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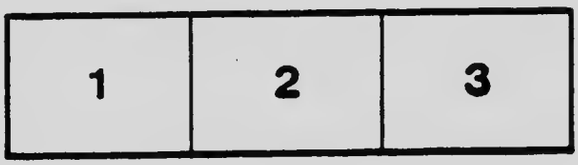

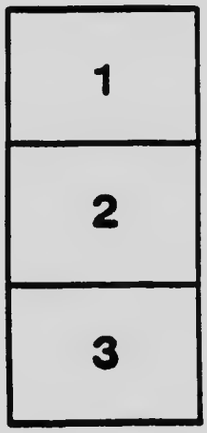

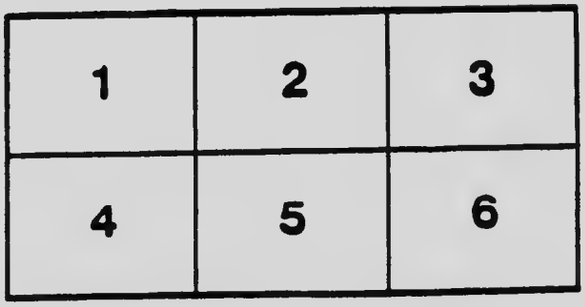

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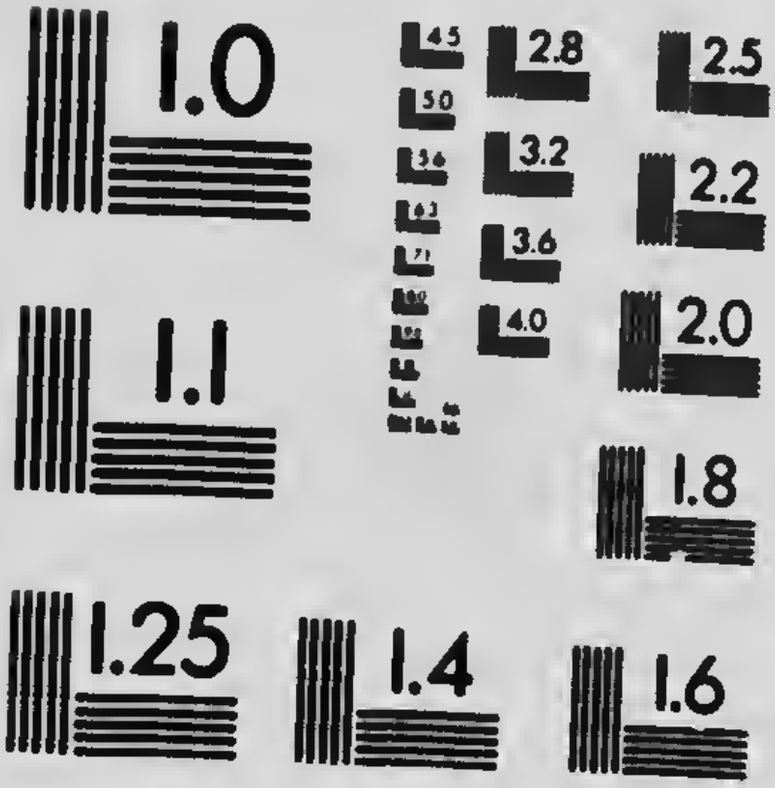

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CANADIAN FISHERIES EXPEDITION, 1914-15.

BIOLOGY OF ATLANTIC WATERS OF CANADA.

SOME QUANTITATIVE AND QUALITATIVE PLANKTON STUDIES OF THE EASTERN CANADIAN PLANKTON.

BY

A. G. HUNTSMAN, B.A., M.B.,

University of Toronto, Curator of the Atlantic Biological Station, St. Andrews, New Brunswick.

1.—Introduction.

2.—Quantity of Plankton.

3.—A special Study of the Canadian Chaetognaths, their distribution, etc., in the waters of the Eastern Coast.

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SOME QUANTITATIVE AND QUALITATIVE PLANKTON STUDIES OF THE EASTERN CANADIAN PLANKTON.

BY

A. G. HUNTSMAN, B.A., M.B., Etc.,

University of Toronto, Curator of the Atlantic Biological Station, St. Andrews, New Brunswick.

PREFATORY NOTE.

By Prof. E. E. Prince, Dominion Commissioner of Fisheries, and Chairman of the Biological Board of Canada.

A note of explanation appears desirable respecting the series of papers by Dr. Huntsman which are here brought together. They are separate reports upon his work during the season of 1915 (under Dr. Hjort's Canadian Fisheries Expedition); but, in subject and treatment, they form practically one research, the first short paper being of the nature of an introduction; the second paper has a general character, the quantitative phase being emphasized in it, and demonstrating that in colder and deeper water the plankton content is more abundant than in warmer, more superficial, strata, while the plankton as a whole seeks during the night a deeper level than during the day. The third paper embodies a detailed study of the distribution of *Sagitta*, or rather of the Chaetognaths, of which Dr. Huntsman determines ten species in our eastern coastal waters, seven species of *Sagitta*, and one species each of *Pterosagitta*, *Eukrohnia*, and *Khronitta*. These delicate, actively swimming creatures, of a glassy translucency and needlelike in form, are typical pelagic forms, at one time included amongst sea-worms; but now regarded as an aberrant group. They proved to be very abundant, and must form an important element of food for fishes, especially in the younger stages of the latter. These Chaetognaths vary in length from half an inch to two inches (50mm.) in length, and Dr. Huntsman's elaborate study is of special interest and importance, and illustrated by twelve figures, four of them being drawings of the creatures themselves, and eight of them charts showing the details of their distribution in the sea.

INTRODUCTION.

By A. G. Huntsman, B.A., M.B., University of Toronto, Curator of the Atlantic Biological Station, St. Andrews, N.B.

In undertaking a study of certain groups of animals from the plankton, as proposed by Dr. Johan Hjort, I have been obliged to limit it to certain forms that could be identified with reasonable ease. Not having a special knowledge of these groups, it has been necessary for me to repeatedly alter the scope and method of work during the progress of the investigation. This has resulted in a lack of uniformity in the records that would have been avoided if it had been possible to formulate a definite plan at the beginning.

This collection of plankton has been of the greatest interest, not only because it came from localities representative of the greater part of our Atlantic waters and permitted a survey of the whole region, but also because it came from waters of such diverse nature. It has afforded an unequalled opportunity for an introduction to, if not a solution of, the problem of the factors that are concerned in the distribution of our planktonic species. The subject has been considered from that standpoint, namely, to determine, if possible, the distribution, both vertical and horizontal, and the relative abundance, of each species.

The time was too short for taking many closing-net hauls, which are so essential in determining the vertical distribution. It was also unavoidable that the hauls were not perfectly reliable for quantitative comparison of the regions covered. Some of the factors to which this was due are: the well-known irregularity in the local distribution of species (their occurrence in streaks or shoals which may be taken or missed in successive hauls at the same locality); the hauls not having been taken uniformly either from the bottom, from a certain depth, or to the surface (at certain stations no vertical hauls were made); the hauls not having been always strictly vertical owing to the drifting of the ship before the wind; the variations in the coefficient of filtration of the net, depending upon its condition, the character of the plankton and the rate of hauling; the individual factor, the hauls having been taken by different persons; occasionally incomplete or faulty preservation; the difficulty in recognizing small specimens in large quantities of plankton; the unsuitability of the method of capture for large species (capturing too few) and for small species (their passage through or retention in the net depending upon the other elements in the plankton).

For these reasons the results as to distribution must be accepted with reserve and considered as tentative merely. It has been necessary, however, to take the results as they stand and, notwithstanding the large element of doubt, to put forth general views which future investigation may either confirm or refute. Where possible, account has been taken of these factors. Knowing the irregularities in the method of obtaining the plankton, I have been frequently astonished at the apparent completeness of the picture presented in the distribution of many of the species.

The charts of distribution have been made graphic by lining in the supposed areas of distribution, the positions of the stations from which data were obtained being indicated by circles. This method is objectionable in that it shows perhaps more than the facts warrant, but, since all the data are published, false impressions may be corrected by reference to them.

In some instances the hauls that were taken were not of the proper kind to show definitely the presence or the absence of a species. Such stations have not been considered in plotting the charts, although many of them have been indicated on the charts. For example, no vertical hauls were taken at Acadia Stations 10, 18-22, 27, 33, 43, 61, 77, and 90; the vertical hauls of the cruises of the *Princess* were not deep

enough to explore the peculiar bottom water of the deeper portions of the gulf. It has not been thought necessary to refer in every instance to these evident imperfections in the material.

The tow hauls are the most unreliable, owing to lack of information in the records as to the manner in which they were taken. The depths given are in most instances merely presumptions from the scanty data available. The tow hauls were taken in a great variety of ways.

There has been a possibility of considerable error arising in counting the specimens, for, owing to the large amount of plankton and the short time available for the work, it was necessary in many cases to take only a portion of the catch for examination and for the determination of the number of individuals. A varying portion was taken, depending largely upon the quantity of the plankton and the number and the range of size of each species. The figures indicate the manner in which the determination was made: 15×10 meaning that 15 individuals were counted in approximately one-tenth of the entire haul. With many of the tow hauls arbitrary signs have been used to indicate roughly the relative number of individuals: × meaning that the species occurred or that only a few specimens could be seen; ×× meaning that there were more numerous; + meaning that there were many; and ++ meaning that there were very many.

There is also a doubt as to proper identification when large numbers are examined rapidly. Errors from these causes have been detected and corrected in a number of instances. Naturally, the larger the individuals the less likelihood is there for such errors to arise.

2.—ON THE QUANTITY OF PLANKTON OBTAINED AT ONE HUNDRED AND SEVENTY-NINE STATIONS DURING THE CANADIAN FISHERIES EXPEDITION, 1915.

(By A. G. Huntsman, B.A., M.B., Curator of the Atlantic Biological Station, St. Andrews, New Brunswick.)

At Dr. Hjort's request, I have determined roughly the amount of plankton taken in the various hauls during the cruises of C.G.S. *Acadia*, C.G.S. *Princess*, and C.G.S. *No. 33*. For a number of reasons the data are far from being accurate. The plankton was not measured at the time it was obtained. In most cases all of the plankton was preserved, but at times only a portion was retained and the rest thrown away. In some of these cases (but not all) an estimate was made of the total amount at the time it was taken. In other cases the plankton was partially sorted or a portion taken out before being measured. As a result, some of the larger quantities should be still larger, but the smaller quantities are approximately correct.

The table given below is self-explanatory, but some comment may be advisable. Under "hour" are given the times of commencement and finish of the station as far as the records were kept. When only one time is given, it is the time at which the station was begun. The depth of water is given in metres. When no sounding in metres was made, the sounding in fathoms has been converted into metres for uniformity.

The hauls of plankton were made in three ways: (1) *Vertical hauls* (vert.) in which the net was lowered to a certain depth and then hauled to the surface; (2) *vertical closing hauls* (vert. clos.), similar but closed some distance before the surface was reached; and (3) *tow hauls* (tow), in which the net was towed at a variable distance from the surface. The vertical hauls were not always vertical owing to the drifting of the ships, which in some cases was considerable. The numbers given for the depths of the hauls indicate the amount of wire out, which was occasionally more than the actual depth at the station. In *Acadia* stations 44 to 91 the vertical hauls were

made in fathoms. These have been converted to round numbers in metres. No time has been given for the tow hauls. The records are not complete in this respect. In many of these hauls the net was towed by the drifting of the ship before the wind. Sometimes it was part drift and part steam towing. The rate at which the net was towed varied within such wide limits that the time could not well be used for purposes of comparison. This does not apply to the tows made by C.G.S. *No. 33*. The letter "c" (*circa*) before the depth indicates that the depth has been presumed only.

With two exceptions all the hauls were made with a net having a mouth with a diameter of one metre and made of silk bolting cloth with from fifteen to sixteen meshes to the centimetre. Certain hauls made at *Princess* stations 1 and 2 were made with a net of finer mesh (gear 20).

When two hauls were made at the same depth at the same station, these have been distinguished by the Roman numerals I and II.

The plankton was measured after settling in the bottles in which it was preserved. Similar bottles were graduated and the amount of plankton determined by comparing the bottle containing the plankton with the graduated bottle of the same kind. This was a quick but rough method of determining the amount.

The measurements confirm the observations made during the cruises that: (1) there is more plankton in colder water, (2) there is more plankton where the water is deeper, and (3) the plankton as a whole is at a deeper level during the day.

PLANKTON.—HAULS AND QUANTITY.

C. G. S. "ACADIA."

No. of Station.	Date.	Hour.	Depth (metres).	Depth of Haul (metres).	Quantity (in c.c.)
2	May 29....	11.05 a.m.-12.05 p.m.....	60	50- 25 (vert. clos.).....	15
				20- 0 (vert.).....	2
3	May 29....	2.30-4.30 p.m.....	99-144	100- 50 (vert. clos.).....	35
				30- 0 (vert.)....	10
				0 (tow).....	30
4	May 29....	7.30 p.m.....	171	150-100 (vert. clos.).....	70
				80- 40 (vert. clos.).....	15
				30- 0 (vert.).....	25
5	May 30 ...	1.00-2.30 a.m.....	72	60- 0 (vert.).....	25
				0 (tow).....	170
6	May 30 ...	5.30-6.30 a.m.....	45	40- 0 (vert.)..... ..	35
				0 (tow)...	35
7	May 30 ...	10.15-11.15 a.m	108	0 (tow).....	5
8	May 30....	12.55 p.m.....	50	50(?)- 0 (vert.).....	5
				0 (tow).....	25
9	May 30....	5.00-6.00 p.m..	104	25- 0 (vert.).....	5
				0 (tow).....	20
10	May 30....	7.15-9.00 p.m.....	732	0 (tow).....	800

PLANKTON.—HAULS AND QUANTITY—*Continued.*

C. G. S. "ACADIA"—*Continued.*

No. of Station.	Date.	Hour.	Depth (metres).	Depth of Haul (metres).	Quantity (in c.c.)
11	May 30-31.	10.50 p.m.-12.50 a.m.	over 2,000	70- 0 (vert.)	70
				0 (tow)	800
12	May 31	4.30-6.35 a.m.	over 2,000	100- 0 (vert.)	70
				0 (tow)	250
13	May 31	8.45-9.45 a.m.	over 2,000	70- 0 (vert.)	30
14	May 31	12.55-2.30 p.m.	over 2,000	200- 0 (vert.)	70
				0 (tow)	5
15	May 31	7.15-9.00 p.m.	over 2,000	100- 0 (vert.)	175
				0 (tow)	550
16	June 1	1.45-3.15 a.m.	over 2,000	200- 0 (vert.)	90
				0 (tow)	160
17	June 1	9.00-10.15 a.m.	over 2,000	200- 0 (vert.)	50
				0 (tow)	20
18	June 1	4.30 p.m.	over 2,000	0 (tow)	60
19	June 1	8.15-10.00 p.m.	over 2,000	0 (tow)	100
20	June 2	1.00 a.m.	90	0 (tow)	45
21	June 2	3.45-4.45 a.m.	115	0 (tow)	45
22	June 2	7.25-7.50 a.m.	75	0 (tow)	25
23	June 2	10.35 a.m.	99	70- 0 (vert.)	10
				0 (tow)	7
24	June 2	2.15-3.00 p.m.	118	100- 0 (vert.)	25
				0 (tow)	25
25	June 2	5.40-6.30 p.m.	122	120- 0 (vert.)	60
				10(?)-0 (tow)	15
26	June 2	10.00-11.15 p.m.	over 400	100- 0 (vert.)	55
				0 (tow)	400
27	June 3	2.10-3.30 a.m.	over 400	0 (tow)	400
28	June 3	6.15-7.45 a.m.	over 400	100- 25 (vert. clos.)	65
				0 (tow)	80
29	June 3	10.55 a.m.-12 noon	57	55- 0 (vert.)	10
				0 (tow)	5
30	June 3	3.00-3.45 p.m.	126	120(?)-0 (vert.)	25
				0 (tow)	25

PLANKTON.—HAULS AND QUANTITY—*Continued.*

C. G. S. "ACADIA."—*Continued.*

No. of Station.	Date.	Hour.	Depth (metres).	Depth of Haul (metres).	Quantity (in c.c.)
31	June 3	7.30–8.30 p.m.	82	75(?)–0 (vert.)	70
				0 (tow)	75
32	June 3–4	11.15 p.m.–12.15 a.m.	153	100– 25 (vert. clos.)	125
				0 (tow)	115
33	June 4	3.50–4.50 a.m.	70	0 (tow)	?
34	June 4	7.45–8.45 a.m.	c. 360	100– 0 (vert.)	90
				0 (tow)	32
35	June 4	11.55 a.m.–12.55 p.m.	c. 450	125– 25 (vert. clos.)	70
				0 (tow)	20
36	June 4	3.30–4.30 p.m.	226	100– 15 (vert. clos.)	20
				0 (tow)	30
37	July 21	5.00 p.m.	62	60– 20 (vert. clos.)	15
				60– 0 (vert.)	15
				20– 0 (vert.)	1 (?)
				0 (tow)	100
38	July 21	8.00 p.m.	170	150– 0 (vert.)	60
				100– 0 (vert.)	75
				0 (tow)	110
39	July 21	11.00 p.m.	95	100– 0 (vert.)	50
				25– ? (vert.)	50
				0 (tow)	75
40	July 22	2.00 a.m.	134	125– 0 (vert.) I	25
				125– 0 (vert.) II	25
				0 (tow)	12
41	July 22	5.30–6.30 a.m.	360	200– 0 (vert.)	5 (?)
				100– 0 (vert.)	2 (?)
				0 (tow)	10 (?)
42	July 22	9.00 a.m.	over 1,000	200– 0 (vert.)	5
				0 (tow)	5
43	July 22	11.50 a.m.	over 1,000	0 (tow)	5
44	July 22	3.00 p.m.	over 1,000	270– 0 (vert.)	25
				0 (tow)	40

PLANKTON.—HAULS AND QUANTITY—*Continued.*

C. G. S. "ACADIA"—*Continued.*

No. of Station.	Date.	Hour.	Depth (metres).	Depth of Haul (metres).	Quantity (in c.c.)
45	July 22	8.10 p.m	over 1,000	270– 0 (vert.)	50
				90– 0 (vert.)	5
				0 (tow)	50
46	July 23	1.00 a.m	over 1,000	270– 0 (vert.)	130
				0 (tow)	25
47	July 23	6.30 a.m	140	125– 0 (vert.)	25
				90– 0 (vert.)	15
				0 (tow)	10
48	July 23	11.00 a.m	248	70–2 0 (vert.)	70
				45– 0 (vert.)	2
				0 (tow)	25
49	July 23	3.35 p.m	126	125– 0 (vert.) I	35
				125– 0 (vert.) II	35
				0 (tow)	100
50	July 23	7.30 p.m	151	145– 55 (vert. clos.)	80
				145– 0 (vert.)	55
				55– 0 (vert.)	25
				0 (tow)	45
51	July 23	10.25 p.m	131	125– 55 (vert. clos.)	60
				125– 0 (vert.)	60
				0 (tow)	100
52	July 24	1.45 a.m	99	90– 0 (vert.) I	40
				90– 0 (vert.) II	45
				0 (tow)	25
53	July 24	4.45 a.m	95	90– 0 (vert.)	40
				0 (tow)	120
54	July 24	7.30 a.m	over 1,000	270– 0 (vert.)	10
				125– 0 (vert.)	5
				0 (tow)	5
55	July 24	10.25 p.m	over 1,000	270– 0 (vert.)	15
				90– 0 (vert.)	5
				0 (tow)	5
56	July 24	2.15 p.m	over 1,000	375–250 (vert. clos.)	15
				50– 0 (vert.)	10

PLANKTON.—HAULS AND QUANTITY—*Continued.*

C. G. S. "ACADIA"—*Continued.*

No. of Station.	Date.	Hour.	Depth (metres).	Depth of Haul (metres).	Quantity (in c.c.)
57	July 24....	7.18 p.m.....	over 1,000	270– 90 (vert. clo ...	50
				90– 0 (vert.)..... ..	35
				0 (tow).....	25
58	July 24....	10.35 p.m.....	187	180– 55 (vert. clos.).....	30
				155– 0 (vert.).....	50
				55– 0 (vert.).....	25
				0 (tow).....	10
59	July 25....	12.00 a.m.....	45	45– 0 (vert.).....	25
				0 (tow).....	500
60	July 25....	6.53 a.m.....	99	90– 0 (vert.).....	65
				0 (tow).....	20
61	July 25....	7.30 a.m.....	72	0 (tow).....	45
62	July 25....	10.05 a.m.....	61	55– 0 (vert.) I.....	40
				55– 0 (vert.) II.....	75
				0 (tow).....	over 65
63	July 25....	11.55 p.m.....	53	55– 0 (vert.).....	60
				0 (tow)	50
65	July 25 ...	5.15 p.m.....	90	110– 0 (vert.).....	10
				90– 0 (vert.)..... .	10
				0 (tow).....	25
66	July 25 ...	7.55–8.30 p.m.....	63	55– 0 (vert.) II.....	15
				55– 0 (vert.) II.....	12
				0 (tow).....	150
67	July 26 ...	11.55–12.30 a.m	198	190– 0 (vert.).....	150
67	July 26 ..	11.55–12.30 a.m	198	90– 0 (vert.).....	50
				0 (tow).....	230
68	July 26....	3.55 a.m.....	53	45– 0 (vert.) I.....	5
				45– 0 (vert.) II.....	8
				0 (tow).....	50
				5– 0 (tow).....	20
				c. 20– 10 (tow)	100

PLANKTON.—HAULS AND QUANTITY—*Continued.*

C. G. S. "ACADIA"—*Continued.*

No. of Station.	Date.	Hour.	Depth (metres).	Depth of Haul (metres).	Quantity (in c.c.)
69	July 26	8.05 a.m.	68	60– 0 (vert.) I.	20
				60– 0 (vert.) II.	5
				5– 0 (tow)	1(?)
				c. 20- 10 (tow)	10
70	July 26	11.40–1.00 p.m.	over 1,000	325– 0 (vert.)	5
				55– 0 (vert.)	1 (?)
				c. 20– 10 (tow)	4
72	July 26	3.45 p.m.	over 1,000	325– 0 (vert.)	20
				55– 0 (vert.)	2
				c. 20- 10 (tow)	5
74	July 26	7.00 p.m.	over 1,000	325– 0 (vert.)	10
				55– 0 (vert.)	2
				c. 20– 10 (tow)	15
75	July 26	10.55 p.m.	over 1,000	325– 0 (vert.)	25
				55– 0 (vert.)	5
				c. 20– 10 (tow)	50
76	July 27	2.45 a.m.	over 1,000	270– 0 (vert.)	40
				c. 20– 10 (tow)	75
77	July 27	7.25 a.m.	over 1,000	c. 20– 10 (tow)	8
79	July 27	12.05 p.m.	360	325– 0 (vert.)	20
				55– 0 (vert.)	35
80	July 27	3.40–4.15 p.m.	168	145– 0 (vert.)	45
				55– 0 (vert.)	25
				c. 20– 10 (tow)	50+
81	July 27	7.20 p.m.	60	55– 0 (vert.)	25
				c. 20- 10 (tow)	85
82	July 27	10.0 p.m.	60	55- 0 (vert.) I.	15
				55– 0 (vert.) II.	20
				c. 20- 10 (tow)	55 + c. 25,000 (Aurelia)
83	July 28	12.45 a.m.	172	160– 0 (vert.)	70
				55–100 (vert.)	45
				c. 20– 10 (tow)	400

PLANKTON.—HAULS AND QUANTITY—*Continued.*

C. G. S. "ACADIA"—*Concluded.*

No. of Station.	Date.	Hour.	Depth (metres).	Depth of Haul (metres).	Quantity (in c.c.)
84	July 28	4.35 a.m.	60	55– 0 (vert.) I	35
				55– 0 (vert.) II	50
				c. 20– 10 (tow)	230
85	July 28	8.05 a.m.	over 400	270– 0 (vert.)	65
				55– 0 (vert.)	20
				c. 20– 10 (tow)	150
86	July 28	11.10 a.m.–12.30 p.m.	over 400	270– 0 (vert.)	60
				55– 0 (vert.)	40
				c. 20– 10 (tow)	60
87	July 28	2.15 p.m.	331	290– 0 (vert.)	50
				55– 0 (vert.)	20
				c. 20– 10 (tow)	125
88	July 28	5.45 p.m.	130	110– 0 (vert.)	15
				55– 0 (vert.)	5
				c. 20– 10 (tow)	20
89	July 28	8.35 p.m.	132	115– 0 (vert.)	80
				55– 0 (vert.)	55
				c. 20– 10 (tow)	235
90	July 29	c. 2.00 a.m.	c. 60	c. 20– 10 (tow)	200+
91	July 29	c. 12.30 p.m.	c. 45	45– 0 (vert.)	5

C. G. S. "PRINCESS."

1	May 11	9.00 a.m.	68	?	100
				?	10 (gear 20)
2	May 11	3.20–4.30 p.m.	45	?	90
				?	10 (gear 20)
3	June 9	11.00 a.m.–12.00 noon	20	20– 0 (vert.)	5
				0 (tow)	50
4	June 9	5.10 p.m.	22	20– 0 (vert.)	15
5	June 10	8.50–9.35 a.m.	32	30– 0 (vert.)	25
				0 (tow)	120+
6	June 10	12.30 p.m.	57	60– 0 (vert.)	20
				0 (tow)	50

PLANKTON.—HAULS AND QUANTITY—*Continued.*

C. G. S. "PRINCESS"—*Continued.*

No. of Station.	Date.	Hour.	Depth (metres).	Depth of Haul (metres).	Quantity (in c.c.)
7	June 10	3.40–4.30 p.m.	80	80– 0 (vert.)	15
				0 (tow)	90
8	June 10	8.15–10.00 p.m.	80	80– 0 (vert.)	90
				40– 0 (vert.)	50
				0 (tow.)	180
				0 (tow)	10 (gear 20)
9	June 11	12.15–1.00 a.m.	over 200	100– 0 (vert.)	55
				80– 0 (vert.)	50
				0 (tow)	50
10	June 11	7.00 a.m.	over 200	100– 0 (vert.)	50+
				0 (tow)	45
11	June 11	9.30 a.m.	48	50– 0 (vert.)	20
				0 (tow)	20
12	June 11	12.30–1.30 p.m.	135	100– 0 (vert.)	30
				0 (tow)	55
13	June 11	4.00 p.m.	over 200	100– 0 (vert.)	10
14	June 11	7.00 p.m.	39	35– 0 (vert.)	3
				0 (tow)	5
15	June 12	9.00–10.00 a.m.	90	80– 0 (vert.)	25
				0 (tow)	15
16	June 12	1.15 p.m.	over 250	100– 0 (vert.) I	40
				100– 0 (vert.) II	45
				0 (tow)	20
17	June 12	4.30 p.m.	130	100– 0 (vert.) I	35
				100– 0 (vert.) II	35
				0 (tow)	40
18	June 12	7.30 p.m.	63	50– 0 (vert.)	15
				0 (tow)	2
19	June 13	2.45 a.m.	81	80– 0 (vert.)	30
				0 (tow)	50
20	June 13	6.00 a.m.	over 200	100– 0 (vert.)	50
				0 (tow)	65
21	June 13	9.45 a.m.	over 400	100– 0 (vert.)	60
				0 (tow)	15

PLANKTON.—HAULS AND QUANTITY—*Continued.*

C. G. S. "PRINCESS"—*Continued.*

No. of Station.	Date.	Hour.	Depth (metres).	Depth of Haul (metres).	Quantity (in c.c.)
22	June 13....	1.30 p.m.....	52	50– 0 (vert.).....	20
23	June 13....	4.00 p.m.....	115	100– 0 (vert.)...	80
24	June 15....	7.30–7.55 a.m.....	40	35– 0 (vert.) I.....	5
				35– 0 (vert.) II.....	8
				0 (tow).....	30
25	June 15....	11.00 a.m.–12 noon	63	60– 25 (vert. clos.) I...	5
				60– 25 (vert. clos.) II..	10
				60– 0 (vert.) I.....	25
				60– 0 (vert.) II.....	40
				0 (tow).....	50
26	June 15....	3.00–4.00 p.m.....	39	40– 0 (vert.) I.....	5
				40– 0 (vert.) II.....	10
				0 (tow).....	20
27	Aug. 3....	5.30–6.30 p.m.....	23	20– 0 (vert.).....	1
				20– 0 (tow).....	(plankton + bottom material)
28	Aug. 3–4..	11.45 p.m.–1.30 a.m.....	19	20– 0 (vert.) I.....	8
				20– 0 (vert.) II.....	1
				20– 0 (tow)....	(plankton + bottom material)
29	Aug. 4....	6.10–7.15 a.m.....	32	30– 0 (vert.).....	12
				c. 20– 10 (tow).....	25
30	Aug. 4....	10.15–11.05 a.m.....	66	60– 0 (vert.).....	20
				30– 0 (vert.).....	10
				c. 20– 10 (tow).....	150
31	Aug. 4....	1.35–2.40 p.m.....	65	60– 0 (vert.).....	30
				30– 0 (vert.).....	5
				c. 40– 0 (tow).....	30
32	Aug. 4....	4.55–5.50 p.m.....	87	80– 0 (vert.).....	50
				30– 0 (vert.).....	25
				c. 40– 0 (tow).....	120
33	Aug. 4....	8.55–9.50 p.m.....	78	80– 0 (vert.).....	30
				30– 0 (vert.).....	25
				c. 40– 0 (tow).....	260

PLANKTON.—HAULS AND QUANTITY—*Continued.*

C. G. S. "PRINCESS"—*Continued.*

No. of Station.	Date.	Hour.	Depth (metres).	Depth of Haul (metres).	Quantity (in c.c.)
34	Aug. 4-5..	11.55 p.m.-2.25 a.m.....	405	130– 0 (vert.).....	45
				30– 0 (vert.).....	10
				c. 40– 0 (tow).....	150
35	Aug. 5...	4.40-6.35 a.m.....	over 350	130– 0 (vert.).....	20?
				30– 0 (vert.).....	30?
				c. 40– 0 (tow).....	140
36	Aug. 5...	9.30-10.20 a.m.....	48	60– 0 (vert.).....	20
				c. 40– 0 (tow).....	75
37	Aug. 5....	12.45-1.35 p.m.....	75	80– 0 (vert.).....	10
				30– 0 (vert.).....	5
				c. 40– 0 (tow).....	50
38	Aug. 5....	4.00-5.00 p.m.....	180	130– 0 (vert.).....	20
				40– 0 (vert.).....	5
				c. 40– 0 (tow).....	30
39	Aug. 5....	7.00-8.35 p.m.....	284	130– 0 (vert.).....	25
				40– 0 (vert.).....	5
				c. 40– 0 (tow).....	25
40	Aug. 5-6 .	11.30 p.m.-12.25 a.m.....	68	70– 0 (vert.).....	15
				30– 0 (vert.).....	15
				c. 40– 0 (tow).....	55
41	Aug. 6....	3.30-4.55 a.m.....	189	130– 0 (vert.).....	10
				30– 0 (vert.)	5
				c. 40– 0 (tow).....	25
42	Aug. 6....	7.25-8.00 a.m.....	90	100– 0 (vert.).....	10
				30– 0 (vert.).....	2
				c. 40– 0 (tow).....	10
43	Aug. 6....	11.00 a.m.-12 noon	265	130– 0 (vert.) I.....	10
				130– 0 (vert.) II.....	8
				30– 0 (vert.) I.....	2
				30– 0 (vert.) II	1
				c. 40– 0 (tow).....	30
44	Aug. 6....	2.30-3.10 p.m.....	157	130– 0 (vert.).....	25
				30– 0 (vert.).....	10

PLANKTON.—HAULS AND QUANTITY—*Continued.*

C. G. S. "PRINCESS"—*Concluded.*

No. of Station	Date.	Hour.	Depth (metres).	Depth of Haul (metres).	Quantity (in c.c.)
45	Aug. 12	2.05-3.50 a.m.	375	130-0 (vert.)	35
				30-0 (vert.)	20
				c. 40-0 (vert.)	300
46	Aug. 12	5.25-6.35 a.m.	over 400	130-0 (vert.)	20
				30-0 (vert.)	15
				c. 40-0 (tow)	210
47	Aug. 12	8.35-10.00 a.m.	over 400	130-0 (vert.) I	15
				130-0 (vert.) II	10
				30-0 (vert.)	3
				c. 40-0 (tow)	30
48	Aug. 12	12.40-2.00 p.m.	171	130-0 (vert.)	30
				30-0 (vert.)	20
				c. 40-0 (tow)	130
49	Aug. 12	6.25-7.05 p.m.	70	70-0 (vert.)	40
				30-0 (vert.)	15
				c. 40-0 (tow)	70
50	Aug. 12-13	11.25 p.m.-12.20 a.m.	52	40-0 (vert.) I	10
				40-0 (vert.) II	10
				c. 40-0 (tow)	100

PLANKTON.—HAULS AND QUANTITY—*Continued.*

C. G. S. "No. 33".

No. of Station.	Date.	Hour.	Depth (metres).	Depth of Haul (metres).	Time.	Quantity (in c.c.)
3	June 2	10.30 p.m	40	2 0 (tow)	5 min	3
		11.00 p.m		20 15 (tow)	10 min	40
4	June 2	2.30 p.m	45	2 0 (tow)	15 min	15
5	June 3	10.55 a.m	23	1 0 (tow)	5 min	2
6b	June 8	3.00 p.m	c. 30	2 0 (tow)	10 min	10
7	June 9	10.30 p.m	20	2 0 (tow)	5 min	7
8	June 9	11.25 p.m	37	2 0 (tow)	5 min	3
9	June 9	12.50 p.m	10	2 0 (tow)	10 min.	10
10	June 9	2.00 p.m	39	2 0 (tow)	5 min	5
				35 25 (vert. clos.)		10
				25 10 (vert. clos.)		7
				10 0 (vert.)		5
11	June 9	5.25 p.m	59	2 0 (tow)	5 min	20
12	June 9	7.50 p.m	67	2 0 (tow)	5 min	70
13	June 9	9.45 p.m	39	3 0 (tow)	5 min	20
14	June 10	1.15 a.m	58	3 0 (tow)	5 min	50
15	June 10	4.35 p.m	38	2 0 (tow)	5 min	5
16	June 10	7.30 a.m	?	2 0 (tow)	5 min	3
17	June 11	8.20 p.m	39 37	2 0 (tow)	5 min	35
				2 0 (tow)	20 min	55
19b	June 24	4.30 p.m	90	2 0 (tow)	5 min	30
19b	June 24	5.45 p.m	...	2 0 (tow)	20 min	40
21	June 25	7.50 a.m	27	5 0 (tow)	10 min	25
22	June 25	11.00 a.m	195	3 0 (tow)	15 min	10
23	June 25	1.00 p.m	355	340 145 (vert. clos.)		100
				100 60 (vert. clos.)		25
				45 0 (vert.)		20
				0 (tow)	5 min	10
24	June 26	5.25 p.m	45	2 0 (tow)	5 min	65
25	June 26	6.20 p.m	271	2 0 (tow)	5 min	15
26	June 26	9.35 p.m	389	30 15 (tow)	40 min	65
				2 0 (tow)	5 min	2
29	June 30	6.00 p.m	41	3 2 (tow)	5 min	75

PLANKTON.—HAULS AND QUANTITY—*Continued.*

C. G. S. No. "33"—*Concluded.*

No. of Station.	Date.	Hour.	Depth (metres).	Depth of Haul (metres).	Time.	Quantity (in c.c).
35	July 7	11.00 a.m	25	15 6 (tow)	? min	50
36	July 8	5.00 p.m	60	20 8 (tow)	45 min	110
40	July 13	? p.m	38	c. 9 (tow)	? min	95
48	July 26	5.00 p.m	?	40 0 (tow)	? min	90
49	July 27	5.00 p.m	?	15 0 (tow)	? min	145
54	Aug. 7	9.15 a.m	110	70 34 (tow)	1½ hours	2,000+
				25 5 (tow)	1½ hours	2,000+
57	Aug. 9	3.15 p.m	210	200 0 (vert.)		75
58	Aug. 10	11.10 a.m	50	c. 40 0 (tow)	20 min	50
59	Aug. 10	12.50 p.m	275	270 0 (vert.)		130
62	Aug. 11	?	?	30 0 (tow).		8
64	Aug. 13	9.30 a.m	?	80 20 (tow)	80 min	75+
67	Aug. 17	?	?	30 0 (tow)	75 min	8
68	Aug. 17	7.00 p.m	?	70 20 (tow)	35 min	350
69	Aug. 18	4.00 a.m	?	100 20 (tow)	45 min	320
70	Aug 18	2.30 p.m	?	8 2 (tow)	75 min	100

BIOLOGICAL LAUNCH "PRINCE."

No of Station	Date.	Hour.	Depth (metres).	Depth of Haul (metres).	Quantity in (c.c.).
1	Sept. 14	3.45 p.m	c. 38	c. 35- 0 (vert.) I	18
				c. 35- 0 (vert.) II	12
				c. 20 10 (tow)	230
				0 (tow)	40
2	Sept. 14	4.30 5.00 p.m	c. 100	100 0 (vert.)	30
				c. 4- 2 (tow)	20
3	Sept. 15	10.00 11.00 a.m	180	180 0 (vert.)	220
				20 10 (tow)	40
				2- 0 (tow)	25
4	Sept 15	5.30 p.m	c. 35	c. 35- 0 (vert.)	10
				15- 5 (tow)	10

3. A SPECIAL STUDY OF THE CANADIAN CHÆTOGNATHS, THEIR DISTRIBUTION, ETC., IN THE WATERS OF THE EASTERN COAST.

By A. G. Huntsman, B.A., M.B., University of Toronto.

(With 12 Figures.)

The transparent worm-like animals of this group were very prominent in the catches, sometimes forming more than half of the entire catch. In comparatively few instances were they lacking. The method employed was therefore a suitable one for studying their distribution, and they are as valuable as any group as an index of the character and origin of the water. They are free-living in all stages and therefore independent of the presence of banks *per se*. Their distribution will depend upon temperature, salinity, light, oxygen, currents, and food.

The measurements given are of the total length. In determining the tail percentage the tail fin was not included in the measurements. The number of jaws at first increases and later may decrease with age.

KEY TO THE SPECIES.

A1. Two pairs of lateral fins. (Sagitta.)
  B1. Fins (lateral) adjacent or connected.
    C1. Anterior fin not extending to ventral ganglion.

S. lyra. Rather soft and stout. Transparent. Fins with anterior end and inner zone free from rays. 8-10-3 jaws. Tail percentage, 21-14. No collarette. Ovary rodlike. Up to 38mm.

    C2. Anterior fin extending to ganglion.

S. maxima. Rather soft and stout. Transparent. Fins with anterior end and inner zone free from rays. 10-11-4 jaws. Tail percentage, 32-19. No collarette. Ovary rodlike. Up to 87mm.

  B2. Fins separated.
    D1. Fins completely traversed by rays.
      E1. Anterior fin extending to ventral ganglion.

S. bipunctata. Stiff and slender. Rather opaque. 8-10-7 jaws. Tail percentage, 28-21. Short collarette. Ovary rodlike. Up to 25mm.

      E2. Anterior fin not exteeding to ventral ganglion.

S. elegans. Stiff and moderately slender. 8-13-8 jaws. Tail percentage, 27-10. Short collarette. Ovary rodlike. Up to 52mm.

    D2. Fins not completely traversed by rays (anterior end and inner zone free).
      F1. Anterior fin extending to ventral ganglion.

S. serratodentata. Stiff and slender. Rather opaque. 5-10 jaws, tips turned inwards and inner edges serrate. Tail percentage, 32-20. Short collarette. Up to 24mm.

      F2. Anterior fin not extending to ventral ganglion.
        G1. Anterior teeth few (3-5), long and diverging.

S. hexaptera. Stout. Transparent. 7-10-4 jaws. Tail percentage, 26-16. No collarette. Ovary rodlike. Up to 70mm.

        G2. Anterior teeth many (5-11), short and overlapping.

S. enflata. Soft and stout. Transparent. 7-10-7 jaws. Tail percentage, 23-14. Short collarette. Ovary sausage-shaped. Up to 30 mm.

A2. One pair of lateral fins.
  H1. Lateral fins on tail only. Two rows of teeth on each side.

Pterosagitta draco. Stiff. Rather opaque. Fins completely traversed by rays. 7-10-8 jaws. Tail percentage, 46-38. Collarette very thick and over whole of trunk. Ovary rodlike. Up to 11mm.

H_2. Lateral fins on both trunk and tail. One row of teeth on each side.

J_1. Fins extending to ventral ganglion and largely without rays.

Eukrohnia hamata. Stiff and moderately slender. 8-11-9 jaws. Tail percentage, 22-32. No collarette. Up to 43mm.

J_2. Fins well behind ventral ganglion, with small inner zone free from rays.

Krohnitta subtilis. Stiff and slender. 7-10 jaws. Tail percentage, 29-38. No collarette. Up to 16mm.

LITERATURE.

Apstein, C.
1911. Chaetognatha. Cons. Perm. Internat., Bull. Trimestr., part 2, pp. 170-175, Plate xxiv.

Bigelow, H. B.
1914. Explorations in the Gulf of Maine, July and August, 1912, etc., Bull. Mus. Comp. Zool., vol. lviii, No. 2.
1915. Exploration of the Coast Water between Nova Scotia and Chesapeake Bay, July and August, 1913, etc. Bull. Mus. Comp. Zool., vol. lix, No. 4.

Conant, F. S.
1896. Notes on the Chaetognaths. Johns Hopkins Univ. Circ., vol. xv, No. 126.

Fowler, G. H.
1906. The Chaetognatha of the Siboga Expedition. Siboga-Exped., Mon. xxi.
1907. Chaetognatha. Nat. Ant. Exped., Nat. Hist., vol. iii.
1896. Plankton of the Faeroe Channel. No. 1. Proc. Zool. Soc., pp. 991-996, Plate L.

Michael, E. L.
1911. Classification and Vertical Distribution of the Chaetognatha of the San Diego Region, etc. Univ. Calif. Publ. Zool., vol. 8, No. 3.
1913. Vertical Distribution of the Chaetognatha of the San Diego Region, etc. Amer. Natur., vol. xlvii, pp. 17-49.

Murray, J. and Hjort, J.
1912. The Depths of the Ocean. London, 1912.

Ritter-Zahony, R. Von.
1910. Chaetognatha from the Coasts of Ireland. Fish. Ireland, Sc. Invest., 1910, iv.
1911. Chaetognathi. Das Tierreich.

Stredtmann, S.
1892. Die Systematik der Chaetognathen. Arch. Natur., vol. 58_1, pp. 338-377.
1911. Die Chaetognathen. Nordisches Plankton, vol. v.

(*a*) **Sagitta hexaptera** d'Orbigny.
1911. Ritter-Zahony, p. 12.
The specimens varied in size from 11-50mm. in length.

DISTRIBUTION.

C. G. S. "ACADIA."

Station No.	Depth (metres).	Depth of Haul (metres).	Length (mm.).	Number.
16	over 2,000	200- 0 (V.)	32 & 50	2
		0 (T.)		0
17	over 2,000	200 0 (V.)	13, 21 & 36	3
		0 (T.)		0
44	over 1,000	270 0 (V.)	17 & 20	2
		0 (T.)		0
56	over 1,000	375-250 (C.)		0
		250- 0 (V.)	50	1
74	over 1,000	325- 0 (V.)	21	1
		55- 0 (V.)		0
		c. 20 10 (T.)	11 & 12	2
75	over 1,000	325 0 (V.)	30	1
		55 0 (V.)		0
		c. 20 10 (T.)		0

VERTICAL.—With one exception this species was obtained only in deep open net hauls down to 200 metres or over, and did not occur in the shallower hauls (55 metres up). The exception was in a tow haul taken about 20 metres below the surface at station 74. The two individuals obtained were the smallest taken (11 and 12mm.).

The small number of individuals found is quite inadequate for determining the distribution, but the hauls made at stations where the species was found show its absence below 250 metres, its rarity above 55 metres (and then only small individuals), and its uniform presence in hauls made through intermediate depths. This agrees with the finding of Michael (1913, p. 34) who suggests its maximum abundance as existing between 50 and 100 fathoms, based upon twenty-eight specimens taken in fourteen hauls. The presence of two small individuals near the surface in station 74 on the edge of the Gulf Stream, is explained by the fact that in warm waters this species occurs quite to the surface in its younger stages.

HORIZONTAL.—*Sagitta hexaptera* is a cosmopolitan oceanic form occurring in tropical regions, but large individuals have been found far into the polar regions.

It was found only in the outermost warm water stations of the *Acadia's* cruises, and it occurred in every one. As it is a form characteristic of intermediate depths, from 100 to 200 metres, its distribution is an indication of the extent to which this intermediate water has pressed in toward our shores from the open Atlantic. The inner limit of its distribution would appear to be well outside the continental shelf, perhaps sixty or more miles in May and June, and rather closer, from twenty to forty miles, in July and August. Its distribution (shown for July-August by the vertical

interrupted lines in fig. 1) does not indicate that there has been any movement of this intermediate water of the Gulf Stream in over the banks or up the gully leading to the gulf of St. Lawrence.

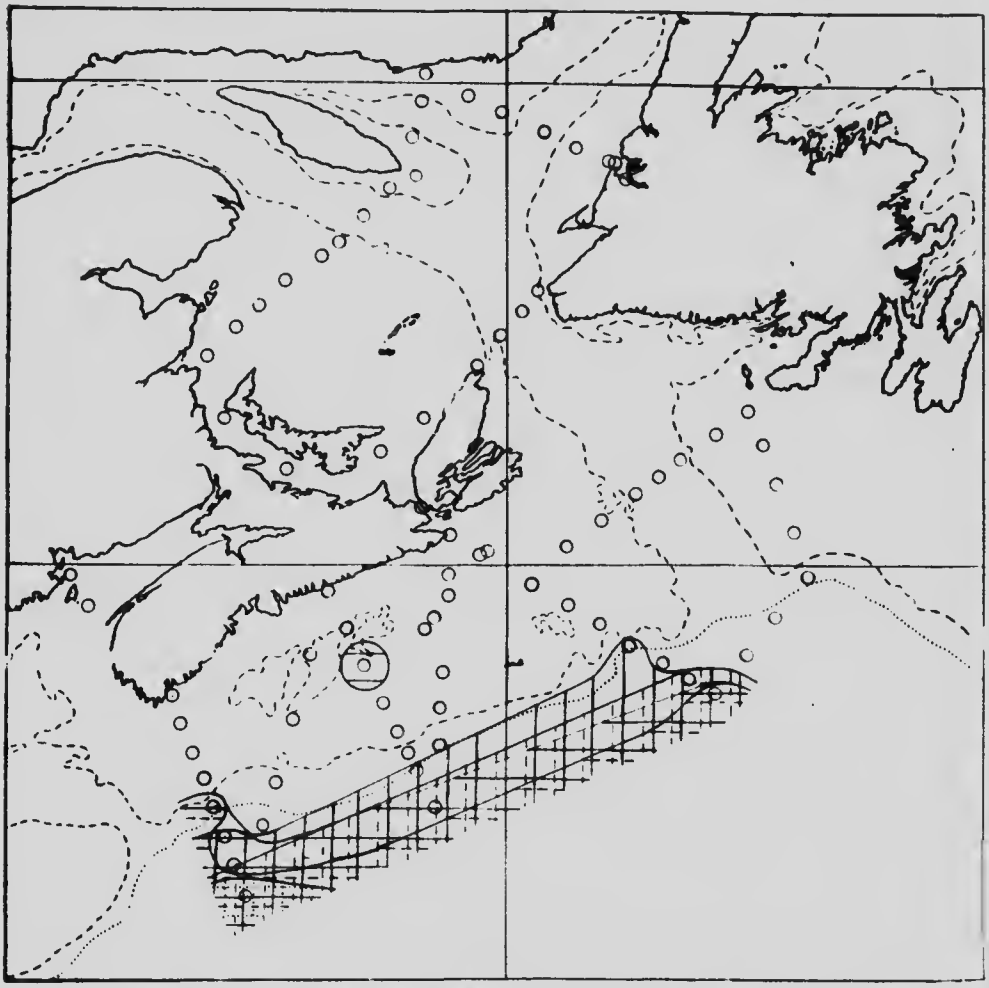

Fig. 1.—Distribution of Gulf Stream Chaetognaths, July-August 1915. *S. enflata* — — *P. draco* — — *S. bipunctata* ..... *S. lyra* | , *S. hexaptera* ¦ , *K. subtilis* ⋮ .

Bigelow (1915, p. 298) obtained it in the July-August cruise (1913) of the *Grampus* only in the outermost stations, apparently from 10 to 20 miles outside the continental shelf, and in the more northern of the outer stations not at all, as these were apparently not far enough out for it. We may perhaps deduce from these facts that this species comes nearer to the coast as the summer progresses, that its distance off the coast increases as we go northward from Chesapeake bay to the Grand Banks, and that along our shores it belongs to the Gulf Stream water coming up from the south, and not to the cold boreal water coming down from the north. The occurrence of this species in the far north (74° N. according to Michael, 1913, p. 26) and in the far south (77° S., Fowler, 1907, p. 3) would lead one to expect it in our

boreal oceanic water. As it belongs typically to lower latitudes, its absence may mean that older individuals when carried toward the poles survive, but do not have any progeny (owing to the absence of the warm salt surface water frequented by the young) and as a result the cold water that passes toward low latitudes is devoid of this species, the old individuals having all died off.

There is, however, some doubt as to how far it is carried toward the poles. Ritter-Zahony considers that Fowler's Antarctic specimens belong to *S. gazellae* and not to this species, and he gives the usual distribution as between the fortieth parallels north and south.

(*b*) **Sagitta enflata** Grassi.

1911. Ritter-Zahony, p. 16.

The range in size of the specimens obtained is from 7-23mm. The larger individuals were all sexually mature. This species is easily recognized by the short tail and the short sausage-shaped ovaries.

DISTRIBUTION.

C. G. S. "ACADIA."

Station No.	Hour.	Depth (metres).	Depth of Haul (metres).	Length (mm.).	Number.
41	6 a.m.	360	200- 0 (V.)		0
			100- 0 (V.)		0
			0 (T.)		1
42	9 a.m.	over 1,000	200- 0 (V.)	8	2
			0 (T.)		0
44	3 p.m.	over 1,000	270- 0 (V.)	7-23	39
			0 (T.)	7-20	170
50	9 p.m.	151	145-55 (C.)		0
			145- 0 (V.)	18	1
			55- 0 (V.)		0
			0 (T.)		0
56	3 p.m.	over 1,000	375-250 (C.)	(fragment)	1
			250- 0 (V.)		0
75	9 p.m.	over 1,000	325- 0 (V.)	13	1
			55- 0 (V.)	6-13	4
			c. 20- 10 (T.)		0

VERTICAL.—All the specimens obtained came from open-net vertical hauls or from horizontal surface hauls. This species is a typical surface form belonging to the upper epiplankton. The majority of the specimens were taken in a surface haul at 3 p.m.

HORIZONTAL.

HORIZONTAL.—*Sagitta enflata* is a tropical form ranging north to the fortieth parallel. The present records appear to be more northern than any hitherto recorded for this species. Two specimens were obtained at *Acadia* station 75, the position of which was 43° 30′ N.

56° 43′ W. It belongs to the surface water of the Gulf Stream. It was not found on the first cruise of the *Acadia*. On the second cruise of the *Acadia* it occurred in abundance only at the southernmost station (station 44), where 209 specimens were obtained. At each of five other stations, one to five specimens were taken (stations 41, 42, 50, 56 and 75). Its occurrence at station 50 is interesting as indicating the movement as far as that point of the surface Gulf Stream water. Its distribution is shown by the horizontal continuous lines in fig. 1.

Bigelow in his July-August cruise of 1913 obtained it south of cape Cod up to a latitude of nearly 40°.

(*c*) **Sagitta lyra** Krohn.

1911, Ritter-Zahony, p. 13.

The specimens obtained varied in size from 15-38mm. in length. The individuals obtained at *Acadia* stations 16 and 17 on June 1 were not sexually mature, seminal vesicles and ovaries not being easily seen, although the tests were distinct. Those obtained on the later cruise were more mature, the ovaries being moderately long but narrow, and the seminal vesicles appearing. This species and the next are easily separated from the other species by the very evident connection between the anterior and posterior fins.

DISTRIBUTION.

C. G. S. "ACADIA."

Station No.	Depth (metres).	Depth of Haul (metres).	Length (mm.).	Number.
16	over 2,000	200– 0 (V.) 0 (T.)	13-30	8 0
17	over 2,000	200– 0 (V.) 0 (T.)	25-30 15, 16 & 19	4 3 0
42	over 1,000	200– 0 (V.) 0 (T.)	(fragment)	1 0
44	over 1,000	270– 0 (V.) 0 (T.)	15-25	5 0
55	over 1,000	270– 0 (V.) 90– 0 (V.) 0 (T.)	24 & 27	2 0 0
56	over 1,000	375–250 (C.) 250– 0 (V.)	26-32 25-32	7 4
70	over 1,000	325– 0 (V.) 55 0 (V.) c. 20– 10 (T.)	38	1 0 0
74	over 1,000	325– 0 (V.) 55– 0 (V.) c. 20– 10 (T.)	18-33	4 0 0
75	over 1,000	325– 0 (V.) 55– 0 (V.) c. 20– 10 (T.)	29-33	10 0 0

VERTICAL.—This species was obtained only in deep open-net hauls down to 200 metres or more, and in one closing-net haul below 250 metres. It was therefore distributed from above 200 metres to below 250 metres. All the hauls from 90 metres up, and shallower, were negative. Michael (1913, p. 31) found it very rarely above 25 fathoms, and attaining its maximum abundance below 250 fathoms. He does not, however, distinguish *S. maxima* from this species. Ritter-Zahony (1911, p. 14) gives its distribution as from 100-200 metres downwards. It is thus typically in the deeper layers of water.

HORIZONTAL.—This species is cosmopolitan and extends well to the north in the Atlantic. It is oceanic, being confined to deep water. In our waters its distribution is very similar to that of *S. hexaptera*, it was found only in the outer stations. But it occurred in more of these than did *hexaptera*, pressing farther in towards the continental shelf. In the May-June cruise it was found at the same stations as *hexaptera*, and did not occur at *Acadia* station 14, where a suitable haul was made. It would seem to have been at that time about sixty miles off the continental shelf, but the data are quite insufficient. In the July-August cruise (its distribution is shown by the vertical continuous lines in fig. 1) it was found in moderate abundance (about half-a-dozen specimens) at the outermost stations (44, 56, 74, 75) with *hexaptera*, and as well in some of the neighbouring stations (42, 55, 70), but only one or two specimens in each case. Thus it virtually came to the edge of the continental shelf. It might have been expected at stations 45, 72 and 76. Station 45 was peculiar in giving only one Chaetognath, *S. serratodentata*. Stations 72 and 76 appear to have had too great an amount of coastal water (witness the presence of *S. elegans*). It is perhaps worthy of note that at only one station (*Acadia* 16) were *S. lyra* and *S. elegans* found together, and at only four stations were they both absent. The inner limit in distribution of *S. lyra* almost corresponds with the outer limit of *S. elegans*. Although coming very close in, *Sagitta lyra* does not appear to be carried over the banks or up the gullies between the banks or up into the gulf of St. Lawrence.

It belongs to the deeper part of the bank of Gulf Stream water, and is carried in small numbers into the "cold wall" of boreal water that Hjort (1912, p. 10) has shown to exist along the southern side of the Grand Banks between the Gulf Stream and the continental shelf, and that Bigelow (1915) has shown to become narrower as we pass southward along the coast. We may take arbitrarily a salinity of 35 per thousand as forming the boundary line between the two. It is present in this boreal water only south of the angle where the Gulf Stream is deflected to the south by proximity to the Grand Banks, as if some mixing of the two waters occurred there.

The passage of this species from the Gulf Stream into the boreal oceanic water, and the failure of *S. hexaptera* to pass in a similar direction is perhaps to be explained by the fact that *S. lyra* occurs in deeper, colder water than *S. hexaptera*, and is therefore more apt to pass through the bottom of the Gulf Stream. The rarity of *S. hexaptera* may also be responsible for our failure to get it in the boreal oceanic water.

Dr. Bigelow (1915, p. 297) lists *S. lyra* from each of his four stations taken just outside the continental shelf south of cape Cod in July-August, 1913, and not from those inside, except for two specimens from the gulf of Maine.

(*d*) **Sagitta maxima.** (Conant.) Fig. 2.

1911. Ritter-Zahony, p. 15.

The range in size is from 7 to 55mm. in length.

Fig. 2.—Sagitta maxima × 2.

With one exception all the individuals were quite immature. Those obtained on the first cruise had no evident gonads. The larger ones of the second cruise had the ovaries of moderate size, but not mature, and the seminal vesicles distinct. Michael (1911, p. 37) has considered this form identical with *S. lyra,* but by following Ritter-Zahony's account I have experienced no difficulty in separating the two species, except with damaged specimens. The points relied upon have been: relation of anterior ends of anterior fins to ventral ganglion and proportionate length of the tail. This species reaches and matures at a much larger size than *Sagitta lyra.*

It is interesting to note that the specimens of this species described by Conant (1896, p. 84) were obtained by the *Albatross* at station 2428, 42° 48′ N. and 50° 55′ 30″ W., just inside the southern tip of the Grand Banks, and therefore in the "cold wall" of boreal water. They were brought up in the trawl wings.

DISTRIBUTION.

C. G. S. "ACADIA."

Station No.	Depth (metres).	Depth of Haul (metres).	Length (mm.).	Number.
14	over 2,000	200- 0 (V.)	15-32	14
		0 (T.)		0
16	over 2,000	200- 0 (V.)	15-25	16
		0 (T.)		0
17	over 2,000	200- 0 (V.)	7-13	3 × 10
			15-30	98
		0 (T.)		0
44	over 1,000	270 0 (V.)	14-19	4
		0 (T.)		0
46	over 1,000	270- 0 (V.)	24	1
		0 (T.)		0
48	248	270- 0 (V.)		0
		45- 0 (V.)	23	1
		0 (T.)		0
54	over 1,000	270- 0 (V.)	19-25	4
		125- 0 (V.)	20 & 22	2
		0 (T.)		0
55	over 1,000	270- 0 (V.)	17-28	6
		90- 0 (V.)		0
		0 (T.)		0
56	over 1,000	375-250 (C.)	20-25	3
		250- 0 (V.)	13-21	5
57	over 1,000	270- 90 (C.)	13-42	7
		90- 0 (V.)		0
		0 (T.)		0
70	over 1,000	325- 0 (V.)	20-30	9
			55	1
		55- 0 (V.)		0
		c. 20- 10 (T.)		0
72	over 1,000	325- 0 (V.)	23-40	8
		55- 0 (V.)	25	1
		c. 20- 10 (T.)		0

"ACADIA" *Concluded.*

Station No.	Depth (metres).	Depth of Haul (metres).	Length (mm.).	Number.
74	over 1,000	325- 0 (V.)	10 16	5
		55 0 (V.)		0
		c. 20 10 (T.)		0
75	over 1,000	325- 0 (V.)	15 24	7
		55 0 (V.)		0
		c. 20- 10 (T.)		0
76	over 1,000	270- 0 (V.)	13 36	14
		c. 20 10 (T.)		0
79	360	325 0 (V.)	12 40	14
		55- 0 (V.)		0
85	over 400	270- 0 (V.)	10 16	6
		55- 0 (V.)		0
		c. 20 10 (T.)		0
86	over 400	270 0 (V.)	15 17	5
		55 0 (V.)		0
		c. 20 10 (T.)		0
87	331	290 0 (V.)	15 & 23	2
		55 0 (V.)		0
		c. 20- 10 (T.)		0

VERTICAL.—Except in three instances, this species was obtained only in hauls taken from a depth of 200 metres or more. The exceptions are small individuals, 25 mm or less in length, and were obtained at *Acadia* stations 48, 54 and 72. The conditions at these stations were peculiar. The surface oceanic species *S. serratodentata*, the coastal species *S. elegans*, and two deep-water boreal species, the present one and *Eukrohnia hamata*, all occurred together. These are undoubtedly places where mixing of the different kinds of water occurs and where vertical currents might be expected to bring temporarily nearer to the surface forms that are ordinarily to be found only in deeper water. The number of individuals in each case was small (1, 2, 1).

On the first cruise of the *Acadia*, numerous specimens were obtained in all the hauls made from 200 metres to the surface (stations 14 16 and 17) outside the continental edge and none in the hauls made from 100 metres to the surface (stations 12, 15, 26 and 27). On the second cruise (with the exceptions noted above) again only the deeper hauls were productive. The shallower hauls were not very deep (90 metres or less). At station 56, three individuals were obtained in the closing net from below 250 metres. These facts show an ordinary distribution of this species in our waters from above 200 metres (but not above 100) to below 250 metres. Michael (1913, p. 32) gives for *S. lyra* (in which he includes *S. maxima*) a maximum abundance below 250 fathoms and a decreasing frequency toward the surface (above 25 fathoms it was

extremely rare) for the San Diego region. Fowler (1896, p. 992 as *S. whartoni*) in his investigations of the Faeroe channel found it only on one occasion above 100 fathoms, and Ritter-Zahony for the coasts of Ireland found it regularly only below 100 fathoms.

In the Gulf Stream stations of the second cruise a gradation in depth according to size is evident. At the southernmost station (station 44), the haul from 270 metres up yielded no specimen longer than 19mm. At station 56, the next station north, the haul from 250 metres up gave specimenes up to 21mm., and the haul from 375 to 250 metres, specimens up to 25 (?) mm. The northern Gulf Stream stations (stations 74 and 75) from a depth of 325 metres to the surface gave specimens up to 16 mm. and 24mm. respectively. The boreal stations yielded much larger specimens from similar depths (e.g. up to 25, 28, 42, 55, 40, 36, and 40mm. at stations 54, 55, 57, 70, 72, 76, and 79 respectively). Therefore, as we pass into warmer water the larger specimens go deeper and deeper down and only the smallest specimens occur near the upper limit of distribution. It is worthy of note that at the Gulf Stream stations of the second cruise (stations 44, 56, 74 and 75) in each of the hauls, the average size of *S. maxima* (the larger species) was less than the average size of *S. lyra* (the smaller species). This seems to indicate that *S. lyra* attains its maturity and perhaps also its maximum abundance in the upper part of the mesoplankton and *S. maxima* its m turity and maximum abundance in the lower part of the mesoplankton. These two closely related species, though having to a great extent a coincident horizontal distribution would be rather sharply separated in their vertical distribution, as Michael (1913) has shown to be the case for other couplets of species in this group. Data as to the lower limit of distribution *S. lyra* are lacking, although Ritter-Zahony (1910) appears to have obtained it in quantity below 700 fathoms.

Hor zontal.—This species is cosmopolitan, extending to the far north in the Atlantic, so that it may be considered a cold-water species, distributed in all oceans in the depths. In our waters in the depths that we have examined (down to from 200 to 300 metres) it occurs in greatest abundance outside the continental shelf and inside the outermost stations, that is, inside the Gulf Stream. Little can be stated as to its distribution during the first cruis of the *Acadia*, owing to the fact that only three deep hauls were made. At station 17 an extraordinary number were obtained, 128 in the one open-net haul from 200 metres to the surface. Larger individuals were obtained at the innermost of the thre stations, 30 and 32mm. at stations 17 and 14, respectively, as opposed to 25mm. at station 16. The records indicate that it was present in maximum abundance between station 16 and the Newfoundland banks, and decreased in abundance toward the west and south. Its distribution in July-August is shown in fig. 3. It occurred in moderate abundance at the outermost stations (7, 5, 8 and 4 specimens at stations 75, 74, 56 and 44 respectively). At the remaining stations outside the continental shelf, it occurred in maximum abundance at the northeast, and decreased in abundance with almost perfect regularity, passing to the southwest, until it disappeared altogether (14, 14, 8, 10, 7, 6, 4, 1, 0, 0 and 0 specimens at station 79, 76, 72, 70, 57, 55, 54, 46, 45, 42 and 41, respectively) considering in each case only the deep open-net haul. It also occurred in fair abundance up the gully leading to the Gulf of St. Lawrence. In the gully it was present in greater amount on the north side, the numbers obtained in the deep vertical hauls being 6, 5 and 2 specimens, respectively, at stations 85, 86 and 87. Inside the Gulf of St. Lawrence, on the cruises of the *Princess*, it was not found, perhaps because the hauls were not deep enough (not over 130 metres). The only other place where it was found was at station 48 in the deep water inside the outer banks off Halifax, where a solitary specimen was obtained. Its distribution (fig. 3) suggests (1) that this species belongs typically to the deep boreal water that is found against the side of the continent; (2) that this water disappears as we pass southwest along the continent, doubtless seeking a lower level, unexplored by our nets; (3) that some of it passes up over the banks south of Sable island to mix

with the shallow coastal water; and (4) that another portion passes up the gully leading to the St. Lawrence gulf but keeping mainly to the north side of the gully.

Its centre of abundance (fig. 3, closely placed lines) is then the deeper part of the northern oceanic (boreal) water which flows to the south around the Newfoundland banks. It is carried by the latter into the coastal water and beneath the Gulf Stream. In the coastal water it must speedily perish, but in the Gulf Stream, the smaller individuals at least find suitable conditions. The Gulf Stream on its way to the north would seem to receive fresh additions of this species from the boreal water beneath. The numbers obtained in the open vertical hauls from the south to the north

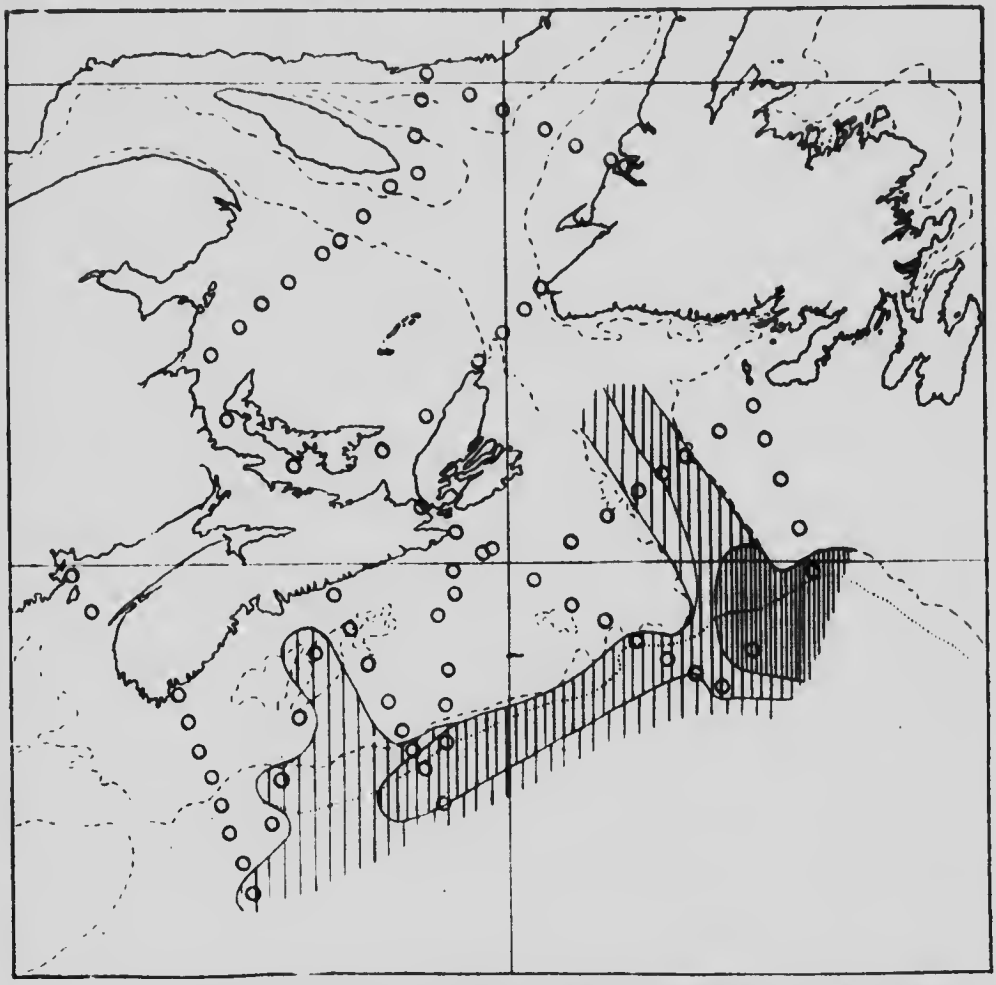

Fig. 3.—Distribution of *S. maximus*, July-August 1915. Zones show frequencies of 1 to 5, 6 to 10 and 10 and over per station.

are 4, 5, 5, 7 at stations 44, 56, 74 and 75, respectively, showing an increase in the number at the north. This may explain how the fauna of the Gulf Stream, as it passes to the north, changes from tropical to boreal, the change in temperature killing the tropical forms which are replaced by the boreal forms that enter the stream as young individuals from the boreal water below. The growth of the boreal forms proceeds *pari passu* with the change in temperature, and they find themselves constantly in water of suitable temperature for their continued existence.

Hjort (1912, p. 640) considers that this species (as *S. gigantea*) is arctic to boreal in its distribution, and has found it as a typical inhabitant of the deep cold water of the Norwegian sea. Apstein (1911, p. 173) records its distribution in European waters as being restricted to the Atlantic and the Norwegian sea, but in one year at least coming down the Norwegian gully to the western part of the Skager-Rack. It was strictly limited to the deep water, remaining below 100 metres. This is very similar to what we have found, the species tending to enter the St. Lawrence gulf along the submerged Laurentian valley. It will probably be found at times well inside the gulf in the deep water.

The distribution of this species may be contrasted with that of *S. lyra*, its closest ally. *S. lyra* belongs to the Gulf Stream, but large individuals wander into the northern oceanic water *S. maxima* belongs to the northern oceanic water, but small individuals wander into the Gulf Stream. Both species are apparently unfitted for life in water of low salinity like the coastal water, regardless of temperature.

(*e*) **Sagitta serratodentata** Krohn. Fig. 4.

1911. Ritter-Zahony, p. 22.

Fig. 4.—Sagitta serratodentata.

The range in size is from 6 to 24mm. in length. All the larger individuals were sexually mature. The slender build of this species and the early appearance of the seminal vesicles on either side of the tail, make it easily distinguishable from our other Chaetognaths. A character to which attention does not appear to have been called is the presence in the young of a distinct bridge between the anterior and posterior fins on each side. This tends to disappear with age. In young individuals the serrations on the hooks are seen with difficulty, if at all. The variations in the descriptions of this species, as taken in different localities, make one question whether several species have not been confounded. The great differences in the conditions throughout our waters give us almost the extremes of these variations. In the warm water at *Acadia* station 41, the largest individuals were only 12mm. long. Both their male and female gonads were mature. The jaws were few (5-8), the tail proportion small (23-27 per

cent) and the body relatively stout. At *Acadia* station 38, individuals as long as 22mm. were obtained, and those as long as 15mm. were immature. The jaws were more numerous in these (7-10), the tail proportion larger (25-32 per cent), and the body more slender. If these are one species, the differences in structure will be due to the differences in the conditions under which they have developed. These differences are similar to those seen in the varieties of *S. elegans* (see under that species) occurring in localities where different climatic conditions prevail. In both the cold water develops a type of larger size, with more jaws, and a higher tail percentage. The number of jaws increases with age (there may be latterly a decrease) and the maximum number in the cold-water type is higher than is found in the warm-water type (though the difference is not great). The following are the numbers of jaws found in the two types:—

TROPICAL WATER. ("ACADIA" STATION 75).

Length (mm.).	7	8	9	10	11	12	13
Number of jaws	6	6	6	6	5	7	6
	7	6	6	6	6	7	7
		6	6	6	6	7	7
		6	6	6	6	7	7
		6	6	6	7	8	7
		7	7	6	7	8	7
		7	7	7	7	8	8
			7	7	7	8	8
			7	7			8
				7	7		8
				7	8		
				8	8		
					8		
					8		
					8		

BOREAL WATER. ("ACADIA" STATIONS 17, 38, AND 85).

Length (mm.).	10	11	12	13	14	15	16	17	18	19	20
Number of jaws	7	7		7	7	7	8	8	8	7	8
	7	7		8	8	8	8	8	8	8	9
	7	7			8	8	8	8	8	8	9
	8	8			8	8	9	8	9	8	
					8	8		8	9		
					9	8		8	9		
					9			9			

The comparative variability in the number of jaws in individuals of the same size makes it necessary to examine larger numbers of individuals than would otherwise be the case. Although the number is not very large, it is fairly evident from the figures given that there is a very gradual but steady increase in the number of jaws, and this is irrespective of the type, individuals of the same length in the two types having equal numbers of jaws (or slightly more in the larger type).

In the case of the tail percentage there is a decrease with age. The following are the results of measurements of the percentages in the two types of *S. serratodentata*.

BOREAL WATER. ("ACADIA" STATION 38.)

Length (mm.).	10	11	12	13	14	15	16	17
Tail percentages	29	28	27	26	26	25	26	25
	30	29	28	27	27	25	26	27
	30	30	28	28	28	26	27	
	32	30	28	28	28	27	27	
	32	30	29	30	28	28		

For the larger sizes it was necessary to examine specimens from another point.

BOREAL WATER. ("ACADIA" STATION 85.)

Length (mm.).	17	18	19	20
Tail percentages	24	23	23	23
		23		
		24		
		24		

TROPICAL WATER. ("ACADIA" STATION 75.)

Length (mm.).	8	9	10	11	12
Tail percentages	26	26	24	24	23
	26	26	24	24	23
	27	26	25	24	23
	28	27	25	25	24
	28	...	25	26	24

For the smallest sizes specimens from another station were taken.

TROPICAL WATER. ("ACADIA" STATION 41.)

Length (mm.).	6	7	8
Tail percentages	30	28	29
	....	30	.....
	.....	30	.....
	.....	32	.....

The range in percentage is the same for the two types (32-23), but for any given length it is very different, for example, for 12mm., 23-24 per cent and 27-29 per cent. If we consider 20mm. the ordinary upper limit for the boreal water and 12mm. that for the tropical water, we find that for corresponding sizes the percentages are as nearly the same as could be expected. Half-grown individuals show percentages of 30 and 27-29, respectively; two-thirds grown individuals of 26-28 and 25-28; fully-grown individuals of 23-24 and 23.

It is probable that we have not to do with two races, but that the tropical form is constantly brought to the boreal water, keeping the strain uniform. The differences may be confidently be referred purely to the environmental factors. Cold may be said in this species to increase the length, delay maturity till a much greater length is attained, delay the decrease in tail percentage correlative to maturity, and increase the number of jaws. We have the number of jaws correlated with size and the tail percentage corrleated with maturity (attainment of maximum size and also maturity of sexual organs).

DISTRIBUTION.

"ACADIA."

Station No.	Hour.	Depth (metres).	Depth of Haul (metres).	Length (mm.).	Number.
5	3 a.m.....	72	60– 0 (V.).....	19	1
			0 (T.).....	10–15	35
				15–20	43
6	6 a.m.....	45	40– 0 (V.).....	14	3
			0 (T.).....	13	2
12	6 a.m.....	over 2,000	100– 0 (V.).....	13–15	3+1×10
				16–17	3
			0 (T.).....	.....	0
13	9 a.m.....	over 2,000	70– 0 (V.).....	14	1
14	3 p.m.....	over 2,000	200– 0 (V.).....	14–15	3
				16–24	18 10
			0 (T.).....	.....	0

"ACADIA"—*Continued.*

Station No.	Hour.	Depth (metres).	Depth of Haul (metres).	Length (mm.).	Number.
15	9 p.m.....	over 2,000	100- 0 (V.)	16-18	9
			0 (T.)	13-15	5×2
				16-20	19×2
16	3 a.m.....	over 2,000	200- 0 (V.).....	6-7	58×10
				13-15	3×10
				15-20	27×10
			0 (T.).....	9-21	+ +
17	9 a.m.....	over 2,000	200- 0 (V.).....	4-12	43+19×10
				15-21	16+13×10
			0 (T.).....	11-20	c. 30
18	6 p.m.....	over 2,000	0 (T.)..—	17-18	2
19	9 p.m.....	over 2,000	0 (T.).....	15-19	c. 20
25	6 p.m.....	122	120- 0 (V.) ..	13	1
			10(?)- 0 (T.).....	.....	0
26	12 m. n.....	over 400	100- 0 (V.).....	15-17	3
			0 (T.).....	.....	0
27	3 a.m.....	over 400	0 (T.).....	c. 17	×
28	3 a.m.....	over 400	100- 25 (C.).....	.....	0
			0 (T.).....	16	1 seen
38	9 p.m.....	170	150- 0 (V.).....	10-15	10+20×10
				15-16	4
			100- 0 (V.).....	7-15	30+25×10
				15-22	19+3×10
			0 (T.).....	9-14	× ×
39	12 m. n.....	95	100- 0 (V.).....	12-15	12×10
				15	4
			25- ? (V.).....	12-15	5×5
				15-17	14
			0 (T.).....	10-17·5	× ×
40	3 a.m.....	134	125- 0 (V.) I.....	12	2
			125- 0 (V.) II.....	10	1
			100- 0 (V.).....	.....	0
			0 (T.).....	shrivelled specimens	×

"ACADIA"—*Continued.*

Station No.	Hour.	Depth (metres).	Depth of Haul (metres).	Length (mm.).	Number.
41	6 a.m.....	360	200– 0 (V.)...	6–9	25
			100– 0 (V.).....	10–12	3
			0 (T.).....	10	1
42	9 a.m.....	over 1,000	200– 0 (V.).....	7–11	67
			0 (T.).....	.....	0
44	3 p.m.....	over 1,000	270– 0 (V.).....	7–11	26
			0 (T.).....	7–12	58
45	9 p.m.....	over 1,000	270– 0 (V.).....	6–11	8×4
			90– 0 (V.).....	7–15	21
			0 (T.).....	.....	0
46	12 m.n.....	over 1,000	270– 0 (V.).....	5–13	14+4×5
				5–16	2
			0	5–14	+
				16–20	×
47	6 a.m.....	40	125– 0 (V.)	9–14	13+2×10
				15 & 17	2
			90 –0 (V.)	.....	×
			0 (T.).....	5–12	+
48	12 m.n.....	250	270– 0 (V.).....	.....	0
			45– 0 (V.).....	11	1
			0 (T.).....	.....	0
50	9 p.m.....	151	145– 0 (V.).....	12·5	2×5
				12–14	12
				16–20	5
			145– 55 (C.).....	16	1
			55– 0 (V.).....	10–14	5+1×5
				17	1
			0 (T.).....	10–16	++
51	12 m.n.....	131	125– 55 (C.)	9 & 15	2×5
			125– 0 (V.)	14–15	3+1×5
				15–19	4
			0 (T.).....	11–16	+

"ACADIA"—*Continued.*

Station No.	Hour.	Depth (metres).	Depth of Haul (metres).	Length (mm.).	Number.
52	3 a.m.	99	90– 0 (V.) II	17	1
			0 (T.)	13 & 14	2
				16–18	2
53	6 a.m.	95	90– 0 (V.)	9	1×5
				11–12	3
				15–19	3
			0 (T.)	19	×
54	9 a.m.	over 1,000	270– 0 (V.)	13–14	3
			125– 0 (V.)		0
			0 (T.)	7–12	c. 12
55	12 m	over 1,000	270– 0 (V.)	8	2
				17	1
			90– 0 (V.)	16	2
			0 (T.)	9–15	7
56	3 p.m.	over 1,000	375–250 (C.)	c. 8	2
			250– 0 (V.)	7–9	[illegible]
57	9 p.m.	over 1,000	270– 90 (C.)	8	1
			90– 0 (V.)	9 & 12	2
			0 (T.)	9–12	15
8	12 m.n.	187	180– 55 (C.)	10 & 12	2
			55– 0 (V.)	9–10	4
			0 (T.)	8–13	c. 15
				18–20	2
	6 a.m.	99	90– 0 (V.)	7·5–9	3×5
				15	1×5
			0 (T.)	small	×
70	12 m.	over 1,000	325– 0 (V.)		0
			55– 0 (V.)		0
			c. 20– 10 (T.)	13–14	4
72	3 p.m.	over 1,000	325– 0 (V.)		0
			55– 0 (V.)		0
			c. 20– 10 (T.)	9–13	7
				16	1

"ACADIA"—*Concluded.*

Station No.	Hour.	Depth (metres).	Depth of Haul (metres).	Length (mm.).	Number.
74	6 p.m.	over 1,000	325– 0 (V.)	8–11	52
			55– 0 (V.)	7–13	21
			c. 20– 10 (T.)	7–12	+
75	9 p.m.	over 1,000	325– 0 (V.)	6–12	25×4
			55– 0 (V.)	6–12	50×5
			c. 20– 10 (T.)	8–14	++
77	9 a.m.	over 1,000	c. 20– 10 (T.)	10–14	c. 12
				18 & 19	2
85	9 a.m.	over 400	270– 0 (V.)	15–21	8
			55– 0 (V.)	11 & 21	2
			c. 20– 10 (T.)	17	××
86	12 m	over 400	270– 0 (V.)	15–20	4
			55– 0 (V.)	19	1
			c. 20– 10 (T.)	19	1 seen
87	3 p.m.	331	290– 0 (V.)	19	2
			55– 0 (V.)	.....	0
			c. 20– 10 (T.)	13 & 14	2 seen
				17–20	5 seen

"PRINCE."

3	12 m	200	180– 0 (V.)	19·5	1
			c. 20– 10 (T.)	5·5	1 seen
			2– 0 (T.)	.....	0

In discussing the distribution of this species, it has been thought advisable to distinguish between small and large individuals.

Ritter-Zahony states that in warm water this specie. rarely reaches more than 15mm. in length. As we have both warm and cold water in the area explored, those under 15mm. may show a different distribution from those over 15mm. In the table given above in most cases these two groups have been separated. It must be remembered, however, that this division is quite arbitrary, warm water individuals being occasionally longer than 15mm. and cold-water individuals being of all sizes.

VERTICAL.—Fowler and Ritter-Zahony regard this species as typically epiplanktonic, but extending int othe mesoplankton. Michael, on the contrary, for the San Diego region, states that the species reaches its maximum abundance below 150 fathoms, and that only the immature were taken above 100 fathoms except at night when the larger specimens came up as far as 50 fathoms (1911, p. 150). This contradiction would indicate that different species have been confounded.

The small individuals of the Gulf Stream stations were taken in abundance at or near the surface at 3 p.m. (station 44), 6 p.m. (station 74), and 9 p.m. (station 75), and these hauls contained mature individuals, though small. At station 56, two specimens were obtained in the deep closing-net haul below 250 metres, and forty-two from 250 metres to the surface. The records at station 74 and 75 show that nearly as many (21 as opposed to 35) or more (50 × 5 as opposed to 25 × 4) were obtained from the shallow vertical haul (55 — 0m.) as from the deep vertical haul (325 — 0m.). These facts indicate that the warm-water variety of the Gulf Stream occurs chiefly near the surface, even during the day.

The large individuals of the colder water are to be found in the intermediate water (between Gulf Stream and coastal water) where mixing may be supposed to be going on. The vertical currents that are doubtless present here would tend to bring them nearer to the surface, and so influence the vertical distribution.

The mixing would also tend to give the opposite result, namely, fewer at the surface, when the surface water comes from the cold shallow coastal water, in which *S. serratodentata* does not occur. However, the records show fairly conclusively that these large individuals do come to the surface at least during the night, numbers having been taken near the surface at 9 p.m. (*Acadia* Stations 19, 38, 50), at 12 midnight (*Acadia* stations 39, 46, 51) at 3 a.m. (*Acadia* stations 5 and 16), at 6 a.m. (*Acadia* station 47), and at 9 a.m. (*Acadia* stations 17 and 85). At no stations taken about the middle of the day were large individuals obtained in numbers, yet specimens were taken near the surface at 12 m. (*Acadia* station 86) and at 3 p.m. (*Acadia* stations 72 and 87). At *Acadia* station 50, twenty-seven specimens were caught in the vertical open net from 145 metres to the surface, one in the closing net from 145 to 55 metres, eleven in the open vertical net from 55 metres to the surface, and very many at the surface. This would indicate that at 9 p.m. the bulk of the individuals were above 55 metres. On the other hand, at station 51 almost as many were obtained from 125 to 55 metres as from 125 metres to the surface, so that the data are inconclusive.

In the Laurentian channel at *Acadia* stations 85, 86, and 87, the vertical hauls indicate that it came very near the surface, but was as abundant in the depths as at the surface, or perhaps more abundant. The three stations gave fourteen in the deep hauls, as compared with three in the shallow hauls. This suggests that it is forced into deeper water by the presence near the surface of water of too low a salinity. If it comes to the surface is spite of the unsuitability of the surface water, it will doubtless perish and thus fail to penetrate as far into the St. Lawrence gulf at does *E. hamata*.

Individuals above 15mm. in length were obtained at or near the surface at practically every hour of the day. Taking the stations at which these large individuals were obtained, we have the following positive and negative results for the near surface hauls:—

—	6 a.m.	9 a.m.	12 m.	3 p.m.	6 p.m.	9 p.m.	12 m.n.	3 a.m.
Positive	1	3	1	2	1	3	4	5
Negative	2	0	2	1	0	1	1	0

There can be no doubt that this species is truly epiplanktonic in both cold and warm water, though whether or not it is driven below the surface to any extent by the light during the day is an open question.

HORIZONTAL.—*S. serratodentata* is cosmopolitan, occurring in all oceans except in the far north and the far south. Its most northerly record is 60° 2′ N. and 22° 56′ W.

It extends farther to the north than any of the other epiplanktonic warm water forms. In our area, too, it extends farther inshore than any of the others, being able to withstand the lower temperature and salinity better. It seems to be equally at home in the Gulf Stream and in the cold boreal water next the banks. It grows to a much larger size in the latter, but this difference can scarcely be used for dividing the species into two groups. The presence of individuals above 15mm. in length is indicative of the presence of boreal water, but the presence of small individuals is not necessarily indicative of the presence of Gulf Stream water. Small sexually mature individuals might be indicative of Gulf Stream water, but I have not correlated

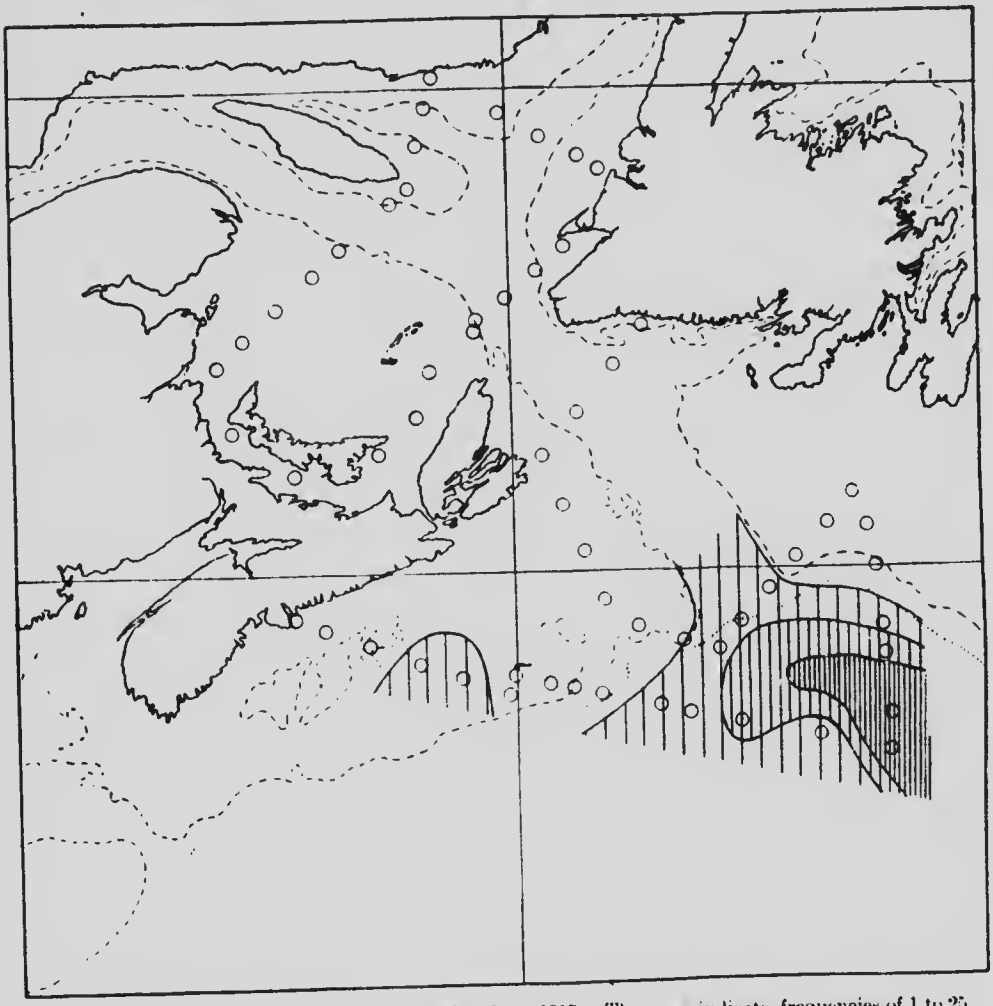

Fig. 5.—Distribution of *S. serratodentata*, May-June 1915. The zones indicate frequencies of 1 to 25, 26 to 100 and 100 and over per station.

distinct from the cold bank water. Fig. 5 shows its distribution during the first cruise of the *Acadia*. It is virtually confined to the deep water off the continental shell, passing upwards over the banks only at stations 5 and 6 on the lower part of Sable sexual maturity with size in my records. Taken as a whole the species is indicative of the extent to which oceanic water (either Gulf Stream or boreal) extends, as

Island bank. The deep water between Sable Island bank and Halifax seems to have been free from it. It can only be considered to have been abundant at the two outer stations (16 and 17), although the lack of uniformity in the hauls renders the point uncertain.

Fig. 6 shows its distribution during the second cruise of the *Acadia*. Owing to the route of the second cruise being different from that of the first, a strict comparison is difficult.

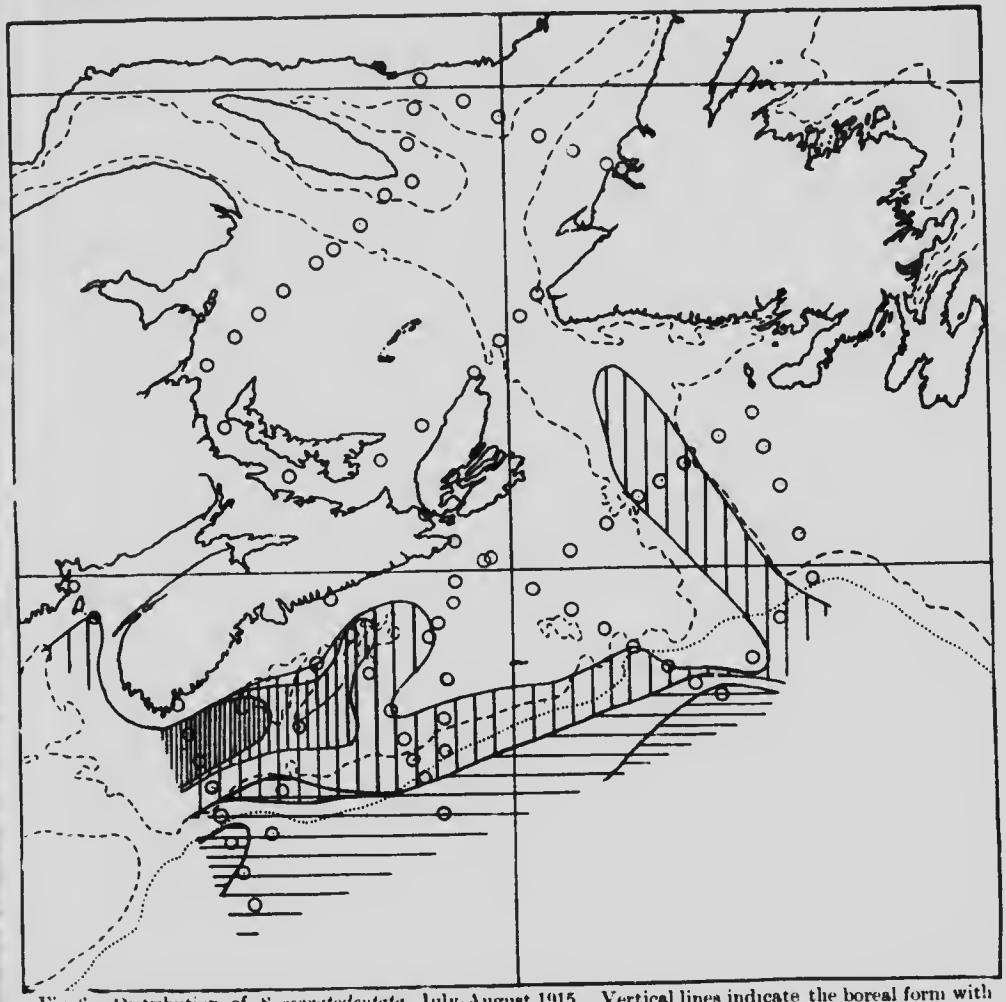

Fig. 6.—Distribution of *S. serratodentata*, July-August 1915. Vertical lines indicate the boreal form with zones showing frequencies of 1 to 25, 26 to 100 and 101 to 300. Horizontal lines indicate the Gulf Stream form with zones showing frequencies of 1 to 50 and 51 to 300.

Several points are noteworthy: first, its presence in quantity in the deep water between Sable Island bank and Halifax; second, its absence on Sable island bank at station 59, where it was present on the first cruise (station 6); and third, its absence at station 76 well out in deep water off the centre of the mouth of the Laurentian channel. The sinuosities in the inner limit of its distribution are much the same in the two cruises, except that they have been shifted toward the west in the second cruise. The species does not seem to have pressed farther in to any appreciable extent

during the intervening two months. With *S. maxima* it extends well up the Laurentian channel as shown at stations 85, 86, and 87 and, like that species it is most abundant on the north side of the channel. The decrease in abundance from north to south across the channel is very evident, for the deep vertical hauls eight, four, and two specimens were obtained at stations 85, 86, and 87, respectively, and for the shallow vertical hauls two, one, and zero specimens for the same stations.

It was not obtained at any of the stations of the *Princess* cruises and, being a surface form, it could scarcely have been missed. It does not therefore extend into the St. Lawrence gulf, doubtless being killed by the cold brackish surface water. Its absence over the banks south of Newfoundland (St. Pierre and Green banks), and over those north of Sable island (Banquereau, Misaine, etc.) and along the Nova Scotia shore is noteworthy as denoting the absence here of oceanic water.

Bigelow has shown that it extends well up into the gulf of Maine, keeping to the deep water near the centre, in July and August of both 1912 and 1913 (1914, p. 121, and 1915, p. 299). Our record of September, 1915, at *Princess* station 3, in the deep water between Grand Manan and Nova Scotia, shows that it extends at least up into the mouth of the Bay of Fundy. It was absent at *Prince* station 2 off Campobello island, farther up the bay. The small number of specimens obtained at *Prince* station 3, and the lateness in the season, indicates that this is its northern limit in the bay.

It may perhaps be possible to delimit pure Gulf Stream conditions as exhibited by this species, when we take note of both size and abundance. This is shown in fig. 6, horizontal lines representing the small variety and vertical lines the large.

The outermost stations gave in the vertical hauls comparatively large numbers of individuals, whose upper limit in length was 13mm. Taking these together with the stations that show similar results and we have the following list of "Gulf Stream" stations: Station 41, 200-0m., 6-9mm., twenty-five specimens; station 42, 250-0m., 7-11mm., sixty-seven specimens; station 44, 270-0m., 7-11mm., twenty-six specimens; station 45, 270-0m., 6-11mm., thirty-two specimens; station 56, 250-0m., 7-9mm., forty-two specimens; station 74, 325-0m., 8-11mm., thirty-five specimens; station 75, 325-0m., 6-12mm., 25 × 4 specimens. The line separating these stations from the others nearly coincides with the outer limit of specimens over 15mm. in length.

There are several stations at which a few small individuals were obtained (station 40, 54, 57, and 70), but the degree of sexual maturity shown by them indicates that they belong to the larger cold water form. A line drawn just inside stations 41, 45, 56, 74, and 75 would separate the warm water form from the cold water form. It must be emphasized, however, that this line cannot be sharp, as there is a transition from one form to the other. A study of the specimens from stations 44, 45, and 46 shows this. At station 44 a maximum size of 12mm. is attained; at station 45, of 15mm.; and at station 46 of 20mm. There is the same gradation in the change from a stout to a slender body and from early to late maturity.

Its absence at *Acadia* stations 59 and 76, where numbers of *S. elegans* were obtained indicates that at these points definite tongues of coastal water extend out into the boreal or mixed water, which doubtless come from the mass of coastal water present over and between the banks north of Sable island. These two tongues are shown in fig. 6. On the earlier cruise of the *Acadia* these two tongues are fused as shown in fig. 5, this species not ocurring at *Acadia* stations 6 to 10. The distribution of *S. elegans* during the same cruise (fig. 8) shows the two tongues but they are close together.

On neither cruise is there any indication that the cold coastal water of the Newfoundland banks (where *S. serratodentata* was not found) has to any extent flowed out from the banks into the water outside the continental shelf, but it does appear that the water north of Sable island has done so.

Though the quantitative data as to the distribution of this species are incomplete, the centre of abundance during the first cruise of the *Acadia*, as shown in fig. 5, was

definitely at the outermost stations (16 and 17). It decreased in abundance to the north and to the west (perhaps also to the south). This perhaps indicates that surface boreal water was at that time coming around the southern side of the Newfoundland banks.

This area was not explored during the second cruise. The distribution at that time, as shown in fig. 6, would indicate the presence of very little surface boreal water south of the Newfoundland banks, probably owning to the pressing in of the surface Gulf Stream water. The centre of abundance at this time was off the lower end of Nova Scotia, where no stations were taken on the first cruise. Whether the animals were transported to this point from the north during the intervening two months or not must remain problematical, although the direction of the known surface currents in these waters would support such a view.

The rarity of *S. serratodentata* in north European waters as recorded by Ritter-Zahony (1910, p. 2) and Apstein (1911, p. 174) is remarkable. It is rare even in the open Atlantic off Ireland. Its occurrence on one occasion in the deep water of the Skager-Rock, and only at a depth of 150 metres or more (Apstein) indicates a restriction to the deep salt water on the rare occasions when it is carried into the North sea.

(*f*) **Sagitta bipunctata**, Quoy et Gaimard.

1911. Ritter-Zahony, p. 19.

"ACADIA."

Station No.	Hour.	Depth (metres)	Depth of Haul (metres).	Length (mm.).	Number.
44	3 p.m.	Over 1,000	270-0 (V.).	12 & 15	2
.			(O. T.)	12-15	5

This species was obtained only at the southernmost station of the second cruise of the *Acadia*, at station 44 (fig. 1, horizontal dotted lines). It occurred in both surface and open-net vertical hauls. It is a tropical surface form, but extends well north in the Atlantic. Owing to its confusion with other species the records of its occurrence are untrustworthy.

It was obtained by Bigelow in July-August, 1913, only in his more southern and outer stations south of cape Cod.

(*g*) **Sagitta elegans** Verrill. Fig. 7.

1911. Ritter-Zahony, p. 17 and figs. 1-3.

This is the characteristic *Sagitta* of our Atlantic waters, from its general occurrence in the shallow water all along the coast.

The range in size is from 2 to 52mm. in length. Ritter-Zahony divides the species into three subspecies, of which two, *elegans* and *arctica*, would be represented here. As these are not distinct but are connected by intermediates, I have not thought it worth while to consider them separately. The differences between the two are similar to the differences between the two types of *S. serratodentata* and are no doubt due to the same cause, namely, difference in temperature during development. It is interesting to note that the only place where individuals longer than 36mm. were found, was in the Bay of Islands. In that place there is an extensive layer of water below the freezing point, from about 50 fathoms to as much as 150 fathoms deep. Such an extreme condition was not found elsewhere, and approaches the conditions in the Arctic regions.

Ritter-Zahony gives the upper limit of *S. elegans* as 30mm. and of *S. elegans arctica* as 44mm. Our measurements would indicate that *S. elegans* reaches a length of 36mm. (an individual from the Bay of Fundy, which is almost in the region from which the species was first described, measured 35mm.), and *S. elegans arctica* a length of 52mm.

The majority of the larger specimens are sexually mature, but even some of the largest are immature. The size at which maturity is attained apparently varies with the region. No measurements of the sexual organs were made, but on examining material from a number of points and observing the state of the ovaries and seminal

Fig. 7.—Sagitta elegans. x 4.

vesicles it was seen that in the Bay of Islands *No. 33* station 57), the sexual organs were maturing only when a length of 30mm. was reached (but even as low as 22mm. in a catch by the young fish trawl); northern part of gulf (*Princess* station 16), 23mm.; middle part of gulf (*Princess* station 33), 23mm.; southern part of gulf (*Princess* station 25), 20 mm.; southern coast of Newfoundland (*Acadia* stations 20, 35, 83), 24mm.; off northern end of Nova Scotia (*Acadia* stations 67 and 90), 25 mm.; off southern part of Nova Scotia (*Acadia* station 38), 24mm.; in the Bay of Fundy, (*Prince* station 1), 22mm. At *Prince* station 3 at the mouth of the Bay of Fundy, the specimens even as large as 35mm. had immature ovaries. Other factors are doubtless involved.

The subject demands much more extensive investigation than the present opportunity affords, but from the cursory examination made, it would appear that in warmer water the species matures at a smaller size, as is seen very definitely to be the case with *S. serratodentata.*

The southern gulf specimens in early maturity approach the Baltic subspecies, *S. elegans baltica.* It is rather difficult to say what is the upper limit in size in this area, owing to the currents bringing outside individuals into the area. As the chief current sweeps across this part of the gulf from west to east, the individuals of the eastern side are perhaps most representative. In June, at *Princess* station 26 the largest individual was 25mm. long, at station 25, farther north, 32mm. long. In August at *Princess* station 50, the largest was 20mm. long; at station 49, 20mm. long, and at station 48, 23mm. long. In June, at *No. 33* stations 4-15 (all in this same area between Prince Edward, Cape Breton, and Magdalen Islands) the largest individuals were 26mm. long. This (26) may be considered as the maximum size for individuals that have grown up in the area (the larger ones at *Princess* station 25 may well have been carried in from without. In the Bay of Fundy at *Prince* station 3 the maximum size was 35mm. In the Bay of Islands at *No. 33* stations 57 and 59 the maximum was 45mm. (at station 57 a very large number were obtained with the young fish trawl, and among these one individual 52mm. long was seen).

The maximum size therefore varies with the temperature, being higher in colder water.

S. elegans baltica, according to Ritter-Zahony, has from eight to ten jaws on each side, the number being largest in specimens of medium size (about 16mm.). In *S. elegans elegans,* the number is from eight to eleven, with probably no decrease in older individuals. In *S. elegans arctica,* the number is from eight to twelve, with apparently no decrease in older individuals.

Counts were made to determine whether a difference could be detected in this respect between the Bay of Islands specimens and those from the Lower Gulf.

BAY OF ISLANDS (NO. 33 STATION 57.)

Length (mm.).	No. of Jaws.	Length (mm.)	No. of Jaws.
20	11-12	39	11-11
21	10-11	40	12-12
22	12-12	40	12-12
24	10-10	40	12-12
24	11-11	40	13-13
25	12-12	42	12-12
25	12-12	43	12-12
26	12-12	44	12-12
28	12-12	46	13-13
29	11-11	49	9-10
35	13-13	52	10-11

BAY OF ISLANDS (No. 33 STATION 54.)

Length mm.).	No. of Jaws.	Length (mm.)	No. of Jaws.
13..	9-9	15	8-9
14	10-10	15	10-11
14	10-11		

LOWER GULF. (PRINCESS STATION 25.)

Length (mm.).	No. of Jaws.	Length (mm.)	No. of Jaws.
22	11-11	26	12-12
24	11-11	27	11-11
24	12 12	27	11-11
25	11-11	30	12-12

LOWER GULF. (PRINCESS STATION 50.)

Length (mm.).	No. of Jaws.	Length (mm.)	No. of Jaws.
9	9-9	14	10-10
11	9-10	15	10 11
14	10-10		

So far as can be seen, the number of jaws is dependent upon the size, irrespective of the degree of maturity. Only in the very largest individuals is there any indication of the decrease in number that is so characteristic of certain other species.

The number of jaws is therefore proportional to the size, and becomes greater in the colder water.

The subspecies *S. elegans baltica* Ritter-Zahony (1911, p. 18) differs from both the typical and arctic subspecies in having a relatively shorter tail, that is, its tail percentage (the percentage of the length of the tail in the total length) is less. It seemed likely that this character would show differences characteristic for each region and that the Lower Gulf specimens would approach the Baltic type. To test this, in the first place a series of small individuals from 11 to 16.5 mm. long, taken in July and August at different poins, were studied. There were none available from the Bay of Fundy. The results were as follows:—

BAY OF ISLANDS (No. 33 STATION 54).

Length (mm.).	12	12·5	13	13·5	14	15	15·5	16
Tail percentages	19	19	18	19	19	19	18	19
	19	20	19	19	21			
	21		20	20				

South Coast of Newfoundland ("Acadia" Station [illegible])

Length (mm.).	12·5	13	13·5	14	15	15·5	16·5	
Tail percentages		19	18	18	20	19	17	18
		20	18					..
		21	18					..

Outer Coast of Nova Scotia ("Acadia" Station 37).

Length (mm.).	11	11·5	12·5	13	15	16	16·5
Tail percentages	20	20	18	19	19	19	18
					19		18
							19

Southern Part of Gulf. ("Princess" Station 48).

Length (mm.).	11	12·5	14·5	15	15·5	16	16·5
Tail percentages	18	18	17	17	18	18	17
		20	18	18	19	18	17
			19				18

The differences shown in the above tables are very slight. The Bay of Islands specimens have, on the whole, the highest tail percentage, and the southern gulf specimens the lowest. Larger individuals show more marked differences. A series from 21 to 27mm. were taken from three localities: (1) Bay of Islands (*No. 33* station 57) with icy cold bottom water doubtless throughout the year; (2) Bay of Fundy (*Prince* station 3) with moderately cool water throughout the year; and (3) the southern part of the gulf (*Princess* station 25) with water very warm in summer and very cold in winter.

The tail percentages for the different sizes are given in the following tables:—

Bay of Islands (No. 33 Station 57).

Length (mm.).	21	22	23	24	25	26	27
Tail percentages	20	20	22	19	20	20	19
	20	...	22	21	20	19	20
			20	20	20	19	20
				21	20	...	20
		...	...	...	19	...	...
	...		...		21	...	...
			...		20	...	...

BAY OF FUNDY. (PRINCE STATION 3).

Length (mm.).	21	22	23	24	25	26	27
Tail percentages	17	16	17	17	17	18	17
	18	18	17	17	19	19	19
	17	16	.....	18	18	17	17
	18	17	.....	.....	19	17	17
	17	16	.....	.....	16	18	17
	.....	18	.....	.....	19	18	17
	.....	.....	.....	.....	17	17	19
	.....	.....	.....	.....	.....	20	19
	.....	.....	.....	.....	.....	18	.....
	.....	.....	.....	.....	.....	17	.....
	.....	.....	.....	.....	.....	17	.....
	.....	.....	.....	.....	.....	18	.....
	.....	.....	.....	.....	.....	19	.....

SOUTHERN PART OF GULF. (PRINCESS STATION 25).

Length (mm.).	21	22	23	24	25	26	27
Tail percentages	16	15	17	15	16	16	16
	16	15	16	16	16	18	16
	17	15	17	14	.....	17	.....
	16	16	19	15	.....	16	.....
	.....	17	18	18	.....	19	.....
	.....	15	.....	16	.....	18	.....
	.....	16	.....	.....	.....	15	.....
	.....	.....	.....	.....	.....	18	.....

The general result is that for the Bay of Islands the percentage varies from 19 to 22, with the greatest number at 20; for the Bay of Fundy, from 16 to 20, with the greatest number at 17; and for the lower part of the gulf from 14 to 19, with the greatest number at 16. The individual sizes show similar gradations.

We have very little knowledge as to the conditions under which these forms grow, and as to their life-histories, but the greater differences in tail percentages shown by the larger individuals is, I think significant.

As will be shown farther on, the young individuals occur much nearer the surface than do the older ones. This surface water becomes quite warm in the summer throughout the region (except in the Bay of Fundy, from which we have no specimens) so that conditions are much the same for the young in all the regions and as a result, the tail percentages do not greatly differ. The older individuals seek the

deeper water and have lived long enough to experience the totality of conditions characteristic of the several regions, and consequently exhibit greater differences.

The next point is: do the cold-water individuals ever attain as low a tail percentage as those of warm water? Large individuals from the Bay of Islands show the following:—

BAY OF ISLANDS. (No. 33 STATION 57).

Length (mm.).	Tail percentage.	Length (mm.).	Tail percentage
30	20		
31	18	44	17, 17
39	18, 20	46	17
40	18, 18, 19, 19, 19	49	17
42	19	52	19

Above 40mm. in length the Bay of Islands specimens reach a tail percentage (17) equal to that of specimens between 20 and 30mm. in length from the Bay of Fundy. They would appear never to reach as low a tail percentage as do those of the lower gulf.

The tail percentage is seen to be a function of the degree of maturity, although the cold water seems to delay the decrease in tail percentage more than maturity.

The general result is definite. The Bay of Islands provides conditions suitable for the Arctic type, the lower part of the St. Lawrence gulf furnishes a type approaching that found in the Baltic sea, and the remainder of the region shows the intermediate type or the typical *S. elegans*.

DISTRIBUTION.

"ACADIA."

Station No.	Hour.	Depth (metres).	Depth of Haul (metres).	Length (mm.).	Number.
2	12 m	60	50–25 (C.)	15–31	28
			20–0 (V.)	25	1
3	3 p.m	99–144	100–50 (C.)	15	1
				19–31	62
			30–0 (V.)	22–29	4
			0 (T.)		0
4	9 p.m	171	150–100 (C.)	12–30	46
			80–40 (C.)	20–27	20
			30–0 (V.)	15–30	15
	3 a.m	72	60 0 (V.)	10	1
			0 (T.)	13–24	6+7×2

"ACADIA"—*Continued.*

Station No.	Hour.	Depth (metres).	Depth of Haul (metres).	Length (mm.)	Number.
6	6 a.m.....	45	40–0 (V.).....	12–26	8
			0 (T.).....	10–23	9
7	12 m.....	108	0 (T.).....	c. 15	2
8	12 m.....	50	50 (?)–0 (V.).....	6	1
				12	1
				17–25	11
			0 (T.).....	25	1
9	6 p.m.....	104	25–0 (V.)	16	1
			0 (T.).....	.....	0
10	9 p.m.....	732	0 (T.).....	17 & 20	2
11	12 m.n.....	over 2,000	70–0 (V.).....	12 & 13	2
				15–20	6
			0 (T.).....	21	1
12	6 a.m.....	over 2,000	100–0 (V.).....	14	1
				19	3
				20–30	41
			0 (T.).....	27	1
13	9 a.m.....	over 2,000	70–0 (V.)	11–24	6
14	3 p.m.....	over 2,000	200–0 (V.)	20	1
			0 (T.)	.....	0
15	9 p.m.....	over 2,000	100–0 (V.)..	20	1
			0 (T.)..	.....	0
16	3 a.m.....	over 2,000	200–0 (V.)..	30	1
			0 (T.)	15 & 19	2 seen
20	12 m. n.....	90	0 (T.)..	11–26	35
? 23	12 m.....	99	70–0 (V.)	4	2
			0 (T.)	.....	0
25	6 p.m.....	122	120–0 (V.)..... ...	11–30	30
			10(?)–0 (T.)..... ...	.....	0
26	12 m. n.....	over 400	100–0 (V.)..	11	1
				18–30	107
			0 (T.).....	17–32	+ +
27	3 a.m.....	over 400	0 (T.)...	15–30	+

"ACADIA"—*Continued.*

Station No.	Hour.	Depth (metres).	Depth of Haul (metres).	Length (mm.)	Number.
28	6 a.m.	over 400	100–25 (C.)	14–28	100
			0 (T.)	15–25	×
29	12 m.	57	55–0 (V.)	17 & 22	2
			0 (T.)		0
30	3 p.m.	126	120(?)–0 (V.)	21	1
			0 (T.)		0
31	9 p.m.	82	75(?)–0 (V.)	12–31	28
			0 (T.)	c. 20	×
32	12 m. n.	153	100–25 (C.)	14–30	130
			0 (T.)	15–32	c. 50
34	9 a.m.	circa 360	100–0 (V.)	16–34	28×5
			0 (T.)		0
35	12 m.	circa 450	125–25 (C.)	14–32	102×2
			0 (T.)	15–24	c. 15
36	3 p.m.	226	100–15 (C.)	26	1
			0 (T.)	18	1
37	6 p.m.	62	60–20 (C.)	8–17	12
				20–30	120
			60–0 (V.)	4–10	31×5
				8–16	120
				20–30	190
			20–0 (V.)	8·5 & 14	
				20–27	5
			0 (T.)	5–19	+ +
				20–23	×
38	9 p.m.	170	150–0 (V.)	7–19	22+15×10
				20–30	115
			100–0 (V.)	5–19	70+63×10
				20–31	104
			0 (T.)	5–16	+
				21–22	×

"ACADIA"—*Continued.*

Station No.	Hour.	Depth (metres).	Depth of Haul (metres).	Length (mm.)	Number.
39	12 m. n.....	95	100–0 (V.).....	7–18	28×10
				20–30	35
			25–? (V.).....	6–12	30×5
				7–15	18
				20–26	7
			0 (T.).....	7–14	+
				20–30	×
40	3 a.m.....	134	125–0 (V.) I.....	12–16	4
				20–25	12
			125–0 (V.) II.....	15	2
				20–30	11
			0 (T.)...	small	?
47	6 a.m.....	140	125–0 (V.).....	8–19	122+2×10
				20 & 22	2
			90–0 (V.)...	8–19	c. 100
			0 (T.)....	... .	0
48	12 m.....	248	270–0 (V.).....	20–30	7
			45–0 (V.)...	....	0
			0 (T.).....	.....	0
49	3 p.m.....	126	125–0 (V.) I..... ...	7–12	82×5
				9–20	175
				23–31	6
			0 (T.).....	6–13	+
50	9 p.m.....	151	145–55 (C.).....	11–13	3×5
				12–20	225
				21–26	9
			145–0 (V.).....	9–17	35×5
				9–20	124×3
				21–28	8
			55–0 (V.)..	9–14	27×5
				7·5–20	164
			0 (T.).....	7–15	+
51	12 m. n....	131	125–55 (C.) .	5–14	76×5
			125–55 (C.).....	11–19	257
				21–25	3

"ACADIA"—*Continued.*

Station No.	Hour.	Depth (metres).	Depth of Haul (metres).	Length (mm.)	Number.
			125–0 (V.)	10–17	86×5
				9–19	96
				28	1
			0 (T.)	8–20	++
52	3 a.m.	99	90–0 (V.) II	13–20	9
			0 (T.)	13–18	14
53	6 a.m.	95	90–0 (V.)	8–13	7×5
				13–15	13
			0 (T.)	10–11	×
54	9 a.m.	over 1,000	270–0 (V.)	30	2
			125–0 (V.)		0
			0 (T.)		0
59	3 a.m.	45	45–0 (V.)	6-12·5	21×10
			0 (T.)	10–14	+
60	6 a.m.	99	90–0 (V.)	13	1×5
			0 (T.)	small	×
61	[illegible]	72	0 (T.)	4–10	×
62	12 m.	61	55–0 (V.) II	7–9	18×10+8×40
				10–19	137
			0 (T.)	7–9	××
63	12 m.	53	55–0 (V.)	8–16	44+31×15
				20–25	4
			0 (T.)	6	×
65	6 p.m.	90	110–0 (V.)	5–17	30+41×4
				18–19	3
				21–33	50
			90–0 (V.)	5–15	75+50×5
				19	1
				22–36	16
			0 (T.)	6–11	++
				[illegible]	×
66	9 p.m.	63	55–0 (V.) II	6–14	90×4
				25–29	3
			0 (T.)	7–14	++

"ACADIA"—*Continued.*

Station No.	Hour.	Depth (metres).	Depth of Haul (metres).	Length (mm.)	Number.
67	12 m.a.....	198	190–0 (V.).....	8–15	109×10
				20–34	20
			90–0 (V.).....	8–14	c. 100+184×5
				21–28	10+2×5
			0 (T.).....	8–15	++
68	3 a.m.....	53	45–0 (V.) II.....	8–20	63
			0 (T.).....	10–13	6
			5–0 (T.).....	10–12	6
69	9 a.m.....	68	60–0 (V.) I.....	11–14	4
			5–0 (T.).....	.....	0
			c. 20–10 (T.).....	.....	0
72	3 p.m.....	over 1,000	325–0 (V.).....	11	1
				18–20	3
			55–0 (V.).....	.....	0
			c. 20–10 (T.).....	.....	0
76	3 a.m.....	over 1,000	270–0 (V.).....	11–18	8+4×4
				20–24	12
			c. 20–10 (T.).....	13–16	××
79	12 m.....	360	325–0 (V.).....	6–11	33×10
				8–15	16
				21	1
			55–0 (V.).....	6–9	18
80	3 p.m.....	168	145–0 (V.).....	8–11	29×20
				9–18	82×4
				21–30	15
			55–0 (V.).....	7·5–18	131×4
				20 & 22	2
			c. 20–10 (T.).....	8–15	++
				17	×
81	9 p.m.....	60	55–0 (V.).....	6–13	44×10
				10–16	201
				22	1
			c. 20–10 (T.).....	10–15	++
82	9 p.m.....	60	55–0 (V.) I.....	9–14	7×4
			c. 20–10 (T.).....	12	1

"ACADIA"—*Continued.*

Station No.	Hour.	Depth (metres).	Depth of Haul (metres).	Length (mm.)	Number.
83	12 m.n.....	172	160–0 (V.).....	8–15	14×40
				17	1
				20–29	8
			55–0 (V.).....	7–15	90×4
				17 & 19	2
				21–24	3
			c. 20–10 (T.).....	7–15	+
84	6 a.m.....	60	55–0 (V.) I.....	9–15	21×5
			c. 20–10 (T.).....	8–14	++
85	9 a.m.....	over 400	270– 0 (V.).....	8–14	12
				19 & 20	2
				25–30	9
			55–0 (V.).....	8–16	11
			c. 20–10 (T.).....	15	×
				20–30	×
86	12 m.....	over 400	270–0 (V.).....	7–11	24×10
				12–19	100
				21–26	9
			55–0 (V.).....	6–16	9×10
			c. 20–10 (T.).....	7–15	× ×
87	3 p.m.....	331	290–0 (V.).....	7–10	6×10
				12–19	29
				23–27	8
			55–0 (V.).....	6–9	5×5
				6·5–17	43
			c. 20–10 (T.).....	6–15	+
				17	×
88	6 p.m.....	130	110–0 (V.).....	6–15	92
			55–0 (V.).....	6–14	86
			c. 20–10 (T.).....	6–15	+ +
89	9 p.m.....	132	115–0 (V.).....	6–14	19+107×5
				22–34	124
			55–0 (V.).....	6–14	113×5
				20–29	61
			c. 20–10 (T.).....	6–14	+
				20–29	+

"ACADIA"—*Concluded.*

Station No.	Hour.	Depth (metres).	Depth of Haul (metres).	Length (mm.).	Number.
90	12 m.n.	c. 60	c. 20–10 (T.)	11·2	×
				20–30	c. 100
91	(?)	c. 45	45–0 (V.)	7–13	17×20
			"PRINCESS."		
1	9 a.m.	68	(?)	14	1
				11–22	22
			(?)	11–22	c. 25
2	3 p.m.	45	(?)	c. 15	×
3	12 m.	20	20–0 (V.)	16	1
			0 (T.)		0
5	9 a.m.	32	30–0 (V.)	4–6	7×5
			0 (T.)		0
6	12 m.	57	60–0 (V.)	6	2
			0 (T.)	4–5	5×6
7	3 p.m.	80	80–0 (V.)	6	2×3·5
			0 (T.)	c. 6	×
8	9 p.m.	80	80–0 (V.)	17–27	13
			40–0 (V.)	28	1
			0 (T.)	10	1 seen
				15–26	c. 40
9	12 m.n.	over 200	100–0 (V.)	15–30	21
			80–0 (V.)	15–30	23
			0 (T.)	15–30	c. 30
10	6 a.m.	over 200	100–0 (V.)	25–33	30
			0 (T.)	15–18	3 seen
11	9 a.m.	48	50–0 (V.)	25–30	9
			0 (T.)		0
15	9 a.m.	90	80–0 (V.)	11–14	4
			0 (T.)		0
16	12 m.	over 250	100–0 (V.) II	16–31	26
			0 (T.)	28	1
17	6 p.m.	130	100–0 (V.) I	21	1
			100–0 (V.) II		0
			0 (T.)		0

"PRINCESS"—*Continued.*

Station No.	Hour.	Depth (metres).	Depth of Haul (metres).	Length (mm.).	Number.
18	9 p.m.	63	50–0 (V.)	23	1
			0 (T.)		0
19	3 a.m.	81	80–0 (V.)	19–32	55×4
			0 (T.)		0
20	6 a.m.	over 200	100–0 (V.)	15–32	67
			0 (T.)	17 & 22	2 seen
21	9 a.m.	over 400	100–0 (V.)	15–32	176
			0 (T.)	16	1
23	3 p.m.	115	100–0 (V.)	20–31	14
24	9 a.m.	40	35–0 (V.) I.	16	1
			35–0 (V.) II.	c. 4	4
			0 (T.)		0
25	12 m.	68 (?)	60–25 (C.) I.	20–30	14
			60–25 (C.) II.	20–30	24
			60–0 (V.) I.		22
			60–0 (V.) II.	20–32	35
			0 (T.)	7	1
26	3 p.m.	39	40–0 (V.) I.	17–20	5
			40–0 (V.) II.	15–25	12
			0 (T.)		0
29	6 a.m.	32	20–0 (V.)	5–13	23×5
			c. 20–10 (V.)		0
30	12 m.	66	60–0 (V.)	10–21	15
				small	9×5
			30–0 (V.)	6–15	3×5
			c. 20–10 (T.)	small	×
31	3 p.m.	65	60–0 (V.)	3–11	23×5
			30–0 (V.)	6–9	11
			c. 40–0 (T.)	2–8	×
32	6 p.m.	87	80–0 (V.)	5	2×10
				10 & 15	2
			30–0 (V.)	6–8	16
			c. 40–0 (T.)		×

"PRINCESS"—*Continued.*

Station No.	Hour.	Depth (metres).	Depth of Haul (metres).	Length (mm.)	Number.
33	9 p.m.	78	80–0 (V.)	10–18	26×10
				20–30	17
			30–0 (V.)	7–26	164
			c. 40–0 (T.)		+
34	12 m. n.	405	130–0 (V.)	8	1×10
				12–19	6
				20–29	13
			30–0 (V.)	9–28	17
			c. 40–0 (T.)	20–30	c. 50
35	6 a.m.	over 350	130–0 (V.)	8–20	19
				20–26	23
			30–0 (V.)	10–20	12+4×4
			c. 40–0 (T.)	10–17	+ +
36	9 a.m.	48	60–0 (V.)	6–16	28+39×4
			c. 40–0 (T.)	6–16	+
				30	1
37	12 m.	75	80–0 (V.)	6–12	10×4
				8–20	32
				25 & 29	2
			30–0 (V.)	6–17	42
			c. 40–0 (T.)	6–21	+
38	6 p.m.	180	130–0 (V.)	6–16	120+12×4
			40–0 (V.)	6–15	64
			c. 40–0 (T.)	6–16	+
39	9 p.m.	284	130–0 (V.)	6–15	108+13×4
				20–26	7
			40–0 (V.)	6–14	24
			c. 40–0 (T.)	6–16	+
40	12 m. n.	68	70–0 (V.)	6–15	59
				26	1
			30–0 (V.)	small	76
				10–23	22
			c. 40–0 (T.)		+

"PRINCESS"—*Continued.*

Station No.	Hour.	Depth (metres).	Dept[h] of Haul (metres).	Length (mm.)	Number.
41	3 a.m.	189	130-0 (V.)	6-15	155
			30-0 (V.)	7-15	116
			c. 40-0 (T.)	6-15	+ +
42	9 a.m	90	100-0 (V.)	7-10	18
			30-0 (V.)	6-12	26
			c. 40-0 (T.)	6-14	+ +
43	12 m.	265	130-0 (V.) I	6-13	49
			30-0 (V.) I	5-9	5
			30-0 (V.) II	7	1
			c. 40-0 (T.)	7	11
44	3 p.m.	157	130-0 (V.)	6-17	192×4
			30-0 (V.)	6-16	64×4
45	3 a.m.	375	130- 0(V.)	12-21	170×8
				24-30	8
			30-0 (V.)	6-20	110×8
				26	2
			c. 40-0 (T.)		+ +
46	6 a.m.	over 400	130-0 (V.)	8-20	90×5
				21-32	13
			30-0 (V.)	8-17	60×4
			c. 40-0 (T.)	c. 13	× ×
47	9 a.m.	over 400	130-0 (V.) I	5-18	110×4
				23 & 26	2
			30-0 (V.)	6-15	102
			c. 40-0 (T.)	c. 12	+ +
48	12 m.	171	130-0 (V.)	6-18	80
				22-26	4
			30-0 (V.)	6-18	50×4
			c. 40-0 (T.)	c. 15	+
49	6 p.m.	70	70-0 (V.)	6-16	42×10
			30-0 (V.)	6-20	52×4
			c. 40-0 (T.)	c. 12	+
	12 m. n.	52	40-0 (V.) I	6-20	148×4
			c. 40-0 (T.)	c. 15	+ +

"PRINCESS"—*Continued.*

Station No.	Hour.	Depth (metres).	Depth of Haul (metres).	Length (mm.).	Number.
4	3 p.m	45	2–0 (T.)	12	1
6b	3 p.m.	c·30	2–0 (T.)	22	1
9	12 m	10	2–0 (T.)	19–24	5
10	3 p.m	39	2–0 (T.)		0
			35–25 (C.)	16–26	32
			25–10 (C.)	14	1
			10–0 (V.)		0
11	6 p.m	59	2–0 (T.)	5	1
12	9 p.m	67	2–0 (T.)	3–6	6
				13	1
13	9 p.m	39	3–0 (T.)	10–22	c·50
14	12 m.n	58	3–0 (T.)	10–26	++
15	6 a.m	38	2–0 (T.)	15	1
19b	6 p.m	90	2–0 (T.)	6	1
23	12 m.	355	340–145 (C.)		0
			100–60 (C.)	20	1
				23–32	29
			45–0 (V.)	15–22	5
			0 (T.)		0
26	9 a.m	389	30–15 (T.)	6	1
				16	1
			2–0 (T.)		0
29	6 p.m	41	3–2 (T.)	6	×
36	6 p.m.	60	20–8 (T.)	6–10	×
40	?	38	c·9 (T.)	6–10	×
48	6 p.m.	?	40–0 (T.)	10–19	c. 100
49	6 p.m.	?	15–0 (T.)	5	1
54	9 a.m	110	70–35 (T.)	11–16	++
			25–5 (T.)	11–16	++
57	3 p.m	210	200–0 (V.)	9–15	12+51×10
				27–33	31
				42	1
58	12 m	50	40–0 (T.)	10–12	+

"PRINCESS" *Concluded.*

Station No.	Hour.	Depth (metres).	Depth of Haul (metres).	Length (mm.)	Number.
59	12 m	275	270-0 (V.)	10-16	106×10
				17-45	70
64	8 a.m	?	80-20 (T.)	11-16	1×2
67	?	?	30-0 (T.)	11	+
68	6 p.m	?	70-20 (T.)	10-30	++
69	3 a.m	?	100-20 (T.)	10-30	+
70	3 p.m	?	8-2 (T.)	13-15	c. 6
			"PRINCE."		
1	3 p.m	c. 38	c. 35-0 (V.) I	....	0
			c. 35-0 (V.) II	....	0
			c. 20-10 (T.)	18-30	41
			0 (T.)		5
2	6 p.m	c. 100	100-0 (V.)	22-28	9
			4-2 (?) (T.)	....	0
3	12 m	180	180-0 (V.)	18-35	98
			c. 20-10 (T.)	9	1 seen
			2-0 (T.)	....	0
4	6 p.m	c. 35	c. 35-0 (V.)	23 & 27	2
			15-5 (T.)	26	1

VERTICAL.—So many factors are involved in the vertical distribution of this species that a discussion of particular stations is necessary. At *No. 33* station 23 in the deep water off Anticosti island no specimens were obtained in the closing-net haul between 340 and 145 metres. Between 100 and 60 metres, one specimen 20mm. long and twenty-nine over 23mm. long were obtained. Between 45 and 0 metres there were five specimens all 22 mm. or under in length, and at the surface none were obtained. These hauls were made about midday (1-2p.m.). The larger specimens were all below 45 metres, the intermediate specimens above 60 metres but not at the surface. No specimens were in the deep saline water. No small specimens were present.

At *No. 33* station 10 off the eastern side of Prince Edward Island in shallow water, the closing haul from 35 to 25 metres gave thirty-two specimens over 16mm. in length. The haul from 25 to 10 metres one specimen 14mm. long; and the hauls from 10 to 0 metres and at the surface, none. These hauls were made about 3 p.m. The larger were in the cold bottom water below 25 metres, and there were none above 10 metres.

In the Bay of Islands at *No. 33* station 54 the tow hauls which were presumed to go as deep as 70 metres brought up an abundance of this species, but all the individuals were 16mm. or less in length. At practically the same spot at *No. 33* station 55, the young-fish trawl brought up from the bottom (about 110 metres deep) an abundance of large individuals (23 to 43mm. in length.) Here again the larger individuals were wholly confined to the cold bottom water below 70 metres, and there was an abundance of small individuals above 25 metres. The time of day was between 9 and 10 a.m.

At *No. 33* station 57 in the Bay of Islands where the depth was 210 metres with moderately saline water below the freezing point quite to the bottom, the young-fish trawl, which was towed along the bottom, brought up an abundance of large individuals between 21 and 52mm. long. These were thoroughly mixed with typical bottom forms (shrimps and Amphipods) so that there can be little doubt but that they were near the bottom. It is at least probable that in the Bay of Islands the larger individuals go down into the deepest water, for example, 270 metres at *No. 33* station 59. More definite information is desirable on this point. There would thus be a marked difference in the vertical distribution depending upon the character of the water. Where proper conditions of salinity and temperature obtained, the species goes far into the depths, but if not, it is restricted to the suitable intermediate layers.

As in the case of *Eukrohnia hamata*, the hauls made in the Bay of Fundy at *Prince* stations 1, 2 and 3 showed the effect of the vertical currents due to the tides. At station 1 where the species was so rare as not to be taken in either of two vertical hauls, the tows taken near or at the surface yielded 46 large specimens. At stations 2 and 3 it was obtained in numbers in the vertical hauls, but failed to occur in the tows, except one small individual in the deep tow at station 3.

Vertical currents doubtless explain many of the irregularities appearing in the vertical distribution elsewhere.

Owing to differences due to this and other factors, it is very difficult to determine what effect light has on the vertical distribution of this species. If we divide the twenty-four hours into three-hour intervals, and designate these by their mid-points, 6 a.m. representing from 4.30 to 7.30 a.m., and others similarly, and then put together the records for each three-hour period, we can to some extent overcome the influence of the other factors. The stations on the first cruise of the *Acadia*, at which this species was obtained, give the following result as to its presence or absence in the surface hauls: 9 a.m., one negative; 12 m., two negative, 3 positive; 3 p.m., three negative, one positive; 6 p.m., two negative; 9 p.m., one negative, two positive; 12 midnight, four positive; 3 a.m., three positive; 6 a.m., two positive. It is noteworthy that large numbers were obtained in the surface hauls only for 12 midnight and 3 a.m. From this we conclude that *S. elegans* comes to the surface from 9 p.m. to 3 a.m., occurring there

in numbers about the middle of that period. From 9 a.m. to 6 p.m. it seeks a lower level. The individuals obtained on this cruise were of large size.

The *Princess cruise* (stations 3 to 26) gives similar results, but the figures require analysis: 9 p.m. and 12 midnight show many large individuals at the surface (stations 8 and 9; 6 a.m. shows several only (stations 10 and 20). For some reason the single 3 a.m. station (19) is negative. From 9 a.m. to 6 p.m. the stations are negative or show only small individuals (9 a.m., 16mm.; 12 midnight, 5-7mm.; 3 p.m., 6mm.); but there is a single exception at station 16, where one large individual was obtained.

The specimens from the second cruise of the *Acadia* (stations 37 to 90) have been divided into two groups, those under and those over 20mm. in length. The larger group is represented in surface hauls in only three instances. A few specimens were obtained in the surface hauls of the first three stations, at 6 p.m., 9 p.m., and 12 midnight. The largest individuals were obtained at the midnight station. In the deeper tow hauls of the latter part of the cruise, they were obtained in only three instances; occasional in one at 9 a.m., abundant in one at 9 p.m., and one at 12 midnight.

Those under 20 mm. show a different distribution. Surface hauls: 9 a.m., two negative, one positive (occasional specimens up to 10 mm. long); 12 m., one negative, two positive (occasional specimens up to 9mm.); 3 p.m., one positive (many specimens up to 13mm.); 6 p.m., two positive (very many specimens up to 19mm); 9 p.m., three positive (very many specimens up to 16mm.); 12 midnight, three positive (many specimens up to 20mm.); 3 a.m., four positive (several specimens up to 18mm.); 6 a.m., one negative, two positive (occasional specimens up to 11mm.). Deeper tow hauls: 9 a.m., one negative, one positive (occasional specimens); 12 m., one negative, one positive (occasional specimens); 3 p.m., one negative, two positive (many specimens); 6 p.m., one positive (very many specimens); 9 p.m., three positive (very many specimens); 12 midnight, one positive (many specimens); 3 a.m., one positive (occasional specimen); 6 a.m., one positive (very many specimens). There is little evidence of any daily migration of the larger individuals at these stations. They remain almost constantly in the depths. The smaller individuals come nearer to the surface. They are less abundant and smaller or entirely absent from 6 a.m. to 3 p.m.

Taking the shallow vertical hauls (30 to 0 metres) of the second *Princess* cruise (station 27 to 50), we have the following upper limits in size for the individuals obtained in the several three-hour periods: 9 a.m., 15mm.; 12m., 18mm.; 3 p.m., 16mm.; 6 p.m., 20mm.; 9 p.m., 26mm.; 12 midnight, 28mm.; 3 a.m., 20mm.; 6 a.m., 20mm. There would seem to be a definite movement of the larger individuals across the 30-metre line during the twenty-four hours.

As to the effect of temperature on the vertical distribution, we may compare the early and late cruises both outside and inside the gulf. On the earlier cruises the surface water was decidedly colder than on the later ones. The *Acadia*'s cruises show that outside the gulf in May-June large individuals came in numbers to the surface during the night, while in July-August they were virtually absent. The *Princess'* cruises show that inside the gulf in June larger individuals came to the surface than came above 30 metres in August, for 9 a.m., 12m., 9 p.m., 12 midnight and 6 a.m. This decrease in the daily vertical migration is doubtless due to the warming of the surface water.

The facts point to the following conclusions *Sagitta elegans* is confined to water of comparatively low salinity, being stopped in its migration into the depths by water of high salinity. It is affected by light, coming nearer the surface at night. It is affected by temperature, keeping to the colder water. The young behave differently from the adults, living in the lighter, warmer surface water. With increasing age it becomes gradually restricted to the darker, colder water, which is deeper.

HORIZONTAL.—This species belongs to the subarctic and arctic regions. Along our coast it is typical of the cold coastal water and is found over practically the whole of the continental shelf. Its distribution in May-June is shown in fig. 8. Of the entire area covered, it was absent at only three places; western part of Northumberland straits (*Princess* station 4), north of Anitcosti island (*Princess* stations 12 to 14) and out in

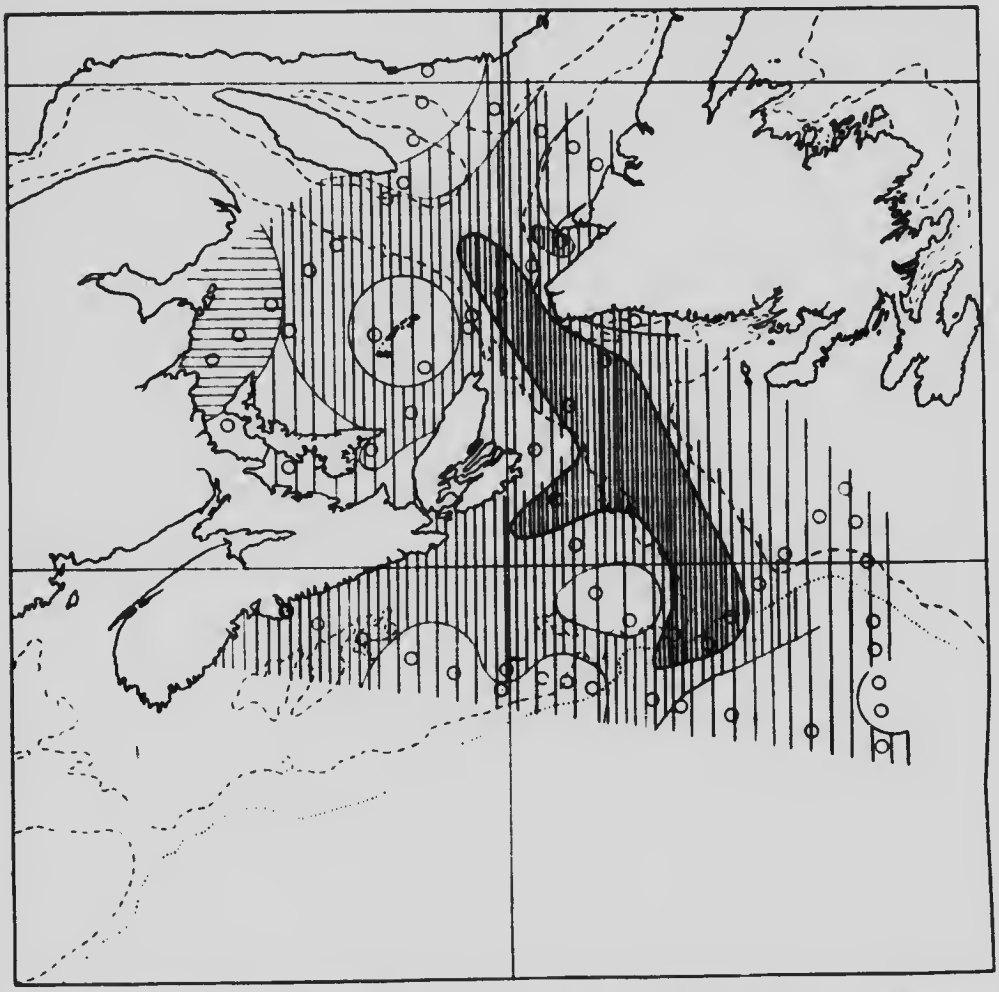

Fig. 8.—Distribution of *S. elegans*, May-June 1915. Zones showing frequencies of 1 to 10, 11 to 100 and 100 and over. Horizontal lines indicate a zone containing none over 10mm in length.

the open Atlantic at one of the outermost (*Acadia* station 17). Its area of abundance corresponded closely with the deeper parts of the coast water, the shallow southern part of the gulf and the shallow banks elsewhere showing only a few or small individuals. Its great abundance at the mouth of the Laurential channel and off Banqueteau at *Acadia* stations 12, 13, 26, 27, and 28 would indicate the presence there of a large amount of cold coastal water. At the remainder of the stations off the continental shelf, it was present in small numbers or altogether absent.

The distribution in July-August is represented in fig. 9. The large individuals (those above 20mm. in length are represented by vertical lines) are more restricted to the deeper parts of the coastal water, and in the northern part of the gulf they are few in number or altogether lacking even in the deep water. We again see them abundant off the mouth of the Laurentian channel on the southern side, at *Acadia* station 76, indicating the presence there of coastal water, that

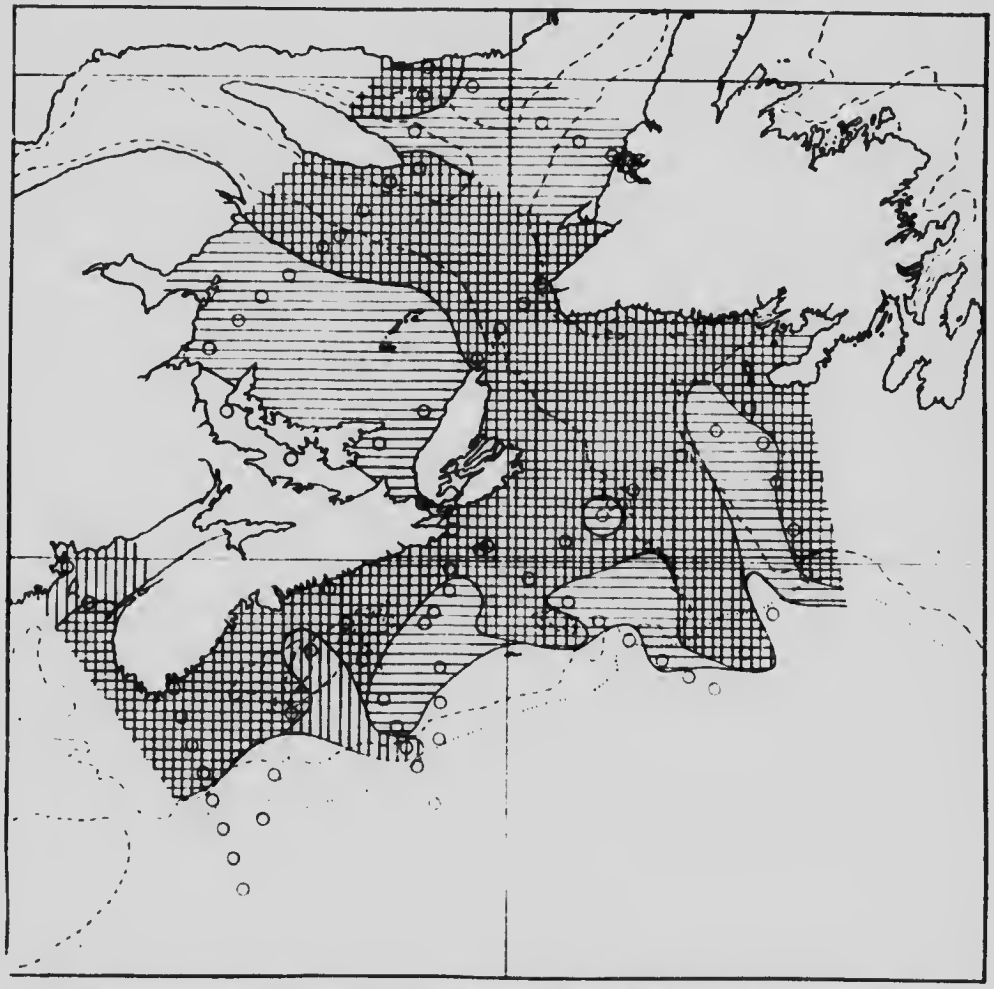

Fig. 9 Distribution of *S. elegans*, July-August 1915. Horizontal lines indicate individuals under 20 mm. in length and vertical lines those over 20 mm.

has doubtless come from inside Banquereau. The absence of large individuals on the banks where warmer water conditions prevail than in the spring is important. The small individuals (represented by horizontal lines) are generally present over the whole of the continental shelf, and pass out with the coastal water from the mouth of the Laurentian channel. In two places they are absent, and for different reasons. In Northumberland straits there were none, perhaps because this area is too far from the places where the adults occur. In the Bay of Fundy, among 156 specimens there was only one individual under 18mm. in length, and that

at *Prince* station 3 in the mouth of the Bay. There can be no doubt that the absence of warm, brackish surface water in this part has prevented their development, the Bay of Fundy being a distinctly unfavourable breeding place, although quite suitable for the adults, as large numbers of them were found. In the Bay of Islands fjord the conditions appear to be ideal for both the old and the young, the icy bottom water containing an abundance of the adults and the warm brackish surface water an abundance of the young. There is therefore a sharp contrast between the conditions in: (1) the Bay of Islands, (2) the lower part of the gulf, and (3) the Bay of Fundy. In the first the conditions are suitable for both adults and young, in the second suitable only for the young and in the third suitable only for the adults.

The virtual absence of small individuals in the Bay of Fundy is important, as indicating the lack of suitable conditions for the breeding of species that require quite warm water of comparatively low salinity for at least the early stages of development. Many fish of economic importance have eggs and young larvæ at the surface that would be affected by this. Further investigation of the Bay of Fundy is needed.

The hauls lacking young *Sagitta elegans* were made in September. Prof. J. P. McMurrich informs me that in a series of tow-nettings taken regularly in Passamaquoddy bay from October, 1914, to May, 1915, only two small *Sagittæ* were obtained, and these at the mouth of the St. Croix river on October 29, 1914. This is a spot with strong tidal currents, where forms brought in from without would appear, if they did appear anywhere. The nets used were more suitable for taking young *Sagittæ* than older ones, and yet ten large individuals from 22·5 to 32·5 mm. in length were taken in a haul on January 1, 1915.

The centre of abundance during the earlier cruises (May-June) is shown in fig. 8. Stations at which more than 100 individuals were obtained in the deep vertical haul occur in an area represented by the most closely placed lines. This area occupies the Laurentian channel from the centre of the gulf outwards to slightly beyond the mouth. Two tongues extend from it to the southwest. One just outside Cape Breton island and the other just outside Banquereau. These may signify the directions in which the currents are carrying the abundant schools. On the later cruises the centre of abundance of the larger individuals is at the lower end of Nova Scotia (as shown in fig. 10). This part of the region was not investigated on the first cruise, but it is at least probable that the currents have during the intervening two months carried large numbers from the Laurentian channel down along the coast, and thus depopulated the northern part of the area. This is all the more probable because the conditions at the lower end of Nova Scotia do not appear to be as suitable for the large individuals as those of the intermediate water in the Laurentian channel.

Another centre of abundance is seen among the banks north of Sable island at *Acadia* station 89 where 124 specimens were obtained in the vertical haul. Their presence near the surface was demonstrated by the taking of sixty-one in the haul from 55 metres to the surface, and by the large number obtained in the tow. This zone apparently extended to station 90, where many were obtained in the tow, but where no vertical haul was made. The neighbouring station (66) showed very few large individuals, but at station 65 off Cape Canso, fifty were obtained in the deepest haul. The distribution suggests that the pressing-in of the boreal water over the banks south of Sable island has tended to separate the zone of abundant *S. elegans* into two parts, one north of Sable island and the other at the lower end of Nova Scotia.

At *Acadia* station 77 at the mouth of the Laurentian channel no vertical haul was made, but since the deep-water form *Eukrohnia hamata* was obtained in the tow haul and no *S. elegans*, it is practically certain that the latter species was absent. This is significant, indicating almost pure boreal water at that point between two stations where coastal water was present. This boreal tongue extends into the Laurentian channel on the north side. Farther up the channel it is covered with coastal water (stations 85 and 86).

The distribution of the large individuals in July-August shows that they have retreated from the shallower banks, also from the lower part of the gulf and curiously enough also from the deep northern part of the gulf. Between Anticosti island and the north shore they were entirely absent in June but present in August. The general circulation in the gulf has doubtless been responsible for this, carrying them around and then out through Cabot strait.

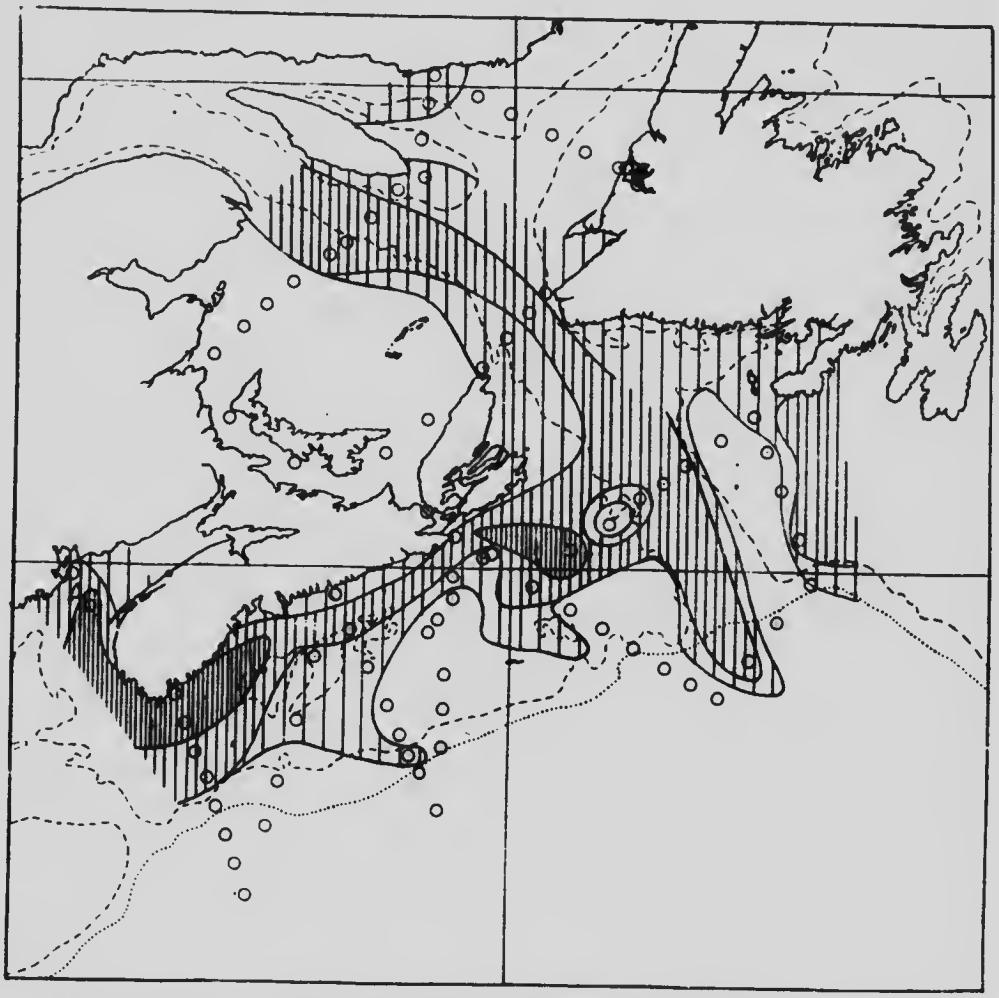

Fig. 10. Distribution of *S. elegans* (those over 20 mm in length). July-August 1915. Zones showing frequencies of 1 to 8, 9 to 90 and 90 and over per station.

The retreat inshore of the species during the summer from the open Atlantic is shown by its absence beyond the continental shelf during the late cruise, except at the mouth of the Laurentian channel, while during the early cruise it occurred at the outermost stations (except *Acadia* station 17), though in small numbers. In some places on the late cruise it was pushed well back from the edge of the shelf, particularly in the southern part.

During the June cruise the western side of the lower part of the gulf contained only small individuals, 6mm. or less in length. This is shown by the horizontal lines

in fig. 8. This is the beginning of the condition that in the August cruise was found over practically the whole of the lower part of the gulf. It is interesting that this change has spread from west to east in the direction of the Gaspé current.

The presence of two large individuals of this species in the boreal oceanic water at *Acadia* station 54 does not, I think, indicate that there has been an outflow of coastal water at this point, but rather that individuals carried into the boreal water by the tongue of coastal water that comes out of the southern side of the Laurentian channel, have been transported in the boreal water along the side of the continent past Sable island along the course shown by the distribution of *E. hamata* (fig. 12). During May-June the tongue of coastal water actually extended from the channel mouth to the southwest for a considerable distance, as found at *Acadia* station 12 (see fig. 8), with boreal water on either side. We can readily believe that early in the year such a tongue extended as far to the south as *Acadia* station 54 at least, and from that point passed up over the banks to connect with the coastal water off Halifax. In July-August this connection of the coastal water outside Sable island had been severed in the middle and only the ends left.

The large amount of boreal water occurring on the shelf off Halifax accounts for the few large *S. elegans* found at stations 47, 48, and 51.

On the New England coast, Bigelow (1915, p. 299) has found the species extending in the coast water as far south as Long island.

In making a comparison of the distribution of this species on the two sides of the Atlantic, there arises a doubt as to the identification of the European specimens. According to Ritter-Zahony this species has been confused with *S. bipunctata*. If the European records of the latter species are referable to *S. elegans*, we have the latter species confined to the epiplankton and occurring down to 100 fathoms off the Irish coast (Ritter-Zahony, 1910, p. 2) with the younger stages in the upper layers, and the older stages in the lower. Its outer limit of distribution is not indicated.

Apstein (1911, p. 171) describes its occurrence throughout the North sea and neighbouring waters, going below 300 metres in depth in the Skager-Rack, and in the Baltic not usually occurring near the surface but only in the deeper water where more saline conditions prevailed; sometimes only on the bottom below 85 metres (Danziger Bucht). The Arctic form occurred only in the Kattegat and Skager-Rack, and was confined to the deeper layers, coming near the surface only in winter.

There is a definite agreement between the distribution on the two sides of the Atlantic—its general occurrence in the coastal waters and usually confined strictly to the epiplankton; its rarity and restriction to the deeper layers in areas where low salinity and high summer temperatures prevail, as in the lower St. Lawrence gulf region and in the Baltic; and the development of a small type in an extensive shallow enclosed area and of a very large type where the true coastal water is deep. One difference is worthy of note: it has (at least in summer) a sharp outer limit on the American coast, where as on the European coast none has been shown, indicating that there is not there the sharp distinction between oceanic and coastal water that is met with on this side of the Atlantic.

(*h*) **Pterosagilla draco** (Krohn).

"ACADIA."

Station No.	Hour.	Depth (metres).	Depth of Haul (metres).	Length (mm.).	Number.
41	6 a.m	360	200–0 (V.)	7	1
			100–0 (V.)		1
			0 (T.)		0
44	3 p.m	over 1,000	270–0 (V.)		0
			0 (T.)	5·9·5	4
75	9 p.m	over 1,000	325–0 (V.)		0
			55–0 (V.)	7·5	1
			c. 20–10 (T.)		0

Only six specimens were obtained, four of which were in the surface haul at station 44. Its distribution is shown by the horizontal interrupted lines in fig. 1. It is a tropical surface form. Bigelow obtained it in July-August, 1913, at his outermost southern stations south of cape Cod. It is noteworthy that it occurred at three of the five stations at which *Sagitta enflata* was found, and that four of the six specimens came from the only station where *S. enflata* was abundant. Fowler notices this agreement in the general distribution of the two species (1906, p. 76).

Fowler gives its most northerly record as 41° 36′ N, 56° 18′ W. (Strodtmann). Its occurrence at *Acadia* station 75 (43° 30′ N., 56° 43′ W.) extends its known northern limit. These two tropical species (for both of which new northerly records are now given and for our waters, their previous northerly records having also been from our waters) come much farther north on this side of the Atlantic than on the European side, where they only reach the latitude of the Mediterranean, thus harmonizing in a general way with the distribution of salinities and temperatures (see Helland-Hansen in Murray and Hjort, 1912, pp. 227 and 297). Strodtmann, who studied the Chaetognaths obtained by the Plankton-Expedition in the North Atlantic, which included a series of stations both north and south of the Newfoundland banks, considers that these two species characterize the true region of the Gulf Stream (1892, p. 369) as opposed to the Labrador current and the northeastern branch of the Gulf Stream.

Their distribution indicates that the surface water of the Gulf Stream presses in much nearer the continental shelf at the lower (southern) end of our range than elsewhere.

(i) **Eukrohnia hamata** (Möbius). Fig. 11.

1911. Ritter-Zahony, p. 30.

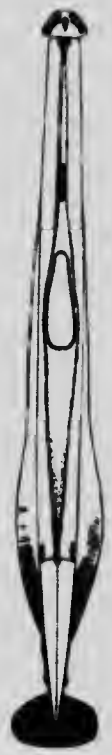

Fig. 11.—Eukrohnia hamata. x 4.

The range in size is from 7 to 35mm. long. The latter is near the upper limit of its length, and yet in none were the ovaries mature, although in some of the larger individuals the seminal vesicles were distinct. It may be doubted whether it breeds in our area, unless in the deeper parts of the outer waters, which we did not investigate. As it is typically a deep-water species, except in polar waters, the absence of mature individuals is not to be wondered at.

DISTRIBUTION.

"ACADIA."

Station No.	Depth (metres).	Depth of Haul (metres).	Lenght (mm.).	Number.
5	72	60–0 (V.)	10	1
		0 (T.)		0
11	over 2,000	70–0 (V.)	12	1
		0 (T.)		0
13	over 2,000	70–0 (V.)	10–14	5
14	over 2,000	200–0 (V.)	9–20	10×10
		0 (T.)		0
15	over 2,000	100–0 (V.)	20	1
		0 (T.)	20	1×2
16	over 2,000	200–0	c. 15	1
		0 (T.)	21	1 seen
17	over 2,000	200–0 (V.)	8–13	3×10
		0 (T.)		0
25	122	120–0 (V.)	10–12	3
		0 (T.)		1
26	over 400	100–0 (V.)	10–22	12
		0 (T.)		×
27	over 400	0 (T.)	c. 20	××
28	over 400	100–25 (C.)	10–16	6
		0 (T.)		0
35	c. 450	125–25 (C.)	15–19	3×2
		0 (T.)		0
47	140	125–0 (V.)	8–14	8
		90–0 (V.)		×
		0 (T.)		0
48	248	270–0 (V.)	14	1
		45–0 (V.)		0
		0 (T.)		0
50	151	145–55 (C.)	10	2×5
			15	2
		145–0 (V.)	10–14	2×5
			18 & 21	2
		55–0 (V.)		0
		0 (T.)		0

"ACADIA"—*Continued.*

Station No.	Depth (metres).	Depth of Haul (metres).	Length (mm.).	Number.
52	99	90–0 (V.) II	12	1
		0 (T.)		0
54	over 1,000	270–0 (V.)	9–16	29
		125–0 (V.)		0
		0 (T.)		0
55	over 1,000	270–0 (V.)	9–11	5
		90–0 (V.)		0
		0 (T.)		0
57	over 1,000	270–90 (C.)	10–13	22
		90–0 (V.)		0
		0 (T.)		0
58	187	180–55 (C.)	12	1
		150–0 (V.)		0
		55–0 (V.)		0
		0 (T.)		0
67	198	190–0 (V.)	24	1
		90–0 (V.)		0
		0 (T.)		0
70	over 1,000	325–0 (V.)	7–15	54
		55–0 (V.)		0
		c. 20–10 (T.)		0
72	over 1,000	325–0 (V.)	7–13	60
			17–23	12
		55–0 (V.)	11–13	3
		c. 20–10 (T.)		0
74	over 1,000	325–0 (V.)	8–12	31
			15–21	2
		55–0 (V.)		0
		c. 20–10 (T.)		0
76	over 1,000	270–0 (V.)	12	11×4
			14–20	9
		c. 20–10 (T.)		0
77	over 1,000	c. 20–10 (T.)	17	1
			24	1

"ACADIA"—*Continued.*

Station No.	Depth (metres).	Depth of Haul (metres).	Length (mm.).	Number.
79	360	325-0 (V.)	5-14	10×10
			10-23	43
		55-0 (V.)	12	1
85	over 400	270-0 (V.)	7-5-10	4×40
			10-19-5	27
		55-0 (V.)	10-20	17
		c. 20-10 (T.)	10-17	× ×
86	over 400	270-0 (V.)	8-10	14×10
			13-23	28
		55-0 (V.)	10-13	5×10
		c. 20-10 (T.)	c. 12	1 seen
87	331	290-0 (V.)	8-11	3×10
			11-22	19
		55-0 (V.)	12-19	5
		c. 20-10 (T.)	14 & 15	2 seen

"PRINCESS".

34	405	130-0 (V.)	18-28	5
		30-0 (V.)		0
		c. 40-0 (T.)		0

"No. 33".

22	355	340-145 (C.)	10-13	3
			22 & 35	2
		100-60 (C.)		0
		45-0 (V.)		0
		0 (T.)		0

"PRINCE".

1	c. 38	c. 35-0 (V.) I		0
		c. 35-0 (V.) II		0
		c. 20-10 (T.)	19-21	3
		0 (T.)		1
3	180	180-0 (V.)	24 & 26	2
		c. 20-10 (T.)		0
		2-0 (T.)		0

VERTICAL.—At station 23 of the cruises of the trawler *No. 33*, three vertical hauls were made from various depths with the closing net. This station is well up in the gulf of St. Lawrence, and so well away from places, where mixing is going on which might through vertical currents vitiate the results. Six specimens of this species were obtained between 340 and 145 metres, and none between 100 and 60 metres and from 45 metres to the surface. On the cruises of the *Princess* in the gulf, numerous hauls were made in the deeper parts with open vertical nets from 100 or 130 metres, and at only one station was this species obtained. Its vertical distribution for the gulf may be considered to lie below 130 metres.

In the Bay of Fundy at station 3 of the *Prince*, two specimens were obtained in the open vertical net from 180 metres and none in the tows above 20 metres in depth. Yet at station 1, although none were obtained in two open vertical hauls from the bottom (showing the rarity of the species there), three specimens were obtained in the tow haul about 20 metres in depth and one in a haul made at the surface. This latter station was in the Friar Roads between Eastport and Campobello island. The tides here are of such magnitude that the water forms whirlpools and the "boiling" up of the deep water to the surface can be seen constantly. These vertical currents are certainly responsible for bringing this deep-water species to the surface at this point. Just outside Campobello island at station 2, both the vertical haul from about 100 metres up and the tow hauls failed to secure any specimens of this form, showing that it was some distance down.

Its presence at or near the surface at *Acadia* stations 15, 16, 25, 26 and 27 indicates that there were strong vertical currents at the mouth of the Laurentian channel on the first cruise of the *Acadia*. On the second cruise it was at or near the surface only at stations 77, 85, 86, and 87 at the mouth and some distance up the Laurentian channel showing strong vertical currents in about the same area. The data from the last three stations are interesting. At stations 85 on the north side of the channel, where *S. serratodentata* and *S. maxima* were most abundant, we find this species coming near the surface in fair numbers (20-10? metres, rather many) and many obtained in both the shallow and deep vertical hauls. At 86 in the middle of the channel, while very many were obtained from both vertical hauls, only one was seen in the material taken by the tow haul. At station 87 on the south side of the channel, while a fair number came up in the deep vertical haul, the shallow vertical haul yielded five only, and a solitary specimen was observed in the tow. This species comes nearer to the surface as we pass to the north across the channel, indicating greater vertical currents on the north side or a greater influx of the cold deep boreal water, from which the vertical currents may bring the species to the surface. There is, of course, the possibility of the species coming to the surface of itself under changed conditions, perhaps of salinity and temperature, as it does in polar regions.

The vertical distribution seems to vary with the region, but these details may more appropriately be considered in connection with the horizontal distribution. Suffice it now to say that it did not appear in the outer and southern stations (stations 41 to 46, 56, 75), the hauls, one of which was from a depth of 375 metres, apparently being too shallow, the cosmopolitan distribution of the species making it fairly certain that it was present but at lower levels. Fowler (1906, p. 73) refers it to the epiplankton (usually young specimens) north of 47° N., and to the mesoplankton in tropical and sub-tropical waters. Michael (1913, p. 35) states that his data suggest "that the region of maximum abundance is in the neighbourhood of 250 fathoms for the San Diego region."

The records are too fragmentary to show whether or not daylight affects the vertical distribution.

HORIZONTAL.—This species is cosmopolitan, being found in all seas, and it extends to both the farthest north and the farthest south. As it is a deep-water form in low latitudes, if we consider only the proper layers of the sea (the part explored by our nets),

this species is characteristic of arctic and antarctic seas. In our region it may be considered the typical form of the deep boreal water next the banks. On the first cruises during May and June it occurred at *Acadia* station 5, inside Sable island, generally in the deep water examined off the mouth of the Laurentian channel, up the channel in Cabot strait (*Acadia* station 35) and far up the channel in the deep water between Anticosti and Gaspé (*No. 33* station 23). It is doubtless present in all the central deep parts of the St. Lawrence gulf. Our other hauls in this area were too shallow to obtain it. The distribution in July and August, as shown in fig. 12, was similar, with the gulf hauls again too shallow except at one station (*Princess* station 34). It is again present in the Laurentian channel and at its mouth, as well as along the outer side of Sable island bank and in the deep water betw[illegible] that bank and Halifax and in the Bay of Fundy. In both cruises it is definit[illegible] [illegible]t over the banks south of Newfoundland, over the banks north of Sable is[illegible] in the gullies or fjords—*Acadia* station 67, one specimen), as well as in [illegible] gulf and close along the Nova Scotia shore. It is therefore a[illegible] the [illegible] water. This is well shown by its absence in the Bay of I[illegible] [illegible] [illegible]d 59), where there is a depth of as much as 150 fathom[illegible] [illegible] [illegible]ity and low temperature all the way to the bottom.

Its outer limit of distribution was no[illegible] [illegible] [illegible]ses, although it was rare at stations 15 and 16) but [illegible] the [illegible] August [illegible] was plainly demonstrated. It failed entirely at the t[illegible] [illegible] *Acadia* stations 41-45, 56, and 75) except the most northerly [illegible] at s[illegible]e of the intermediate southern stations (*Acadia* stations 38-40 [illegible] of the *Prince* in September show that it occurs in all the deeper [illegible] Fundy. Bigelow found it in July-August, 1913, in all the deeper p[illegible] gulf of Maine and under the edge of the Gulf Stream, but never at the surface.

The absence of any connection being shown between its distribution off the Nova Scotia coast and in the gulf of Maine is apparently owing to the pressing in of the Gulf Stream close against the continental shelf (*Acadia* station 41), and also owing to the hauls at this point not being deep enough to get below the Gulf Stream. This phenomenon of the sinking of the species to lower levels as we pass out into the Gulf Stream is very well shown in the records. At *Acadia* station 72, three individuals were obtained in the shallow vertical haul (55-0 metres), and 72 in the deep vertical haul (325-0 metres). At station 74 there were none in the shallow haul, but thirty-three in the deep haul. At station 75 there were none in either haul. At stations 52 and 58 on the continental shelf it was obtained in hauls from 90 and 180 metres, respectively. At stations 54, 55 and 57 it occurred in fair numbers in the vertical hauls from 270 metres, but not in the vertical hauls from 125 and 90 metres. And at station 56 it was not present even in the deep haul from 375 metres. The gradation in size as we pass into warm water is equally distinct. For the same depth, the individuals become distinctly smaller as we pass to warm water. At station 72 the proportion of small to large (those under and those over 15mm.) was 5 to 1. At station 74 for a si[illegible]r haul it was 15·5 to 1, and at the same time the maximum size changed from 23mm. [illegible] 21mm. Off Sable Island bank the stations taken in order of their nearness to the continental shelf show the following for similar hauls (270-0 metres): Station 54, twenty-nine specimens with a maximum size of 16 mm.; station 57, twenty with a maximum of 13 mm.; station 55, five with a maximum of 11 mm.; and station 56, none. There is a decrease in maximum size as well as in the number taken. Although the records are fragmentary this species is seen to resemble others in that the younger individuals are to be found in the upper, warmer water, as described by Broch and Fowler for this species.

The records are too incomplete to show where the centre of abundance was during the earlier cruises, but it must have been north of *Acadia* station 16, between that point and the continental shelf, as shown by the numbers at stations 14 and 17, the

only two where deep hauls were made. On the later cruises the centre of abundance (as shown by the closely placed lines in fig. 12) was definitely in the northern oceanic water just south of the Newfoundland banks. It decreased in quantity to the north,

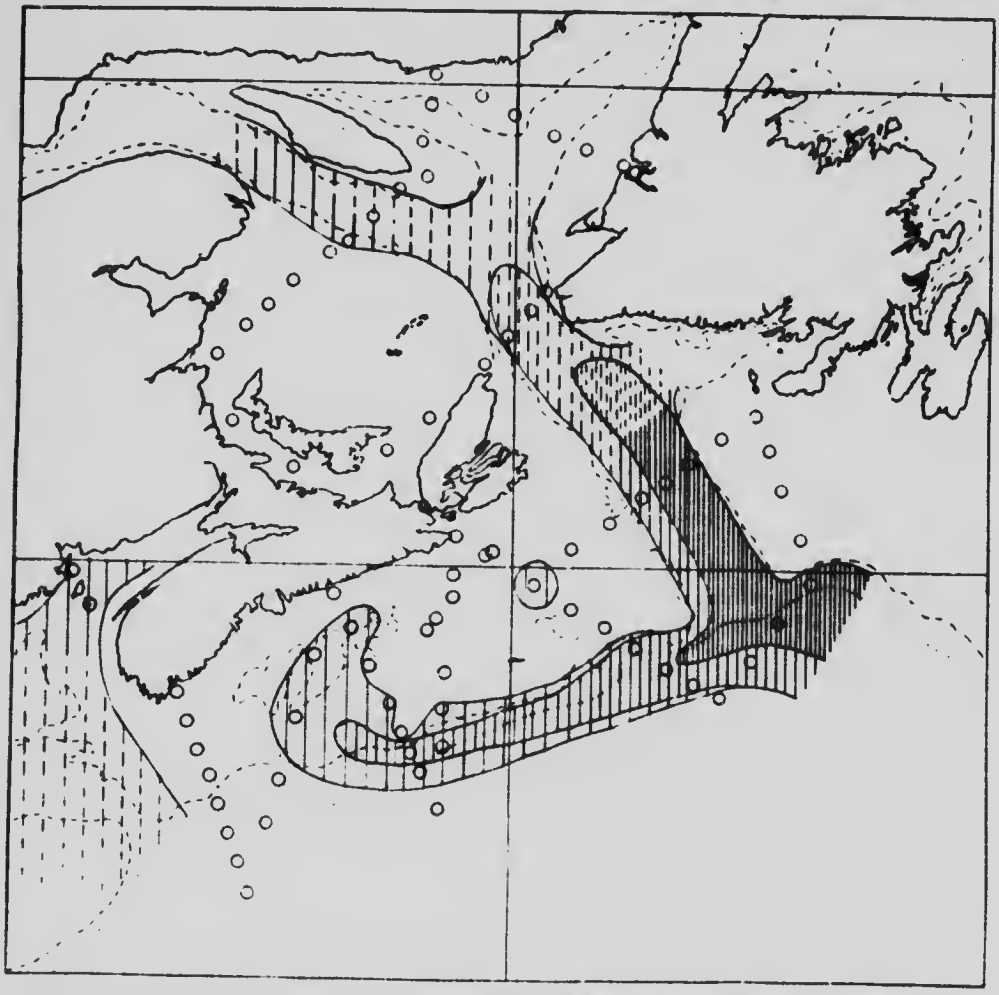

Fig. 12.—Distribution of *E. hamata*, July August 1915. Zones showing frequencies of 1 to 20, 21 to 75 and 75 and over per station.

west, and south. The agreement with the distribution of *S. maxima* is very evident. They both belong to the deeper part of the boreal oceanic water and show its extension up the Laurentian channel and to the south along the outer side of the continental shelf and to some extent over the banks, but diminishing in amount in each direction. The two species differ in that *S. maxima* can not endure as much of a decrease in salinity as can *E. hamata*, and does not extend as far up the Laurentian channel or over the banks as the latter species. It can, however, endure an increase in salinity better than *E. hamata*, as it occurs in the outer Gulf Stream stations, where the latter is absent on the later cruise though present on the earlier. High temperature may, however, be as potent a factor in excluding *E. hamata* from the Gulf Stream as high salinity.

The absence of this species generally in the hauls from 130 metres to the surface in the gulf on the August cruise of the *Princess* and its occurrence in such a haul at *Princess* station 34 indicates an upwelling of the deep boreal oceanic water at that point.

The definite separation of this species from *S. elegans* in vertical distribution as seen at *No. 33*, station 23, shows that they belong to waters of different salinities. Where they occur together in mixed water, as south of Sable island or in the Bay of Fundy, *E. hamata* is to be found only in small numbers, showing that this mixed water is not suitable for it.

To the south of our area, Bigelow, (1915, p. 297) has found this species in the deeper parts of the gulf of Maine and along the edge of the continental shelf as far south as Chesapeake bay in July-August, 1913. Its outer limit was, however, not determined. It decreased in quantity to the south.

Apstein (1911, p. 174) for European waters gives its distribution as similar to that of *S. maxima*, but occurring regularly in the Norwegian channel; and in the Skager-Rack, where it was abundant, it occurred at the surface, but was most abundant in the depths. This is quite similar to the conditions on our coast, where it passes landward up the deep gullies, and much farther than does *S. maxima*.

(*j*) **Krohnitta subtilis** (Grassi).

1911. Ritter-Zahony, p. 32.

"ACADIA".

Station No.	Depth (metres).	Depth of Haul (metres).	Length (mm.).	Number
44	over 1,000	270–0 (V.)	13·5	1
		0 (T.)	...	0

A single specimen of this species was obtained at station 44, the southernmost station of the second cruise of the *Acadia*, in an open-net vertical haul from 270 metres (fig. 1, vertical dotted lines). It is a tropical species occurring chiefly in the mesoplankton; according to Ritter-Zahony, chiefly in the lower epiplankton and upper mesoplankton; according to Fowler (1906, p. 74), and according to Michael (1913, p. 35), chiefly between 200 and 250 fathoms (none above 50 fathoms). Fowler gives its most northerly record in the Atlantic as 60° 12′ N., 22° 56′ W.

GENERAL SUMMARY OF DISTRIBUTION.

In summarizing the distribution of the Chaetognaths it will be well to review briefly the principal features of the region covered.

The general topography as shown in the charts is too well known to require description. The submarine physiography has been described by J. W. Spencer (*see* chapter ix of Sub-Oceanic Physiography of the North Atlantic Ocean, by E. Hull, London, 1912; and Bull. Geol. Soc. Amer., vol. xiv, 1903, p. 207). The main feature is the submerged Laurentian valley cutting across the middle of the St. Lawrence gulf and passing out to the open ocean through Cabot strait and between St. Pierre bank and Banquereau. We have referred to this as the Laurentian channel. Another

channel, the Cansan, cuts through between Sable Island bank and Banquereau. Farther to the south is the Fundian channel passing out from the Bay of Fundy and through the gulf of Maine. These three channels delimit two portions of the continental shelf off Nova Scotia. That to the north between the Laurentian and Cansan channels includes the Banquereau, Misaine, and Cansan banks, and may be called the Breton portion of the shelf, or the Breton bank, since it lies off Cape Breton island. The southern part lies between the Cansan and Fundian channels and includes La Have and Sable Island banks. It may be called the Scotian bank since it lies against the main portion of the province of Nova Scotia.

In the St. Lawrence gulf we have to the north of Anticosti island, the Anticostian channel, and running north towards the straits of Belle Isle the Esquiman channel. To the south of the Laurentian channel in the gulf is an extensive submarine plateau with, for the most part, less than 30 fathoms of water covering it. Cropping up from it are the Magdalen islands and Prince Edward island. This area is peculiar in its biological and hydrographical characters. We have referred to it as the Lower Gulf region. It might be called the Magdalen bay.

The currents of the region have been thoroughly investigated by Dr. W. Bell Dawson, and his results published in the reports of the Tidal and Current Survey of Canada from 1894 to 1913, including special reports on the currents. In the gulf of St. Lawrence he finds that the general circulation is in a left-handed direction and chiefly confined to the deep central portions. A current enters the gulf through Cabot strait off cape Ray and spreads out to the north and northeast. Part runs up the Esquiman channel on the east side and returns on the west. Similarly a current runs up the Anticostian channel on the north side and returns on the south, and up the Laurentian channel between Anticosti island and the Gaspé coast on the north side and returns on the south. The last of these, the Gaspé current, is very strong and spreads to the southeast over the Magdalen bay, passing to either side of the Magdalen islands, and finally as a single stream of constant strong character, the Cape Breton current, it emerges from the gulf on the south side of Cabot strait.

Dr. Dawson has shown by density determinations that the inflowing water is more saline than the outflowing and, as a result, the northern part of the gulf is constantly more saline than the southern, a line of division passing from East cape, Anticosti island, to the middle of Cabot strait.

The shallower channels of the gulf show the same circulation but to only a slight degree. Through the straits of Belle Isle and the Mingan channel on the north there is a general inward or westward tendency, and through the Northumberland strait (and perhaps also the Gut of Canso[1]) on the south a general outward or eastward tendency.

Outside the gulf there is a slight westward tendency on the southern coast of Newfoundland and a southwestward drift along the outer coast of Nova Scotia. In the gulf of Maine, Bigelow has found a general left-handed circulation, entering the gulf on the north and leaving it on the south. In the Bay of Fundy there is doubtless a similar circulation, although so masked by the heavy tides that Dawson has been unable to determine it by current measurements.

Farther out we have two well-known strong currents, the Polar or Labrador current coming down from the north along the outer coast of Newfoundland, flooding the Grand Banks and then turning to the east at their southern border; and the Gulf Stream coming from the southwest along the coast of the United States and being deflected to the east and south just south of the Grand Banks.

As a basis for our knowledge of the different kinds of water occurring in the region we may take the three sharply marked zones found by Hjort off our coasts in 1910 (Murray and Hjort, 1912, p. 109) in his section from the Azores to Newfoundland. There are the following: (1) a Northern Coastal zone (Arctic?) on the Newfoundland

[1] I have just received from Dr. Dawson a proof sheet of a forthcoming report in which he describes a preponderance of outflow to the south through the Gut of Canso.

banks, with water of low salinity (under 33‰) and very low temperature (down to 1·5° C.) except at the surface in summer; (2) a Northern Oceanic zone (boreal) along the southern side of the Grand Banks, with water of moderately high salinity (33-35‰) and moderately low temperature (3°-8° C.), which connects with the bottom water of the Atlantic; and (3) a Southern Oceanic zone (tropical) farther to the south in the Gulf Stream, with water of high salinity (over 35‰) and high temperature (10°-25° C.).

The northern coastal water owes its low salinity to the fresh water poured in by the rivers and to the melting of the icebergs from the north, and its low temperature to the cooling effect of the rigorous winters and to floating ice.

The southern oceanic water is brought up from the tropics by the Gulf Stream. This accounts for its high temperature and salinity.

The northern oceanic water may be derived in part from a mixture of the two preceding kinds. It is essentially an intermediate water, and in its circulation will, on the one hand, have its temperature and salinity reduced by mixture with the coast water and, on the other hand, have its temperature and salinity increased by mixture with the Gulf Stream water. As it is heavier than they, it will be found beneath them and, particularly toward the south, where it is less extensive, it will permit of their mixing together above it. It is continuous around the south side of the Grand Banks with the open water of the northwestern Atlantic, where is found the Labrador current. The latter doubtless contributes along this course (around the banks) to our northern oceanic water, but for the most part only at some depth and not on the surface.

To these may be added a fourth, the Southern Coastal zone existing in the Magdalen bay, to which certain southern coastal forms, e.g., the oyster, are restricted. It is characterized by water of very low salinity and very high summer temeprature, and is therefore similar to the upper layers of the northern coastal water. Its low salinity is due to the large amount of fresh water poured into it by the St. Lawrence and other rivers. Its high summer temperature is due to the same cause and to the shallowness of this part of the gulf. In a negative way the absence of heavy tides contributes to both the low salinity and the high temperature.

In the Southern Oceanic zone we have at the surface *Sagitta enflata*, *S. bipunctata*, small *S. serratodentata*, and *Pterosagitta draco*. In the depths there are *S. hexaptera*, *S. lyra*, and *Khronitta subtilis*. The extent of this zone in July-August is shown in fig. 1. Surface species are indicated by horizontal lines, deep-water species by vertical lines. The further extension landwards of the surface forms in the southwest part of the region and of the deep-water forms in the northern part is noteworthy. This is corroborated by the distribution of small *S. serratodentata* as shown in fig. 6. The nearness of the zone to the continental shelf on the south as compared with the north is also important, indicating a turning of the Gulf Stream to the east.

On the May-June cruise only the northern part of the area was investigated. Only deep-water species were obtained. The records show that the surface Gulf Stream forms, which were not found, must have been farther out than the deep-water forms, and that both were at that time farther from the continental shelf than in July-August.

There is the question as to what part the Gulf Stream plays in mixing with either the coastal or the boreal oceanic waters. The sharp inner margins of the areas of distribution of most of the Gulf Stream species is against the view that the Gulf Stream by any back eddies remains as a distinguishable part of our waters. In the upper layers the most abundant species (*S. enflata*) decreases in abundance toward the inner side of the stream, and may even be lacking, showing that this inner margin is mixed water going with the stream. A solitary individual was found inside the stream, far in on the Scotian bank off Halifax. Its ability to survive in the water of intermediate salinity and temperature indicates that there can be little water of Gulf Stream origin in the intermediate boreal oceanic zone, otherwise individuals of this species would have been obtained at some of the nine intervening stations. *S. serra-*

todentata is a Gulf Stream form, but its occurrence in the boreal water is not indicative of a recent Gulf Stream origin, since it is of a decidedly different type in the boreal water. Its abundance in our boreal water and its rarity on the European coast may be due to its ability to live and grow to maturity but not to reproduce successfully in boreal water. With this interpretation our boreal water would have a very slight but constant contribution from the Gulf Stream.

Of the deep-living species, *S. hexaptera* is absent from the boreal water, but *S. lyra* was found at two of the boreal stations. One of these stations was, however, really on the edge of the Gulf Stream, and the single specimen found at the other station (*Acadia* station 70) was much larger than any others obtained. This individual may have passed through the bottom of the Gulf Stream, since the species goes into very deep water and is a constant inhabitant of the depths of the Atlantic; or if it has entered the boreal water by the mixture of the latter with the Gulf Stream, its size precludes a recent entrance.

We have therefore no certain evidence of any deep contribution of Gulf Stream water to the boreal zone in our region, and evidence of only a slight surface contribution.

Of movement in the opposite direction, from the boreal water to the Gulf Stream, since there is no peculiar surface boreal form, we have merely the negative evidence of rarity of the surface tropical species at the northern Gulf Stream stations. The deep-living boreal species, *S. maxima*, was regularly found at the Gulf Stream stations except at the extreme southwest, and it was more abundant at the north, while *Eukrohnia hamata* was found at only one of the stations, the most northerly (*Acadia* station 74). There is therefore evidence that the boreal water does contribute to the Gulf Stream in the deeper part, and perhaps also at the surface. The latter contribution will tend to be indistinguishable from coastal water.

In the Northern Oceanic zone we have large *S. serratodentata* at the surface, and in the depth, *S. maxima* and *E. hamata*. For its extent in July-August see figs. 3, 6 (vertical lines), and 12. There is to be seen an extension of the surface water over the Scotian bank to the south, and of the deep water up the Laurentian channel to the north. The deep water is present in small amount over the Scotian bank, the surface water in the Laurentian channel, and both in the gulf of Maine and Bay of Fundy. The virtual absence of this water over the Newfoundland banks is worthy of note, it being held off by the coastal water. Its centre is seen to be a narrow zone close against the continental shelf, decreasing in width to the southwest. The vertical distribution of *S. maxima* and *E. hamata* shows that it passes to a deeper level below the coastal water up the Laurentian channel and below the Gulf Stream to the south and southwest.

On the May-June cruise the small area explored showed a similar distribution, but extending farther out from the continental shelf.

The absence of any continuation of the deeper part of this water (as indicated by *E. hamata* and *S. maxima*) along the continental shelf off Shelburne in July-August as shown by our most southern section, indicates the abruptness of the transition from Gulf Stream to coastal water at this point, the boreal water having been squeezed out by the pressing in of the Gulf Stream close to the continent. This is doubtless temporary. At another time, perhaps earlier in the season, the boreal water would be much more extensive and pass continuously down the coast and up into the gulf of Maine.

Dawson has shown that in the deep parts of the St. Lawrence gulf there is water with the characters which we have given above for boreal oceanic. The *Albatross*, as reported by Townshend, found in July, 1885, very low temperatures at the bottom which would indicate no boreal water on the bottom on the banks just south of Newfoundland, on the Breton bank, nor close along the shore of Nova Scotia; but in the mouth of the Laurentian channel and off Shelburne near La Have bank, the bottom

temperatures were higher (37·8°—40° F.), indicating boreal water. For the banks just south of Newfoundland, Dawson's investigations did not go deep enough, but Hjort failed to find it at the bottom, or only in very small amount at the north. The *Challenger*, on May 20, 1873, found, just east of La Have bank, water at the bottom with too low salinity and temperature to be boreal. For the early part of the year the boreal water may be absent from the Scotian bank. Bigelow has found boreal water at the mouth of the Bay of Fundy. With the exception of the *Challenger* record, for which the season of the year may be responsible, the distribution of the Chaetognaths agrees with what has been found as to the extent of the boreal oceanic water.

As to its origin and movements, we have seen that there is little reason to suppose that the Gulf Stream contributes appreciably to it. It must therefore come either from the deeper part of the Polar current around the outer side of the Grand Banks (its comparative purity at the north as shown by the quantitative distribution of *S. maxima* and *E. hamata* support this view) or by upwelling from the depths of the Atlantic, since it is being constantly dissipated by mixture with the coastal water. That it is actually moving toward the southwest seems to be shown by the movement of the centre of abundance of *S. serratodentata* to the southwest during the summer, and also by the rarity of the boreal species over the Scotian bank, which is an indication that boreal water is passing in that direction and being dissipated.

The greater abundance of the boreal species on the northern side of the Laurentian channel is an evidence that the boreal water forms part of the current entering the gulf. On its way it must be mixing with the coastal water, as is witnessed by the presence of *E. hamata* near the surface. This doubtless explains the failure of two of the species to enter the gulf. The third species certainly passes up the Laurentian channel as far as the Gaspé coast, although it is unlikely that it reproduces there.

The boreal oceanic water may be considered as coming from the northeast, and in our region disappearing partly by mixing with the coastal water, particularly in the Laurentian channel, on the Scotian bank and in the gulf of Maine, partly by mixing with the Gulf Stream and returning to the northeast and partly by sinking beneath the Gulf Stream to pass into the Atlantic bottom water.

In the Northern Coastal zone there is only a single species, *S. elegans*. Young individuals characterize the upper layers, large individuals the lower layers, and very large ones the deepest parts. Fig. 9 shows the distribution in July-August, horizontal lines representing individuals under 20mm., and vertical lines those over 20mm. The general extent of the zone corresponds with the continental shelf, but passes beyond it to some extent in the north, particularly at the mouth of the Laurentian channel. The only parts of the shelf not in the zone are the Northumberland strait and the extreme outer part of the Scotian bank. The former is occupied by the southern coastal water, and the latter by the boreal oceanic water. If we exclude the smaller individuals, considering that they belong properly to the southern coastal water, the zone is more restricted, the shallower banks and particularly the Magdalen bay being excluded. This intermediate water containing chiefly the large individuals over 20mm. in length has a salinity of from 31‰ to 33‰ and temperature ranging from about 10° C. down to —1·5° C. Its apparent absence in the northern part of the gulf will be explained later. Its full development as indicated by the largest individuals of *S. elegans* occurs in deep fjords like the Bay of Islands, and to a less extent over the Breton bank. The May-June cruises show less difference between the upper and lower layers, large *S. elegans* being nearer the surface, and therefore in shallower water and more generally distributed. The zone as a whole was at that time more extensive, covering parctically the whole area investigated, extending into Northumberland strait and out to the outermost station in the Atlantic. The species was, however, not abundant near these limits nor over the shallower banks.

The effect of the currents on the coastal water and this coastal species would seem to be the following: The circular motion around the gulf acts as a huge whirlpool and tends to collect *S. elegans* in the central portions. Wherever data are available they

show that more individuals were in the middle in the various channels, where Dawson has shown that the water is comparatively stationary, than along the sides. Four of the channel sections show this.

The outflowing Cape Breton current depopulates the gulf to a considerable extent, the older individuals being much less numerous during the second cruise. They are carried by the current along the southern side of the Laurentian channel out into the open Atlantic off the continental shelf for some distance and also into the deeper water on the Breton bank. Such a course for the coastal water is indicated imperfectly by Dickson's charts for surface temperature and salinity for the North Atlantic for the years 1896 and 1897 (Phil. Trans., A, vol. 196, pls. 1-4, 1901), in which can be seen a tongue of water of low salinity, warm in summer and autumn and cold in winter and spring, extending along this course from Cabot strait. This is evidently a very permanent condition. The continuation of this tongue toward the southwest along the outer side of the continental shelf, as appears in fig. 8 at *Acadia* station 12, may well be a regular course for a part of the coastal water in the colder part of the year. It will connect south of Sable island over the Scotian bank with the band of coastal water along the Nova Scotia shore. This view is supported by the finding of coastal water at the bottom near La Have bank by the *Challenger* in May, 1873, and by the presence of *S. elegans* at *Acadia* station 54 (see fig. 10) which would be a last remmant for the summer of this current. This current and the more constant one close to the Nova Scotia coast carry the species to the southern end of Nova Scotia and heap it up there as is seen in fig. 10. During the two months between cruises the currents have transferred the centre of abundance from the Laurentian channel to the lower end of Nova Scotia, only a part being left on the Breton bank.

The current along the southern coast of Newfoundland may carry coastal water and with it this species [illegible] Cabot strait and possibly into the gulf. That it does not enter to any great extent into the current running in past cape Ray will appear from the following considerations. The stations in the northern half of the gulf during both cruises show [illegible] no large *S. elegans*. The cold intermediate water in which it lives is present [illegible] part of the gulf but will have been formed by the mixture of the inflowing boreal water with the surface water, neither of which contain large *S. elegans*. Consequently few or no large individuals are to be expected in the first part of the water's course that is in the northern half of the gulf. If it were derived from the coastal water south of Newfoundland, this would not be the case.

The loss of large individuals from the gulf through Cabot strait being greater than the gain, the gulf would be depopulated were it not for the yearly swarms of young individuals growing up in the surface layers. These will likewise be carried out, but since they are several times as numerous as the adults, enough will be left to keep up the stock. The more or less stagnant areas in the gulf, for example the Bay of Islands fjord, will aid in repopulating the whole area. The conditions in that fjord are most suitable for this species. The bar at the mouth prevents the egress of the large individuals during the summer at least and yet permits of many of the young escaping. We found only the latter at the mouth in August. In the deepest haul in the bay, where there was over 200 metres of suitable water, seventy large individuals were obtained. This may be considered the upper limit for the number that is normal to an area. More than this would certainly be due to concentration, as for example the areas of abundance shown in figs. 8 and 10. The numerical relation between the adults and young is interesting. At both stations in the Bay of Islands where vertical hauls were made (*No 33* stations 57 and 59) the young were about fifteen times as numerous as the adults ($\frac{52\frac{3}{4}}{52}$ and $\frac{1060}{70}$). This provides a very considerable surplus to overflow into the neighbouring depopulated part of the gulf.

The areas of distribution of the boreal oceanic and northern coastal waters overlap to a great extent. In the gulf of St. Lawrence where conditions are moderately static they are separated vertically, the boreal water being below. Elsewhere the separation is not so complete, more or less active vertical mixing going on, as is evidenced by the

two groups of species being mixed and the deep forms found near the surface. The chief large areas of this kind are along the Laurentian channel from Cabot strait out to some distance beyond the edge of the continental shelf, the central portion of the Scotian bank, and the Bay of Fundy.

The typical northern coastal water, as we have described it, has been found by Dawson generally in the gulf of St. Lawrence, along the outer coast of Nova Scotia and around the southeastern corner of Newfoundland. The *Albatross* records show that it was present in July, 1885, on the banks off cape Race, on the Breton bank and along the Nova Scotia shore. Bigelow's results show it in the mouth of the Bay of Fundy, and Copeland's account demonstrates its presence at the bottom in Passamaquoddy bay, as at *Prince* station 4. This is in entire accord with the distribution of *S. elegans*.

In the Southern Coastal zone there are no Chaetognaths or merely small *S. elegans*. It is scarcely distinct from the northern coastal and might be taken to include the surface layers of the latter. This would give it a salinity of less than 31‰ and a summer temperature of from 10° to 20° C., although a somewhat higher salinity would not be excluded. It occurs typically in the Magdalen bay, particularly toward the south. Elsewhere it is not so typical and grades into the northern coastal water. The surface waters generally over the continental shelf approximate to the southern coastal type, except in the Bay of Fundy where the heavy tides increase the surface salinity and lower the temperature. As a result of this there is a virtual absence of small *S. elegans* in the Bay of Fundy.

The movements of this water are not indicated by the Chaetognaths, but it will be carried out of the gulf by the Cape Breton current, and perhaps also to a slight extent through the Gut of Canso. It arises hy a mixture of the river water with the northern coastal, and is dissipated by mixture with the latter and with the boreal oceanic.