadian Fisheries Expedition, 1914-1915.

BY

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Comparatively few individuals of this group were obtained on the expedition, forty-five in all, belonging to five different species. The nomenclature is that of Ihle (1912) for the Desmomyaria and that of Neumann (1913) for the Cyclomyaria.

Key to the Species.

A1. Muscles of body forming usually incomplete rings. A single pair of large branchial stigmata. *Salpidae.*

Alimentary canal coiled to form a nucleus, or, if not, muscles of the body very numerous. *Salpa.*

B1. Muscles not in groups.

C1. Muscle bands, more than six. 18 to 22 more or less interrupted muscle bands. A pair of long posterior processes or spines. *S. vagina solitar.*

C2. Muscle bands, not more than six.

D1. Muscle bands all incomplete above. Five broad and one narrow muscle bands. *S. zonaria solitar.*

D2. Muscle bands not all incomplete above. Five muscle bands between ganglion and atrial opening, the first incomplete above. *S. zonaria gregat.*

B2. Muscles arranged in groups.

E1. An anterior group of three. Muscles incomplete above. Anterior three muscle bands approaching each other, more or less interrupted. Two solitary bands behind. *S. vagina gregat.*

E2. An anterior group of three. Muscles not incomplete above.

F1. Not more than six muscle bands. An anterior group of three and a posterior group of two muscle bands, widely separated. *S. democratica.*

G1. Test with posterior spines. *S. democratica solitar.*

G2. Test without posterior spines. *S. democratica gregat.*

F2. More than six muscle bands. An anterior group of three, a posterior group of two, and between these four solitary muscle bands. *S. fusiformis solitar.*

E3. An anterior group of four muscle bands. A posterior group of two muscle bands. Muscle just behind peripharyngeal band diverging from it dorsally. *S. fusiformis gregat.*

A_2. Muscles of the body forming complete rings. On each side a row of slit-like stigmata. *Doliolidae.*

Body barrel-shaped or cylindrical. 8 or 9 muscle bands. *Doliolum.*

H_1. Nine muscle bands. Oozooid.
H_2. Eight muscle bands. Other stages.
Stigmata beginning at second band above and ending just behind fourth band below. *D. nationalis.*

Salpidae.—The salpae occur frequently in chains of individuals, which are readily broken up. These individuals (*proles gregata*) alternate with those of another kind (*proles solitaria*), which are always found singly. The two differ markedly in structure.

Salpa fusiformis Cuv., **forma aspera** Chamisso.
1912. Ihle, p. 39.

C.G.S. *Acadia.*

Station No.	Depth of Haul. (metres).	Length (mm.)	Form.	Number.
44	270–0 (V)	10	greg.	4
	0 (T)	6–20	greg.	12
		40	sol.	1
75	325–0 (V)	....	....	0
	55–0 (V)	22	greg.	2
	Ca. 20–10 (T)	....	....	0

This species is widely distributed through all the warmer seas and is carried by currents into the colder waters. Of all the Salpae that are carried into the north Atlantic by the Gulf Stream, *S. fusiformis* goes the farthest. It is apparently better able to endure the lowered temperature and salinity than the remaining species. It was the most abundant *Salpa* of our cruises and was the only one to occur at more than one station. Bigelow obtained it in the gulf of Maine on August 14 and 15, 1912 (1914, p. 121) and south of cape Cod in July, 1913 (1915, p. 275). On the European coast it appears regularly during the course of each summer, passing into the English Channel and north of the British isles to the coast of Norway and into the Skager Rak (Apstein, 1911, p. 151).

Five *Salpae* in a bad state of preservation but apparently belonging to this species are before me. They were obtained on the beach at Campobello island in the autumn of 1913 and sent in by Captain Shepard Mitchell. They are from 33 to 35 mm. in length.

Salpa vagina (Tilesius) **proles gregata** (= *tilesii*).
1912. Ihle, p. 47.

C.G.S. *Acadia.*

Station No.	Depth of Haul (metres).	Length (mm)	Number.
56	375–250 (C)	....	2
	250–0 (V)	180	0

This species is widely distributed but not found in abundance. It is rare in the north. Bigelow obtained it in July, 1913, south of Cape Cod (1915, p. 275), and in

December, 1913, in Massachusetts bay (1917, p. 246). On the European coast it occurs in the Mediterranean and was found by Traustedt in the English Channel (Apstein, 1894, p. 36).

Salpa democratica Forsk. **proles solitaria** (= *mucronata*).
1912. Ihle, p. 51.

C.G.S. *Acadia.*

Station No.	Depth of Haul (metres).	Length (mm.).	Number.
44	270–0 (V) 0 (T)	.... 2·5–6	0 14

This is the most widely distributed and the most abundant of all the Salpae, according to Apstein (1894, p. 32). In northern waters the records seem to show that it does not extend as far to the north as *S. fusiformis,* but, where it does occur, it is more abundant than the latter. Bigelow obtained it in the gulf of Maine in 1912 (1914, p. 121), and south of New York in 1913 (1915, p. 275). On the European coast it appears rather regularly. It enters the English Channel and reaches the coast of Norway, but does not enter the North sea (Apstein, 1911, p. 153).

Salpa zonaria (Pallas) **proles gregata.**
1912. Ihle, p. 54.

C.G.S. *Acadia.*

Station No.	Depth of Haul (metres).	Length (mm.).	Number.
16	200–0 (V) 0 (T)	35	7 0

This species is widely distributed but not abundant. In the north, its distribution extends as far as Iceland (Apstein, 1894, p. 36). On the American coast Bigelow (1915, p. 275) obtained it south of the latitude of New York in 1913. On the European coast, Farran (1906) obtained it off the Irish coast in 1903 and 1905.

An individual of the aggregated generation, 40 mm. long and one of the solitary generation, 55 mm. long, are in the collection of the Atlantic Biological Station, St. Andrews, New Brunswick, and are presumed to have been obtained at Grand Manan in 1910, which shows that it occasionally enters the bay of Fundy.

Doliolidae.—The larva develops into an oozooid, which by budding produces trophozooids, phorozooids and gonozooids. Only the gonozooids become sexually mature. The oozooids rapidly degenerate and cannot be identified as to the species.

Doliolum nationalis Borgert. Phorozooid stage.
1913. Neumann, p. 18.

C.G.S. *Acadia.*

Station No.	Depth of Haul (metres).	Length (mm.).	Number.
44	270–0 (V) 0 (T)	 1	0 1

From the results of the Plankton expedition (see Borgert, 1894) it was to be expected that *D. tritonis* or *D. krohni* would appear in our Gulf Stream stations. These species have been found much farther to the north than has *D. nationalis.* This latter species is rare on the European coast, but was found at a number of points in the English Channel in November, 1904 (Apstein, 1911, p. 156).

Doliolum sp. Oozooid stage.

C.G.S. *Acadia.*

Station No.	Depth of Haul (metres).	Length (mm.).	Number.
41	200–0 (V)	18	1
	100–0 (V)	....	0
	0 (T)	....	0
44	270–0 (V)	....	0
	0	9	1

Bigelow obtained *Doliolum* south of New York in 1913 (1915, p. 275). It is found regularly in the Gulf Stream.

Summary.

The Thaliacea as a whole occurred in all the outermost stations of the cruises of the *Acadia* and at one station ("Acadia" Station 41) on the edge of the continental shelf. They are typical inhabitants of tropical waters. Their presence in the north

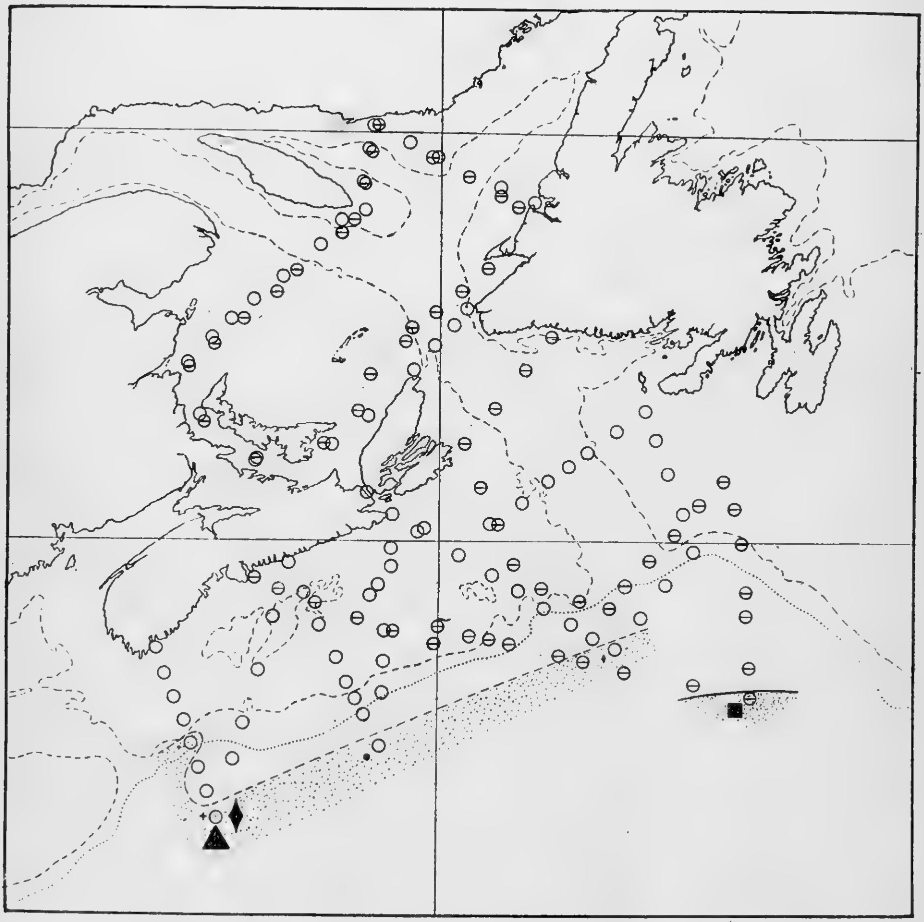

FIG. 1. Distribution of *Thaliacea.* May-June,—dotted area margined by continuous line. July-August,—dotted area margined by broken line. Divided circles,—stations of May-June cruises. Plain circles,—stations of July-August cruises. Solid circle.—*S. vagina.* Square.—*S. zonaria.* Lozenge.—*S. fusiforms.* Triangle,—*S democratica.* Cross,—*Doliolum.*

is entirely owing to the action of currents, since they do not survive in the north from one year to the next, as Apstein has so well shown. In our waters they are excellent indicators of the extent of the Gulf Stream. Their distribution for May-June and July-August is shown in Fig. 1. They were nearer the continental shelf in the later cruise than in the earlier one and to the south than to the north. Their much greater abundance at the southernmost station is very evident, this station providing practically three-quarters of the total number of individuals obtained.

The fact that no Thaliacea were obtained from the water over the banks or near the coast indicates the absence, during the period investigated, of any Gulf Stream component within the edge of the continental shelf. That this condition does not always obtain is shown by the two records of *Salpæ* from the Bay of Fundy.

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IX

An Investigation into the Rate of Putrefaction in the Commoner Food Fish caught in and around Passamaquoddy Bay, N.B.

BY

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(With Plate).

The present methods of storing and shipping fish take little or no cognizance of differences in the rate of putrefaction, a fact that is of considerable economic interest and value.

In the following investigation an effort was made to divide fish into groups which represent their rate of putrefaction, and thus to determine different methods necessary for handling the various fish. For example, fish which spoil readily would have to be disposed of more quickly or else subjected to more careful storage, and vice versa.

Pursuing the method which I used to determine the relative rate of putrefaction of eviscerated fish in which the gills are left and removed[1], I proceeded to investigate the comparative rate of spoiling of some of the commoner fish.

The fish studied were:—

Flounder, *Pseudopleuronectes americanus* (Walbaum).
Hake, *Urophycis chuss* (Walbaum).
Eel Pout, *Zoarces anguillaris* (Peck).
Skate, *Raja erinacea* (Mitchill).
Cod, *Gadus callarias,* L.
Sardine, *Clupea harengus,* L.
Haddock, *Melanogrammus aeglifinus* (L).
Pollock, *Pollachius virens* (L).

From each fish broth and agar was made according to the formula in the report referred to above, the gills, mucus and meat being used. The broth was tubed in 5 cc. amounts and the agar for plating in 10 cc. amounts.

As formerly, in order to retain the inherent titre of the fish so that they might resemble as closely as possible that of the recent condition, neutralization and standardization was not carried out.

To determine how closely the titre of the media resembled that of a cold aqueous extract of the fish meat, and also to see whether the difference in rate of putrefaction bore any relation to the Hydrogen Ion concentration, titrations were made of both. (Table 1).

The cold extract was made by triturating 50 gms. of fresh fish meat with 100 cc. of distilled water. This was allowed to stand for one hour and then filtered. The figures given represent the amount of(N-10) NaOH necessary to neutralize the acidity in 10 cc. of the extract or medium, phenolphthalein being used as the indicator.

TABLE I.

Fish.	Media.	Cold ext.	Difference.
Flounder	1·9	1·5	0·4
Hake	1·3	1·17	0·13
Eel Pout	2·0	2·07	0·07
Skate	0·85	1·85	1·0
Cod	1·3	1·3	0·0
Sardine	1·8	2·1	0·3
Haddock	1·8	1·73	0·07
Pollock	2·0	2·35	0·35

It will be seeen from this table that with the exception of the skate, the media bear a close resemblance to the fresh meat in their titre. The discrepancy in the skate is probably due to the rather frequent variation of the urea and ammonia content of the meat, a condition said to be common for elasmobranchs.

As far as possible all the material was obtained at the same time and the media made up from fresh material.

To determine whether a relatively small difference in the time of death of a fish made any appreciable variation in its titre, cold aquaeous extracts from various fishes were titrated, allowed to stand for sixteen hours, and at the end of this time titrated again. No difference was found in the titre.

A Rose fish (*Sebastes marinus*, Linnæus) was now allowed to putrefy, and four different strains of bacteria in pure culture were isolated at random.

The following are the main characteristics of the organisms used[2]:—

Alpha.—On agar plate small round colonies, light greyish yellow, sharply limited. Gram negative rather long diplococci, occurring occasionally in short chains of four. Nonmotile and does not ferment lactose or dextrose broth.

Beta.—On agar plate pale green tiny whetstone colonies. Gram negative rods, nonmotile. Produces acid but no gas in lactose and dextrose broth.

Gamma.—On agar plate tiny white sharply demarcated round colonies. Gram positive thick diplococci, nonmotile. Does not ferment lactose. Produces acid in dextrose broth.

Delta.—On agar plate white pin-point colonies. Gram negative rods, actively motile. Does not ferment lactose. Produces acid in dextrose broth.

With these bacteria eight sets of plates were prepared. Each set consisted of four plates representing the four bacteria plated on the same fish agar from the dilution made in the same fish broth.

Thus the sets can be diagrammatically represented, as in Table II.

TABLE II.

Flounder agar Bacter......... Alpha.........	Hake agar Bacter...... Alpha......	Eel pout agar Bacter...... Alpha......	Skate agar Bacter...... Alpha......	Cod agar Bacter...... Alpha......	Sardine agar Bacter...... Alpha......	Haddock agar Bacter..... Alpha......	Pollock agar Bacter. Alpha.
Flounder agar Bacter......... Beta..........	Hake agar Bacter...... Beta.......	Eel pout agar Bacter...... Beta.......	Skate agar Bacter...... Beta.......	Cod agar Bacter...... Beta.......	Sardine agar Bacter...... Beta.......	Haddock agar Bacter...... Beta.......	Pollock agar Bacter. Beta.
Flounder agar Bacter......... Gamma........	Hake agar Bacter...... Gamma....	Eel pout agar Bacter...... Gamma....	Skate agar Bacter...... Gamma....	Cod agar Bacter...... Gamma....	Sardine agar Bacter...... Gamma....	Haddock agar Bacter...... Gamma....	Pollock agar Bacter. Gamma.
Flounder agar Bacter......... Delta..........	Hake agar Bacter...... Delta.......	Eel pout agar Bacter...... Delta.......	Skate agar Bacter...... Delta.......	Cod agar..... Bacter...... Delta.......	Sardine agar Bacter...... Delta.......	Haddock agar Bacter...... Delta.......	Pollock agar Bacter. Delta.

Growth was now allowed to proceed at the room temperature of the laboratory which ranged between sixteen and twenty degrees Centigrade. Observations on the rate of growth of the organisms on the media as judged by the rate of growth of the individual colonies were made every twenty-four hours.

For practical purposes we recorded our growths in three categories:—

1. Rapid growth.
2. Medium growth.
3. Slow growth.

Fig. 1 on plate shows by way of illustration organisms *Alpha* and *Beta* plated in sardine agar after forty-eight hours' growth. Fig. 2 shows organisms *Alpha* and *Beta* plated in eel pout agar after forty-eight hours' growth.

It will be plainly seen that sardine agar is the much more suitable culture medium for the early and rapid growth of these organisms.

After forty-eight hours our results for the complete sets were as follows:—

1. Rapid growth—Sardine and cod.
2. Medium growth—Flounder, hake and skate.
3. Slow growth—Eel pout, haddock and pollock.

After five days a curious change occurred in the rate of growth. A number of plates in which the colonies had at first grown slowly caught up to and in some cases grew more rapidly than others that had shown the greatest growth at the beginning, so that the plates could now be classified as follows:—

1. Rapid growth—Sardine and eel pout.
2. Medium growth—Haddock, cod and hake.
3. Slow growth—Skate, pollock and flounder.

These experiments were carried out in duplicate with practically identical results.

The explanations which suggest themselves for this phenomenon of change in the rate of growth are, (1) that organisms which grow slowly at first on a given medium may by adapting themselves to the medium later grow more abundantly; (2) that the media which are more suitable for rapid growth early after seeding may present their maximum growth quickly, and by the rapid accumulaion of deleterious waste products before they can diffuse into the surrounding medium, somewhat retard the rate of growth.

Whatever the explanation, it seems quite reasonable to assume that the media giving the earliest and most abundant growth of the colonies represent the fish which will be the first to show putrefactive changes, and that those which give the slowest growth represent the fish which will show putrefaction last. As this is what is needed for our present purposes, we may take our first readings as indicating the relative order of spoiling of the fish.

Indeed when these fish are allowed to spoil it is found that in the rough way in which this can be measured, viz., odour and firmness of the meat, the order is somewhat that which our first readings show.

It is possible that after spoiling has proceeded for some time, the order may change to that represented by our last readings. To establish this fact, more observations are necessary.

Finally a word on the significance of the observations recorded here.

It is obvious that in order to establish a more definite and detailed order of the spoiling of fish, many more organisms of putrefaction should be isolated and plated than were used for our experiments, also more fish should be investigated. The purpose of this work, however, was not so much to give an accurate list of the numerical order in which certain fish spoil as *to establish the fact that there is a definite difference in the rate of putrefaction in the various fish and that measures should be taken to adopt different methods of handling, storing and shipping the fish according to the specific ability of each fish or group of fish to resist putrefaction.*

REFERENCES.

1. An Investigation into the Question of Early Putrefaction of Eviscerated Fish in which the Gills have been left. Report No. 6. The Honorary Advisory Council for Scientific and Industrial Research, Dominion of Canada, Ottawa, 1919.

2. For a detailed report and identification of the organisms see Miss Shanly's report for 1919-1920 to the Honorary Advisory Council for Scientific and Industrial Research. Dominion of Canada.

Fig. 1

Fig. 2

X.

Canned Sardines.—The cause of "Swells" or "Blown Cans."

BY

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INTRODUCTION.

For many years, the fisheries of Canada have constituted a pronounced national asset. Latterly, there is every reason to believe that the importance of the industry is being recognized as never before by all who are concerned with the industrial prosperity of the country. Professor Prince, Dominion Commissioner of Fisheries, has recently stated that the financial returns from the fisheries have increased from $10,788,000 in 1872 to $52,312,000 in 1917. Of this very satisfactory sum, a goodly proportion represents the income derived from the production of canned sardines. It is more or less common knowledge that the sardine of the French is a pilchard, and that the North Atlantic sardine of this American continent is the young immature herring. The canners engaged in the packing of sardines have found from time to time that, for various reasons, a proportion of their pack has spoiled. In a recent issue of the *Canadian Fisherman*, it is estimated that from five to ten per cent of the total sardine output of the Maritime Provinces goes to waste through spoling. Part of this wastage is due to the development of "swells"; and while the trouble is less common than formerly, the appearance of swells is still a matter of very considerable concern.

The methods of packing in vogue have been gradually evolved from the original procedure adopted in the early days of the industry. In spite of the recurrence of swells, it is only recently that efforts have been made to discover the actual specific causes of the trouble. The desirability of attempting to discover these causes occurred to Dr. F. C. Harrison in the summer of 1915. The matter was brought to the attention of the Biological Board of Canada, and in the summer of 1916, I commenced on behalf of the Board, an investigation of the problem. The object of the inquiry was to secure such information from experimental evidence as would enable the canners to eliminate any risk of cans developing the "swelled" or "blown" condition.

Preliminary Enquiry.

It was decided that the work should commence at the Biological Station, St. Andrews-on-the-Sea, N.B. The station is in the heart of the sardine canning industry, closely situated to the important canneries of New Brunswick ,Canada, and also to those in the state of Maine, U.S.A. Dr. Huntsman, Biologist to the Board, and Curator of the St. Andrews Station, arranged the necessary visits to the various factories on the New Brunswick coast; and through the courtesy of Dr. Loomis, National Canner's Asociation of America, the privilege of successive visits to the factories in the state of Maine, U.S.A., was extended. It was possible during those visits to see and study the general practices followed in the respective canneries or factories, and also any variations which appeared to have a particular bearing on the quality of the final product. To the proprietors and managers of all the factories it is but justice to record here the warmest appreciation of the courtesy and candour shown by them at all times. Every opportunity was given me to study the practical aspects of canning, and the fullest information as to details of procedure was offered. This hearty co-operation of the canners on both sides of the International Boundary with the Biological Board of Canada has facilitated the work to a marked degree.

General Practice in the Canneries.

There does not seem to be any necessity for entering into a detailed description of the equipment of the canneries. Articles have been published in the journals directly concerned with the fishing and canning industries, and from these journals such information as may be desired is readily to be secured. For a complete discussion of the methods of treating the fish, of the systems of packing, and of the general procedure of the factories engaged therein. I would refer the readers to these journals*[1] Herein it is not proposed to deal even with these latter phases except in the briefest possible manner.

The herrings, caught in the weirs, are brought by boat to the canneries, are hoisted into conveyers, and are rapidly deposited in the brine tanks; here they lie for a period of one and a half to two hours. The constitution of the brine varies; usually sea-water with added salt is used, but in some cases I have seen emergency supplies of fresh water for the purpose. After lying in the brine, the common method is to put the fish on flakes, subject them for ten minutes to a treatment of live steam, and later dry them in a room through which hot air is continually circulated for one hour. The flakes laden with the steamed and partially dried fish are then distributed among the packers; the heads are cut off, and the fish packed in cans with oil. The cans are automatically sealed, either by the rolling or the pressing process, and are at once ready for the heating. In some factories the preliminary steaming is dispensed with, and a continual progression through a bath of cottonseed oil at a temperature of 200°C. is substituted; such occupying two to three minutes; when this procedure is adopted a slightly different flavour can be detected in the final product. In some instances spices are added, more particularly where the object of the packer is to provide a sardine which can compete with the brands imported from Italy.

CLEANING THE FISH.

One important feature of the preparation of the fish for packing, is the frequent practice of leaving in the entrails. In the early days of the industry, when the methods of the European packers were more closely copied, it was usual to pull off the head of the fish in such manner as drew out a large portion of the viscera. To-day, however, while a few individual packers have the viscera removed, the greater proportion of the sardines of the American continent are prepared with the entrails intact. In view of the methods usually adopted in the canneries, there are certain practical difficulties which present themselves in connection with the eviscerating of the small herrings. Of those difficulties I am fully aware, particularly when the object is to produce a cheap sardine. At the same time, it is likely that such can be overcome by mechanical means. When the investigation was started I was struck by the possible influence of the retention of the viscera, on the production of "swells" in the canned sardine. Later work has thrown much light on the question, and in a paper published separately the relationship here referred to is dealt with more fully, and in the light of proof secured from considerable experimental work.

HEATING, PROCESSING OR STERILIZING.

After the fish are packed, and the cans have been sealed, the next step is the heating. I use the term "heating" advisedly. It should be here stated, that the most common size in which sardines are canned is a size weighing from three to four ounces; and the temperatures discussed are such as are applied to cans of this size. The object of the heating is of course to sterilize the sardines, prevent subsequent spoiling and insure the necessary keeping qualities. In the majority of the factories visited, the cans are immersed in baths of boiling water for a period of one and half to two hours; and where this method is adopted, no further heating is done; the preparation of the sardines is presumed to be complete, and the product ready for sale. In a few factories, the heating is done in retorts or autoclavs at a temperature of 225°F. for a shorter period. This variation in treatment is sufficient reason for the using of the term " heating " with very definite qualifications. To say that the sardines are sterilized, when the heating has consisted of a treatment in boiling water even for two hours, is not correct. Sterilization in the true sense of the term means heating for such time, and to such temperature, as will kill all bacterial life. And the work of Pasteur, in the early days of the study of bacteriology, proved conclusively that wine for instance would always be subject to spoiling unless all bacterial life had been destroyed. The same principle holds good in the case of sardines. It is important that the possible sources of contamination shall be reduced to a minimum. Then, if the cans have been properly sealed, and in such manner as prevents the access of air and consequently the bacteria which are present in the air, the presence or absence of bacteria in the finished sardine product depends upon the efficiency or non-efficiency of the heating. That such a large proportion of canned sardines heated in the manner indicated are suitable for consumption is proof that the heating in the factories is frequently satisfactory; but entire satisfaction is impossible unless all the cans are fit for food.

Those canners who use retorts or autoclavs are using a method, which, provided the temperature is sufficiently high, and the heat assured for a proper length of time, will efficiently sterilize the sardines. It will be possible to discuss the question of heating, in the report on the later part of the investigation. For the present, it will suffice to say that the heating must be sufficiently satisfactory to warrant the packer in feeling justified when he guarantees the quality of his product.

Material examined.

Some forty samples were examined. Swelled canned sardines were secured first-hand from many of the canneries, from a city health department in the Maritime Provinces and from various retail grocery stores. A number of apparently normal cans were also obtained from several sources. Owing to the varieties of " brands " of sardines produced by the canning factories, the various methods of treatment, and the different substances utilized for the giving of flavour and consistency to the finished product, it is not possible other than in a general way to describe the conditions met with on the opening of the cans.

APPEARANCE OF CANS.

Normal Cans.—In outward appearance there is a complete absence of any " bulging "; the top and bottom are quite flat or almost imperceptibly concave; on opening, the contents are found to be firm, not macerated and often white in colour; this latter, however, depending to some extent upon the materials used in the preparations for packing. The smell is mildly characteristic of the fish, qualified by the variety of oil or tomato sauce used. There is in appearance and odour, a complete absence of putrefaction.

Swelled Cans.—Outwardly the cans vary from a slight " bulged " appearance to a more pronounced swelling. The top and bottom are forced out as a result of the pressure, and present a decided convex surface. As the swelling becomes greater, the oil or sauce will be forced out between the soldered parts of the can, and in pronounced cases the outside surface is greasy and wet, and possibly covered with the oil or sauce.

Swelled cans, when shaken, have a characteristic "rattle." When the cans are opened, gas is expelled, accompanied in advanced swellings by portions of the liquid contents. The condition of the contents varies considerably. Usually the fish are macerated, disintegrated, and soft, and are intermixed with the oil or sauce; they have lost their entity. The odour is variable—frequently it is not unpleasant, resembling to an accentuated degree the natural smell of normal sardines. In other instances a pronounced putrefactive odour is evident. It may be that the putrefactive odour is present at all times and is masked by the spices or other ingredients of the sauce. That is a point upon which I have no evidence.

Examinations in the Laboratory.

Much of the work at the commencement was done in the Biological Station, St. Andrews, as already stated, and further researches were carried on principally in the laboratories at Macdonald College. Using the necessary laboratory methods, a search was made in the contents of both normal cans, and swelled cans for bacteria. A number of varieties of bacteria have been isolated, and their characteristics determined. The bacteria with which the inquiry has been chiefly concerned are those varieties or types which are capable of producing the "blown" condition in the cans. If the blown condition is due to the action of bacteria and not to other agencies, the bacteria secured from the samples will show that characteristic or quality in the experimental work in the laboratory. The production of gas by micro-organisms—of which the bacteria are the smallest forms—is in all cases the result of the organisms splitting or breaking up certain substances in order to obtain the food or nutrition necessary to life. This general statement holds good if the gas is produced during the digestion of food by the human subject, if it is produced in a can of condensed milk, or if it is produced in a can of sardines. In order to produce gas, the bacteria must have access to some form or other of carbohydrate, a very well known example of which is ordinary table sugar. Hence, having secured strains of bacteria from the canned sardines, the method has been to test their ability to produce gas by growing them in suitable concoctions which contain the necessary amount of sugar or other carbohydrates. In this manner I found that eight strains of the bacteria secured from the material examined were able to produce gas when grown in solutions containing the various carbohydrates used. These eight strains were not alike in all their characteristics, but all would split up many of the test substances. A full account of the detailed studies on these bacteria is given in the more technical scientific report on the "Bacteriology of Swelled Canned Sardines," prepared by me, and published by the Biological Board of Canada, Ottawa.* No bacteria obtained from the presumed normal cans could produce gas in the test substances. All the gas-producing bacteria were isolated from the material in the "swells" or "blown cans."

Experimental Swelled Cans.

The fact that gas-producing bacteria had been secured from swelled canned sardines, and that these bacteria had produced gas in test substances used in the laboratory was not proof that the bacteria involved were necessarily the causes of "swelled" or "blown cans." Before it could be said that actual proof had been secured, it became necessary to determine whether or not the same bacteria, when put into normal canned sardines could produce the typical swelling. Accordingly a sufficient number of cans of sardines which had been properly sterilized, were obtained. These cans were infected with a small amount of growth or culture of certain of the bacteria which had been recovered from the original swells, and which had produced gas from test substances in the laboratory. For this purpose three of the eight strains were used. In

* See Contributions to Canadian Biology, 1917-1918, Report XII(pp. 181-215, Supp. to 7th Ann. Rept. Naval Service Dept., Fisheries Branch.

a few days the cans which had been thus infected were definitely "swells," having all the appearances of the original swelled cans upon which the work was begun. On opening the cans the contents presented the characteristics of the contents of the original cans. The material was examined, and bacteria secured which proved to be identical with the bacteria injected into the cans at the beginning of the experiments. The bacteria isolated from swelled canned sardines and injected into normal cans of sardines had produced typical swells; and from the experimental swells, bacteria had been secured which were identical with those originally isolated. Thus the "Rules of Proof" currently relied on by investigators, have been satisfied. As a result of these experiments we have the proof that "swells" are produced by bacteria; and that the bacteria isolated during this investigation are some of the bacteria which are responsible for "swells" or "blown canned sardines."

Significance of the Bacteria Isolated.

It is desired to keep this paper as free as possible from technical terms, but some reference must be made to the significance of the bacteria isolated from the cans of sardines. Although eight definite strains of organisms capable of producing gas were isolated or secured, they may all be divided broadly into two main classes:

I. *The class of bacteria commonly associated with putrefaction of foodstuffs, and the putrefaction of organic matter generally.*—Two of the strains recovered are included here; and in the scientific report, already mentioned, have been classed as belonging to the group or type *Bacillus vulgaris.* There are many organisms to which this name is given, and they will frequently be found in stagnant water, and in cases of putrefaction or rotting as already stated above. In connection with cases of food poisoning, some investigators have found large numbers of these bacteria in the particular food suspected of being the cause of the poisoning. In the absence of feeding experiments it is impossible to say whether or not the organisms isolated by me from sardines would have caused poisoning had they been eaten. The only statement which can be made with safety, is that bacteria having indentical characteristics have been found by some investigators in cases of food poisoning; and the investigators concerned have been strongly of opinion that such organisms were the responsible agents.

II. *The bacteria which are searched for in all cases of water and milk pollution as an index of contamination due to fæces or manure.*—There are very many varieties of these bacteria, but they are commonly classed under a general heading as the *colon group;* the specific name being *Bacillus coli.* Six of the strains of bacteria recovered in this investigation are members of the colon group, and that fact is one of considerable import. The original *Bacillus coli* was isolated in 1885, from the intestines of a sick child. Organisms which are common in the intestinal tract are designated as *fæcal organisms.* And, just as we have these in the human intestines, so also are they to be found in the intestinal contents of cattle: for this reason, when milk is suspected of being unclean, and unfit for human consumption, particularly if the supply is being used for babies, it is necessary to examine samples of such milk for organisms of the colon group. Certain varieties of this group are also found in soil, on grains and in dust; these may have come immediately from manure, or they may have lived for several generations in their new home. Of the colon bacteria secured from the cans of sardines, the laboratory tests would suggest that some have been derived immediately from fæces or intestinal contents; others would appear to have come from a less objectionable source. As to whether they all came originally from fæces, I cannot say. The bacteria which suggest intestinal contamination may have been in the viscera of the fish before packing, or may have been added during the packing by unclean hands of workers. If they were in the intestines of the herrings, and this is probably the more likely source, it is important that packers should know whether or not the feeding ground of the fish, and the location of the weirs are subject to contamination from sewage.

From this discussion it will be obvious that whatever the source of the colon bacteria, there is reason for investigation when they are present in the finished product—the canned sardines of commerce. In a report of the subsequent work which has been undertaken for the Biological Board refinite results are to be given from the later experiments which bear directly on some of the points referred to above.

The relationship of bacteria of the colon group to food poisoning is worthy of attention. In some cases of poisoning where these organisms have been recovered from the patient in large numbers, there has been no evidence to show that they have been the direct or indirect cause of the illness. In other instances, the workers investigating the cases have stated as their conclusion that the illness has been the direct result of infection of the food by bacteria of the colon group.

On the whole, it may at least be said that any consumer in using sardines from swelled or blown cans as food, is taking a quite unnecessary and unwarrantable risk.

Summary.

(1) Forty cans of sardines, "normals" and "swells" have been examined.

(2) Eight varieties of gas-producing bacteria have been recovered from the material in the swelled cans.

(3) Certain of the bacteria on injection into normal cans have produced typical "swells."

(4) From the experimental cans the bacteria have again been recovered, and have been proved identical with the organisms taken from the original cans.

(5) The rules of proof have thus been applied, and the investigation has shown that,—

(6) *"Swells" or "blown cans" are caused by gas-producing bacteria.*

(7) No gas-producing bacteria have been found in normal cans of sardines.

Note.

(*a*) The technical scientific report of the investigation with which this paper deals, has been issued. See "The Bacteriology of Swelled Canned Sardines," by Wilfrid Sadler, published by the Biological Board of Canada, Ottawa.

(*b*) The investigation has now reached the stage where it will be possible to follow this paper almost immediately with further papers on the later work. These further papers will deal with:—

(1) Experiments conducted under commercial conditions.

(2) The sources of the bacteria responsible for the "swells".

(3) Practical suggestions, based on the results of the investigation, as to how losses and wastage due to "swells" may be eliminated.

XI

List of Fishes collected in 1917 off the Cape Breton coast and the Magdalen Islands.

BY

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The fishes embraced in this list were collected at Cheticamp and adjacent points of the Cape Breton coast, as well as at the Magdalen islands, by the Biological Launch *Prince,* under Dr. A. G. Huntsman, Curator of the Atlantic Biological Station, during the summer of 1917. The classification employed in the following list is that of Jordan and Evermann in "Fishes of North and Middle America, Washington, 1898." The list, a mere by-product of the investigations carried on, does not pretend to be, nor is it, exhaustive of the fish fauna of that part of the gulf of St. Lawrence, yet it may be of passing interest at least to students of Canadian Ichthyology.

Squalus acanthias Linn. GRAY-FISH.

Rarely seen at Cheticamp or the Magdalen islands before the first week in August. Suddenly abundant after that all along the coast and on the off banks. Incredibly numerous on the southern side of the Magdalens; rare on the northern side. An intolerable nuisance, causing the suspension of the codfishery at certain points.

Raia radiata Donovan. THORN-BACK, STARRY RAY.

Examples seen on the shores, wharves, etc. Taken on cod trawls at considerable depths. Fairly common. No immature specimens met with.

Raia ocellata Mitchill. BIG SKATE.

Taken on trawl lines, and seen dead on the shore. Seemingly not very plentiful. Freely swimming young not seen.

Raia lœvis Mitchill. BARN-DOOR SKATE.

Fairly common. Many caught in salmon nets and on cod trawls. All large fish.

Acipenser sturio Linn. STURGEON.

A specimen 100 cm. long and weighing 10 pounds was taken in a salmon net at Cheticamp, July 6, the second captured during the summer.

Sometimes taken in a similar way at White Point, Aspy bay.

Anguilla chrysypa Rafinesque. COMMON EEL.

Abundant in all tidal pools, estuaries, and shore waters with grassy bottoms. Very rarely is one under 30 cm. in length encountered in such places. They range from 35 to 66 cm. Esteemed as a food-fish and taken from their "beds" through the ice in winter. Every October a northward movement of large black eels from 100 to 130 cm. long and excessively fat is observed on the gulf shore of Cape Breton. They are highly prized, taken in large quantities with the spear, but cannot be found in the ordinary winter "beds".

Clupea harengus Linn. HERRING.

About July 20, some large herring were caught at Cheticamp, but in a few days they disappeared.

June 4, three specimens 14 cm. long were collected at Cheticamp, but at no other point were young fish met with.

Pomolobus pseudoharengus (Wilson) Gill. GASPEREAU. ALE-WIFE.

A single specimen 12 cm. long was taken in Deadman's pond, St. Lawrence bay, July 26. Gaspereau run up the Margaree river every spring to spawn.

Salmo salar, Linn. ATLANTIC SALMON.

Taken all along the gulf shore of Cape Breton. Spawns in the Cheticamp and Margaree rivers.

Speciments from 13 to 16 cm. long seined in salt and brackish water in June, with lateral dark bars very distinct.

Salvelinus fontinalis, Mitchill. SPOTTED TROUT.

Some were collected in seines about the mouths of streams. Said to be abundant in the rivers and lakes.

Osmerus mordax (Mitchell) Jordan and Gilbert. SMELT.

Seined in numbers at many points along the coast. Rare at the Magdalens. Large seine hauls at Cheticamp, the fish running from 5 to 9 cm. in length. In other hauls they varied from 14 to 24 cm.

Mallotus villosus (Müller) Günther. CAPELIN.

One specimen collected at Cheticamp, June 4. Reported rare at the Magdalens.

Fundulus heteroclitus (Linn.) Günther. KILLIFISH.

In tidal pools and all estuaries. In similar places around the Magdalen islands.

Fundulus diaphanus (Lesueur) Jordan. SPRING MINNOW.

McIsaac's pond, Margaree; fresh-water pond on Cheticamp island, and at mouth of a small river, Pleasant bay.

Scombresox saurus (Walbaum) Fleming. BILL-FISH. SKIP-JACK.

One from the stomach of a cod at Cheticamp.

Pygosteus pungitius (Linn) Eigenmann. NINE-SPINED STICKLEBACK.

In lagoons and estuaries—not aboundant. The spines of the dorsal are usually ten or eleven.

Gasterosteus bispinosus, Walbaum. WWO-SPINED STICKLEBACK.

Very abundant in all sheltered waters, bays, tidal pools, and marsh ponds. Exceedingly abundant at the Magdalens. The Common Eel, *A. chrysypa,* fed on it largely in Aspy bay.

Gasterosteus gladiunculus, Kendall. STICKLEBACK.

Cheticamp, Aspy Bay, and Magdalens. Rare.

Apeltes quadracus (Mitchill) Jordan and Gilbert. Four-Spined Sticklebacœ.

Quite common in the more shallow waters with the other forms of this family.

Siphostoma fuscum, (Storer) Swain. Common Pipefish.

Six specimens of this curious fish were taken in a seine haul at Dingwall, Aspy bay, July 27.

Menidia notata, (Mitchill). Silverside.

Mature specimens of this species were rare, but young from 2 to 4 cm. long were taken in numbers in Deadman's pond, St. Lawrence bay, and at Alright island, Magdalens.

Ammodytes americanus De Kay. Sand Launce.

Not common. A few seined, and others taken from stomachs of cod at Cheticamp. Abundant at Amherst island, Magdalens, in June.

Scomber scombrus, Linn. Common Mackerel.

Some were taken in June at Cheticamp in the herring nets. Large catches at the Magdalens about the middle of June.

Xiphias gladius, Linn. Swordfish.

Two seen swimming at the surface some miles off Aspy bay, July 28. Taken in quantity every summer by the fishermen on the eastern side of Cape Breton, with specially prepared gear. A food fish of some importance.

Morone americana, Gmelin. White Perch.

A sample 22 cm. in length captured in a seine at Dingwall, North arm, Aspy bay, July 31.

Tautogolabrus adspersus, Wal. Cunner, Blue Perch.

Everyhere in abundance. Swarming in shore waters and taken in traps to a depth of 10 to 20 m.

Sebastes marinus, Linn. Rose Fish, Norway Haddock.

Specimens taken from the stomachs of codfish caught some miles off Cheticamp harbour.

Triglops ommatistius.

Found frequently in stomachs of cod brought to the harbour. Took one 14 cm. long in fish trawl July 10, in deep water—a gravid female. Eggs pinkish, 2 mm. in diameter with many oil globules.

Centridermichthys uncinatus.

A specimen 25 mm. collected in young fish trawl June 28 in 90 m.; temperature at bottom-0·72 C.

Myoxocephalus aeneus, Mitchill. Grubby.

The most abundant of the Sculpins, taken in shore waters and also at considerable depths. Found also in the stomachs of cod taken in 60 or 70 fathoms. A gravid female 6 cm. long, collected at Amherst island, June 18. Eggs $1\frac{1}{3}$ mm. in diameter. Smallest taken in Deadman's pond, July 26, 3 cm. long.

Myoxocephalus octodecimspinosus, Mitchill. Long-spined sculpin.—Widely but sparingly distributed. Largest seen 28 cm. in length; the smallest 7 cm. More abundant at Amherst island, where from 7 to 13 specimens were taken at each haul of the seine in the harbour. Fish under 7 cm. in length do not seem to frequent the shallow inshore waters. August 29, one 25 cm. taken on cod trawl line in 30 m. off Cheticamp.

Hemitripterus americanus, Gmelin. Sea raven. "Gurry" Sculpin (local).

Widely but sparingly distributed. Taken here and at many points along the Cape Breton coast. Frequently caught in the salmon nets. Sometimes taken on trawl lines.

Aspidophoroides monopterygius, Bloch. ALLIGATOR FISH.

One from a cod's stomach, July 26.

Cyclopterus lumpus, Linn. LUMPFISH, LUMP SUCKER.

Taken in salmon nets in quantities, decreasing as summer advances. Not used as a food-fish. Larvæ are occasionally met with adhering to stones and rock weed at low tide, or dredged from considerable depths.

Eumicrotremus spinosus, Müller. SPINY LUMP-FISH.

A specimen 6 cm. long found adhering to the cheek of a codfish caught in 28 fathoms off Cheticamp, July 4.

Liparis. SEA SNAIL.

Fry from 7 to 8 mm. taken in young fish trawl at 90 m., June 28.

Pholis gunnellus, Linn. BUTTER FISH.

Rather common among rocks on exposed shores and occasionally in tidal ponds. Specimens taken ranged from 5·5-16 cm. in length.

Like many inshore fishes of the gulf, the number of dorsal and anal fin rays is appreciably below the specific of standard works. In 15 specimens the maximum dorsal rays were 77 (one specimen), the minimum 73 (6 specimens); the average of the 15 was 74.

The maximum anal rays 41 (one specimen), the minimum 37 (3 specimens), and average 38. In "Fishes of North and Middle America", Jordan and Evermann, Washington 1898, the count is given as D. 76 to 85; A. 38-44.

Stichaeus punctatus, Fabricius.

A sample 22 cm. long from stomach of a cod caught in 30 metres off Cheticamp, August 25.

Anarhicas.—?

Fragments from stomach of a cod, Cheticamp, August 25.

Anarhicas lupus. WOLF-FISH. GURRY-FISH (local).

September 1, one specimen 70 cm. long taken on trawl line, station 53A, off Cheticamp, in 40 metres. Known all along the coast, but not common.

Zoarces anguillaris, Peck. EEL POUT, MOTHER OF EELS.

Some examples brought in by line-men from the cod grounds. Does not seem to be abundant. No larvæ, nor small specimens taken in our fish or shrimp trawls. Not used as a food-fish.

Pollachius virens, Linn. POLLACK. COAL-FISH.

A few brought in by line-men. One taken on trawl line of the *Prince*. All seen were very large. No young fish taken in tow nets.

Microgadus tomcod, Walb. TOMCOD.

Taken in the seine at various points along the coast. Not plentiful. Young from 4-9 cm. in length captured in Deadman's pond, bay of St. Lawrence, July 26.

Gadus callarias, Linn. COMMON CODFISH.

Abundant in off shore waters. A few young fish 15 mm., collected in Eastern harbour, June 28.

Melanogrammus aeglefinis, Linn. HADDOCK.

Frequently brought in by line-men as a part of their catch. Not abundant. No young specimens were seen.

Large catches made in traps along the eastern coast of Cape Breton in May.

Urophycis tenuis, Mitchill. WHITE HAKE.

Extremely rare. A specimen 46 cm. in length taken off Cheticamp, July 18. Pectoral fins reddish brown.

Urophycis chuss, Walb. HAKE, SQUIRREL HAKE.

Frequently seen among codfish brought to the harbour. Small fish from 20-25 cm. long, found very often in the stomach of the cod. Samples ranging from 7-10 cm. collected frequently in shallow water with the seine. Larval forms were not seen.

Macrourus bairdii, Goode and Bean. GRENADIER, COMMON RAT-TAIL.

This species was collected in a shrimp trawl in 205 fathoms, thirty miles off North cape, in Cabot's strait.

Hippoglossus hippoglossus, Linn. HALIBUT.

A not uncommon fish seen among the catches of cod all along the coast. It seems to be more frequent off Aspy bay than at Cheticamp.

Hippoglossoides platessoides, Fabr. SAND DAB.

Numerous examples of this fine flounder taken on trawl lines in 75 metres and upwards. The young at various stages also were taken in shrimp and young fish nets.

Limanda ferruginea, Storer. RUSTY DAB.

A fairly common flounder, taken at various points in shallow water, Amherst island, Cheticamp harbour and St. Lawrence bay. Like most of the flat fishes it varies greatly in coloration according to the character of the bottom.

Pseudopleuronectes americanus, Walb. WINTER FLOUNDER.

Everywhere the most abundant shallow water form. Taken in exceptionally large quantities at Amherst island, especially young fish from 4-7 cm. Our smallest specimens taken at Eastern harbour, July 24, were from 20 to 25 mm. in length.

Liopsetta putnami, Gill. EEL-BACK FLOUNDER.

Next to *P. Americanus* the most common form. The young are found in great numbers in tidal pools, and shallow sheltered waters with eel-grass bottom. Our smallest were 20 mm.

Glytocephalus cynoglossus, Linn. WITCH, CRAIG FLUKE.

The following are a few of the records: "July 9, off Cheticamp in 75 m., trawl, one speciman, 55 cm. in length." "July 16, near Station 32, three specimens, 57, 56 and 52 cm, in length". "July 30, 30 miles E. by N. off North cape, Cabot's strait. 205 fathoms, bottom net, one specimen 23 cm." Many others large and small were taken during August.

Lophopsetta maculata, Mitchill. WINDOW PANE.

This handsome fish is by no means uncommon at Amherst island, Magdalens, but rare elsewhere. Collected in seine and averaging 8 or 9 cm. in length. No large specimens were seen.

ADDENDUM.

Though the following fishes were not collected or seen at Cheticamp and other points visited, it is thought best to include them in the fauna of the region as they were frequently referred to and described by fishermen with whom we conversed.

Mola mola. Sun Fish.

Thunnus thynnus. Albacore, Tunny.

Brosmius brosme. Cusk.

Merluccius bilinearis. Silver Hake.

Enchelyopus cimbrius. Four-bearded Rockling.

Lophius piscatorius. Goose-fish. Angler.

Roccus lineatus. Striped Bass.

Petromyzon marinus. Sea Lamprey.

XII

The Diatoms of Canada.

BY

L. W. Bailey, LL.D., F.R.S.C., and A. H. Mackay, LL.D., F.R.S.C.

At the present time nothing like a synopsis of the diatoms of Canada has been prepared. Indeed with the exception of a few short lists, and the more elaborate papers published by the authors of this article on the diatoms of the Atlantic and Pacific seaboards—the Maritime Provinces in the one instance and Vancouver island in the other—hardly a single note bearing upon the subject is anywhere to be found. True, in the "Diatoms of North America," as published by Wolle, are contained a large number of forms to be met with in Canada, but there are no descriptions nor anything to indicate whether the species figured occur in the latter or only at points much farther south. To make the proposed synopsis satisfactory, it is obviously desirable that it should cover the whole Dominion, and contain records of gatherings from as many different parts of the latter as is possible. It is the object of this paper to contribute to the result referred to by giving lists of species obtained from several widely separated and comparatively inaccessible localities, viz: the Magdalen islands in the gulf of St. Lawrence, St. Mary's Bay, N.S., Montreal, P.Q., the region about Cobalt, Ont., Parry Sound, Georgian bay and lake Winnipeg.

DIMENSIONAL FORMULAE USED FOR DIATOMS.

The dimensions of each specimen measured are noted in a brief formula to save space and time, and show at a glance the general shape of the individual and the coarseness or fineness of its sculpture.

The figures represent microns (the thousandth part of a millimeter). The first number is its length. The numbers within the parenthesis following are breadths which are measured at the centre or in more places if the breadth varies at distinct flexures. When measuring breadths it is important to note whether it is the *valval* or *zonal* aspect of the specimen that is in view. Hence V or Z is placed immediately in front of the formula to indicate the side. The figure following "s" after the parenthesis indicates the number of lines, dots, etc., in the sculpture within the space of ten microns, thus: V80 (20:15:20) s7 means that the *Navicula,* for instance, is seen from the valval side, is 80 microns long, is bilobed, 20 microns broad with a contraction to 15 microns at the centre. And the sculpture, lines or striae, *seven* in 10 microns.

In the case of a band of *Fragillaria* forming a ribbon, say of 3 valves side by side aggregating 15 microns, each 20 microns long, we can take the breadth of the three divided by 3 to get the average, thus:—

V20(15/3)s17=V20(5)s17.

The first form is fuller—15 divided by 3 being equal to 5; but it shows the number of valves attached, the breadth of some being possibly greater or less than the average.

The formula is an adaptation to the ordinary type found in the printing office, and is used here seldom beyond conveying an exact idea of the length and breadth, and fineness of sculpture. When there are two orders of sculpture prominent, the two indices are noted. In authors' notes a still neater formula is used; a method of indicating by formula the general shape, smooth areas, ribs, striae, etc., has not yet been satisfactorily devised. Such formulae are very time saving and luminous. But it is difficult to construct them out of the characters in the ordinary printer's font.

1. Diatoms (Marine) from the Magdalen Islands.

Acnanthes lanceolata (Breb) Grun.
Actinoptychus undulatus Kutz.
Amphiprora (Tropidoneis) lepidoptera Bail.
Amphora augusta Greg. var. *ventricosa* Greg.
" *arenaria* Donk.
" *cingulata* Cleve.
" *ocellata* var.
" *ostrearia* Breb. var *vitrea. Cl.*
" *ovalis* var. *affinis* Gran.
" *proteus.* Greg.
Biddulphia aurita Breb.
" *pulchella* Gray.
Cocconeis scutellum E. var.
Coscinodiscus concavus. Greg.
" *concinnus* W. S.
" *nitidus* Greg.
" *oculus-iridis* Ehr.
" *scintillans* Grev. var.
Cymbella tumida Breb.
Encyonema gracile Rhab.
" *ventricosum* Ktz.
Eunotia pectinalis var. *undulata* Ralf.
" *triodon* Ehr.
Grammatophora oceanica Ehr.
" *marina* Ktz.
Hantzschia marina Ktz.
" *virgata?*
Gomphonema acuminatum Ehr.
Hyalodiscus
Mastogloia exigua Low.
Melosira sulcata Ktz. var.
" *scalaris.*
" *nummuloides* Ktz.
Navicula abrupta var. *Atlantica* A.S.
" *arenaria* Donk?
(*Trachyneis*) *aspera* var. *pulchella* Cl.
" *Brebissonia* Ktz.
" *brevis* var. *elliptica* V. H.
" *cancellata* Donk. var *sub-apiculata.* Grun.
(*Trachyneis*) *clepsydra* Donk.
" *consanguinea* Cl?
" *crabro* var. *perpusilla* Cl.
" *cruciformis* Donk.
" *cyprinus* Sm.
" *digitoradiata* Greg.
" *Lyra* var. *intermedia* Per.
" *directa* Sm.

1. Diatoms (Marine) from the Magdalen Islands.—*Continued.*

(Trachyneis) forcipata Grev.
" *Kennedyi* Sm.
" *humerosa* long, short and intermediate forms.
" " var. *Arabica* Grun. var *Kamorthensii.*
" *longa* Ralfs.
" *mollis..* Sm.
" *ramosissima* Cleve?
Nitzschia acuminata Sm.
" *dubia* Sm.
" *flumenensis* Grun.
" *lanceolata* Sm.
" *socialis* Greg. var.
" *longissima* Ralfs.
" *sigmoidea* W. S.
Plagiogramma Gregoryanum Grev.
Pleurosigma attenuatum vel Hippocampus Sm.
" *Balticum* Sm.
" *formosum* W. S.
" *estuarii* W. S.
Rhabdonema adriaticum Ktz.
" *minutum* Ktz.
Rhizosolenia styliformis. Bright.
Scoliopleura.
Stauroneis Gregorii Ralfs.
Surirella spiralis? Kütz.
Synedra Gallionii. Ehr.
" *pulchella.* Ktz. var.
Tabellaria fenestrata. Lyng.
" *flocculosa* Ktz.
Van Heurkia (Navicula) rhomboides Breb.
Triceratium alternans Bail.

The above collection was made (June, 1917) by Dr. Phillip Cox, on behalf of the Biological Station at St. Andrews, N.B., from the long sandbars which form a distinctive feature in the physiography of the Magdalen islands. As might be expected the diatom-flora of the latter bears a general resemblance to that of other parts of the gulf of St. Lawrence and especially Prince Edward island, but at the same time a number of forms found on the Magdalens have not been found elsewhere in the gulf, while forms common on the shores of Prince Edward Island and the mainland of New Brunswick have not been observed on the Magdalens.

2. Diatoms from St. Mary's Bay (Mink Cove), N.S.

Acnanthes longipes Ag.
Actinoptychus undulatus Ktz.
Amphora ovalis Kutz.
Amphiprora alata Kutz.
Cocconema lanceolatum Ehr.
Biddulphia aurita Breb.
Coscinodiscus eccentricus Ehr.
" *minutus* "
" *concinnus* W. S.
Cyclotella striata Thw.
Cymbella.
Eunotia.
Epithemia turgida Ehr.
Gomphonema.
Grammatophora marina K
Hyalodiscus.
Licmophora tincta Grün.

2. DIATOMS FROM ST. MARY'S BAY (MINK COVE), N.S.—*Continued.*

Navicula aspera Ktz.
" *Baileyana.*
" *convexa.*
" *elegans* W.S.
" *didyma* Ktz.
" *distans* A. S.
" *Jenneri*
" *interrupta*
" *Smithii* Ag.
" *viridis* Kg.
Nitzschia closterium S.B.D.
" *Hungarica* Grun.
" *dubia* S.B.D.
" *angularis* S.B.D.
" *longissima* Ralfs.
" *sigmoidea* W. S.
" *vermicularis* Han.
Orthosira marina
Pleurosigma aestuarii W.S.
Pleurosigma Balticum W.S.
" *fasciola* W.S.
" *decorum* W.S.
" *angulatum* W.S.
Pinnularia directa
" *cyprinus* Ehr.
Pyxidicula compressa Bail.
Plagiotropis vitrea Grün.
Rhabdonema arcuatum K.
Rhizosolenia setigera Br.
" *sp.*
Podosphenia
Stauroneis aspera
" *salina* W.S.
" *phenicenteron?* Ehr.
Surirella gemma Ehr.
Tabellaria flocculosa Ktz.
Tryblionella punctata acuminata.

3. DIATOMS FROM DRINKING WATER OF THE CITY OF MONTREAL.

The Diatoms enumerated in the following list were obtained by Mr. H. C. Wheeler, of Montreal, by attachment of a patent filter to a kitchen tap, and have been identified by the combined work of the authors, while the measurements, to be interpreted by the accompanying explanations, are wholly the work of Dr. A. H. Mackay. The preparation and mounting of the material was effected by the efforts of Mr. Oliver Kendall, of Providence, R.I., an observer possessing remarkable skill in that direction.

The principal source of supply water for the city of Montreal is the Ottawa river, and the collection under consideration is believed to come wholly from that source. Some portions of the city are apparently supplied from other sources, but these have not yet been examined. Nor is it known to the authors just what methods are adopted for filtration or chemical treatment before use, the information sought being very unsatisfactory on this subject. The cleaning cannot, however, be very complete, as the material obtained from the kitchen faucet was found, upon treatment, to contain very considerable quantities of organic matter, and especially diatoms. Among the species represented *Stephanodiscus Niagaræ* and two species of *Cymatopleura* are particularly abundant.

Amphora ovalis Ktz. and var. *affinis* Ktz. v46 (11), V66 (13:17:13) v 29.

Asterionella formosa, Hasal. 96, 72, and var. *subtilis, gracillima* and *subtilissima* appear to be found in the slide of uncleaned diatoms, and a long species, v216 (10:5:10).

Campylodiscus 90 (84)S 2, somewhat suggesting sp. *Hibernicus* or *Costatus,* W. Sm., and another like *Noricus,* and one like *imperialis* Grün. or *decorus* v115 (115) S2: but none quite certain.

Ceratoneis arcus Ktz. v67 (5:6:5) S. 15.

Cocconeis placentula or *pediculus,* v20 (13), v18 (10).

Cymatopleura solea var. *spiculata* W.S. abundant v100 (30:24:32).
" *elliptica* S.B.D. and a var. *ovalis* v143 (64:40) S3.

Cymbella lanceolata E. v86, not uncommon. v176 (29), v130 (24).

Diatoma vulgare, var. v 40 (5:13:5) s 13, abundant.

Encyonema prostratum (Berk.) Ralf. not uncommon, 70 long.

Epithemia gibba (E) Ktz, rare v202 (9:12:9) s 7.
" *turgida,* Grün. Var. 60 long.
" *musculus?*

3. Diatoms from Drinking Water of the City of Montreal.—*Continued.*

Eunotia monodon E. v 106 (10:9:12:9:10).
" *pectinalis* Rab. v 85 and *E. formica* E. v104 (10:8:9:8:10) S8.
Frustulia rhomboides, var. *amphipleuroides* Grün. One species, v 112 (8:20:8) Soo.
Fragillaria virescens Ralf. (v38 144/36) s O, v29 (40/15) s 17, v53 (?).
Gomphonema arcticum Grün v64 (6:23:11) s 9, v75 ( ) s 10; or
Gomphoneis herculanea (E) Cl. Also another sp. z24 (3:6) and z 64 (8:24:10).
Hantzschia elongata Grün. v200 ( ) One sp.
Amphioxys (see *Nitschia*).
Melosira arenaria Moore. v50 (60/3) s 13. Rare.
" *crenulata* Ktz. v11 (28/6). Common.
" *distans* Ktz. or *granulata* v10 ( ) and *M. varians.*
Meridion circulare Ag. v56, v70 ( ).
Navicula appendiculata Ktz.? v 75 (7:12:7) or *N. parva E.*
" *bacilliformis* Grün. One specimen.
" *cryptocephala* Ktz. ? v 90 (5:22:5) s 8.
" *major* Grüu. v 224 (32:31:35:31:32) s 6+.
" *nobilis* E. v 225 (36:35:37:35:36) s 6.
" *rostellata* Ktz. v 75 (:15:).
" *stauroptera* Grün. var. *parva E.* ? or *N. appendiculata.*
" *viridis* Ktz. v170 (25) s 7.
Nitzschia amphioxys W. Sm.=*Hantzschia amphioxys* (E.) Brün. One sp 70μ long.
" *hungarica* Grün. v300 (10) s 6 and °°
" *sigma* Sm. var? common, 105μ, 224μ.
" *Sigmoides* (E). W. Sm. common, v280 (II) s4+, v340 (13) s7·5.
spectabilis (E) Ralfs, rare v320 (:18:) s12 and 4.
" *vermicularis* (Ktz.), Grün. Common, v240 (3:7:3) s12 and °°, v224 (12) 17.
Pleurosigma acuminatum (Ktz.) Grün, v150 (37) ?, v172 ( ), v 200 (20)?
" *attenuatum,* W. Sm. more common, v150 (30) s9.
Stauroneis acuta, W. Sm. one specimen v336 (61)[11]=v336 (61) s11.
Schizonema (Navicula) ramosissimum C. Ag. v50 (10)[12].
Stephanodiscus Niagaræ E. most common and distinctive species on the slide. Diam. varying from 30μ, 40μ, 60μ, 65μ, 70μ, 74μ, 80μ to 90μ, smaller forms look like foreign sp. (Europe, Asia), like varieties of *St. astraea* (E) Grün, but they must be all one species, 60 to 70μ being the more common size.
Surirella biseriata Breb. v112 (36) s1-5. Not common.
" *elegans* E. v190 (50) s1-6.
" *Guatemalensis* E. Microg. or *cardinalis* Kitton. One sp. v136 (65:50) s3. Might be *S. elegans,* with a hinge-like defect.
" *gracilis* Grün. var? v136 (18) s3 v136 (18)[3].
" *recedens* A. S. One specimen v64 (30)[2].
" *robusta* E. v270 (55)[·8] v208 (56)[1·3].
" *splendida* v220 (65)[1], v74 (20)[2·5].
Synedra acus (Ktz), common, v82 (4:6:4)[11].
" *capitata* E. one good sp. v325 (10:7:10)[9].
" {*delicatissima* var. *angustissima* Grün. 400 (3:5:3)[8]+.
" {v 500 (3:4:3)[2], common in uncleaned material.
" *ulna* E. var? common. v225 (3:2:5:2:3:).
Tabellaria fenestrata Ktz. common. 70 and 94 μ.
" *floculosa* Ktz. rarer 10μ.

4. Diatoms from streams, Tichborne, Ontario, November, 1918.

Collected by H. C. Wheeler, Montreal.

Amphiprora ornata Bail. 100 microns long.
Amphora ovalis Ktz. v30 (8) s14.
Cocconeis pediculus E. v20 (11).

4. DIATOMS FROM STREAMS, TICHBORNE, ONTARIO, NOVEMBER, 1918.—*Continued.*

Cymatopleura elliptica (Breb.) S. Sm. v150 (60) s3.
" *Solea* (Breb) W. Sm. 72, v101 (20:17:20) s7-8, v155 (30:20:30) s8.
Cymbella cistula Hempr. v84 (5:20:5) s7-8.
" *cuspidata* Ktz. v60 (5:21:5) s7-9, 67.
" *cymbiformis* E. v77 (5:15:5) s7-8.
" *gastroides* Ktz. v160 (10:35:10) s8-10.
" *lanceolata* ? v196 (15:40:15) s7-9.
Epithemia gibba (E) Ktz. v125 ( ) s7.
" *zebra* (E) Ktz. v50 (6:10:6).
Eunotia diodon E. v30 (9) s11.
" *major* (W. Sm.) Rab. (fragment.)
Frustulia rhomboides var. *amphipleuroides* Grun. v108 (8:20:8).
Fragilaria construens E. var. 9 (5) s15, 10 (5) s15.
" *virescens* Ralfs., 38 (7) s17, 58 (8) s17.
Gomphonema acuminatum E. var. ? v50 ( ) s11.
" *constrictum* E. 40.
Hantzschia amphioxys (E) Grun. var. *vivax* z72 (10:8:10) s5 & 19.
" *elongata* Grun. v300 (4:13:4) s14.
Melosira crenulata Ktz. z11 (8) s18.
Meridion circulare Ag. z32 (22:4) s10.
Navicula affinis Ktz. v52 (7:13:7).
" *bicapitata* Lagersted. v46 (6:11:6) s9-10.
" *cryptocephala* Ktz. (?) v45 (3:11:3) s11.
" *cuspidata* Ktz. v98 (4:23:4) s14.
" *Iridis* var. *dubia* E. v52 (6:13:6) s19.
" *legumen* E. var. *decrescens* Grun. v87 (11:17:18:17:11) s9.
" *major* Ktz. v240 (36:40:36) s4.5.
" *peregrina* Ktz. v110 (12:25:12) s7.
" *radiosa* Ktz. var. *acuta* W. Sm. v72 (5:11:5) s10.
" *silicula (caloneis)* (E) Cl. v 58 (12:11:12:11:12) s17 ? or *N. limosa* Donk.
" *Smithii* Breb.
" *stauroneiformis* Lewis.
" *stauroptera* var. parva E. v72 (10:11:10) s10.
" *viridis* Ktz. v51 (12) s9-10, z47 (10) s10, v72 (13) s8.
Nitzschia sigmoidea (E) W. Sm. v350 (10) s6-7.
" *vermicularis* Ktz.) Grün. v90 (2:4:2) s13 & ?, v155 (1.5:5:15) s11 & v170 (1.5:4:1.5).
Stauroneis anceps E. v60 (5:13:5) s20.
" *Gregorii* Ralfs. (?)
" *Phoenicenteron* E. v96 (6:20:6) s16, v275 ( ).
Stephanodiscus Niagarae E. (33) s3 & 12, (46) s3 & 12, (50) s3 & 12.
Surirella robusta E. 165 (42) s2.
" ? v70 (4:11:4) s5-6 & 20.
Synedra acus var. *angustissima* Grün. v275 (4:4:54:4) s10.
" *Gaillonii* E. v255 (5:7:5) s9.
Tabellaria fenestrata 58, 72, 80, 95, 130.

(Spicules of Fresh Water Sponges, smooth and tuberculate, present, and one fine birotulate also present).

5. DIATOMS FROM LAKE MUD—COBALT, ONTARIO.

Amphiprora ornata Bail.
Amphora affinis Ktz.
Cocconeis placentula Ehr.
" *lineata* Grün.

5. Diatoms from lake mud—Cobalt, Ontatrio.—*Continued.*

Cocconema lanceolatum Ehr.
Cyclotella Meneghiniana Ktz.
Cymatopleura solea.
" *elliptica.*
Cymbella gastroides Ktz.
" *cuspidata* Ktz.
" *tumida* Breb.
" *cistula?* Hum.
Epithemia argus. W. Sm.
" *gibba?* Ktz.
" *sorex.*
" *parallela* Grun.
" *turgida* var. *granulata* West. var. *Westermanii.*
" *zebra* var. *probosidea* Grun.
Eunotia monodon Ehr.
" *diodon* Ehr.
" *tetraodon* Ehr.
" *pectinalis* Rab.
" *formica* Ehr.
" *praerupta* var. *bidens,* var. *inflata.*
Fragillaria construens Grun.
Gomphonema acuminatum Ehr.
" *capitatum* Ehr.
" *abreviatum* Ag.
" *constrictum* Ehr.
" *geminatum* Ag.
" *sphaenophorum* Ehr.
Himantidium gracile Ehr.
" *majus* W.S.
Hantzschia amphioxys.
Melosira varians Ag.
Navicula Americana Ehr.
" *amphirhynchus* Ehr.
" *Bacillum* Ehr.
" *Braunii* Grun.
" *Canadensis.*
" *cardinalis* Ehr.
" *cuspidata* Ktz.
" *dilatata* Ehr.
" *distans.*
" *dicephala* Ehr.
" *digito-radiata* Grun.
" *elongata* Grun.
" *elliptica* Kutz.
" *Hitchcockii* Ehr.
" *iridis* Ehr., var. *affinis.*
" *limosa* Ktz.
" *major* Ktz.
" *mesolepta* Ehr.
" *nobilis* Ehr.
" *oblonga* Ktz.
" *pseudo-bacillum* Grun.
" *peregrina* Ehr.
" *radiosa* var., *acuta* Ktz.

5. DIATOMS FROM LAKE MUD—COBALT, ONTARIO.—*Concluded.*

" *scutelloides* Sm.
" *viridis* Kg.
Nitzschia sigma Ktz.
" *tryblionella* Han.
Pleurosigma attenuatum W. Sm.
" *hippocampus?*
" *acuminatum.*
Raphalodea (Epithemia) musculus.
" " *gibba.*
Stauroneis anceps Ehr.
" *acuta* W.S.
" *phoenicenteron* Ehr.
" *punctata.*
" *ventricosa.*
Surirella splendida Ehr.
" *elegans* Ehr.
Synedra ulna Ehr.
Tabellaria floculosa Kutz.
" *fenestrata* Ktz.

This is a fresh-water and recent deposit, of interest on account of its high northern latitude. It is very rich in Naviculæ and also in Cymatopleuræ, though no new forms were recognized. It is probably representative of most of the similar deposits in the extreme northern parts of Canada.

6. DIATOMS FROM GEORGIAN BAY—DREDGING 36 FEET, 1912.

(Lengths and breadths are given in *microns*, without and with brackets respectively.)

Amphiprora ornata Bailey.
Amphora ovalis Ktz. 60, 84.
Campylodiscus (near decorus Breb.) 102, 105.
Cyclotella (?)
Cymatopleura elliptica (Breb.) W. Sm. 144 (62).
" " forma *spiralis.* 146.
" *Solea* (Breb.) W. Sm.
Cymbella lanceolata E. 100.
Epithemia Argus Ktz. 60, 66.
" *gibba* Ktz var. *ventricosa.*
Eunotia monodon E. 60.
Melosira crenulata Ktz. 5 (7), 5 (8).
" *varians* Ag. ?
Navicula nobilis E. 162 (38).
" *radiosa* Ktz. 84 (12).
" *Smithii* Breb. 60 (36).
Pleurosigma acuminatum (Ktz) Grun. 200 (20).
" *attenuatum* W. Sm. 300 (30).
Stauroneis Phoenicenteron E. 110 (38).
" *Gregorii* Ralfs. ?
Stephanodiscus Niagarae E.
Surirella elegans E. 240.
" *robusta* E. 194 (72).
" *splendida* Ktz. 196 (52).

7. Diatoms from Parry Sound, Ontario (W. B. Tindall).

Collected by H. C. Wheeler, Montreal.

Identified and measured by L. W. Bailey and A. H. MacKay.

Cocconeis pediculus E. 32 (22), 30 (21).
Cymbella cuspidata Ktz. 34 (3:11:3).
Diatoma vulgare Bory. v54 (7:10:7) s 7.
Encyonema gracile Rabh. or *Amphora lanceolate* var.? 28.
" *turgidum* (Greg). Grun. v40 (11) s7-8.
Eunotia diodon E. v40.
" *formica* E. v117 (11:8:9:8:11) s11, v130, v180.
" *major* Rab. v235 (19:13:15:13:19).
" *monodon* E. v48 (8:10:8) s12.
" *pectinalis* Rab. v80.
" " var. *curta* v55 (8:11:8).
" " var. *undulata* Ralfs. v104 (5:7:5).
" *robusta*, var. *tetraodon* (E) Ralfs. v48 (20).
Fragilaria capucina Desm.? z77 (19/2) s10.
" *entomon* E.? z16 (24/6) 50.
" *mutabilis* var. *intercedens* W. Sm. z22 (8) s5.
Frustulia rhomboides (E)De Toni var. *amphipleuroides* Grun. v123 (10:22:10) s? v130 (7:15:7) s?
Gomphonema accuminatum E. var. *coronatum* v56 (8:16:14).
" *lanceolatum* E. var. *insignis* v50.
Melosira crenulata Ktz. z8 (8) s16.
Navicula divergens W. Sm. v85 (17) s10.
" *nobilis* E., (near major). v198 (23:29:23) s6-7.
" *radiosa* Ktz. v72 (11) s10.
" *rostellata* Ktz. v63 (5:14:5) s9.
" *Smithii* Breb. v69 (37) s7.
" *tenella* Breb. v38 (0:8:0) s18.
Nitzschia angustata (W. Sm.) Grun. v42 (0:8:0) s13.
" *fluminensis* Grun. (?) v160 (0:8:0) s5 & 0.
" *vermicularis* (Ktz) Grun. 200 (6:6:5:6) s?
Pleurosigma acuminatum (Ktz Grun. v123 (16), 134 (16), 149 (11). (Some forms like *P. Spenceri* W. Sm.).
Stauroneis Phoenicenteron E. v185 (12:24:12) s13.
Stephanodiscus Niagarae E. 20 (20), 27 (27), 30 (30) s6 & 12.
Surirella amphioxys W. Sm. v33 (16), 40 (17) s3.
" *Guatimalensis* Grun. v128 (64) s3, 136 (64) s3+
" *Molleriana* Grun. v43 (13) s9+
" *robusta* E. v130 (40) s1.4., 160.
" *robustior* McK. v140 (61) s.5 (Var. of *robusta*).
" *splendida* var. *bifrons* A.S. v138 (43).
Synedra delicatissima W. Sm. v256 (3:5:3) s10.
" *ulna* var. z189 (24:6:24) s9-10, v88 (3:7:3).
Tabellaria fenestrata Ktz. 85, 74, 53, 51.
(Spicules, smooth and rough, of Fresh Water Sponges also present).

8. Diatoms from Lake Winnipeg, Manitoba.

For the sake of comparison the following list of species, prepared by Dr. Charles W. Lowe, of the University of Manitoba, is appended:—

Amphiprora ornata Bail.
Asterionella formosa Hall.
Cocconeis placentula Ehr.
Cocconema cymbiforme Ehr.
" *lanceolata* Ehr.
Cymatopleura solea (Breb.) W. Sm.
" *elliptica* V. H.
Epithemia turgida Ehr.
Fragillaria capucina Des.
" *crotonensis* (Edw.) Kelton.
Melosira varians Ag.
" *gastrum* (Ehr.) Don.
Ropalodia (Epithemia) gibba (Kütz) Müll.
Rhizosolenia morsa W. West.
Stephanodiscus Niagarae Ehr.
Synedra ulna Ehr.
" " var. *splendens* (Kütz) H. V. H.
" *revaliensis* Lem.
Tabellaria fenestrata (Lyngb.) Kütz.
Surirella ovalis Breb.

XIII

The Utilization of Dog-Fish and Selachian Fishes of Eastern Canada.

BY

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CONTENTS.

1. NATURAL HISTORY OF THE GROUP.

(a) CHARACTERISTICS.

The Selachii[1] form one of the subclasses[2] of the class Pisces or fishes and includes dogfishes, sharks, skates and rays. The fishes in this subclass are characterized by having a cartilaginous skeleton, the skin either naked or covered with small rough scales or spines, the gill clefts opening separately on the surface of the body and not covered by an operculum, the jaws distinct from the skull and no air bladder. The Canadian representatives are all large marine fishes.

(b) DISTRIBUTION, MIGRATIONS, ETC.

Most sharks and dogfishes roam the ocean and have a wide distribution, while most skates and rays live on the sea bottom usually near shore. Probably nearly all sharks and dogfishes show an anadromous migration, living at large in the deeper waters during late summer and winter and migrating in shoals in the spring and early summer to shallower water, where the young are born or the eggs deposited. A detailed account of the distribution of the commoner Canadian species will be found in a later section.

1 Called also Elasmobranchii, Plagiostomata, Chondropterygia, or Placoidei.
2 In the present paper the classification of Jordan and Evermann ('96) is followed.

2. THE FLESH OF SELACHIANS WITH PARTICULAR REFERENCE TO ITS USE AS FOOD.

(a) THE STRUCTURE OF THE FLESH.

The fleshy part or muscle tissue of Selachians is light in colour and of a texture not very different from that af the halibut. As in all fishes the muscular part of the body is distributed on either side of the "backbone" or vertebral column. Owing, however, to the fact that Selachians are without true bones and the cartilagninous ribs are only short rods, the flesh of sharks and dogfish can be easily taken off in two large fillets, corresponding to either side of the body and entirely free from bone. This is an advantage in preparing the fish both for the table and for canning.

The shape and size of dogfish is such that they can be handled and prepared for shipping fresh or for salting in exactly the same way as cod or haddock. The flesh is as firm or firmer than that of the cod or haddock and stands handling well.[3] The shape of a fillet of dogfish, which is long, narrow and of nearly uniform thickness for the greater part of its length, is convenient for canning, it being possible to roll the fillet into an ordinary cylindrical can.

In the case of skates and rays the usable part of the flesh is found in the "wings" or pectoral fins. The practice is to cut the wings from either side of the body including in them the large cartilaginous fin-rays. These wings are convenient for cooking. The writer is not aware of any attempts made to prepare skates and rays for canning, although he sees no reason why they should not be canned as successfully as dogfish.

The skin of most sharks and dogfishes is leathery. There are no true scales like those of the bony fishes but in their place are small polygonal plates each bearing a spine which projects above the surface, giving to the skin a rough and rasping quality.

The toughness of the skin of the dogfish and shark makes them more difficult to skin than most fishes, and hence tends to make the handling of them unpopular with the fisherman, to whose lot usually falls this part of the preparation. This difficulty is a serious one from the point of view of some of the firms[4] which handle dogfish and can it under the name of "grayfish."[5] The labour involved may, however, be partly reduced by the development of improved methods of skinning and more practice in handling this kind of fish by fishermen and factory hands; also the greater labour may be partly compensated for by the utilization of the skin.

(b) THE CHEMICAL COMPOSITION OF SELACHIAN MUSCLE.

(1) *As to Nutrient Value.*

The chemical composition of fish in general resembles that of meat in the nature of its constituents but differs in the proportions in which those constituents occur. "Comparing the nitrogenous components of each, we find in fish more of the gelatine-yielding matter (collagen) and less of the extractives than in meat."[6] The mineral content of fish, as a rule, exceeds that of meat and contains more phosphates."[6]

Hutchison classifies fish as follows with reference to their content of fat[6]:—

Lean: Fish having less than 2 per cent fat, such as cod and haddock.
Medium: Fish having 2 to 5 per cent fat, such as halibut and mackerel.
Fat: Fish having more than 5 per cent fat, such as eel, salmon and herring.

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[3] For the keeping qualities of dogfish see section on chemical composition.

[4] The writer was told in an interview with Mr. McDonald, manager of one of the Gordon-Pew factories in Boston, that the skinning was one of the most troublesome parts of the process.

[5] The term "grayfish" has been adopted in Canada and the United States as the trade name of the dogfish.

[6] The writer here quotes from Leach, 1909, p. 254.

The following figures are selected from the tables of Atwater and Bryant, given in Leach 1909, pp. 213 and 255:—

Kind of Flesh.	Water.	Protein.		Fat.	Ash.	Fuel Cals. per lb.
		N x 6·25	by difference.			
Beef, medium	68·3	19·6	18·9	11·9	0·9	865
Cod (lean fish)	82·6	16·5	15·8	0·4	1·2	325
Salmon (fat fish)	64·6	22·0	21·2	12·8	1·4	950
Skate	82·2	18·2	15·3	1·6	1·1	400

From this table it will be seen that the flesh of the skate compares favourably with that of the cod in nutrient value. "The dogfishes are not only palatable in the fresh condition, but are as good as many other fishes when preserved by the standard methods. The spiney dogfish (*Squalus acanthias,* the common Canadian species) being in composition most like the salmon is best adapted for canning and is considered as good as the medium grades of salmon."[7]

(2) *As to Urea and Ammonia.*

Although comparing favourably with other food fishes in nutrient value the flesh of selachians contains a larger proportion of certain excretory products of the organism. Most important of these are urea and ammonia. Analysis of the flesh of the skate, *Raja ocellata,* in the fresh state were made by the urease method. This method consists in allowing a ferment urease to convert the urea into ammonium carbonate. The amount of ammonium carbonate formed was determined by titrating against sulphuric acid before and after the ferment had been allowed to act and the urea calculated from this. The results of these analyses show that the flesh of the skate contains when fresh about 2 per cent of its total weight of urea. There is probably about the same proportion of urea in most selachians. Comparing this with meat we find for example that beef contains only 0·01–0·03 per cent[8], which is about the same as our own blood and flesh.

There is undoubtedly very little ammonia present in the fresh skate. It is, however, rapidly formed as decomposition sets in.[9]. Under ordinary summer conditions in the laboratory at St. Andrews skate may be kept overnight without giving an odour of decomposition or ammonia. After forty-eight hours the ammoniacal odour becomes quite strong.

The canned product has been analysed by Dr. E. Baumann, of the Department of Biological Chemistry of Toronto University, and his report is given as Appendix A to this paper. Calculating the urea from the figures given in the report for urea nitrogen one obtains for the Red label, analysis I, 0·79 per cent urea, and for the Blue label, analysis III, 0·34 per cent. In the latter case some of the urea had undoubtedly changed into ammonia (see Appendix A).

The amount of ammonia nitrogen in the canned samples is given in Dr. Baumann's report (Appendix A). Taking the Red label I, with ammonia-N (calculated on the total weight) 0.09 per cent, the ammonia is 0.11 per cent. This amount is very much greater than that found in fresh cod, which was found to be 0.017 per cent, by E. D. Clark and L. H. Almy (1918).

[7] Field, 1910, p. 248.

[8] Leach, 1909.

[9] See statement by Dr. A. B. Macallum in Appendix B.

(3) *On the Physiological Effect of Urea Taken in the Food.*

(a) *Toxic Effect.*

The symptoms of urea poisoning or asthenic urenia are headache, dizziness, fatigue and weakness (Hewlett, Gilbert and Wickett, 1918). These symptoms "Are rarely well defined when the concentration of urea in the blood is less than 100 mg. per 100 cc. of blood and they are rarely absent when the concentration exceeds 200 mg." The normal amount of urea in the blood is 0.036 to 0.043 mg. per 100 cc. In order to produce a concentration of over 100 mg. per 100 cc. of blood it is necessary to give a dose of urea amounting to 100 to 125 gms. (Hewlett, Gilbert and Wickett). Furthermore this urea is almost entirely eliminated by way of the urine in twenty-four hours and the symptoms last only a few hours.

(b) *Effect of Repeated Doses.*

T. Addis and C. K. Watanabe (1916) have given urea in doses of 20 gms. per day for three successive days to young healthy adults. The experiment showed that the administered urea had been almost completely excreted at the end of the third day, there being an average retention on the fourth day of only 4.96 gm. urea, which was excreted during the next twenty-four hours if no urea were taken. When 40 gm. of urea were taken on each of three successive days the results were substantially the same, the amount of urea retained, to be excreted on the first day after the administering of urea had ceased, being 4.46 gms. T. Addis and C. K. Watanabe conclude that "The rate of excretion of the administered urea during successive periods of the twenty-four hours showed that the repetition of large doses of urea did not elicit the condition which has been described as kidney "fatigue."

(c) *The Effect of Taking Small Amounts.*

The facts cited in the previous paragraph indicate that there is no injurious effect either during or after the taking of such large doses of urea as 20 or 40 gm. There would seem, therefore, little doubt that the taking of such quantities of urea as would come in a meal of dogfish, say 4 gm., is without injurious effect on normal persons even if repeated on successive days. O. Folin (1911) has further shown that there may be a variation in the daily excretion of urea of from 5.6 to 8.1 gm. in the same person within a few days, which shows that the amount of urea taken into system in a meal of dogfish would not be greater than that which might be added to the body by additional exercise or a change of diet.

For expressions of opinions with regard to the effect of taking urea in dogfish flesh, see Appendix B.

(d) *Palatability of Selachian Flesh.*

With regard to the palatability of the flesh of the spiny dogfish, *Squalus acanthias*, the common dogfish of the Canadian Atlantic coast, Mr. Irving Field of the United States Fish Commission says:[10] "The Commissioners on Fisheries and Game of Massachusetts have personnally reported its palatability, the lack of odour or "strength" and the good consistency when cooked or canned. They say it closely resembles halibut. The spiney dogfish has in recent years been exploited in England as a valuable cheap food. A writer in a London paper states that the Plymounth council engaged an expert cook to prepare dogfish for the table with and without sauce, and that those who partook pronounced it excellent as to colour, flavour and firmness.

"The dogfishes are not only palatable in the fresh condition, but are as good as many other fishes when preserved by the standard methods. The horned dogfish being

[10] *Field*, 1908, p. 248.

in composition most like the salmon is best adapted for canning and is considered as good as the medium grades of salmon. A packer in Petit de Grat, Cape Breton, in 1904 sent me a dozen cans of dogfish he had packed. I passed them round to my friends, who prepared the contents in different ways (fried, scalloped, creamed, etc.). In these forms the canned article was highly praised for flavour and palatability. Samples were also sent to several hotels where the fish was served to the guests as 'Japanese halibut,' and was pronounced most acceptable. An establishment at Halifax has been canning large quantities and putting them on the market labelled 'Ocean whitefish.' A firm at Charlottetown, Prince Edward Island, has been successful in selling the canned article as 'sea bass.'"

The flesh of the skate has long been relished in England and on the continent; during the last two years it has been for sale in fish stores in the Eastern United States. Shark flesh has been sold for the last two years in New York.

3. THE UTILIZATION OF SELACHIANS FOR OTHER PURPOSES THAN FOR FOOD.

(*a*) TO OBTAIN OIL.

Oil can be obtained from the liver of nearly all selachians. The "Dogfish oil" of the American market is said by Jordan and Evermann (1896) to be obtained from *Squalus acanthias*. "Shark oil" and "Ray oil" are also on the market. These oils are used in the currying of leather.

(*b*) TO MAKE GLUE.

Glue has been made from the smooth dogfish, *Mustelus canis*, of American waters. This form does not occur commonly as far north as the Canadian coast. Our own horned dogfish, *Squalus acanthias*, is said by G. F. White (1917) not to be suitable for the production of glue. "Attempts to produce glue from the grayfish (*Squalus acanthias*) have not been successful on account of the large amount of oil and water in the fish, the difficulties attended with the extraction of the oil, and the presence of dark pigments in the skin which discolour the extracts. It is also probable that the skeleton contains only a small amount (if any) of collagen or glue-forming substance. The flesh of the smooth dogfish (*Mustelus canis*) contains gelatin-forming material and presents possibilities as a source of glue." ([11]) "That the manufacture of fish glue alone is not very profitable may be seen from the fact that glue manufacturers do not rely on this one product as a source of profit." ([12])

(*c*) AS A FERTILIZER.

The flesh of selachians, like that of other fishes, for example the menhaden, is rich in fertilizing constituents, containing from 7 to 8 per cent of nitrogen and 6 to 8 per cent of phosphoric acid. The availability of this nitrogen is much reduced if oil is present. Hence in the case of selachians containing a considerable quantity of oil, as for example our horned dogfish, the oil ought to be extracted.

(*d*) OTHER USES.

The skin of dogfish is used for the preparation of shagreen, a kind of rough leather. It was also used for polishing, its place being now, however, largely taken by the various kinds of sand and emery papers.

The eggs of the dogfish have been found to be a good substitute for hen eggs in the process of tanning.

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11 C. F. White, 1917, p. 12.
12 C. F. White, 1917, p. 14.

4. THE DISTRIBUTION AND USES OF THE COMMON SELACHIANS OF EASTERN CANADA.

(*a*) SHARKS AND DOGFISHES. (13)

Squalus acanthias Linnaeus.

Synonyms—
Squalus acanthias Linnaeus.
Squalus acanthias Jordan and Gilbert.
Acanthias americanus Storer.
Acanthias vulgaris Risso.
Acanthias vulgaris Günther.

Common names—
Dogfish; Picked dogfish; Horned dogfish; Bonedog; Skittle-dog; Spiny dogfish.

Characteristics: Body slender; head depressed, about 6½ times in length; depth about 8 times in length; snout pointed; eyes lateral without nictitating membrane; mouth inferior, rather large, slightly arched, a long, straight, deep, oblique groove on each side; nostrils inferior, separate; spiracles rather wide, just behind the eye; gill openings moderate, all in front of the pectoral fins; dorsal fins two, the first larger than the second and much in advance of the ventrals which are behind the middle of the body and in advance of the second dorsal; each dorsal fin armed with a strong ungrooved spine, the first about two-fifths height of fin, the second about three-fifths height of fin; anal fin wanting; caudal fin with the lower lobe small and the upper lobe slightly bent upward; ventral fins inserted posteriorly, not much before the second dorsal. Slate colour above, pale below, back with oblong, whitish spots, especially in the young. Length, 2 to 3½ feet; weight, 5 to 15 pounds.

This is the common Canadian dogfish; it is stated by Günther to occur in the temperate seas of the Southern as well as the Northern hemisphere but not in the intermediate tropical zones.

Cornish (1907) writes concerning this fish at Canso: "This is an extremely common species and often a great nuisance to the fishermen fishing with trawls of baited hooks. I have known gear with 700 hooks to have 690 of these dogfish upon it. No use is generally made of these fish; they are difficult to release from the hooks, and they generally snap off the snood; they are regarded with much disfavour." As Professor Prince pointed out in his report on the "Dogfish Pest in Canada" (Fisheries Report, Department of Marine and Fisheries, Ottawa, 1903), this species has proved a most destructive enemy to the sea fisherman's pursuits, and his recommendations to the Government favouring reduction works for converting dogfish into fertilizer, oil and glue, etc., are being carried out."

Concerning this fish at Tignish, Prince Edward Island, Cornish further writes: "The picked dogfish is very common and extremely destructive. It appears about the end of July and remains until the end of the fishing season in the autumn. It is noticed on the east a few days before it reaches the west coast (of Prince Edward Island). As a result of its appearance fishing for cod may often cease entirely early in August; the trawls of hooks are set for cod at night and when raised in the morning sometimes every fish has been devoured by this pest, only the head and vertebral column remaining on the hook. The females were generally gravid, containing four or five well-developed embryoes about 15 cm. long."

[13] The names and characteristics are taken in large part from Jordan and Evermann (1896).

At St. Andrews, N.B., and in the Passamaquoddy bay generally, the horned dogfish has been somewhat rare during June, July, August, and September in the past four years.

I am indebted to Dr. A. G. Huntsman for the following note on the distribution of *Squalus acanthias:* "It extends in its distribution well into the Bay of Fundy and into Passamaquoddy bay and the St. Croix river.

"In the gulf of St. Lawrence it is found generally distributed, but is apparently not as abundant on the north shore, although reported from that part by Storer (1850, p. 270) and Fortin (1864). In the St. Lawrence river, Bell (1859, p. 208) records it for Les Islets on the south shore.

"It is probably not to be found on the outer coast of Labrador, although listed from Greenland by Fabricius (1780, p. 127), and stated by Perley (1852, p. 223) to range as far north as Davis strait, on what authority I know not.

"The Acadian region is evidently the region of abundance for this species, although it passes beyond the limits of the region, both to the north and to the south."

At Woods Hole, Mass., this species is "Less abundant than formerly and comparatively scarce in 1897. When the fish factory was established at Woods Hole, this was the principal fish utilized in the manufacture of guano; later the scarcity or irregularity of the supply necessitated the use of menhaden." [14]

Dogfish feed on mackerel, herring and other small fish.

The flesh of the dogfish has been canned under the supervision of the U.S. Fish Commission as "grayfish". It is also used as fertilizer, being used by both Canadian and United States factories for making guano or fish manure. In this latter case the oil is first extracted. The liver may be used alone to make dogfish oil, used in currying leather. On certain parts of cape Cod the fish has been dried for fuel. The skin of the dogfish has been used for polishing and for making shagreen, a kind of rough leather.

The following species of shark is found in Canadian waters although not so abundantly as the dogfish:—

Carcharias littoralis Mitchell, the sand shark. It is found along shores or within soundings and reaches a length of twelve feet.

(*b*) RAYS.

Günther (1880) states that all rays are considered edible and some of them are regularly brought to the English market. The commoner Canadian rays are:—

Raja erinacea Mitchill.
Synonym—
Raja eglanteria Günther.
Common names—
Common skate; Little skate; Tobacco box.

Characteristics: Form rhomboid, with all the angles rounded; spines largest on the anterior extensions of the pectorals, where they are close set, strong, laterally compressed, and hooked backward, smaller ones are scattered over the head above the spiracles, above and in front of the eyes, and on the back, the median line of which is comparatively smooth, without larger median series, except in the young; a triangular patch on the shoulder girdle; inner posterior angles of the pectorals nearly smooth; in the males near the exterior angles of the pectorals are two rows of large erectile hooks pointing backward. Females with groups of small scales on each side of the vent; teeth small, the middle ones sharp in the males; all blunt in the females; jaws much

[14] Quoted from H. M. Smith, 1897.

curved; each side of tail with a dermal fold. Colour light brown, with small round spots of dark brown; no pectoral ocelli. Length 1 to 2 feet.

Raja laevis Mitchill.

Synonyms—
Raja laevis Storer.
Raja granulata Gill.
Common name—
Barndoor skate.

Characteristics: Angles of the disk more acute than in any of the others; muzzle much produced, somewhat shovel-shaped at tip. Spines of the body very few and small; some present above the eyes and spiracles, on the snout, along the anterior border of the pectorals, and on the back; those on the back very small; a median dorsal row of larger hooked spines extending along the median line of the posterior portion of the back and the tail; usually two lateral rows on the tail. Colour variable, brownish, with paler spots, which are usually ringed with darker. Length reaching 4½ feet.

"This species is frequently captured by the cod fishermen (out of Canso) on their deep sea trawls of hooks. The only specimen minutely examined by me was 1,075 mm. long."[16] "The barndoor skate is very common at Tignish."[17]

One specimen which was stranded at the Biological Station, at St. Andrews on August 27, 1917, measured 1,450 mm. or about 4½ feet in length, and 1,100 mm. or about 3½ feet in width, and weighed 40 pounds. The wings, representing the edible portion, when cut from this fish weighed together 12 pounds.

This species is used to some extent as food in the United States and is sold in fish markets.

Raja ocellata Mitchill.

Synonyms—
None.
Common name—
Big skate.

Characteristics: General form and appearance that of *Raja erinacea* but much larger; the arrangement of spines similar, except that additional rows of spines are present down the back and along the sides of the tail; caudal fin not separate, rough with small spines; jaws curved. Colour light brown, with round dark spots; a translucent space on each side of the snout; near the posterior angle of the pectoral there is usually (but not always) a large white ocellus, with a dark spot in the centre and a darker border; two smaller similar spots often present. Length reaching three feet.

"A most common species at Canso although some of the specimens which I examined may belong to the allied species, *R. erinacea.* I found it difficult to decide finally in the case of some examples. They were all taken in the trap-nets set for mackerel, close along the shore." "Four specimens measured ranging from 61 to 70 cm."[18]

"This skate is caught very commonly on the set trawl of hooks, it is also seen swimming within a few feet of the beach, and is often speared from wharfs."[19]

Raja radiata Donovan.

Synonym—
Raja americanus DeKay.
Common name—
Starry ray.

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16 Cornish, 1907.
17 Cornish, 1912.
18 Cornish, 1907.
19 Cornish, 1912.

Characteristics: Besides the spines on the pectorals, head, back, and tail common to most species, this species is marked by the presence of large spinous plates or bucklers; these are large, strong spines, with broad, stellate or shield-like bases arranged as follows: one or two in front of each eye; one on each side between the eye and the spiracle; a pair on the shoulder, the smaller in front; and fourteen or more forming a dorsal row, beginning just back of the head and extending to the caudal; an irregular row of spines on each side of the tail, separated from the membrane by a band of shagreen; males with two or more rows of claw-like spines on the pectorals. Length 1½ to 2 feet.

"This skate or ray is usually called the Starry Ray and it is the most common species taken on the local cod trawls. I have seen several dozens taken in about three hours by one dory" (at Canso).[20]

This species occurs frequently at St. Andrews, N.B.

APPENDIX A.

REPORT ON ANALYSES OF CANNED GRAYFISH (DOGFISH) (21).

By Dr. Emil J. Baumann,

Department of Biochemistry, University of Toronto.

The cartilaginous bones were removed from the muscle and the entire contents of the can (meat and liquor) were put through a hashing machine two or three times. A more or less pasty mass resulted, which was carefully mixed, and a portion containing 300 grams was taken for analysis. These were heated on a water bath for one half-hour, with three or four times their weight in water. (Made acid with 1 cc. 50 per cent acetic acid) with occasional shaking. The liquid was decanted through cheesecloth. The muscle was again comminuted and re-extracted with hot acidulated water, as above, four times, making five extractions in all. The combined extracts were filtered through a paper pulp filter. This was a slow and tedious process, but resulted in a clear opalescent filtrate.

The extracts were then concentrated under diminished pressure in a water bath, the temperature of the water in the bath never rising above 55° C. When the extracts had been reduced from 150 to 100 cc., 5 volumes of 90 per cent alcohol were added to precipitate any remaining protein. A little glycogen was probably precipitated also. After standing overnight the alcohol solution was filtered and the precipitate carefully washed with 75 per cent alcohol. The solution at this stage was distinctly acid. The alcohol filtrate was evaporated under diminishing pressure to about 75 or 100 cc., about 100 cc. of water added and concentration repeated to remove the last traces of alcohol. (Alcohol sometimes interferes with amino nitrogen determination.)

The concentrated extract was washed from the distilling flask and made up to a volume of 250 cc. Urea determination was made on 1 cc., aliquots (measured with a calibrated Ostwald pipette) by the Urease method of Van Slyke and Cullen, Jour. of Biol. Chem., Vol. 24, p. 17, 1916.

Ammonia was determined by the usual aeration method of Folin, on a 1 cc., aliquot.

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20 Cornish, 1907.

21 The cans of grayfish used for these analyses were put up by the Gorton-Pew Company of Boston. The Blue Label samples were obtained by the writer from the factory about June 30, 1917, were taken to St. Andrews and forwarded from there to Dr. Baumann in Toronto. The cans were understood to be put up in April or May of the same year. The Red Label samples were obtained directly from the Gorton-Pew Company by Dr. Baumann in July, 1917. The analyses were made in the latter part of July, 1917.

In a letter, Dr. Baumann remarks: "The material I received from the factory (Red Labels) was better looking, whiter and meat more firm."

Total solids were determined by the official method of the United States Department of Agriculture on a fair sample of about 5 grams.

All the determinations were made in duplicate.

——	Red Label I.	Red Label II.	Blue Label
	%	%	%
Total Solids	26·77	26·60	26·86
Urea—N	0·37	0·355	0·16
Ammonia—N	0·09	0·09	0·145
Urea—N (Calc. on dry wt.)	1·38	1·34	0·59
Ammonia—N (Calc. on dry wt.)	0·35	0·35	0·54

Red Label samples obtained from factory. Blue Label sample from St. Andrews

There is probably some significance in the high ammonia and low urea figures which I obtained from the sample sent from St. Andrews as contrasted with the high urea and low ammonia content of the fish sent from Gorton-Pew. Probably some change has occured.

There was no odour of decomposition from the sample having the high ammonia content, though it would be difficult to distinguish between the odours of decomposition and that of fish. If any extensive decomposition had occured, probably much higher ammonia figures would have been obtained.

APPENDIX B.

(Extract from a letter by Dr. A. B. Macallum to the writer.)

" There are two handicaps regarding dogfish as food, from the point of view of its urea content. One is that the urea changes to ammonium carbonate when the dogfish stands at ordinary temperatures, and the amount thus transformed is in proportion to the time during which the fish is allowed to stand at such temperature after it is caught. The presence of ammonium carbonate with the other odour of the fish makes it exceedingly disagreable to the taste and smell, and, accordingly, dogfish as food must be used soon after caught, or else it must be frozen and kept frozen in order to prevent transformation of urea into ammonium carbonate.

" The other handicap is an æsthetic one. One does not relish eating food in which there is such a waste product as urea in abundance.

" In canning fresh dogfish, of course, the water used in heating may withdraw a considerable portion of the urea. That explains why in Dr. Baumann's experiments the quantity found was much less than the 2 per cent present in the muscle of the living animal.

" The observations regarding the dogfish are applicable to the skate and shark for food."

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XIV

Key to the Hydroids of Eastern Canada.

BY

C. McLean Fraser.

(With 109 Figures.)

INTRODUCTION.

A recent paper contained a complete list of the hydroids that have been found in the waters of Eastern Canada, so far as is known, with synonymy and distribution of each species as related to this area and the literature pertaining to it.[1] In the present paper the same species are considered and an attempt is made by key, short description and characteristic figure, to put in concise form for handy reference, a means of diagnosing at least the typical hydroids. The investigator who wishes to study more minute details, will find them given in the papers referred to in the bibliography in connection with the previous paper.

No new matter is introduced. In some cases where the writer had not previously described the species, the description was made directly from the specimen, but in substance this would naturally be similar to descriptions given by others. Similarly many of the drawings have been made specially for this paper. Descriptions given in, and drawings made for, previous papers, have been used in many instances, but only in cases where specimens of the species recorded by other investigators were not available for description have quotations or copies been made from other authors. In the list there were thirteen of these species and in some other cases the description of the gonosome had to be obtained, but in all cases the authority for the description or figure has been given. The specimen of *Lafoea symmetrica* obtained some years ago at Canso has been lost and the drawing is made from a sketch made at the time, but it seems to agree with that given by Bonnevie, although it may not be exactly typical. Two species described by Stimpson, viz., *Eudendrium cingulatum* and *Grammaria gracilis*, were not figured by him, and apparently they have not been described or figured since, hence no figures of these appear. The only difference between *Tubularia spectabilis* and *Tubularia tenella* seems to be one of size, if that is sufficient difference to separate species. As *T. spectabilis* is too large to admit of the enlargement that is used throughout, the difference in size could not readily be shown, hence there is no figure given of *T. tenella*. All drawings taken from other sources have been reduced to one-third diameter. Figures 20, 21, 23 and 25 have been magnified but little, figures 37, 52, 53, 54, 56, 61, 69, 76 are magnified 30 diameters, figures 4, 6, 9, 10, 11, 26, 41 are magnified 15 diameters and the remainder of the figures 10 diameters.

For a copy of a plate containing the figure of *Dicoryne flexuosa*, I am indebted to Mr. Dayton Stoner, of the State University of Iowa, and for a copy of the figure of *Tetrapoma quadridentatum*, as well as the description, and for the description of the coppinia of *Lafœ a pygmæa* I am indebted to Dr. A. G. Huntsman, of the University of Toronto. Mrs. Fraser has made the drawings for the paper.

Although the same species are here treated, there is practically no duplication of what is included in the previous paper. It seems entirely unnecessary to repeat the synonymy and distribution in what is intended to be merely a handbook for

[1] Hydroids of Eastern Canada. Contributions to Can. Biol., 1917, pp. 329-370, Supp. to 7th Ann. Rept., Department of Naval Service.

ready reference. That the paper may be useful even to those who have not had previous acquaintance with hydroid taxonomy, a glossary of the principal hydroid terms is included.

GLOSSARY.

Acrocyst. An extra-capsular marsupial sac, surrounded by a gelatinous covering, in which development of the ova takes place in certain species.

Actinula or *actinule.* A medusoid structure developed from the reproductive buds in the genus *Tubularia*, in which radial canals and rudimentary tentacles appear but in which no mouth is present. In this structure the ova are developed into the young hydroids while the structure is still attached.

Cœnosarc. The common flesh-like substance that binds the zooids together in a colony.

Colony. A number of zooids connected together by a common cœnosarc.

Coppinia. A mass formed of a close aggregation of gonangia, among which are scattered modified hydrothecæ, which serve as a protection for the mass. Found in the *Lafœidæ*.

Corbula. A specially modified branch or hydrocladium which forms an envelope for the gonangia in certain Plumularians.

Diaphragm. A cross partition in the hydrotheca which forms a support for the base of the hydranth.

Fascicled. A stem or branch is said to be fascicled when it consists of two or more tubes closely applied. There are varying degrees of intimacy in this application. The tubes may be only in loose contact or there may be cross communications.

Gonangium or *gonotheca.* The protective chitinous envelope that protects the developing reproductive elements in calyptoblastic forms.

Gonophore or *gonozooid.* A zooid specially modified for the purpose of reproduction.

Gonosome. A collective term for all the generative zooids of a colony and structures that are directly associated with them.

Hydranth. The nutritive zooid of a colony, consisting of a digestive sac, proboscis, mouth and tentacles.

Hydrocladium. A term applied to the hydrotheca-bearing branchlets in the *Plumularidæ*.

Hydrophore. A hydrotheca reduced to be saucer-shaped,—not deep enough to contain the contracted hydranth. Found in the *Halecidæ*.

Hydrotheca. A chitinous protection for the hydranth in calyptoblastic forms.

Internode. The portion of a stem or branch between two succeeding joints.

Manubrium. The hollow pedicel supporting the mouth of a medusa. It hangs freely into the sub-umbrellar cavity.

Nematophore. A chitinous receptacle into which the defensive zooid, in the form of a sarcodal process, retracts. Also applied to the receptacle and the sarcodal process taken together.

Node. A joint in the stem or branch.

Operculum. A chitinous structure of one or more segments, that closes the hydrothecal aperture when the hydranth is retracted within.

Otocyst or *lithocyst.* A small sac present in the margin of the umbrella of many medusæ, containing refractory spherules with a sensory function.

Pedicel. The stalk supporting a hydranth or a gonophore.

Phylactogonium. An appendage of a hydrocladium, protecting or assisting to protect the gonangia of certain Plumularians.

Planula or *planule.* An oval or pyriform, ciliated, free-swimming embryo, developed from the ovum, which later becomes attached to form the beginning of a hydroid colony.

Proboscis. The hollow elevation from the body of the hydranth which supports the mouth.

Sessile. A hydranth or a gonophore is said to be sessile when no pedicel is present.

Simple. A stem or branch is said to be simple when it consists of a single tube.

Sporosac. The sac that contains the generative elements.

Stolon. A creeping stem. This may be filiform, or may have cross communications with other stolons to form a network.

Trophosome. A collective term for all the nutritive zooids that go to make up a colony and structures that are directly connected with them.

Zooid. One of the individuals, more or less independent, that go to make up a colony. Zooids may be nutritive, generative, defensive or sensory.

HYDROIDS OF EASTERN CANADA.

KEY TO FAMILIES.

Sub-order A. GYMNOBLASTEA.

Hydroids with hydranths unprotected by hydrothecæ and gonophores unprotected by gonangia or other structures having a similar function.

a Hydranths with scattered filiform tentacles. *Clavidæ.*

aa Hydranths with one whorl (or two whorls closely approximated) of tentacles around the base.

b Hydranths with tentacles much reduced in number, even on the nutritive zooids. *Laridæ.*

bb Hydranths with tentacles not reduced in number.

c Proboscis conical, dome-shaped or clavate.

d Colony regularly branched.

e Gonophores producing fixed sporosacs. *Bimeridæ.*

ee Gonophores producing free-swimming sporosacs. *Dicorynidæ.*

eee Gonophores producing free medusæ. *Bougainvillidæ.*

dd Colony not branched, with basal encrusting cœnosarc. *Hydractinidæ.*

cc Proboscis trumpet-shaped. *Eudendridæ.*

aaa Hydranths with a proximal and a distal set of filiform tentacles.

f Proximal set in a single whorl, distal set in several closely placed whorls. *Corymorphidæ.*

ff Proximal and distal set each in a single whorl. *Tubularidæ.*

aaaa Hydranths with all tentacles capitate.

g Tentacles scattered. Gonophores producing free medusæ. *Syncorynidæ.*

gg Tentacles extremely numerous and closely set. Gonophores producing fixed sporosacs. *Myriothelidæ.*

aaaaa Hydranths with a single whorl of filiform tentacles around the base and capitate tentacles scattered over the rest of the body. *Pennaridæ.*

Sub-order B. CALYPTOBLASTEA.

Hydroids with hydranths protected by hydrothecæ and gonophores protected by gonangia or other similar structures.

a Hydranths with trumpet-shaped proboscis and campanulate hydrothecæ. *Campanularidæ*.

aa Hydranths with conical proboscis and tubular or turbinate hydrothecæ.
b Hydrothecæ with an operculum of converging segments. *Campanulinidæ*.
bb. Hydrothecæ without operculum.
c Gonosome a coppinia mass. *Lafœidæ*.
cc Gonangia not collected into a mass. *Hebellidæ*.

aaa Hydrothecæ reduced to saucer-shaped hydrophores. *Halecidæ*.

aaaa Hydrothecæ sessile, adnate to main stem or branches.
d Hydrothecæ arranged on both sides of branches. *Sertularidæ*.
dd Hydrothecæ on one side only of branches. *Plumularidæ*.

Sub-order *GYMNOBLASTEA*.

Family CLAVIDÆ.

Trophosome. Hydranths clavate or fusiform with scattered filiform tentacles.
Gonosome. Gonophores producing fixed sporosacs.

KEY TO GENERA.

a Colony branched. *Cordylophora*.
b Zooids rising singly from the stolon. *Clava*.

Genus CORDYLOPHORA.

Trophosome. Colony branched, main stem well developed; hydranths with scattered filiform tentacles; proboscis fusiform.

Gonosome. Gonophores borne on the stem or branches, produce fixed sporosacs.

Cordylophora lacustris Allman.

Trophosome. Colony regularly branched, main branches also branched, 6 cm. in height; branches and pedicels annulated at the base; hydranth with 16-20 scattered filiform tentacles.

Gonosome. Gonophores oval on very short, annulated pedicels, borne on the stem or branches, invested by a thin perisarcal covering.

No. 1.
Cordylophora lacustris

Genus Clava.

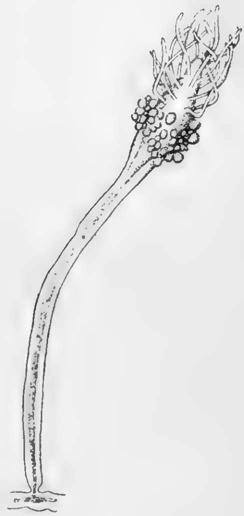
Trophosome. Zooids rising singly from a reticular stolon; tentacles numerous, scattered, filiform; proboscis clavate.

Gonosome. Gonophores produce fixed sporosacs in clusters a short distance below the proximal tentacles.

Clava leptostyla Agassiz.

Trophosome. Zooids clustered, 1 cm. in height, constricted at the base; proboscis clavate, tentacles 20-30.

Gonosome. Sporosacs spherical, appearing in large clusters just below the proximal tentacles.



No. 2.
Clava leptostyla.

Family LARIDÆ.

Trophosome. Zooids rising singly from a reticular stolon; tentacles much reduced in number, very extensile; proboscis fusiform.

Gonosome. Gonophores producing free medusæ.

Genus Monobrachium.

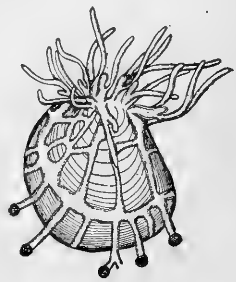
Trophosome. Zooids, each with a single tentacle which has great freedom of movement; mouth terminal.

Gonosome. Medusa buds grow from the stolon; medusæ with four radial canals.

Monobrachium parasitum Mereschkowsky.

Trophosome. Stolon growing over living mollusc shells; the zooids appear at the hinge of the shell and the network spreads over the surface to the margin, with a number of free ends supplied with batteries of thread cells, projecting beyond it; proboscis about one-third the length of the whole zooid; tentacle when extended longer than the body of the zooid; zooid 0·7 or 0·8 mm. long, tentacle extended 1 mm.

Gonosome. Gonophores grow on short pedicels from stolon, one medusa bud to each gonophore; medusa globular, with four radial canals.



No. 3.
Monobrachium parasitum.

Family DICORYNIDÆ.

Trophosome. Colony branched or unbranched; hydranths with a single whorl of filiform tentacles.

Gonosome. Gonophores producing free-swimming, ciliated sporosacs, each with two filiform, ciliated tentacles.

Genus Dicoryne.

Trophosome. Stolon reticular; stem unbranched or branched; hydranths with a single whorl of filiform tentacles; proboscis conical.

Gonosome. Gonophores borne on aborted hydranths, from the stem or stolon; sporosacs, ciliated, free-swimming, with two ciliated tentacles.

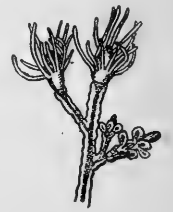
KEY TO SPECIES.

a Stem thin, flexible, not annulated, slightly branched and sometimes dichotomously divided. *D. flexuosa.*
b Stem stiff, erect, distinctly annulated, not dichotomously divided. *D. conferta.*

Dicoryne conferta (Alder).

Trophosome. Stem unbranched or with irregularly arranged, erect branches, from a recticular stolon, annulated towards the base and more or less wrinkled throughout; 15 mm. in height; hydranth long-fusiform, with 16 tentacles.

Gonosome. Gonophores borne in a cluster at the base of an aborted hydranth, from the stolen and from the stem, oval; pedicel long, sporosacs oval.



No. 4.
Dicoryne conferta.

Dicoryne flexuosa Sars.

Trophosome. Stem flexible, slightly branched or dichotomously divided; 7 mm. in height; hydranth short fusiform with about 12 tentacles.

Gonosome. Gonophores on short pedicels, growing from the stem only; sporosacs more numerous in the cluster than in the preceding species.

No. 5.
Dicoryne flexuosa (after Sars).

Family SYNCORYNIDÆ.

Trophosome. Hydranths club-shaped, with numerous scattered, capitate tentacles.

Gonosome. Gonophores on body of the hydranth produce free medusæ.

Genus Syncoryne.

Trophosome. Colony unbranched or slightly branched; tentacles strongly capitate.

Gonosome. Gonophores producing free medusæ with four radial canals and four rudimentary tentacles.

Syncoryne mirabilis (Agassiz).

Trophosome. Colony unbranched or slightly and irregularly branched; hydranth stout; tentacles 15 or more.

Gonosome. Gonophores nearly spherical, borne among or below the proximal tentacles.

No. 6.
Syncoryne mirabilis.

Family BIMERIDÆ.

Trophosome. Hydranth with conical or dome-shaped proboscis, surrounded by a single whorl of filiform tentacles.

Gonosome. Gonophores producing fixed sporosacs.

KEY TO GENERA.

a Sporosacs permanently surrounded by perisarc. *Bimeria.*
b Sporosacs not permanently surrounded by perisarc. *Garveia.*

Genus Bimeria.

Trophosome. Colony usually branched, invested with a conspicuous perisarc, which covers the base of the tentacles; hydranths fusiform.

Gonosome. Gonophores covered with perisarc throughout the whole period of development.

Bimeria brevis Fraser.

Trophosome. Zooids often appearing singly but sometimes as unbranched or slightly branched colonies; 8 mm. in height; branches given off irregularly; perisarc wringled but not annulated; creased around the base of the small hydranth; tentacles 11-12.

Gonosome. Unknown.

No. 7.
Bimeria brevis.

Genus GARVEIA.

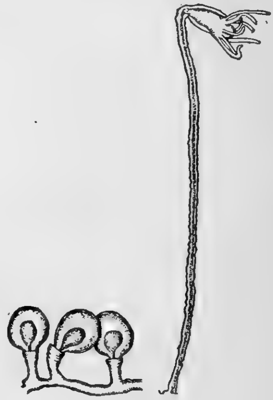
Trophosome. Colony branched or unbranched; perisarc conspicuous; hydranth fusiform.

Gonosome. Gonophores borne on branch-like pedicels; if perisarc covers the gonophore at early stage, it later bursts off, leaving a cup-like expansion around the base.

Garveia grœnlandica Levinsen.

Trophosome. Stems unbranched or very slightly branched, 8 mm. high; perisarc wrinkled or sometimes irregularly annulated; perisarc passing over the lower part of the body of the hydranth; tentacles 10.

Gonosome. Gonophores borne on the stolon; pedicels short with wrinkled flap or cup of perisarc around the base of the gonophore.



No. 8.
Garveia groœnlandica.

Family BOUGAINVILLIDÆ.

Trophosome. Hydranths fusiform or clavate; proboscis conical or dome-shaped; one whorl of short filiform tentacles.
Gonosome. Gonophores producing free medusæ.

Genus BOUGAINVILLIA.

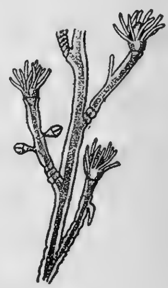
Trophosome. Perisarc well developed on the branches as well as on the main stem.

Gonosome. Gonophores supported on short pedicels; medusæ with four radial canals and four clusters of tentacles.

Bougainvillia carolinensis (McCrady).

Trophosome. Colony irregularly branched, 30 cm. high; branches annulated proximally; hydranths with long conical proboscis; tentacles 10-12.

Gonosome. Gonophores singly or in small clusters on stem and branches.



No. 9.
Bougainvillia carolinensis.

Family EUDENDRIDÆ.

Trophosome. Colony branching, perisarc well developed; proboscis trumpet-shaped but with much freedom of movement; tentacles filiform in a single whorl.

Gonosome. Gonophores producing fixed sporosacs; male and female gonophores usually dissimilar; male gonophores in whorls, female gonophores in clusters.

Genus EUDENDRIUM.

Characters as in the family.

KEY TO SPECIES.

a Main stem, primary and even secondary branches, fascicled.
  b Branches and pedicels slightly annulated proximally or pedicels only annulated throughout. *E. rameum.*
  bb Branches and pedicels extensively annulated. *E. cingulatum.*

aa Main stem fascicled.
  c Colony very bushy with branches extremely numerous. *E. annulatum.*
  cc Colony not bushy.
    d Branches and pedicels annulated proximally. *E. ramosum.*
    dd Branches and pedicels entirely annulated. *E. dispar.*

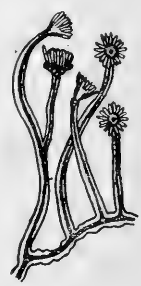
aaa Stem simple.
  e Gonophores at the base of hydranths that are not aborted. *E. album.*
  ee Gonophores at the base of aborted hydranths.
    f Branches short and strong. *E. capillare.*
    ff Branches if present long; main stem, branches and pedicels tenuous. *E. tenue.*

Eudendrium album Nutting.

Trophosome. Colony minute, 8 mm., stem unbranched, or with a few straggling branches; stem, branches and pedicels very slender; annulations indefinite.

Gonosome. Gonophores borne at the base of the hydranth, which may be smaller but not entirely aborted; male and female gonophores in small clusters.

Colour. Hydranths and female gonophores white; male gonophores pale yellow; hydrocaulus nearly transparent.



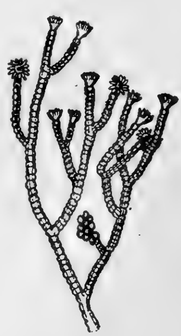
No. 10.
Eudendrium album.

Eudendrium annulatum Norman.

Trophosome. Stem shrubby, covered with a dense network of anastomosing tubes, 10 cm., branches very numerous making the colony look bushy, fascicled in the proximal portion; ultimate branches slender, these and the pedicels closely annulated throughout.

Gonosome. Gonophores clustered at the base of hydranths that are on short, annulated pedicels.

Colour. Yellowish throughout in preserved specimens.



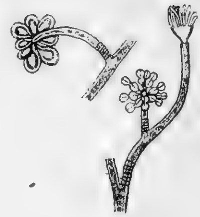
No. 11.
Eudendrium annulatum.

Eudendrium capillare Alder.

Trophosome. Colony small, 12 mm., usually branched, with the branches as strong as the main stem; branches and pedicels annulated proximally.

Gonosome. Male and female gonophores at the base of aborted hydranths, on long, rather rigid pedicels, rising from either the stem or stolon.

Colour. Hydranths and male gonophores light green; female gonophores reddish orange.



No. 12.
Eudendrium capillare.

Eudendrium cingulatum Stimpson.

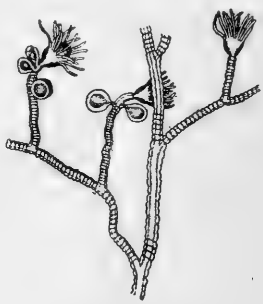
"Polypidom small, very irregularly branched, somewhat as in *E. rameum,* but not so thickly; branches strongly ringed, sometimes throughout their length, always near their origin; polypes small with long tentacles and broad blunt proboscis. It differs from *E. rameum* in the more numerous rings on the branches, and from *E. ramosum* in the mode of branching." (Stimpson).

Eudendrium dispar Agassiz.

Trophosome. Colony large, 10 cm., main stem slightly fascicled; branches and pedicels extensively annulated and the main stem wrinkled or annulated to some extent; branching irregular.

Gonosome. Gonophores at the base of the hydranth or scattered down the strongly annulated pedicel; hydranth, although sometimes smaller, is often of normal size.

Colour. Stem greenish; hydranths rose-coloured; male gonophores orange; female gonophores pink.



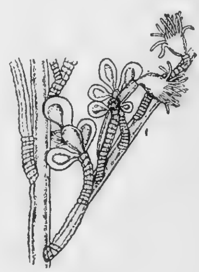
No. 13.
Eudendrium dispar.

Eudendrium rameum (Pallas)

Trophosome. Stem large, fascicled, much and irregularly branched, large branches fascicled; stem and main branches, smooth or but slightly wrinkled or annulated; small branches annulated proximally; pedicels annulated throughout.

Gonosome. Gonophores borne at the base of hydranths that are normal or not entirely aborted.

Colour. Stem dark brown; hydranths reddish; female gonophores yellow.



No. 14.
Eudendrium rameum.

Eudendrium ramosum (Linnæus).

Trophosome. Stem slightly fascicled, much and irregularly branched, height 15 cm.; hydranth pedicels usually vertically placed on the pinnately arranged branches; annulations at base of branches and pedicels.

Gonosome. Gonophores borne at the base of the hydranth or some distance down the pedicels; hydranths normal or reduced in size.

Colour. Hydranths and male gonophores vermilion or pink; female gonophores bright orange-red.

No. 15.
Eudendrium ramosum.

Eudendrium tenué A. Agassiz.

Trophosome. Stem simple, height 15 mm.; branching irregular, the branches and pedicels long and very slender, scarcely annulated.

Gonosome. Gonophores borne on aborted hydranths on pedicels shorter than those supporting the normal hydranths.

Colour. Bright pink throughout.

No. 16.
Eudendrium tenue.

Family HYDRACTINIDÆ.

Trophosome. Colony formed of distinct nutritive and generative zooids from a common basal cœnosarc, which ordinarily is beset with spines; other kinds of zooids may be present; hydranths with one row of filiform tentacles; proboscis conical or clavate.

Gonosome. Gonophores in the form of fixed sporosacs on special generative zooids.

Genus Hydractinia.

Characters as in the family.

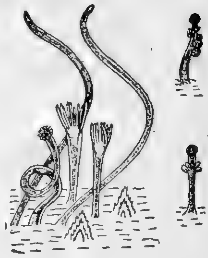
Hydractinia echinata (Fleming).

Trophosome. Colony rising from a basal cœnosarc, which overlies a chitinous, encrusting plate, provided with jagged spines at intervals; hydranths capable of great contraction and extension, hence the body or the tentacles may be long and slender or short and stout.

Gonosome. Sporosacs borne on special generative zooids, usually smaller than the nutritive, without tentacles or mouth; male and female zooids in different colonies.

Other zooids. Defensive zooids are present, long, slender, often doubled on themselves to form spirals, without tentacles but well supplied with batteries of nematocysts.

Sensory zooids, longer even then the defensive zooids, without tentacles or nematocysts.



No. 17.
Hydractinia echinata.

Family MYRIOTHELIDÆ.

"Polypites solitary, with very numerous, minute, capitate tentacula scattered over the body" (Hincks).

Genus Myriothela.

Trophosome. "Polypites solitary, cylindrical, terminating above in a conical proboscis, springing from an adherent base, which is clothed with a chitinous polypary; tentacles very small, capitate, covering the greater portion of the body" (Hincks).

Gonosome. "Gonophores borne on coryniform processes, clustering around the base of the polypites, and containing fixed sporosacs" (Hincks).

Myriothela phrygia (Fabricius).

Trophosome. "Polypite cylindrical, very extensile; tentacles extremely numerous and closely set, covering about three-fourths of the body, with a reddish-brown spot on the capitulum; the basal portion of the body minutely speckled with white and crowded with the processes bearing the gonophores, which are slender, pointed above with a few wart-like tentacles on the upper portion; the adherent base massive, of a dark brown colour, sending out a few tubular and root-like prolongations" (Hincks).

Gonosome. "Gonophores produced a little below the tentacles, subsessile, globular, when mature of a very large size and a pink colour; embryo actiniform" (Hincks).

No. 18.
Myriothela phrygia (after Hincks)

Family PENNARIDÆ.

Trophosome. Hydranths with a proximal whorl of long filiform tentacles around the body, and several capitate tentacles scattered distally.

Gonosome. Gonophores producing free medusæ.

Genus Acaulis.

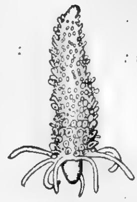
Trophosome. Hydranth stemless, sub-cylindrical; tentacles of proximal set filiform; tentacles of distal set, short, strongly capitate, numerous, scattered over the body of the hydranth. (From Stimpson's description.)

Gonosome. Gonophores scattered, sessile on the body of the hydranth between the proximal and distal set of tentacles. (From Stimpson's description.)

Acaulis primarius (Stimpson).

Trophosome. Hydranth with 8 proximal tentacles and numerous short capitate tentacles scattered over the distal two-thirds of the body. (From Stimpson's description.)

Gonosome. Gonophores thickly scattered over the space between the proximal and distal tentacles. (From Stimpson's description.)



No. 19.
Acaulis primarius (after Stimpson)

NOTE.—Allman came to the conclusion that this was really a stalked form in which the hydranth had merely broken away. He was also of the opinion that the specimens that Stimpson described as later stages of this species were really of an entirely different species, belonging to the genus *Corynitis* or *Halocharis.* As Stimpson gives but the one figure, that of the earlier form, and as it is impossible at present to place the other form, it has not been included.

Family CORYMORPHIDÆ.

Trophosome. Zooids solitary, large; hydranths with a proximal and a distal set of filiform tentacles.

Gonosome. Gonophores producing free medusæ with four radial canals and three of the four tentacles aborted or very much reduced.

Genus CORYMORPHA.

Trophosome. Pedicel with perisarc represented by a thin pellicle; tubular, fleshy processes growing from the pedicel near the base; hydranth abruptly distinct from the pedicel; proximal tentacles longer than distal; distal set in several continguous rows.

Gonosome. Gonophores borne on branched pedicels between the two sets of tentacles.

Corymorpha pendula Agassiz.

Trophosome. Zooid 9 or 10 cm. high, when fully extended; pedicel with an anastomosing canals in the cœnosarc, but they usually run in the same direction; the place of the hydrorhiza taken by the free ends of the cœnosarcal tubes.

Gonosome. Gonophores producing medusæ with one long and three short tentacles.

No. 20.
Corymorpha pendula.

Family TUBULARIDÆ.

Trophosome. Stem unbranched or irregularly branched; perisarc definite; hydranths with a distal and a proximal set of filiform tentacles.

Gonosome. Gonophores producing actinulæ.

Genus TUBULARIA.

Trophosome. Stem unbranched or irregularly branched; proximal set of tentacles longer than the distal set, each set in one whorl.

Gonosome. Gonophores in clusters, attached by means of stalked peduncles to the body of the hydranth just distal to the proximal tentacles; female gonophores producing actinulæ.

KEY TO SPECIES.

a Perisarc extensively annulated. — *T. larynx.*

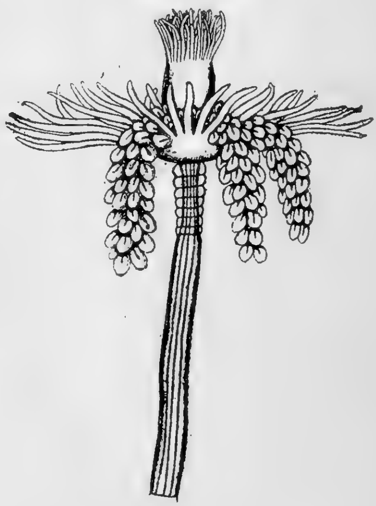
aa Perisarc not extensively annulated.

- *b* Stems unbranched
  - *c* Stems jointed. — *T. couthouyi.*
  - *cc* Stems not jointed. — *T. indivisa.*
- *bb* Stem irregularly branched.
  - *d* Medusoids with laterally compressed apical processes. — *T. crocea.*
  - *dd* Medusoids with conical apical processes.
    - *e* Hydranths large — *T. spectabilis.*
    - *ee* Hydranths small. — *T. tenella.*

Tubularia couthouyi Agassiz.

Trophosome. Stem unbranched, height 15 cm.; deep annulations at intervals dividing the stem; hydranth large, 3 or 4 cm. in diameter when tentacles are extended; proximal tentacles 30-40, long; distal up to 50, shorter and smaller.

Gonosome. Gonophores growing in dense racemes; sporosacs with 4 radial canals but without apical processes.

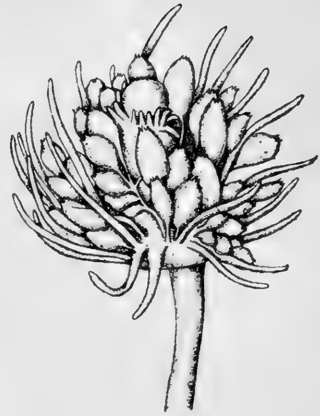


No. 21.
Tubularia couthouyi.

Tubularia crocea (Agassiz).

Trophosome. Colony growing in thick tufts which make a tangled mass below, but separate into long stems above which reach out of the mass; branching irregular; stems slightly and irregularly annulated; proximal and distal set of tentacles each 20-24.

Gonosome. Gonophores growing in long racemes, without radial canals, but with 4 laterally compressed apical processes.

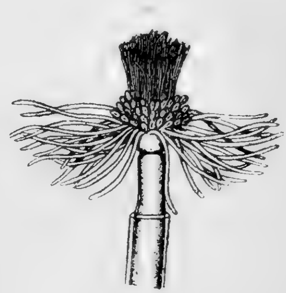


No. 22.
Tubularia crocea.

Tubularia indivisa Linnæus.

Trophosome. Stems growing in clusters, unbranched, height 30 cm.; perisarc heavier than in other species; little or no sign of annulation; proximal tentacles up to 40, long and slender; distal set much more numerous but shorter.

Gonosome. Gonophores in racemes; sporosacs with 4 radial canals but without apical processes.

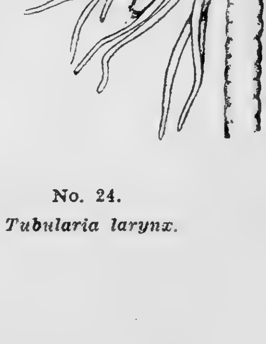


No. 23.
Tubularia indivisa.

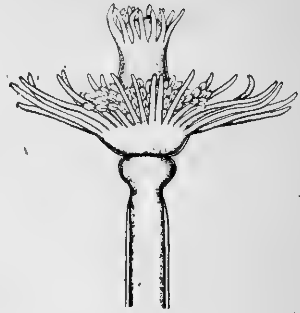
Tubularia larynx Ellis and Solander.

Trophosome. Stems clustered, often tangled at the base, height 2 cm.; perisarc extensively annulated, annulations varying from deep to shallow; proximal and distal set of tentacles each about 20.

Gonosome. Gonophores in denser, more compact racemes; sporosacs without radial canals; apical processes scarcely developed.



No. 24.
Tubularia larynx.



No. 25.
Tubularia spectabilis.

Tubularia spectabilis (Agassiz).

Trophosome. Stem irregularly branched; height 10 cm.; with few or no annulations; proximal and distal set of tentacles each about 20.

Gonosome. Gonophores in large, loose racemes; sporosacs without radial canals but with conical apical processes.

Tubularia tenella Agassiz.

Similar to the preceding species but smaller, 2 cm. high. It is possible that it is not a distinct species.

Sub-order *CALYPTOBLASTEA.*

Family CAMPANULARIDÆ.

Trophosome. Hydrothecæ campanulate, never sessile, never adnate or immersed in the stem or branches; diaphragm always present; hydranth with trumpet-shaped proboscis.

Gonosome. Gonophores produce fixed sporosacs or free medusæ; the medusæ when produced usually have otocysts in the margin and have the gonads along the course of the radial canals.

KEY TO GENERA.

a Gonophores producing fixed sporosacs in which the planulæ are developed.
  b Reproduction by sporosacs which remain within the gonangia during the development of the planulæ. *Campanularia.*
  bb Reproduction by sporosacs which are extruded into a sac at the summit of the gonangium, in which sac the planulæ are developed. . . . . *Gonothyræa.*
aa Gonophores producing medusoids without mouth or digestive cavity. *Eucopella.*
aaa Gonophores producing free medusæ.
  c Medusæ globular, with four tentacles at time of liberation *Clytia.*
  cc Medusæ flatter, with 16 or more tentacles at time of liberation. *Obelia.*

Genus Campanularia.

Trophosome. Stem unbranched, regularly or irregularly branched.

Gonosome. Gonophores producing sporosacs, which remain within the gonangium while the planulæ develop.

KEY TO SPECIES.

a Stem fascicled.
  b Hydranth pedicels appearing in whorls. *C. verticillata.*
  bb Hydranth pedicels given off singly. *C. gelatinosa.*

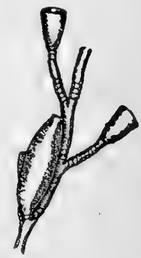
aa Stem branched but not fascicled
- *c* Hydrothecal margin entire.
  - *d* Diameter of hydrotheca as great as its depth. — *C. flexuosa.*
  - *dd* Diameter of hydrotheca much less than its depth. — *C. amphora.*
- *cc* Hydrothecal margin with teeth having two cusps. — *C. neglecta.*

aaa Stem unbranched or but slightly branched.
- *e* Hydrothecal margin entire. — *C. integra.*
- *ee* Hydrothecal margin toothed.
  - *f* Hydrothecæ with vertical lines.
    - *g* Lines very distinct throughout the whole length.
      - *h* Gonangia annulated. — *C. hincksi.*
      - *hh* Gonangia smooth. — *C. grœnlandica.*
    - *gg* Lines distinct towards margin only.
      - *i* Gonangia long, with bottle neck. — *C. magnifica.*
      - *ii* Gonangia bowl-shaped. — *C. speciosa.*
  - *ff* Hydrothecæ without vertical lines.
    - *j* Hydrothecæ small, tubular, with blunt, shallow teeth. — *C. volubilis.*
    - *jj* Hydrothecæ large, broadening towards the margin, teeth blunt, deep. — *C. gigantea.*

Campanularia amphora (Agassiz).

Trophosome. Colony loosely branched, height 15 cm.; annulations at the base of the branches and above the origin of the branches on the main stem; pedicels unusually annulated throughout; hydrothecæ deeper than wide; margin entire.

Gonosome. Female gonangia elongate-oval, about four times as long as the hydrothecæ, somewhat truncate at top, aperture small; male gonangia more slender with a slightly produced neck.

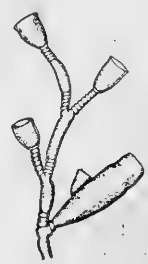


No. 26.
Campanularia amphora.

Campanularia flexuosa (Hincks)

Trophosome. Stem flexuous, 3 cm. high; pinnately branched; annulated at the base and above the origin of the pedicels; pedicels annulated throughout; hydrothecæ as broad as deep, margin entire.

Gonosome. Gonophores axillary, on annulated pedicels; gonangia large, elongate, ovoid but truncated distally.



No. 27.
Campanularia flexuosa.

Campanularia gelatinosa (Pallas).

Trophosome. Stem and main branches fascicled; height 25 cm.; branchlets numerous, whitish, appearing gelatinous in the water; branches annulated at the origin; pedicels vary in length, short ones annulated throughout, long ones annulated towards each end; hydrothecæ deeply campanulate, tapering gradually from margin to base; margin with about 10 teeth, each with two sharp cusps

Gonosome. Gonangia elongated oval, with distinct neck and tapering base; pedicels short, annulated.

No. 28.
Campanularia gelatinosa.

Campanularia gigantea Hincks.

Trophosome. Stem delicate, slightly branched, each branch forming a pedicel for a hydrotheca; pedicels annulated at the base; hydrothecæ large, much deeper than wide, the lower portion tapering gradually to the base; margin with about 10 rounded, deeply-cut teeth.

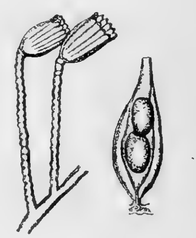
Gonosome. Unknown.

No. 29.
Campanularia gigantea.

Campanularia grœnlandica Levinsen.

Trophosome. Stem unbranched, forming the pedicel for the hydranth, annulated or wavy throughout; hydrothecæ tubular, urceolate, the base hemispherical; margin with 10-12 teeth, rounded or squared at the tip; lines running down from the spaces between the teeth, the full length of the hydrotheca.

Gonosome. Gonangia large, with smooth surface, bottle-shaped with long neck; pedicel short.

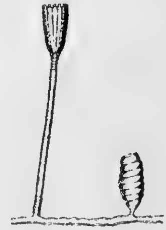


No. 30.
Campanularia grœnlandica.

Campanularia hincksi Alder.

Trophosome. Stem unbranched, forming the pedicel for the hydranth, long, slender, annulated below the hydrotheca and at the base; hydrothecæ deep, nearly tubular, with lines running from the margin almost to the base; margin with square-topped teeth.

Gonosome. Gonangia borne on the stolon, ovoid, truncate, corrugated; pedicel short, not annulated.

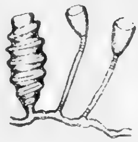


No. 31.
Campanularia hincksi.

Campanularia integra MacGillivray.

Trophosome. Stem unbranched, forming the pedicel for the hydranth, long and slender, varying much in the amount of the annulation but always annulated at the base and below the hydrotheca; hydrotheca small, tapering gradually from margin to base; margin entire.

Gonosome. Gonangium large, deeply corrugated, each corrugation with a distinct keel; pedicel short, annulated.



No. 32.
Campanularia integra.

Campanularia magnifica Fraser.

Trophosome. Stem unbranched, growing from a stout stolon that is not annulated; hydrotheca large, slightly urceolate; margin flaring slightly, with 10-12 low, blunt teeth; lines running some distance down from the margin; pedicel annulated throughout.

Gonosome. Gonangium large, longer than the hydrotheca, oval, distal end drawn out into a bottle-neck, very slightly corrugated; pedicel short.

No. 33.
Campanularia magnifica.

Campanularia neglecta (Alder).

Trophosome. Stem pinnately branched, annulated above the margin of each pedicel; pedicels annulated at each end or throughout; hydrothecæ narrow, deep, nearly tubular; margin toothed, each tooth provided with two sharp points.

Gonosome. Gonangium pyriform, axillary or on the pedicels; pedicel short, annulated.

No. 34.
Campanularia neglecta.

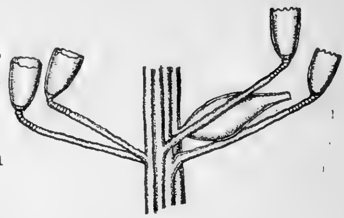
Campanularia speciosa Clark.

Trophosome. Stem unbranched from an annulated stolon; pedicels short, annulated throughout; hydrotheca large, urceolate; margin with low, rounded teeth; lines running down a short distance from the margin.

Gonosome. Gonangium bowl-shaped, as wide as deep; pedicel short.

No. 35.
Campanularia speciosa.

Campanularia verticillata (Linnæus).

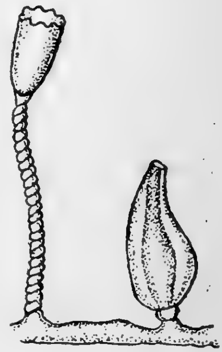


No. 36.
Campanularia verticillata.

Trophosome. Main stem fascicled throughout, ending like a stump; main branches also fascicled; hydranths arranged in irregular whorls, with long pedicels, annulated or wavy throughout, hydrotheca rather large, not much deeper than wide; margin with 12-14 blunt teeth.

Gonosome. Gonangia sessile on the main stem, fusiform with bottle neck; surface smooth; ova large.

Campanularia volubilis (Linnæus).



No. 37.
Campanularia volubilis.

Trophosome. Stem unbranched; stolon smooth or twisted; pedicel slender, spirally twisted or annulated; hydrotheca small, narrow and deep, tubular; margin with about 10 rounded, often very low teeth.

Gonosome. Gonangium flask-shaped, with long narrow neck, borne on the stolon; pedicel short, annulated.

Genus Clytia.

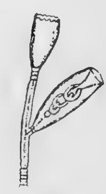
Trophosome. Stem unbranched or irregularly branched.

Gonosome. Gonophores producing free medusæ which are somewhat spherical, with four tentacles at the time of liberation.

KEY TO SPECIES.

a	Stem usually much branched.	
	b Gonangium corrugated.	*C. edwardsi.*
aa	Stem usually unbranched.	
	c Hydrotheca cylindrical, margin with sharp teeth.	*C. cylindrica.*
	cc Hydrotheca campanulate, teeth blunt or rounded.	
	d Gonangium smooth.	*C. noliformis.*
	dd Gonangium corrugated.	*C. johnstoni.*

Clytia cylindrica Agassiz.



No. 38.
Clytia cylindrica.

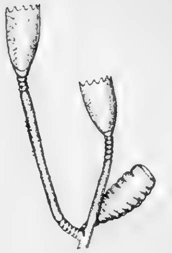
Trophosome. Stem unbranched; the slender pedicel annulated proximally and distally; hydrotheca cylindrical, twice as deep as wide, suddenly constricted at the base where the diaphragm appears inside; teeth 10-12, sharp pointed and deeply cut.

Gonosome. Gonangium from the stolon or pedicel, oblong, or obovate, smooth; pedicel short, with one or two annulations.

Clytia edwardsi (Nutting).

Trophosome. Stem usually with few or many irregularly arranged branches, 3 cm. high; pedicels long and slender, annulated proximally and distally; hydrotheca deeply campanulate with 10-14 deeply-cut, slender teeth, rounded at the tip.

Gonosome. Gonangium oblong or oval, corrugated; pedicel short, annulated.



No. 39.
Clytia edwardsi.

Clytia johnstoni (Alder).

Trophosome. Stem unbranched or with a single branch, annulated proximally and distally; hydrotheca broadly campanulate, depth and width nearly equal; margin with 12-16 teeth, slightly rounded or sharper.

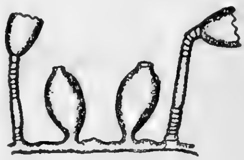
Gonosome. Gonangium on the stem or stolon, oval or oblong, truncate, corrugated; pedicel short, annulated.

No. 40.
Clytia johnstoni.

Clytia noliformis (McCrady).

Trophosome. Stem unbranched, short, stout, extensively annulated, sometimes throughout he whole length; hydrotheca broadly campanulate, as wide as or wider than deep; teeth 10-12, rounded at the tip.

Gonosome. Gonangium on the stolon, almost sessile, broadly oval, distal end with a short neck below the rim.



No. 41.
Clytia noliformis.

Genus Eucopella.

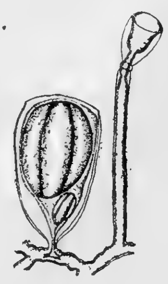
Trophosome. Stem unbranched; hydrotheca with very thick wall and entire margin.

Gonosome. Gonophores producing large medusoid structures of elongated dome-shape, without mouth or digestive cavity.

Eucopella caliculata (Hincks).

Trophosome. Stem unbranched, varying in length, slightly wavy or annulated, with a distinct double annulation below the hydrotheca; hydrotheca with very thick wall and entire margin.

Gonosome. Gonangium large, irregularly obovate, the distal end somewhat rounded or truncate, almost sessile on the stolon; two medusoids in the gonangium at the one time, a large one occupying the greater portion of the space and a much smaller one below; these are elongated oval in shape.



No. 42.
Eucopella caliculata.

Genus Gonothyræa.

Trophosome. As in the family.

Gonosome. Reproduction by fixed medusiform sporosacs, furnished with tentacles, that at maturity become extra-capsular, remaining attached until their contents are discharged.

KEY TO SPECIES.

a Colony slightly and irregularly branched, margin with sharp teeth. *G. gracilis.*
b Colony large, more regularly branched, margin with blunt, square-topped teeth. *G. loveni.*

Gonothyræa gracilis (Sars).

Trophosome. Colony slightly and irregularly branched; stem, branches and pedicels, long and slender; stem annulated at the base and above the origin of each branch; pedicels annulated at each end; hydrotheca deep, cylindrical for the upper half and gradually tapering to the base; margin with 10-14 deeply-cut, sharp teeth.

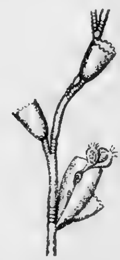
Gonosome. Gonangium oblong-oval, often flaring at the rim; on the stem or stolon; pedicel annulated.

No. 43.
Gonothyræa gracilis.

Gonothyræa loveni (Allman).

Trophosome. Stem branched, flexuose, annulated above the origin of the branches and pedicels; pedicels short, annulated; hydrotheca slightly deeper than wide; margin with teeth that are usually square-topped but may be more rounded.

Gonosome. Gonangium axillary, obconic, on a short annulated pedicel.



No. 44.
Gonothyræa loveni.

Genus Obelia.

Trophosome. Stem branched, simple or fascicled.
Gonosome. Gonophores producing free medusæ, that are flattened dorso-ventrally and when liberated possess more than eight tentacles.

KEY TO SPECIES.

a Margin toothed.
  b Gonangium much shorter than the stem internodes. *O. longissima.*
  bb Gonangium usually longer than the stem internodes. *O. articulata.*

aa Margin entire.
  c Hydrotheca pedicels usually forming the only branches.
    d Hydrotheca deeper than wide. *O. dichotoma.*
    dd Hydrotheca as wide as deep.
      e Hydrotheca pedicel supported on a shoulder-like process of the stem internode. *O. geniculata.*
      ee No shoulder present on the stem internode. *O. hyalina.*
  cc Stem with other branches than those formed by the hydranth pedicels.
      f Hydrotheca deeper than wide. *O. commissuralis.*
      ff Hydrotheca as wide as deep. *O. flabellata.*

Obelia articulata (A. Agassiz).

Trophosome. Colony much branched, 7 cm. high; stem usually simple but in some cases slightly fascicled; main stem continuous throughout and distinctly stouter than any of the branches; stem and branches annulated above the origin of branches and pedicels; hydrotheca deeper than wide; margin with 12-14 low, rounded teeth, pedicel annulated throughout

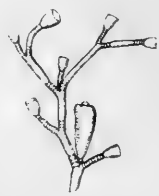
Gonosome. Gonangium axillary, long, usually longer than the stem internode, a distinct collar present; pedicel annulated.

No. 45.
Obelia articulata.

Obelia commissuralis McCrady.

Trophosome. Colony large, 20 cm.; main stem geniculate; branches numerous; stem and branches annulated above the origin of the branches and pedicels; hydrotheca small, deeper than wide; margin entire; pedicels usually annulated throughout.

Gonosome. Gonangium axillary, obovate, smooth, with a distinct collar.

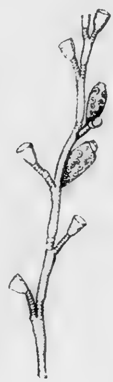


No. 46.
Obelia commissuralis.

Obelia dichotoma (Linnæus).

Trophosome. Stem 25 mm. high, slender, erect, unbranched or slightly and irregularly branched; stem annulated above the nodes; hydrotheca funnel-shaped with polyhedral margin; pedicel usually annulated throughout.

Gonosome. Gonangium axillary, obovate, smooth, with tapering collar; pedicel short, annulated.



No. 47.
Obelia dichotoma.

Obelia flabellata (Hincks).

Trophosome. Colony 25 cm. high; stem and primary branches branched, spreading; stem and branches annulated above the origin of the branches and pedicels; hydrotheca as wide as deep; margin entire, pedicel annulated.

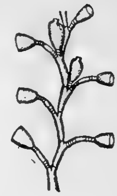
Gonosome. Gonangium axillary, obovate, with a terminal collar; pedicel short, annulated.

No. 48.
Obelia flabellata.

Obelia geniculata (Linnæus).

Trohphosome. Stem simple, geniculate, 25 mm. high, bearing alternate pedicels on shoulder processes of the internodes; hydrotheca as wide as deep; margin entire; pedicels annulated at each end or throughout, usually curved away from the stem.

Gonosome. Gonangium axillary, oval or slightly obovate; terminal collar present.

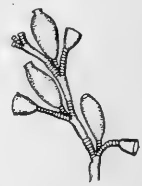


No. 49.
Obelia geniculata.

Obelia hyalina Clark.

Trophosome. Stem 20 mm. high, unbranched or occasionally branched, geniculate, with several annulations above the origin of each pedicel; hydrotheca as wide as deep; margin entire, sometimes flaring; pedicels annulated at each end or throughout.

Gonosome. Gonangium axillary, obovate, with or without terminal collar.



No. 50.
Obelia hyalina.

Obelia longissima (Pallas).

Trophosome. Stem filiform of great length, 60 cm., much branched, branches alternate; stem horn colour or black, annulated at base and above each node; hydrotheca deeper than wide; margin wavy or with low, rounded teeth; pedicel annulated at each end or throughout.

Gonosome. Gonangium axillary, oval, with a distinct collar, pedicel annulated.

No. 51.
Obelia longissima.

Family CAMPANULINIDÆ.

Trophosome. Colonies branched or unbranched; hydrothecæ pedicellate or sessile, always operculate, the operculum formed of converging segments; hydranths with conical proboscis.
Gonosome. Gonophores producing fixed sporosacs or free medusæ.

KEY TO GENERA.

a Hydrotheca pedicellate.
  b Hydrothecal margin distinct.
    c Operculum of several converging segments. — ***Calycella.***
    cc Operculum of four segments. — ***Tetrapoma.***
    ccc Operculum shaped like an A-tent. — ***Stegopoma.***
  bb Hydrothecal margin not distinct.
    Reproduction by fixed sporosacs. — ***Opercularella.***
aa Hydrotheca sessile.
  Hydrotheca tubular, margin indistinct. — ***Cuspidella.***

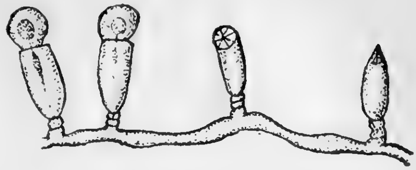
Genus CALYCELLA.

Trophosome. A creeping stolon gives rise to tubular hydrothecæ on annulated pedicels; margin distinct; several segments to the operculum.
Gonosome. Gonangia borne on the stolon; acrocysts produced.

Calycella syringa (Linnæus).

Trophosome. Stolon smooth, not reticulated; hydroteca tubular; margin distinct; operculum of 8 or 9 converging segments; pedicel annulated.

Gonosome. Gonangium on the stolon, oval or obovate; sporosacs extruded into an acrocyst; pedicel short, annulated.



No. 52.
Calycella syringa.

Genus Cuspidella.

Trophosome. Hydrotheca tubular, sessile on a creeping stolon.
Gonosome. Unknown.

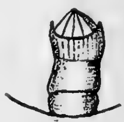
KEY TO SPECIES.

a	Gonangium obvate.	*O. lacerata.*
b	Hydrotheca segmented.	*C. costata.*

Cuspidella costata Hincks.

Trophosome. "Hydrothecæ somewhat broadly cylindrical, encircled by two or three rather prominent ribs, or lines of growth, dividing them into segments, the uppermost or opercular segment formed of thinner material than the rest and supporting a conical, operculum, composed of very numerous convergent pieces" (Hincks)..

Gonosome. Unknown.

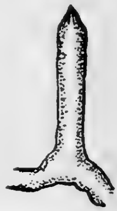


No. 53.
Cuspidella costata (after Hincks).

Cuspidella grandis Hincks.

Trophosome. Sessile, tubular hydrothecæ grow from regularly creeping stolon; operculum of 8-10 segments.

Gonosome. Unknown.



No. 54.
grandis.
Cuspidella

Genus Opercularella.

Trophosome. Hydrotheca elongate-oval with no distinct margin; opercular segments long and narrow.

Gonosome. Reproduction by sporosacs that are extruded into an acrocyst.

KEY TO SPECIES.

a	Gonangium obovate.	*O. lacerata.*
b	Gonangium fusiform.	*O. pumila.*

Opercularella lacerata (Johnston).

Trophosome. Stem short, 25 mm., branched, some of the branches being almost as long as the main stem; stem and branches flexuous, annulated throughout; hydrotheca with proximal half oval, distal half conical; no distinct margin; segments of the operculum long and slender.

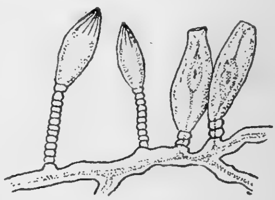
Gonosome. Female gonangia obovate, sessile or on short, annulated pedicels, axillary or in place of hydrothecæ; male gonangia narrower.

No. 55.
Opercularella lacerata.

Opercularella pumila Clark.

Trophosome. Stem erect or creeping, sparingly branched, annulated throughout; hydrothecæ similar in shape to those of *O. lacerata* but smaller.

Gonosome. Gonangia fusiform on short annulated pedicels on the stem or stolon.



No. 56.
Opercularella pumila.

Genus Stegopoma.

Trophosome. Hydrotheca with an operculum formed of two membranes folded lengthwise and which come together roof-like, with their long edges; each of these is separated from the remainder of the hydrotheca by a curved line; at each side the hydrothecal wall forms a triangular gable-like structure, between the two opercular membranes.

Gonosome. Gonophores producing fixed sporosacs.

Stegopoma plicatile (Sars).

Trophosome. Stem large; stem and main branches fascicled; hydrotheca long, tubular or nearly so, sessile or with a short pedicel.

Gonosome. Gonangium long, oval or cylindrical, adhering to the branch for a portion of the length.

No. 57.
Stegopoma plicatile.

Genus Tetrapoma.

Trophosome. Hydrothecæ pedicellate, with distinct four-toothed margin, operculum of four segments.

Gonosome. Unknown.

Tetrapoma quadridentatum (Hincks).

Trophosome. "Hydrothecæ cylindrical, usually slightly incurved on one side, the height about three times as great as the breadth, with a quadridentate margin and an operculum composed of four pieces, borne on ringed pedicels of variable lengths (3 to 7 rings) which rise at intervals from a creeping stem" (Hincks).

Gonosome. Unknown.

No. 58.
Tetrapoma quadridentatum (after Hincks).

Family HALECIDÆ.

Trophosome. Hydrothecæ reduced to saucer-shaped hydrophores which usually pass without constriction into the large tubular pedicels; margin entire, often flaring; reduplication common; hydranths with conical proboscis.

Gonosome. Gonophores producing fixed sporosacs.

Genus Halecium.

Trophosome. As in the family.

Gonosome. Gonangia often of different shape in the two sexes which are found on different colonies.

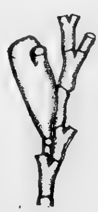
KEY TO SPECIES.

- *a* Stem simple.
  - *b* Stem annulated or wavy throughout.
    - *c* Gonangium laterally compressed, small, with regular margin. — *H. tenellum.*
    - *cc* Gonangium very large with wavy or spiny margin. — *H. minutum.*
  - *bb* Stem not annulated.
    - *d* Colony minute, with no definite main stem. — *H. curvicaule.*
    - *dd* Colony large, with main stem and branches. — *H. sessile.*
- *aa* Stem fascicled.
  - *e* Branches not fascicled.
    - *f* Gonangium large, aperture lateral. — *H. articulosum.*
    - *ff* Gonangium smaller, aperture terminal. — *H. gracile.*
  - *ee* Stem and main branches fascicled.
    - *g* Gonangium spiny. — *H. muricatum*
    - *gg* Gonangium smooth.
      - *h* Gonangium aperture terminal. — *H. halecinum.*
      - *hh* Gonangium aperture lateral. — *H. beani.*

Halecium articulosum Clark.

Trophosome. Stem coarse, fascicled; primary branches scarce but long, hence colony has a loose appearance; branches alternate, pinnate; internodes short and getting shorter towards the ends of the branches, where they may be as broad as long; hydrothecæ sessile; margin not flaring.

Gonosome. Female gonangia large, obovate, borne in rows on the upper side of the branches; aperture lateral but near the distal end; male gonangia oblong.



No. 59.
Halecium articulosum.

Halecium beani (Johnston).

Trophosome. Stem and main branches fascicled; nodes oblique; hydrophore margin flaring little.

Gonosome. Gonangia borne at the base of the hydrophores; male, regular oblong-oval; female, mitten-shape, aperture lateral; two small hydranths are present in the aperture.

No. 60.
Halecium beani.

Halecium curvicaule Lorenz.

Trophosome. Colony minute; no continuous main stem; a single pedicel grows out from the stolon, just below the hydrophore another pedical is given off, or one on each side; these bend upward almost at the base; each of them may give rise to others in the same way until there may be four or five sets of them; each pedicel has an annulation at its base or occasionally more than one; margin of hydrophore flaring but little.

Gonosome. Male gonangium cylindrical; female pyriform, with terminal aperture from which two hydranths appear, both almost sessile, borne on the pedicel just below the hydrophore.

No. 61.
Halecium curvicaule.

Halecium gracile Verrill.

Trophosome. Stem fascicled, much branched; branches long and slender; internodes long and slender; margin of hydrophore flaring but little.

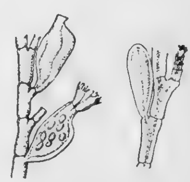
Gonosome. Male gonangia oblong-ovate; female pyriform, emarginate; aperture terminal.

No. 62.
Halecium gracile.

Halecium halecinum (Linnæus).

Trophosome. Stem fascicled, erect, rigid; primary branches fascicled, few; secondary branches and pedicels pinnately arranged; hydrophore margin not flaring.

Gonosome. Gonangia arranged in rows on the upper side of the branches; male gonangia obovate-oblong; female pyriform; aperture elevated on a collar; two hydranths in the aperture.



No. 63.
Halecium halecinum.

Halecium minutum Broch.

Trophosome. Stem simple, slender, irregularly branched, wavy or annulated throughout; hydrophores with flaring margin, often much reduplicated.

Gonosome. Gonangia very large, 3 mm. in diameter, cockle-shaped, with the margin wavy below and spiny above.

No. 64.
Halecium minutum.

Halecium muricatum (Ellis and Solander).

Trophosome. Stem fascicled, stout, rigid, irregularly and densely branched; primary branches fascicled; ultimate branches and pedicels pinnately arranged; hydrophores with margin flaring.

Gonosome. Gonangia crowded on the branches, ovate, much greater in the one diameter than the other; numerous prickles on the surface, arranged in raised rows.

No. 65.
Halecium muricatum.

Halecium sessile (Hincks).

Trophosome. "Stem slender, irregularly branched, branches not in the same plane; branches jointed, the joints consisting of a single stricture; hydrothecæ alternate, very short, and perfectly sessile, not rising at all separately from the lateral stem processes of which they are mere openings, without being raised into a tube" (Hincks).

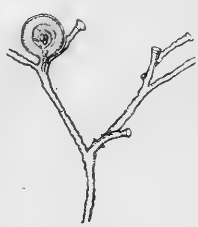
Gonosome. Unknown.

No. 66.
Halecium sessile (after Hincks).

Halecium tenellum Hincks.

Trophosome. Colony small, 15 mm. high; stem delicate, annulated or wavy, irregularly branches, sometimes dichotomously; margin of hydrophore strongly flaring.

Gonosome. Gonangia oval or ovate, broader in one diameter than in the other, smooth, axillary or on the branch below the hydrophore.



No. 67.
Halecium tenellum.

Family HEBELLIDÆ.

Trophosome. Colony simple, creeping; hydranths with conical or dome-shaped proboscis; hydrothecæ tubular, diaphragm present, no operculum.

Gonosome. Gonangia separate, not collected in a mass.

Genus Hebella.

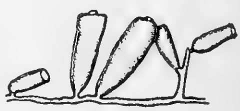
Trophosome. A creeping stem gives rise to single hydranths, attached by short pedicels; diaphragm present in the hydrothecæ.

Gonosome. Gonophores producing free medusæ.

KEY TO SPECIES.

a Hydrotheca tubular, pedicel very short. *H. calcarata.*
b Hydrotheca urceolate, pedicel longer, annulated. *H. pocillum.*

Hebella calcarata (A. Agassiz).



No. 68.
Hebella calcarata.

Trophosome. Colony creeping over hydroids or occasionally the stem may be free for a short distance; hydrothecæ tubular, coming off singly or in pairs from the stolon, almost sessile.

Gonosome. Gonangia large, oblong-obovate, smooth, almost sessile; aperture terminal, small.

Hebella pocillum (Hincks).

No. 69.
Hebella pocillum.

Trophosome. Stem creeping, hydrothecæ urceolate, on relatively long, annulated pedicels.

Gonosome. Unknown.

Family LAFŒIDÆ.

Trophosome. Hydrothecæ tubular; margin entire; no operculum; hydranth with conical proboscis; no diaphragm in any of the genera here included.

Gonosome. Gonangia closely crowded to form a coppinia mass.

KEY TO GENERA.

a Hydrothecæ directly attached to a reticular stolon. *Filellum.*
b Hydrothecæ attached to a fascicled stem.
c Hydrothecæ free or very slightly adherent. *Lafœa.*
cc Hydrothecæ partly immersed in the main portion of the stem but not distally. *Cryptolaria.*
ccc Hydrothecæ partly immersed in the stem throughout its whole length. *Grammaria.*

Genus Cryptolaria.

Trophosome. Stem strongly fascicled; portion of branches simple; hydrothecæ on the stem more or less immersed, everywhere partly adherent.

Gonosome. A coppinia mass.

Cryptolaria triserialis Fraser.

Trophosome. Stem fascicled, very coarse; hydrothecæ on the stem few in number, appearing singly or in opposite or sub-opposite pairs, the distal half free, curves outward; on the simple portion of the branches the hydrothecæ are arranged in three series.

Gonosome. Unknown.

No. 70.
Cryptolaria triserialis.

Genus Filellum.

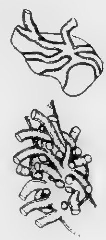
Trophosome. A creeping stem gives rise to partly adherent hydrothecæ, the free portion curved upward.

Gonosome. A coppinia mass.

Filellum serpens (Hassell).

Trophosome. Stolon reticular; hydrothecæ adherent from one-half to two-thirds of their length, nearly the same size throughout, not annulated but sometimes transversely striated.

Gonosome. Coppinia mass compact; gonangia not so closely placed as in some other species; hydrothecal tubes long and slender.



No. 71.
Filellum serpens.

Genus Grammaria.

Trophosome. Stem fascicled, consisting of a hydrothecate axial tube surrounded by a number of peripheral non-hydrothecate tubes; hydrothecæ partly adherent.

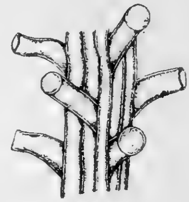
Gonosome. A coppinia mass.

KEY TO SPECIES.

a Portion of hydrotheca not immersed, curved outward. *G. abietina.*
b Portion of hydrotheca not immersed, curved inward. *C. gracilis.*

Grammaria abietina (Sars).

Trophosome. Stem stout, irregularly branched; branches constricted at the base, resembling the main stem in all particulars; a large portion of the hydrotheca extending beyond the outer tubes of the stem, the free portion directed outwards; orifice nearly circular; margin vertical.



No. 72.
Grammaria abietina.

Gonosome. "Coppinia generally of an irregular or oval form; all the tubes extending radially from it bend at a certain distance from the surface in all directions, thus forming a network, lying like a capsule outside the cluster of gonangia" (Bonnevie).

Grammaria gracilis Stimpson.

"Polypidom slender, with a polished appearance; cells small, elongated, projecting, but curved inward at the extremities, and distant from each other in the very irregular rows; colour dark brown, sometimes black" (Stimpson).

Genus Lafœa.

Trophosome. Mature stems strongly fascicled and erect; young stems may be simple and creeping; hydrothecæ nearly always entirely free from the stem, never immersed.

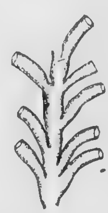
Gonosome. A coppinia mass.

KEY TO SPECIES.

a No erect or fascicled stem. *L. pygmæa.*
aa Stem when mature, erect, fascicled.
  b Hydrothecæ sessile, sometimes slightly adherent at the base. *L. dumosa.*
  bb Hydrothecæ pedicellate.
    c Hydrothecæ convex, convex side uppermost.
      d Hydrothecæ making an angle of less than 45° with the stem or branch, stem not distinguishable from branches. *L. gracillima.*
      dd Hydrothecæ making an angle of 45° to 60° with the stem, main stem distinct. *L. fruticosa.*
    cc Hydrothecæ symmetrical. *L. symmetrica.*

Lafœa dumosa (Fleming).

Trophosome. Mature stem strongly fascicled, erect, coarse, much branched; young stem either erect or creeping over other hydroids; hydrothecæ sessile, usually free from the stem but occasionally those on the distal part of the stem are slightly adherent.



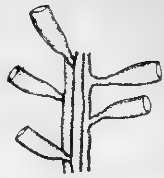
No. 73.
Lafœa dumosa.

Gonosome. The gonangia of the coppinia mass, as seen from the surface, are hexagonal, containing the orifice at the centre; they are closely set out and the elongated hydrothecæ come out at intervals among them.

Lafœa fruticosa Sars.

Trophosome. Stem fascicled, with many large branches regularly arranged; pedicels long with three or four twists, passing out at an angle of 45° to 60° from the stem; hydrothecæ slightly convex with the lower wall more nearly in line with the pedicel than the upper.

Gonosome. Coppinia with long hydrothecæ curved spirally.

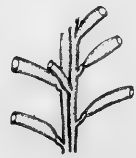


No. 74.
Lafœa fruticosa.

Lafœa gracillima (Alder).

Trophosome. Stem fascicled, very much branched but the main stem is indistinguishable from the branches; hydrothecæ long, tubular, convex, coming off from the stem at an angle of less than 45°; pedicels with one or two twists.

Gonosome. Coppinia similar to that of *L. dumosa* but the gonangia as viewed from the surface are more nearly circular than hexagonal.

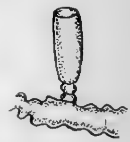


No. 75.
Lafœa gracillima.

Lafœa pygmæa Hincks.

Trophosome. Stem creeping; hydrothecæ small, almost symmetrical; pedicels with two or three twists.

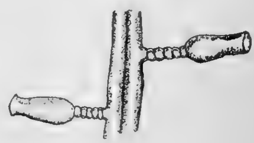
Gonosome. Coppinia oval, tubes long, stout, strongly bent, forming a complete network around the gonangia. (According to Broch.)



No. 76.
Lafœa pygmæ.

Trophosome. Stem erect, fascicled, irregularly branched hydrothecæ symmetrical, coming off from the stem nearly at right angles; pedicels longer than in other species, with five or six annulations or twists.

Gonosome. "Coppinia with regular hexagonal facets in the middle of which is a tubular opening; the tubes are comparatively few in number, very thick and strong, quite irregularly curved" (Bonnevie).



No. 77.
Lafœa symmetrica.

Family SERTULARIDÆ.

Trophosome. Hydrothecæ sessile, usually arranged on both sides of the stem or branches and more or less adnate to them.

Gonosome. Gonophores producing fixed sporosacs.

KEY TO GENERA.

a Hydrothecæ all on one side of the branches, their distal ends alternating right and left. *Hydrallmania.*
aa Hydrothecæ arranged in two longitudinal rows.
  b Hydrothecæ in opposite pairs. *Sertularia.*
  bb Hydrothecæ alternate.
    c Operculum of one adcauline flap.
      d Hydrothecal aperture small, body flask-shaped. *Abietinaria.*
      dd Hydrothecal aperture large, body not flask-shaped. *Diphasia.*
    cc Operculum abcauline or with more than one flap.
      e Operculum of three or four pieces. *Sertularella.*
      ee Operculum of one or two pieces. *Thuiaria.*
aaa Hydrothecæ arranged on all sides of the branches. *Selaginopsis.*

Genus Abietinaria.

Trophosome. Hydrothecæ alternate, flask-shaped, aperture small; operculum with a single adcauline flap.

Gonosome. Gonangia without spines or internal marsupium.

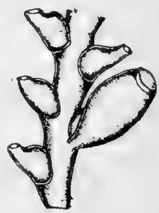
KEY TO SPECIES.

a Much more than one-third of the hydrothecæ free.
- *b* Stem stout. — *A. abietina.*
- *bb* Stem slender. — *A. filicula.*

Abietinaria abietina (Linnæus).

Trophosome. Main stem stout, straight or slightly flexuous; branches stout, pinnately arranged; hydrothecæ large, broad at the base, tapering to a distinct neck and expanding again slightly to the round, entire margin; much of the hydrotheca, often more than one-half, free from the stem.

Gonosome. Gonangia oval, with a short collar and wide aperture; surface smooth or slightly annulated.



No. 78.
Abietinaria abietina.

Abietinaria filicula (Ellis and Solander).

Trophosome. Stem slender, straight proximally, flexuous in the branched portion; branches regularly pinnate, often branched again and sometimes the secondary branches are branched; hydrothecæ sub-opposite, shaped like those of *A. abietina* but much smaller.

Gonosome. Gonangia oval, tapering to a neck above, with narrow aperture; surface smooth.

No. 79.
Abietinaria filicula.

Genus Diphasia.

Trophosome. Hydrothecæ in two rows on the stem and branches; operculum of a single adcauline flap.

Gonosome. Gonangia provided with spines or lobes; an internal marsupium usually present in the female.

KEY TO SPECIES.

a Less than one-third of the hydrothecæ free. — *D. fallax.*
- *b* More than one-third of the hydrothecæ free.
  - *c* Hydrothecal margin sinuous not toothed. — *D. rosacea.*
  - *cc* Hydrothecal margin with three prominences; hydrothecæ and gonangia very large. — *D. tamarisca.*

Diphasia fallax (Johnston).

Trophosome. Stem erect; branching irregular; branches often terminating in long hooked tendrils; hydrothecæ almost opposite, short, stout, only a small distal portion free; margin sinuous.

Gonosome. Gonangia borne in rows on front of branches; male obovate with distal portion quadrangular, constricted to a tubular process for the aperture; female gonangia larger, terminating in four, long-pointed lobes; an internal marsupium present.

No. 80.
Diphasia fallax.

Diphasia rosacea (Linnæus).

No. 81.
Diphasia rosacea.

Trophosome. Colony delicate; branching irregular; hydrothecæ opposite, long and slender, with at least the distal third free; margin sinuous.

Gonosome. Male gonangium long and slender, with tubular neck; female gonangium larger, pyriform, distally terminating in two long and six shorter, pointed lobes, the shorter ones curved to the centre; an internal marsupium present.

Diphasia tamarisca (Linnæus).

No. 82.
Diphasia tamarisca.

Trophosome. Stem, branches and hydrothecæ very stout; hydrothecæ sub-opposite, nearly one-half free; three low elevations are present on the margin.

Gonosome. Gonangia both male and female with one diameter greater than the other, obovate, spiny, the female with lobes forming coarse serrations as well, the two distal lobes much elongated.

Genus Hydrallmania.

Trophosome. Hydrothecæ in groups on the side of the branches, their bases in line but the distal ends curved alternately to right and left; operculum of one adcauline flap.

Gonosome. Gonangia without spines or internal marsupium.

Hydrallmania falcata (Linnæus).

No. 83.
Hydrallmania falcata.

Trophosome. Colony long and slender; main branches spirally arranged and of much the same length; hydrothecæ tubular or very slightly urceolate, arranged in a row on one side of the branch, bases in line, distal portions turned alternately to right and left, five or six to an internode.

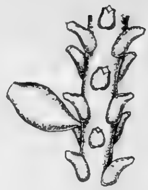
Gonosome. Gonangium oval, with tubular neck, smooth or with indistinct longitudinal lines.

Genus Selaginopsis.

Trophosome. Hydrothecæ arranged in more than two longitudinal rows, at least on the branches.

Gonosome. Gonangia oval or obovate, smooth or nearly so.

Selaginopsis mirabilis (Verrill).



No. 84.
Selaginopsis mirabilis.

Trophosome. Stem stout; branches regularly alternate; hydrothecæ tubular, distal portion free and turned out from the stem, in two rows on the stem and six rows on the branches; margin oval, with two lateral teeth; operculum of two flaps.

Gonosome. Gonangia oval, not constricted to form a neck; aperture large, circular; surface smooth.

Genus Sertularella.

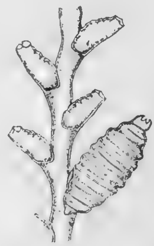
Trophosome. Hydrothecæ in two rows, alternate, usually with three or four teeth and an operculum of three or four flaps.

Gonosome. Gonangia usually supplied with ridges or corrugations.

Key to Species.

a Hydrotheca with four teeth.
  b Stem more or less regularly annulated. *S. fusiformis.*
  bb Stem not regularly annulated.
    c Hydrothecæ annulated or rugose.
      d Hydrothecæ decidedly rugose. *S. rugosa.*
      dd Hydrothecæ with complete or incomplete annulations. *S. conica.*
    cc Hydrothecæ smooth. *S. polyzonias.*
aa Hydrothecæ with three teeth, stem lax, hydrothecæ smooth. *S. tricuspidata.*

Sertularella conica Allman.



No. 85.
Sertularella conica.

Trophosome. Colony small, either unbranched or with a few small branches like the main stem; hydrothecæ nearly tubular, rather distant; annulations complete or on the adcauline side only; margin with four teeth; operculum with four flaps.

Gonosome. Gonangia oval; margin with four stout teeth; surface rugose with distinct crests on the rugosities.

Sertularella fusiformis Hincks.

No. 86.
Sertularella fusiformis (after Hincks).

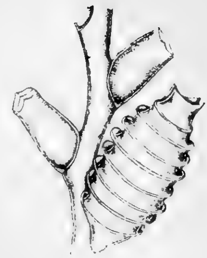
Trophosome. "Stem slender, slightly zigzag, generally simple, annulated at the base and below each calycle; hydrothecæ bent in opposite directions, elongate, somewhat flask-shaped, smooth, one to each internode; aperture quadridentate; operculum composed of four pieces, each internode, with its calycle, of a fusiform figure" (Hincks).

Gonosome. "Gonothecæ elongate, ovate, slender, ribbed across, produced at the upper extremity into a short neck and toothed" (Hincks).

Sertularella polyzonias (Linnæus).

Trophosome. Stem slender; branching irregularly alternate; hydrothecæ alternate, rather distinct, large, tapering but slightly, the distal half or more, free; margin with four teeth; operculum of four flaps.

Gonosome. Gonangia large, oval; margin with four stout spines or teeth; surface strongly and regularly rugose.

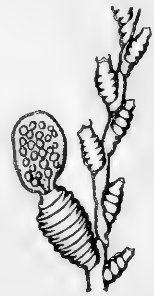


No. 87.
Sertularella polyzonias.

Sertularella rugosa (Linnæus).

Trophosome. Colony small, stem usually unbranched, constricted at regular intervals; hydrothecæ alternate, rather distinct, fusiform, distinctly rugose; margin with four tentacles; operculum with four flaps.

Gonosome. Gonangia oval, rugose; margin with four teeth.



No. 88.
Sertularella rugosa.

Sertularella tricuspidata (Alder).

Trophosome. Stem slender, lax, branching irregularly alternate or dichotomous; hydrothecæ alternate, very slightly immersed, tubular, sometimes curved; margin with three teeth; operculum with three flaps.

Gonosome. Gonangia oval, with strongly crested rugosities; a small, smooth tubular neck bears the aperture.

No. 89.
Sertularella tricuspidata.

Genus Sertularia.

Trophosome. Hydrothecæ in two rows, occurring in pairs, which are strictly opposite throughout, or at least on the distal portion of the branches.

Gonosome. Gonangia oval or ovate.

KEY TO SPECIES.

a Stem with opposite branches, the two hydrothecæ of a pair not in contact. *S. pumila.*

b Stem unbranched, the two hydrothecæ of a pair in contact. *S. cornicina.*

Sertularia cornicina (McCrady).

Trophosome. Stem unbranched, divided into regular internodes, each of which bears a pair of hydrothecæ, which are in contact for about two-thirds of their length and then turned abruptly outward; margin with two teeth and a two-parted operculum.

Gonosome. Gonangia oval, with distinct, short collar; surface regularly annulated.

No. 90.
Sertularia cornicina.

Sertularia pumila Linnæus.

Trophosome. Stem unbranched or with opposite branches; a pair of hydrothecæ to each internode, tubular, free from each other, curved outward, the distal half free; margin with two teeth.

Gonosome. Gonangium obovate, with a narrow collar and wide aperture.

No. 91.
Sertularia pumila.

Genus Thuiaria.

Trophosome. Hydrothecæ in two rows on stem and branches; hydrothecæ with not more than two teeth; operculum of one abcauline flap or two flaps.

KEY TO SPECIES.

a Branches only on two sides of the stem.
  b Stem long and slender, primary branches much branched. — *T. cupressina.*
  bb Stems shorter and more rigid; branches relatively longer.
    c Hydrothecæ sub-opposite. — *T. similis.*
    cc Hydrothecæ strictly alternate.
      d Branches stout and rigid. — *T. lonchitis.*
      dd Branches slender. — *T. latiuscula.*
aa Branches on all sides of the stem.
  e Distal branches forming a dense tuft.
    f Hydrothecæ sub-opposite. — *T. fabricii.*
    ff Hydrothecæ definitely alternate.
      g Primary branches branched dichotomously, all branches short and stiff. — *T. thuja.*
      gg Branches long and less rigid. — *T. robusta.*
  ee Branches on the distal portion of the stem loosely arranged.
      h Hydrothecæ almost wholly immersed. — *T. immersa.*
      hh Hydrothecæ less than half free. — *T. argentea.*
      hhh Hydrothecæ more than half free. — *T. tenera.*

Thuiaria argentea (Linnæus).

Trophosome. Colonies often growing in clusters, stem slender; branches rise from all sides of the stem but irregularly, these branch dichotomously; hydrothecæ usually definitely alternate but occasionally sub-opposite, rather distant, curved gradually outward, nearly one-third free; margin with two teeth, one often larger than the other; operculum with two flaps.

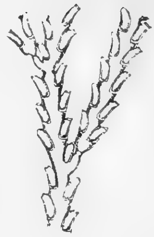
Gonosome. Gonangia long-obovate, usually with two shoulder spines; collar short.

No. 92.
Thuiaria argentea.

Thuiaria cupressina (Linnæus).

Trophosome. Colonies clustered; stem long, flexuous; branching alternate but not always exactly in the same plane; branches branch dichotomously and these branches again do so; hydrothecæ alternate, short, the free portion, about one-third, divergent, narrowed towards the margin; margin bi-labiate; operculum with two flaps.

Gonosome. Gonangia obovate or triangular, with two shoulder spines; collar short.



No. 93.
Thuiaria cupressina.

Thuiaria fabricii (Levinsen).

Trophosome. Stem erect, rather rigid, branches on all sides of the stem, distally forming a dense tuft; repeated dichotomous branching; hydrothecæ sub-opposite, narrowing slightly from base to margin, about one-third free; margin with two teeth; operculum with two flaps.

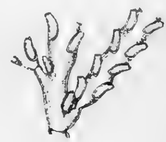
Gonosome. Gonangia borne in two rows on the branches, oblong or obovate, with circular aperture and two shoulder spines.

No. 94.
Thuiaria fabricii.

Thuiaria immersa Nutting.

Trophosome. Stem long, flexuous, branches coming out on all sides in a loose spiral arrangement; main branches sparingly dichotomously branched; hydrothecæ alternate, almost entirely immersed, tapering from base to margin.

Gonosome. Unknown.



No. 95.
Thuiaria immersa.

Thuiaria latiuscula (Stimpson).

Trophosome. Main stem stout, rigid, much larger than the slender, alternate branches, that are not again branched; hydrothecæ slender, tubular, tapering to the margin, about one-fourth free.

Gonosome. Unknown.

No. 96.
Thuiaria latiuscula.

Thuiaria lonchitis (Ellis and Solander).

Trophosome. Main stem stout, rigid; branching pinnate; branches stout, stiff, white, not again branched; hydrothecæ alternate, tubular, but little tapered, about one-fourth free.

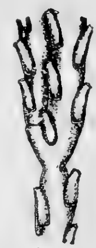
Gonosome. "Gonangia borne on upper side of branches, long, slender, with a round aperture, narrow collar and operculum" (Nutting).

No. 97.
Thuiaria lonchitis.

Thuiaria robusta Clark.

Trophosome. Stem stout, with deeply cut internodes; branches also stout, rising from all sides of the stem, dichotomously branched, distally forming a dense tuft; hydrothecæ alternate, not closely placed, almost wholly immersed in the proximal portions, less so distally, tubular; margin bi-labiate; operculum with two flaps on the distal hydrothecæ and one on the proximal.

Gonosome "Gonangia borne in rows on the terminal branchlets, slender, with a terminal collar and aperture and two long curved spines rising from the antero-lateral corners of the shoulders" (Nutting).



No. 98.
Thuiaria robusta.

Thuiaria similis (Clark).

Trophosome. Colony bilateral, with the stem very distinct and much stouter than the branches; hydrothecæ sub-opposite, slender, tubular, tapering very little, distal portion free and turned well outward; margin with two distinct teeth; operculum with two flaps.

Gonosome. Gonangia fusiform, short collar, circular aperture; no spines or annulations.

No. 99.
Thuiaria similis.

Thuiaria tenera (Sars).

Trophosome. Stem slender; branching loose from all sides of the stem; branches dichotomously branched; hydrothecæ alternate, distant, enlarged above the base, then tapered to the margin, one-half free; margin with two blunt teeth; operculum with two flaps or one abcauline flap.

Gonosome. Gonangia single on the branches, oval, with short collar and wide aperture; no spines or annulations.

No. 100.
Thuiara tenera.

Thuiaria thuja (Linnæus).

Trophosome. Main stem rigid, not very stout, branches from all sides of the stem, stiff, branching dichotomously several times; ultimate branches rigid, distally forming a dense tuft (bottle brush); hydrothecæ alternate, closely placed, almost wholly immersed, tubular; margin without distinct teeth; operculum of one abcauline flap.

Gonosome. Gonangia in rows that may be crowded on the stem and proximal portions of the branches, oval, with short collar and large terminal aperture; a short distinct pedicel; surface without annulations or spines.

No. 101.
Thuiaria thuja.

Family PLUMULARIDÆ.

Trophosome. Hydrothecæ growing only on one side of the branches (hydrocladia), sessile, more or less adnate; nematophores always present.

Gonosome. Gonophores producing fixed sporosacs, which are often protected by special modifications of the branches.

KEY TO GENERA.

A. Statoplean forms, i.e., those with fixed nematophores that are usually monothalamic.
  a Gonangia protected by branchlets, each of which is an appendage of a hydrocladium (phylactogonium).
    b Cauline nematophores not crenulated, phylactogonia not jointed. *Cladocarpus.*
    bb Cauline nematophores crenulated, phylactogonia jointed. *Aglaophenopsis.*
  aa Gonangia protected by corbulæ, each of which is a modified hydrocladium. A hydrotheca at the base of each gonangial leaf. *Thecocarpus.*
B. Eleutheroplean forms, i.e., those with movable nematophores that are usually bithalamic.
  c Gonangia not specially protected.
    d Hydrocladia pinnately arranged. *Plumularia.*
    dd Hydrocladia in whorls or scattered over the stem. *Antennularia.*
  cc Gonangia protected by phylactogonia, hydrocladia branched. *Schizotricha.*

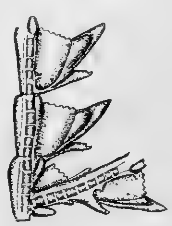
Genus AGLAOPHENOPSIS.

Trophosome. "Stem usually fascicled; hydrocladia with numerous internal septal ridges; hydrocladium margin toothed; nematophores with crenulated margin" (Nutting).

Gonosome. "Gonangia protected by special appendages, growing from the proximal joint of the hydrocladia and apparently of the nature of greatly modified mesial nematophores of the proximal hydrothecæ" (Nutting).

Aglaophenopsis cornuta (Verrill).

Trophosome. Colony branched repeatedly, each branch and hydrocladium at right angles to that from which it springs; stem fascicled; hydrocladia growing on an anterior tube; internodes with about six strong septal ridges and an external longitudinal ridge; hydrothecæ obconical, with a large anterior wing-like keel; margin with five small teeth on each side; intrathecal ridge small, oblique; supracalycine nematophores long, tubular, with crenulated margin; mesial nematophore nearly straight, spur-like, margin crenulated; three cauline nematophores to each node. (From Nutting's description.)



No. 102.
Aglaophenopsis cornuta
(after Nutting).

Gonosome. "Gonangia borne on the terminal branchlets, oblong-oval, with latero-terminal apertures; protective appendage unbranched or bifurcated, borne at the side of the proximal hydrotheca on each hydrocladium, having a hydrotheca at its distal end, and two when it is forked; there is an axial cavity divided by numerous septal ridges" (Nutting).

Genus Antennularia.

Trophosome. Hydrocladia arranged in whorls or scattered over the stem.

Gonosome. Gonangia unprotected.

KEY TO SPECIES.

a Proximal hydrothecæ not divided from stem by nodes. *A. americana*
b Proximal hydrothecæ divided from stem by two nodes. *A. antennina*

Antennularia americana Nutting.

Trophosome. Stem slender, hydrocladia usually in whorls of four; proximal hydrothecæ on a long process from the stem, one or two intermediate internodes; between each two succeeding hydrothecate internodes; hydrothecæ cup-shaped; two nematophores above the hydrotheca, one below, two on the intermediate internodes, two on the shoulder that supports the hydrocladium, cauline nematophores scattered.

No. 103.
Antennularia americana.

Gonosome. Gonangia borne at the base of the hydrocladia, oblong-oval, aperture latero-terminal.

Antennularia antennina (Linnæus).

Trophosome. Stems clustered, slender; hydrocladia whorled, short, incurved; internodes alternating with and without hydrothecæ, the former nearest the stem; hydrothecæ cup-shaped; nematophores similarly placed to those in *A. americana.*

No. 104.
Antennularia antennina.

Gonosome. Gonangia produced singly, in the axils of the hydrocladia, obovate, with latero-terminal aperture.

Genus Cladocarpus.

Trophosome. Hydrothecæ deep with the margin smooth or with low, blunt teeth; mesial nematophores short.

Gonosome. Gonangia borne on the stem, at the base of the hydrocladia, protected by processes (phylactogonia) springing from the base of the hydrocladia; these have nematophores but no hydrothecæ.

KEY TO SPECIES.

a Hydrothecæ without teeth. *C. pourtalesi.*
b Hydrothecæ with two large, rounded, anterior teeth and shallow lateral teeth. *C. speciosus.*

Cladocarpus pourtalesi Verrill.

Trophosome. Stem fascicled, irregularly branched, the anterior tube bearing the hydrocladia; hydrocladia closely approximated, alternate, divided into regular, short internodes, each with three or four septal ridges; hydrothecæ closely approximated, broader towards margin; margin entire; intrathecal ridge short, curved sharply upward; supracalycine and mesial nematophores stout, cauline nematophores numerous. (From Nutting's description.)

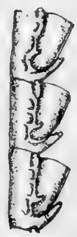
Gonosome. "Gonangia oblong-ovate, with lunate, sub-terminal aperture, borne on an unbranched phylactogonium springing from the side of the base of the proximal hydrotheca of the hydrocladium; there are from one to five gonangia to each phylactogonium" (Nutting).

No. 105.
Cladocarpus pourtalesi (after Nutting).

Cladocarpus speciosus Verrill.

Trophosome. Stem fascicled, distal portion simple, divided into long internodes, each with a hydrocladium from near the middle; hydrocladial internodes with seven septal ridges; hydrothecæ short, widening from base to margin; margin with two rounded anterior teeth and four or five shallow teeth on each side; intrathecal ridge low, straight, horizontal; supracalycine nematophores and mesial, with crenulated margin, cauline nematophores four to each internode. (From Nutting's description.)

Gonosome. "Gonangia not known, phylactogonia branched, arising from the side of the proximal hydrothecæ and not morphologically a modified mesial nematophore, the latter being present" (Nutting).



No. 106.
Cladocarpus speciosus (after Nutting).

Genus Plumularia.

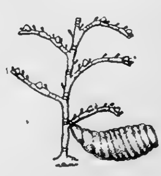
Trophosome. Hydrocladia unbranched, pinnately arranged, each having more than one hydrotheca; hydrothecæ with entire margin; all nematophores movable.

Gonosome Gonangia without extra protection.

Plumularia setaceoides Bale.

Trophosome. Stem simple, unbranched, divided into regular internodes, each of which gives off a hydrocladium distally; two to four annulations above each node; hydrocladia slender, recurved; non-hydrothecate and hydrothecate internodes alternating, each with two or three internal ridges; hydrothecæ cup-shaped, about one-third free; supracalycine nematophores present, one nematophore below the hydrotheca, one on each intermediate internode, one in the axil of each hydrocladium and one on each cauline internode.

Gonosome. Gonangia very large, on the face of the stem at the base of the hydrocladium, obovate, curved, truncate, several distinct, though not deep corrugations.



No. 107.
Plumularia setaceoides

Genus SCHIZOTRICHA.

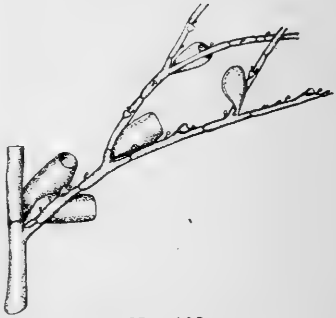
Trophosome. Colony simple, branched, with hydrocladia pinnately arranged.

Gonosome. Gonangia springing from the stem, branch or hydrocladium, not directly protected.

Schizotricha gracillima (G. O. Sars).

Trophosome. Stem fascicled, sparingly branched; branches fascicled proximally; each hydrocladium, one to an internode, usually branched dichotomously, one, two or three times; few intermediate internodes; hydrothecæ small, cup-shaped, about as wide as deep; nematophores large, a supracalycine pair, three or four mesial on each internode, one in the axil of each hydrocladium and others scattered over the stem. (From Nutting's description.)

Gonosome. "Gonangia borne in pairs on the stem near the axils of the hydrocladia, and also at the forkings of the latter; they are cylindrical in shape, tapering at the proximal end and almost sessile, the pedicel being much reduced" (Nutting).



No. 108.
Schizotricha gracillima
(after Nutting).

Genus THECOCARPUS.

Trophosome. Stem fascicled; hydrothecæ with one or two large, anterior teeth, the others small.

Gonosome. Corbulæ composed of widely separate leaves, each bearing a hydrotheca near its base.

Thecocarpus myriophyllum (Linnæus).

Trophosome. Stem fascicled, swollen at intervals, but slightly branched; hydrocladia alternate, closely approximated; hydrothecæ deep, cylindrical, with one large anterior tooth; supracalycine and mesial nematophores small; cauline nematophores numerous but small.

Gonosome. Corbulæ open, some distance from the stem, each with a hydrotheca near its base and a row of nematophores along its distal leaflet.

No. 109.
Thecocarpus myriophyllum.

XV

A New Genus and Three New Species of Algae from the Miramichi River, New Brunswick.

(With 1 plate)

BY

A. BROOKER KLUGH, *M.A.*

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During the course of an ecological investigation of the algae of the Miramichi river, New Brunswick, undertaken as part of a biological survey of this river by the Biological Board of Canada, in May and June, 1918, the writer collected some species of Cyanophyceae which proved to be undescribed. The diagnoses of these species, and of the new genus which had to be established on account of the peculiarity of one of these species, are presented in this paper. The full report on the algae of the region will appear later in the report of the biological survey of the Miramichi.

I wish here to express my gratitude to Dr. A. G. Huntsman, Curator of the Atlantic Coast Biological Station and chief of the party engaged in the survey of the Miramichi, for his kindness in furthering my work in every possible way.

The diagnoses are as follows:—

OLIGOCLONIUM. Gen. nov. Strato mucoso expanso. Trichomatibus cum pseudoramosis sparsis, cum 1-3 cellulis multo minoribus positis ad intervalla. Trichomatibus 1 vel 2 intra vaginam. Vaginis hyalinis, lamellosis. Cellulis diam, aequalibus vel paulo longioribus.

OLIGOCLONIUM INAEQUALE. Sp. nov. Strato atro-olivaceo. Filamentis 18-25 micra diam. Trichomatibus 8-9 micra diam, minime constrictis inter cellulas, fastigatis in apicem. Vaginis 5-8 micra crassis, lamellosis, transverse rugosis. Cellulis principalibus trichomatum 8-10 micra longis; cellulis minoribus 5 micra diam., et 6 micra longis. Contentu caeruleo-viridi, maxime granuloso. Trichomata fieri tendunt ubi cellulis minoribus sunt adjuncta, et e vagina effugere. (Fig. 1.)

OLIGOCLONIUM. New Genus. Plant mass forming an expanded mucous stratum. Trichomes sparingly branched, having at intervals from one to three much smaller cells. Trichomes single, or two, within the sheath. Sheaths colourless, lamellose. Cells as long as, or slightly longer than, the diameter of the trichomes.

This genus belongs to the order Hormogoneae, but occupies a peculiar systematic position. It most nearly approaches the Family Oscillatoriaceae but is excluded from that family, as at present defined, by the marked characteristics of possessing the series of from one to three much smaller cells at intervals in the trichome and a tapering filament, as the present definition of that family calls for a filament "uniform throughout its entire length." Either the definition of the Family Oscillatoriaceae will have to be changed to embrace this genus, or a new family, will have to be established to receive it. Personally I feel inclined towards the former alternative.

OLIGOCLONIUM INAEQUALE. New Species. Plant mass dark olive-green. Filaments 18-25 micra in diameter. Trichomes 8-9 micra in diameter, very slightly constricted between the cells, tapering at the apex. Sheaths 5-8 micra thick, lamellose, transversely wrinkled. Main cells of the trichome 8-10 micra long; smaller cells 5 micra in diameter and 6 micra long. Cell contents pale blue-green, very strongly granulated. The trichomes tend to break into hormogonia at the small cells, and to escape from the sheath.

On timbers of a wharf at half-tide mark on the Miramichi river at Chatham, N.B. (Fig. 1.)

TOLYPOTHRIX BREVICELLARIS. Sp. nov. Fronde penicillata, caerulea-viridi. Filimentis 14-20 micra diam., repetite pseudoramosis, 1.4 mm. altis. Pseudoramis erectibus. Trichomatibus 6-9 micra diam. Cellulis brevissimis, 2-4 micra longis. Heterocystis ovalibus vel ovatis, et basilaribus, plurumque 15 × 12 micra, cum muris crassissimis. Vaginis 4-7 micra crassis, firmis, hyalinis, lamellosis. (Fig. 2.)

TOLYPOTHRIX BREVICELLARIS. New Species. Plant mass penicillate. Pale blue-green. Filaments 14-20 micra in diameter, repeatedly branched, 1-4 mm. long, strict. Trichomes 6-9 micra in diameter. Cells very short, 2-4 micra long. Heterocysts basal, oval or ovate, averaging 15 × 12 micra, with very thick walls. Sheaths 4-7 micra thick, firm, hyaline, lamellose. (Fig. 2.)

At "Prince" Station No. 96, in the Northwest Miramichi river, N.B., June 24, 1918. Found also at Station 98.

The filaments of this species, from both stations, exhibited the peculiar condition shown in Fig. 2 C and D, hormogonia having apparently, while still enclosed in their sheaths, become attached near the apex of many of the filaments. In some cases this arrangement had the apeparance of the beginning of a false branch, but in no case was a heterocyst present at the point of contact.

STIGONEMA SUBSALSA. Sp. nov. Filamentis caespitulis. Filamentis 15-22 micra diam., usque ad 960 micra altis. Trichomatibus cum binis ordinibus cellualarum in portione inferiore et cum singulari ordine in portione superiore. Cellulis in portione superiore 8 micra diam., 4-5 micra longis. Cellulis in portione inferiore 6-10 micra diam., 5-6 micra longis. Vaginis firmis, fuscis, hyalinis, non-lamellosis. Heterocystis nullis. Contentu pallido-olivaceo. Cellulis cum 2-3 granulis magnis.

Cellulae primordiae sunt similes Gloeocapsae. *Gradus Gloeocapsa.*—Cellulis globosis vel oblongis, 9-11 micra diam. cum, 5-7 micra sine, teg, crassis. Vaginis hyalinis, minime lamellosis. Contentu pallido-olivaceo, cum uno magno granolo. (Fig. 3.)

STIGONEMA SUBSALSA. New species. Filaments growing in small tufts. Filaments 15-22 micra in diameter, up to 960 micra long. Trichomes consisting of two rows of cells in the basal portion and of one row of cells in the apical portion. Cells in basal portion 6-10 micra in diameter, 5-6 micra long. Cells in apical portion 8 micra in diameter, 4-5 micra long. Sheaths firm, brownish, translucent, not lamellose. Heterocysts absent. Cell-contents light olive-green. Cells with two or three large granules.

The young stages of this species are Gloeocapsa-like. *Gloeocapsa stage.*—Cells, 5-7 micra in diameter. Sheaths colourless, slightly lamellose, 2 micra thick. Cell-contents olive-green, with one large granule. (Fig. 3.)

On *Scytosiphon lomentarius* growing on a sunken log in Miramichi bay, N.B. Salinity of water in this habitat ranging from 16·04 per mille to 22·77 per mille. Temperature of water ranging from 3·94°C. to 17·31°C. Collected June 10, 1918.

FIG. 1. *Oligoclonium inæquale.* Portion of filament.

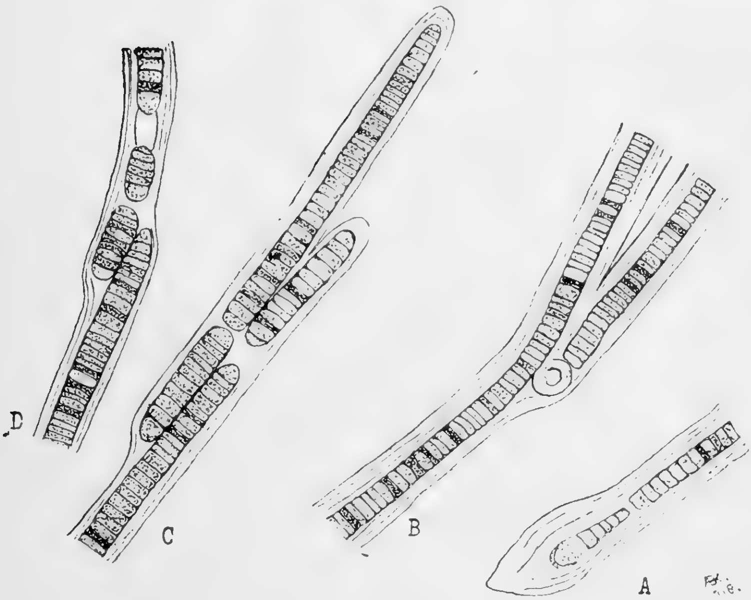

Fig. 2 *Tolypothrix brevicellaris.* A—Base of filament. B—False branch and Heterocyst. C and D—Hormogonia, still enclosed in a sheath, adhering to apical portion of a filament.

FIG. 3. *Stigonema subsalsa,* showing development from the Glœocapsa stage of the mature filament.

XVI.

THE HISTOLOGY OF THE FLEXOR TENDON IN THE CRUSHING CLAW OF THE LOBSTER.

By A. P. Knight, M.A., M.D., F.R.S.C.,

Emeritus Professor of Biology, Queen's University, Kingston, Ont.

(With 8 Figures.)

"The crushing claw has a far more powerful musculature than its fellow, and is accordingly richer in its supply of blood-vessels and nerves. Two tendons spring from opposite sides of the proximal end of the free dactyl and afford a surface for the attachment of the huge flexor and smaller extensor muscles. Each tendon is a keeled oval plate which is developed in a flattened pocket of the skin, but the closing muscle of the great claw being the largest and the strongest in the body, requires the largest tendon. The tendon of the flexor is a broad leaf-shaped plate, keeled above and below, while that of the weaker opening muscle is narrow and strap-shaped. * * * * * * ."

"At the time of moulting these huge tendons, like all others in the body, are withdrawn attached to the cast-off shell, and leave deep open pockets into which, in a large animal, the little finger can easily be inserted. As soon, however, as the soft claw becomes tense with blood, the opposed surfaces of the muscle substance unite and a new tendon is formed at the site of the old one." (From Dr. Herrick's American Lobster.)

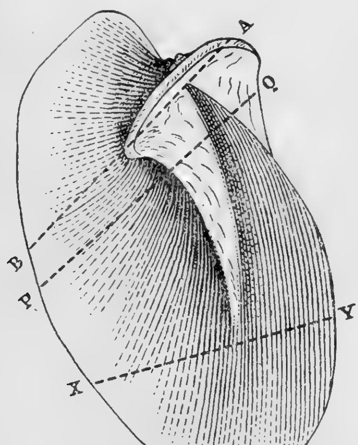

Fig. 1. Gross appearance of the tendon viewed from such a position that both the upper and the lower keels can be seen. A.B. section through both keels and one-half of the oval plate of disc as shown in figure 3. P.Q. section through both keels and both halves of the oval plate as shown in figure 5. X.Y. section through the oval plate only as shown in figure 2.

It will be remembered that the general outline of the tendon is that of a flat oval-shaped disc. Along both its upper and its under surface a keel or ridge runs from the broad end towards the narrow end for about half its length. These ridges are for the purpose of increasing the surfaces for the attachment of the muscle fibres. The edges of the flat disc are thinner than the central portion, so that a cross-section of the narrow end where there are no keels has very much the appearance represented by figure 2.

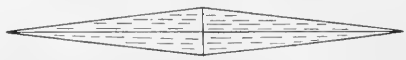

Fig. 2. Diagrammatic outline of the naked eye appearance of a cross-section of the flexor tendon towards its narrow end, that is, the end which is distal to the dactyl.

On the other hand a transverse section close to the opposite end shows a section of one keel and of the two leaves of the disc. The reason that both keels do not show is because one keel develops further back on the disc on one side than on the other. Figure 3 illustrates the appearance of a transverse section from that end of a flexor tendon which lies nearest the proximal end of the free dactyl.

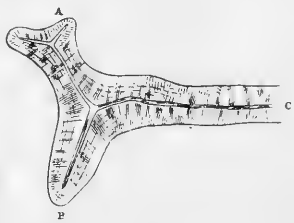

Fig. 3. A.B. represents cross-sections of the two keels, while C represents a section of the larger portion of the oval plate or disc; the smaller portion is out of the plane of section.

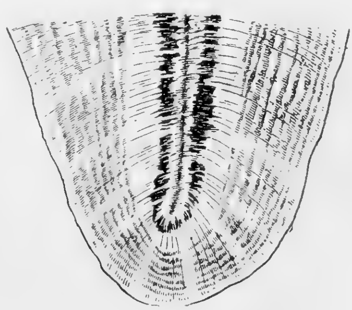

Fig. 4. Represents the tip of a section of one of the keels at the end next to the dactyl. This drawing is an enlarged one of figure 3 at A.

When a cross-section of the disc is made at about one-quarter of its length from the end next to the dactyl, the general appearance is that of a cross, because both keels or ridges then come into view, as well, of course, as both halves of the oval disc or plate.

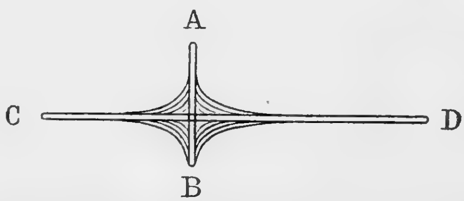

Fig. 5. Diagrammatic outline of the naked eye appearance of a cross-section of the flexor tendon, at a short distance from where it is attached to the free dactyl. A.B. upper and lower keels; C.D. larger and smaller portions of the oval disc or plate.

In all sections, whether of the disc or of the keel, there is a central portion or flattened core which can easily be recognized by a hand lens and sometimes with the naked eye. The portions of the disc and keel, external to this core, consist essentially of a network of fibres which cross each other at right angles. One set of fibres,—the longer ones—run parallel with each surface of the disc, and extend from the keels to the edge of the leaf-like disc. The other set run at right angles to the surfaces of the disc and extend from the flattened core to the surface.

The most prominent feature in all the sections under low powers of the microscope is their laminated structure. The laminæ resemble stratified limestone or stratified clay. In the greater part of the disc, the layers are evenly disposed upon one another and are parallel to the upper and lower surfaces, but in the keels and in the disc nearest to the keels the stratification is wavy, but this appearance may be an artefact.

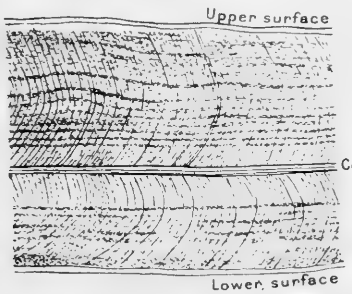

Fig. 6 shows the even laminated structure or stratification in the disc portion of the tendon.

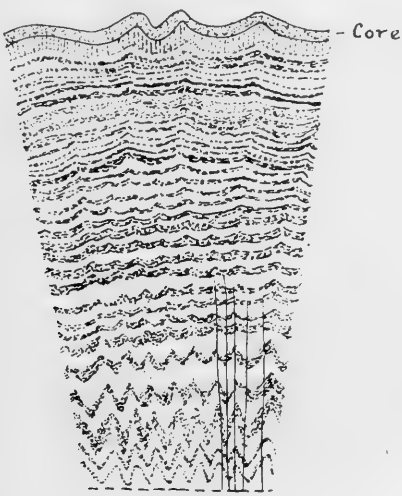

Fig. 7 shows wavy stratification. Low power.

In a medium-sized animal the laminæ of the disc vary in number from 20 to 40 above and below the flattened core, being more numerous in the middle of the disc and decreasing towards the circumference, where their number may not exceed from 2 to 5.

The laminæ vary in colour from almost black to grey, shading to white. These differences are probably due to the fact that all of the sections were prepared by grinding on an emery wheel in much the same way as rock sections are made. Consequently, small particles of the emery as well as some from the hard tendon would become inserted between the laminæ and would colour the sections. In one section of the disc of a rather large tendon, there were 32 dark-coloured laminæ, 57 snow-white ones and a large variable number of grey ones. In younger animals with smaller tendons the laminæ are fewer in number. It may be, as explained in the next paragraph, that all three shades are in reality similar in structure, and that the particles of emery and the dust of the tendon during the process of grinding cause the apparent differences.

The structure thus far referred to has been described under low powers of the microscope. When higher powers are employed, as by the use of eye-piece 4 and objective 6 of a Leitz microscope, the distinction between the dark and grey laminæ tends to disappear. The fundamental structure then becomes like that of the finest lawn. The whole tendon appears to be made up of a network of delicate white fibres which cross each other at right angles. This appearance is best seen in the thinnest portions of a section. Where the sections are at all thick, the laminated structure is still apparent, and the fine fibrils appear to combine and form bundles like those of connective tissue in mammals.

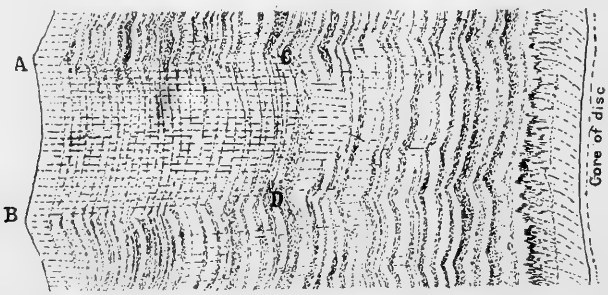

Fig. 8. Within the area A.B.C.D. almost all lamination has disappeared and the fine delicate fibres form a network like the finest lawn.

In animals recently killed, the tendons are soft and look as if they contained cartilage, but when boiled and dried, as was the case in all those from which sections were made for this paper, they become hard and so brittle that the thin edges easily crack and break away from the rest of the disc.

I am indebted to the Biological Board of Canada for laboratory privileges at St. Andrews, New Brunswick, during the study of these sections.

DEPARTMENT OF NAVAL SERVICE

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