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Title

The Copepod Food Cycle

Author

Nelda E. Wright

Atlantic Biological Station

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THE COPEPOD FOOD CYCLE

by

Nelda E. Wright

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Since nearly all the food of fishes and higher animals ultimately depends on plant life, it is interesting to determine the various chains of food formed, from the plants up to these higher animals.

The particular food chain in question includes the Diatom, the Copepod, and the Jellyfish. It is formed on the assumption that the Diatom constitutes food for the copepod; the copepod in turn becomes food for the Jellyfish; and the latter, on disintegration produces nutriment for the Diatom again.

This cycle does not necessarily mean that these organisms are entirely dependent on one another, for to begin with, it is generally known, that the Diatoms get a great deal of their nourishment by means of chlorophyll and sunlight.

Only the first half of the food-chain pertaining to the copepod is dealt with here.

The problem is then resolved into determining (1) whether or not copepods eat diatoms (2) whether or not jellyfish eat copepods.

The following questions suggested by Dr. A. G. Huntsman have also been worked over, along with the main problem.

1. What are the most abundant Copepods in Passamaquoddy Estuary?

2. How do they vary in size and number during the year? Some preliminary experiments were also done on the lethal temperatures and salinites for Copepods.

This work, reported below, was begun at the Atlantic Biological Station, St. Andrews, N. B. during the summer of 1925, and was continued during the fall and winter months of 1925-26, in the Department of Zoology, at the University of Western Ontario, London, Canada.

1. Lethal Temperatures and Salinities for Copepods

The following experiments were undertaken to determine the limits of temperature and salinity at which copepods will survive.

These experiments were tried first on the small copepods such as were found in tows taken from the wharf, or at Prince Station 6. Several genera were included, but Acartia occurred most frequently. These experiments were set up on July 7, 1925, and ended on August 3, 1925, at which time the last copepod died.

Running along with these, were similar experiments on the larger copepods,--mostly Calanus finmarchius caught near Campo Bello, at a depth of 30 meters.

These latter experiments were started on July 13, and one copepod was still alive on October 12, when the ice supply gave out, and thence conditions could not be kept constant.

In each set of experiments, there were set up two series (1) and

(2), of 30 bottles each (the one series duplicating the other as a check), at salinities of 30,25,20,15,10, and they were kept at temperatures of 25,20,15,10, 5 and 0 C., or as near those temperatures as possible.

An electric incubator was used for the 25 degree C. series.

A large insulated box in the basement of the Biological Station, was used for the 20 degree C. series, the temperature being kept constant by large tins of warm water, replenished at intervals.

The 15 degree C. series was placed on one of the large aquarium tables in running water, and was covered with brown paper to keep the copepods in the dark, as in the other cases.

The 10 degree C. series was placed in cold water on one of the large insulated boxes on the ground floor of the laboratory. Ice was added frequently to keep the temperature constant.

The 0 degree C. series was kept in the insulated ice box in a mixture of ice and water.

In each bottle were placed 5 copepods in about 50 cubic centimeters of water. The bottles were made water tight with paraffined stoppers.

The water in the bottles was renewed almost every day, with fresh filtered sea water of the same salinity. The full strength of sea water was diluted, when necessary, by the addition of aerated distilled water.

Each time the water was changed it was noted whether or not the copepods were alive. At the lower temperatures (0o and 5oC.) the animals were often quite inactive, and it was difficult to determine whether or not they were alive; but for the larger copepods, in doubtful cases, a delicate electric shock was administered, which proved their vitality whenever possible.

The salinities given, correspond to the total salt content by weight in a liter of sea water.

The temperatures are always in degrees centigrade.

The following tables give the specific results, in each case.

Temperature 25 degrees C.

Salinity	Small forms		Large forms		Duration of Experiment	Limit of Survival	
	No. living		No. living		Days	small forms	calanus
	1	2	1	2			
50	3	3	3	3	1	5 days	1 day
	1	1	0	0	2	5 days	1 day
	1	0	0	0	3		
	1	0	0	0	4		
	1	0	0	0	5		
	0	0	0	0	6		
25	3	3	3	3	1	1 day	1 day
	0	0	0	0	2		
	0	0	0	0	3		
20	3	3	3	3	1	3 days	1 day
	2	0	0	0	2		
	1	0	0	0	3		
	1	0			4		
	0	0			5		
15	3	3	3	3	1	5 days	1 day
	2	0	0	0	2		
	1	0	0	0	3		
	1	0			4		
	1	0			5		
	0	0			6		
10	3	3	3	3	1	1 day	1 day
	0	0	0	0	2		
			0	0	3		

Temperature 20 degrees C.

Salinity	Small No. living 1	Small No. living 2	Calanus No. living 1	Calanus No. living 2	Days	Limit of Survival small	Limit of Survival large
30	3	3	3	3	1		
	2	2	3	3	2		
	1	1	3	3	3	5	3
	1	0	0	0	4		
	1	0			5		
	0	0			6		
25	3	3	3	3	1	1	3
	0	0	3	3	2		
			2	1	3		
			0	0	4		
20	3	3	3	3	1	2	2
	0	1	3	3	2		
	0	0	0	0	3		
15	3	3	3		1	2	2
	2	0	3	3	2		
	0	0	0	0	3		
10	3	3	3	3	1	1	1
	0	0	0	0	2		

Temperature 15 degrees C.

Salinity	No. living 1	No. living 2	No. living 1	No. living 2	Days	Limit of Survival small	Limit of Survival large
30	3	3	3	3	1	22	24
	2	2	3	3	2		
	2	2	3	3	3		
	2	2	2	3	4		
	1	1	2	3	5		
	1	1	1	3	6		
	1	1	1	3	7		
	1	1	1	3	8		
	1	1	1	3	9		
	1	1	1	3	10		
	1	1	1	3	11		
	1	0	1	3	12		
	1		1	3	13		
	1		1	3	14		
	1		1	3	15		
	1		1	0	16		
	1		1	0	17		
					–		
					–		
	1		1	0	22		
	0		1	0	23		
			1	0	24		
			0	0	25		

Temperature 15 degrees C.

Salinity	Small No. living 1	Small No. living 2	Calanus No. living 1	Calanus No. living 2	Days	Limit of Survival small	Limit of Survival large
25	3	3	3	3	1	9	35
	2	2	3	3	2		
	1	1	2	3	3		
	–	–	–	–	–		
	1	1	2	3	6		
	1	0	2	3	7		
	1	0	2	3	8		
	1	0	2	3	9		
	0	0	2	3	10		
			–	–	–		
			2	3	14		
			1	3	15		
			–	–	–		
			1	3	22		
			1	1	23		
			1	1	24		
			1	0	25		
			–	–	–		
			1	0	35		
			0	0	36		

Temperature 15 degrees C.,

Salinity	Small No. living 1	Small No. living 2	Calanus No. living 1	Calanus No. living 2	Days	Limit of Survival small	Limit of Survival large
Sal. 20	3	3	3	3	1	3	3
	2	2	3	3	2		
	1	0	0	2	3		
	0	0	0	1	4		
			0	1	5		
			-	-	-		
			0	1	8		
			0	0	9		
Sal. 15	3	3	3	3	1	6	1
	2	2	0	0	2		
	1	0	0	0	3		
	1	0			4		
	1	0			5		
	1	0			6		
	0	0			7		
Sal. 10	3	3	3	3	1	1	1
	0	0	0	0	2		

Temperature 10 degrees C.,

Salinity	Small No. living 1	Small No. living 2	Calanus No. living 1	Calanus No. living 2	Days	Limit of Survival small	Limit of Survival large
Sal. 30	3	3	3	3	1	22	25
	1	3	3	3	2		
	-	-	-	-	-		
	1	3	3	3	6		
	0	2	3	3	7		
		2	2	3	8		
		2	2	2	9		
		-	-	-	-		
		2	2	2	14		
		2	12	2	15		
		-	-	-	-		
		2	1	2	18		
		2	1	1	19		
		2	1	1	20		
		1	1	1	21		
		1	1	1	22		
		1	1	1	23		
		0	1	1	24		
			1	0	25		
			1	0	26		
			0	0	27		

Temperature 10 degrees C.

Salinity	Small No. living 1	Small No. living 2	Calanus No. living 1	Calanus No. living 2	Days 1	Limit of Survival small	Limit of Survival large
Sal. 25	3	3	3	4	1	4	18
	2	3	3	4	2		
	2	5	3	4	3		
	2	3	3	4	4		
	0	0	3	4	5		
			2	3	6		
			2	3	7		
			1	3	8		
			1	2	9		
			0	2	10		
				-	-		
				2	13		
				1	14		
				-	-		
				1	18		
				0	19		
Sal. 20	3	3	3	3	1	6	5
	2	2	3	3	2		
	1	2	0	1	3		
	1	2	0	1	4		
	0	1	0	1	5		
	0	1	0	0	6		
	0	0					
Sal. 15	3	3	3	3	1	6	4
	2	3	3	3	2		
	2	3	0	1	3		
	2	3	0	1	4		
	2	0	0	0	5		
	2	0			6		
	0	0			7		
Sal. 10	5	3	5	5	1	1	1
	0	0	0	0	2		

Temperature 5 degrees C.

Salinity	Small No. living 1	Small No. living 2	Calanus No. living 1	Calanus No. living 2	Days	Limit of survival small	Limit of survival large
Sal. 30	3	3	3	3	1	14	41
	3	2	3	3	2		
	3	1	3	3	3		
	3	1	3	3	4		
	2	1	3	3	5		
	2	1	3	3	6		
	1	0	3	3	7		
	–	–	–	–	–		
	1	0	3	3	14		
	0	0	2	3	15		
			–	–	–		
			2	3	21		
			1	3	22		
			1	3	27		
			1	2	28		
			1	1	29		
			0	1	30		
			–	–	–		
			0	1	34		
			–	–	–		
			0	1	41		
			0	0	42		
Sal. 25	3	3	3	4	1	25	68
	3	2	3	4	2		
	3	2	3	4	3		
	3	2	3	4	4		
	21	1	3	4	5		
	2	1	3	4	6		
	0	1	3	4	7		
	–	–	–	–	–		
	0	1	3	4	17		
		1	3	2	18		
		1	3	1	19		
		–	–	–	–		
		1	3	1	25		
		0	3	1	26		
			3	1	27		
			2	1	28		
			–	–	–		
			2	1	48		
			1	0	49		
			–	–	–		
			0	0	69		
Sal. 20	3	3	3	5	1		
	2	2	3	4	2		
	2	2	3	4	3		
	2	2	2	4	4		
	1	2	1	2	5		
	0	0	1	2	6		
	0	0	1	1	7		
			1	1	8		
			–	–	–		

Temperature 5 degrees C.

Salinity	Small No. living 1	Small No. living 2	Calanus No. living 1	Calanus No. living 2	Days	Limit of survival small	Limit of survival large
Sal. 15	3	3	3	3	1	5	1
	2	3	0	0	2		
	1	3			3		
	1	3			4		
	1	1			5		
	0	0			6		
Sal. 10	3	3	3	3	1	1	1
	0	0	0	0	2		

Temperature 0 degrees C.

Salinity	Small No. living 1	Small No. living 2	Calanus No. living 1	Calanus No. living 2	Days	Limit of survival small	Limit of survival large
Sal. 30	3	3	3	3	1	8	39
	3	3	3	3	2		
	4	2	3	3	3		
	4	2	3	3	4		
	4	0	3	3	5		
	4	0	3	3	6		
	2	0	3	3	7		
	1	0	3	3	8		
	0	0	3	3	9		
			3	2	10		
			–	–	—		
			3	2	16		
			2	2	17		
			–	–	—		
			2	2	23		
			1	2	24		
			1	2	25		
			1	1	26		
			–	–	—		
			1	1	34		
			1	0	35		
			–	–	—		
			1	0	39		
			0	0	40		
Sal. 25	3	3	3	3	1	9	23
	2	3	3	3	2		
	2	2	3	3	3		
	2	2	3	3	4		
	1	1	3	3	5		
	1	1	3	3	6		
	0	1	3	3	7		
	0	1	3	3	8		
	0	1	3	2	9		
	0	0	2	1	10		
			–	–	—		
			2	1	13		
			2	0	14		
			–	–	—		
			2	–	17		
			1	0	18		
			0	0	24		

Temperature 0 degrees C.

Salinity	Small No. living 1	Small No. living 2	Calanus No. living 1	Calanus No. living 2	Days	Limit of survival small	Limit of survival large
Sal. 20	3	3	3	3	1	5	91 days
	2	3	1	3	2		still
	2	3	1	1	3		living
	2	3	1	1	4		
	2	2	1	0	5		
	2	2	1	0	6		
	0	0	1	0	7		
			-	-	-		
			1	0	91	still living	
Sal. 15	3	3	3	3	1	4	1
	0	1	0	0	2		
	0	1			3		
	0	1			4		
	0	0			5		
Sal. 10	3	3	3	3	1	1	1
	0	0	0	0	2		

The following table gives a summary of the length of time (in days) which copepods can remain alive, in filtered sea water, at the different temperatures and salinities noted above.

Temp.	0		5		10		15		20		25	
	s	l	s	l	s	l	s	l	s	l	s	l
Sal.												
10	1	1	1	1	1	1	1	1	1	1	1	1
15	4	1	5	1	6	4	6	1	2	2	5	1
20	5	91	5	58	6	5	3	8	2	2	3	1
25	9	23	25	68	4	18	9	35	1	3	1	1
30	8	39	14	41	22	25	22	24	5	3	5	1

s– Small Copepods

l– Large Copepods

Summary

A salinity of 10 can not be tolerated.

" " " 15 is slightly more tolerable but not inducive to longevity.

" " " 20 –

" " " 25 – are quite favorable at low temperatures.

" " " 30 – is the most favorable at all temperatures.

A temperature of 0 degrees C. is the most advantageous for longevity.

A temperature of 5 degrees C. is also quite favorable.

Temperatures of 10 and 15 degrees C. are not very suitable except at a salinity of 30.

Temperatures of 20 degrees and 25 degrees C. are not suitable at any salinity.

Also, the larger copepods have greater vitality than the smaller forms.

2. <u>To Determine the Food of Copepods.</u>

A large number (about 85) were dissected carefully, and the contents of the digestive tract were examined microscopically.

The results were as follows:-

Copepod	Food
1 Copepod species undetermined -	6 coscinodiscus- some only empty shells, large mass of green material - may be unicellular algae or bits of higher plant tissue.
1 Acartia bifilosa	1 coscinodiscus masses of green material.
1 Acartia	1 coscinodiscus mass of green and broken plant material, with a few unicellular algae.
1 Acartia	1 coscinodiscus, with 3 times the mass of plant tissue and algae.
1 Acartia	Green plant material with a few unicellular algae.
26 Copepods	1 diatom-coscinodiscus and twice as much unicellular algae and plant fratments.
1 Calanus finmarchius	1 pleurosigma, and clumps of small green particles.
1 Calanus finmarchius	Unicellular algae, and bits of green plant material.

Copepod	Food
1 Calanus Fin.	1 nitzchia, 1 campulodiscus.
1 Calanus fin.	a great many bits of Pediastrum.
1 Calanus Fin.	Bits of pediastrum, 3 Thalassiothrix, and a mass of green material, probably plant cells.
1 Calanus Fin.	4 Thalassiothrix bits of coscinodiscus a number of pieces of pediastrum.
1 Eurytemora herdmani	1 coscinodiscus, 1 Thalassiothrix mass of green material
1 Calanus Finmarchuis.	Pieces of Pediastrum, pieces of coscinodiscus, 5 Thalassiothrix, 1 piece of navicula
1 Calanus Fin.	A great many pieces of pediastrum also many pieces of Thalassiothrix.
1 Calanus Fin.	1 Coscinodiscus, 2 Thalassiothrix, 3 small bits of Pediastrum.
1 Calanus Fin.	3 Thalassiothrix, a few bits of pediastrum
1 Eurytemora hirundoides	several pieces of Coscinodiscus
1 Eurytemora herdmani	several pieces of shell of Cosinodiscus, a few small pineces of Pediastru. a mass of green material
1 Temora longicornis	several small bits of pediastrum a mass of irregular green particles
1 Eurytemora herdmani	1 whole Coscinodiscus, 1/2 and severals smaller pieces of Coscinodiscus, a mass of irregular green material.
1 Eurytemora herdmani	2 whole coscinodiscus and several pieces a few clumps of irregular green material

Copepod	Food
1 Eurytemora herdmani	1 piece of Coscinodiscus and a mass of irregular particles.
1 Eurytemora herdmani	1 whole coscinodiscus, and several pieces, also a mass of irregular green particles
1 Eurytemora herdmani	1 Coscinodiscus, and a mass of green particles
1 Temora longicornis.	1 Coscinodiscus and a mass of green material
1 Calanus finmarchius	6 pieces of Thlassiothrix few pieces of Podiastrum
1 Calanus finmarchius	2 Thallassiothrix, 4 small cells of Pediastrum.
1 Calanus finmarchius	12 pieces Thalassiothrix bacteria were abundant
1 Calanus finmarchius	7 pieces Thalassiothrix 3 cells of Pediastrum a great many bacteria.
1 Eurytemora herdmani	8 pieces Thalassiothrix, 3 small pieces Pediastrum
1 Eurytemora herdmani	2 small bits of coscinodiscus a mass of green material.
1 Eurytemora herdmani	a mass of greenish brown material, in which nothing could be identified.
1 Eurytemora herdmani	several pieces of coscinodiscus shell in a mass of small green particles.
1 Acartia bifilosa	A mass of green material on which nothing definite could be identified.
1 Eurytemora herdimani	A mass of irregular green particles
1 Eurytemora herdmani	A piece of coscinodiscus and a mass of green material.
1 Tortanus discaudatus	A mass of green material

Copepod	Food
1 Eurytemora herdmani	6 large pieces of Rhizosolenia, 1 Biddulphia 1/2 Coscinodiscus and several small pieces, 3 Thalassiothrix, and a quantity of irregular green material
1 Acartia bifilosa	A mass of green material
1 Eurytemora herdmani	1 small piece of Rhizosolenia, several small pieces of Coscinodiscus and a mass of green material.
1 Eurytemora herdmani	2 Rhizosolenia, peridinium, 1 small piece of Coscinodiscus and a mass of green particles.
1 Eurytemora herdmani	3 pieces of Rhizosolenia, and a mass of green material.
1 Eurytemora hirundoides	3 pieces of coscinodiscus a mass of irregular particles
1 Temora longicornis	1 whole coscinodiscus a mass of irregular greenish particles
1 Eurytemora herdmani	a mass of green material
1 Acartia bifilosa	3 pieces of coscinodiscus a mass of green particles.
1 Eurytemora herdmani	1 whole coscinodiscus, 4 pieces of coscinodiscus a mass of greenish-brown material.
1 Pseudocalanus elongatus	A mass of greenish-brown material.
1 Temora longicornis	2 pieces of coscinodiscus, 4 pieces of Rhizosolenia.
1 Eurytemora herdmani	4 pieces of Coscinodiscus, a mass of irregular greenish-brown material.
1 Acartia bifilosa	3 whole coscinodiscus, several pieces of coscinodiscus, part of the body of a crustacean.
1 Temora longicornis	Several small pieces of Podiastrum, 2 large and a few small pieces of Coscinodiscus, a mass of greenish-brown particles.

Copepod	Food
1 Eurytemora hirundoides	3 small pieces of coscinodiscus a mass of greenish-brown material.
1 Temora longicornis	2 Coscinodiscus several pieces of coscinodiscus, a mass of greenish particles.
1 Acartia bifilosa	A mass of irregular green material
1 Temora longicornis	3 Coscinodiscus, 1 piece of Rhizosolenia 2 Thalassiothrix in a mass of greenish-brown particles.

Summary:

In all the copepods, dissected, the principal form of food (that could be identified) consisted of diatoms. Other material was present which resembled broken-down plant tissue, a little of it resembling unicellular algae, but nothing definite could be determined from it. It might possibly be diatom contents, since the majority of diatoms were found, crushed.

The principal diatoms found, were as follows, named in the order of their frequency;-

Coscinodiscus
Thalassiothrix
Rhizosolenia
Nitzchia
Pleurosigma
Campylodiscus
Navicula
Biddulphia

Bits of Pediastrum occurred quite frequently and 1 peridinium was found.

Marie Lebour also found in her work on "The Food of Plankton

Organisms" that the copepods, "as is already well known, depend largely on the diatoms for food, in fact, many seem to be almost wholly diatom feeders. This seems to be the case with pseudocalanus, also with Acartia clausi, Paracalanus parvus, and probably many other. Temora longicornis, although feeding largely on Diatoms, also sometimes eats copepods, and it is the same with Calanus, finmarchius and centropages typicus".

It seems justifiable, then, from the evidences stated above, to say that copepods eat diatoms.

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3. To Determine the Food of Jellyfish

Over 150 of the genus aurelia were examined. The tentacles, lips, manubria, and stomach were investigated carefully for food. Sometimes food was also found in the radial canals, and rarely in the circumferential canals.

The Jellyfish were caught in different localities: from the wharf of the Biological Stations; Brandy Cove; Station 6-between the Biological Station and Robbinstown, Maine; and between Deer and Navy Islands in Passamaquoddy Bay.

The Aurelia were also taken from different depths. In any case the food varied little, so that one may say they had found the natural food of the jellyfish.

The results of the investigation were as follows:-

No. of Aurelia examined	Copepods	Mussel larvae	other food
July 30,- caught from the wharf.			
6	1	few	1 ceratium
Aug. 2- 1		6	
1		8	
1		46	1 gastropod larva
1		Large masses	few " "
1	1	few	
1	1	masses	
1		"	
1		few	
1		masses	
1		"	
Aug. 6- 1	5	"	Some Nitzschia & Pleurosigma, several ceratium, 6 Tintinnids some filamentous algae, few gastropod larvae.
4		few	
7		"	
Aug. 7- 1 caught between Deer and Navy Islands at the surface			
1	10	abundant	Few diatoms, ceratium tintinnids, gastropod larvae
1	Pieces of several	few	Tintinnids, ceratium few diatoms.
1		few	
1	1	few	
3		few	
1		few	few gastropod larvae
Aug.11- 1 caught at wharf	1 & part of another	few	few diatoms, ceratium, tintinnids,
3		few	
Aug.13- 1	2	abundant	1 gastropod larva-littorina polychaete annelid.
1		2	few diatoms & tintinnids
1		1	" " "
1		3	" " "

No. of Aurelia examined	Food Copepods	Mussel Larvae	Other Food
Aug. 13 1		6	2 gastropod larvae
1	1	2	
3		few	
1	2	few	
1			polychaete annelid
1		1	
1		24	
Aug. 17- Caught off the wharf and in Brandy Cove.			
1		several	1 gastrapod larva
1	2	abundant	few certium, few pleurosigma other bits of diatoms in chins.
1	1	abundant	
1		masses	few gastropod larvae
1		few	" " "
1	1	few	
1		5	
1	6	masses	
1		"	1 cladoceros & part of another.
1		several	
Aug. 18- Brandy Cove.			
1	9 3 larvae	3 dozen	2 annelids, few ceratium pleurosigma,
1	1 part of 2. 2 larvae. 7 exoskeletons	72	5 gastropod larvae, few diatoms.
1	3	5	
1		4	1 gastropod larva
1		1	
1		masses.	few " "
1	1	24	
1	3	masses	" " "
1		several	
1		6	
1		few	
1		"	
Aug. 19- caught at Station 5, depth 30 meters.			
1		masses.	
1	1	16	few diatoms
1		20	
1	1	17	
1	1		
1	1	masses	
1	1	23	
Aug. 20 caught at wharf.			
1	1 1 broken	masses	few diatoms, few gastropods
1		6	mass of unicellular green
1		40	algae, 12 tintinids
Aug. 23. Brandy Cove.			
1	2	40	3 gastrapod larvae

	Copepods	Mussel larvae	other foods
Aug. 23, Brandy Cove.			
1		1	
1		7	few diatoms
1		few	
1		1	
1		2	bit of green algae
1	1	6	1 chain of diatoms 2 mm. long.
1		few.	
1		11	1 gastropod
1	1	7	
1		12	
Aug. 24- Station 6.			
1	6	28	Few ceratium, few diatoms, (pleurosigma thalassiosira) few tintinnids, few small crustaceans unable to identify.
1	4	few	few coscinodiscus, few certatium, few tintinnid shells.
1		1	
1	1	7	1 piece green algae (2 mm. long)
1	1	22	1 diatom pleurosigma, small bit of green algae.
1		3	
1	2	10	1 coscinodiscus.
1	5	few	few pleurosigma, bits of green algae.
1		1	
1	1	15	
1		few	
Aug. 26- Brandy Cove.			
1	2	14	Bits of green algae, few pleurosigma 44 coscinodiscus.
1	3 3 exoskeltons 1 larva	122	cosc.58. gastropods 9
1	5 1 larva	41	62 Coscindodiscus 4 gastropods larvae littorina littorea some of the shells empty
1	6 3 larvae.	63	24 Cosc.
1		7	6 Cosc.
1		16	5 "
1	1	15	17 Cosc. 1 gastropod larva.
Aug. 26.1	1	6	3 Cosc. 1 Pleurosigma
1		37	20 "
1	2	41	1 Crustacean belonging to cumacea 97 Cosc., 4 gastropod larvae.
1	1	3	3 Cosc.
1		1	8 " , 1 gastropod larva
1		9	35 " ,
Aug. 26, Station 6., 35			
1	1 broken part	55	3 " , 3 " "

		Copepods	M. Larvae	Other food
August 26. St. 6				
	1	8	4	
		1 exoskeleton		
	1		1	
	1	1		
	1	2	10	
	1	6	10	3 Cosc. 2 gastropod larvae
	1	2	3	2 " "
	1	4	1	
	1		1	1 Amphipod
Aug. 28, St. 493				
	1	5	3	
		part of 1		
Sept. 3. Wharf.				
	1	5 1/2		
	1		1	
	1		1	
	1		1	1 Cosc.
	1		2	1 polychaete annelid
	1			1 amphipod
	1		1	
	1	1 part exo.		
Sept. 9.				
	1			1 Coscinodiscus
	1		2	
	1		5	2 "
	1	6	17	11 "
				1 crustacean larva
				1 gastropod larva
				3 amphipods
	1			6 Coscinodsicus
	1		1	
	1	3	1	2 "
	1	5	5	1 "
				1 polychaete annelid
	147	209	2022	

Summary

Of the 159 Aurelia examined, 12 contained no food at all, while in the remainder mussel larvae (mytilus edulis) formed by far the most abundant food. The number of Copepods found were roughly, about one tenth the number of mussel larvae. There were also a variety of other food- as listed- in smaller quantity.

Although not forming the predominant food of the Aurelia, it seems evident that Jellyfish do eat copepods.

4. <u>In order to determine the most abundant copepods in Passamaquoddy Estuary</u>, vertical tows were taken at Prince Station 6, and at Prince Stations 488, 480, 493, 494, 495, and 498. The tows were taken from a depth of 30 meters to the surface; vertical hauls being considered more reliable and more truly representative of any region since the number of copepods varies irregularly with the depth. All the tows were taken with 5 net, and the contents were preserved immediately in formalin.

The tows for stations 488-498 were all taken on the same day, August 28.

The volume of water in each jar was determined by placing the same depth of water in a similar jar, and measuring the amount of water in the second jar by means of a graduate.

The liquid in each jar was stirred about thoroughly and before settling, 1 cubic centimeter of the material was removed, and the contained copepods were counted. Several of such trials were made, and the average taken. By multiplying this number by the volume of liquid in the jar, the total number of copepods in each tow was determined. The results obtained were as follows:-

Date	Station	Total no. of Copepods in Tow
Aug. 19	6	3588
Aug. 26	6	4577
Sept. 1 A.M.	6	6408
Sept. 1 P.M.	6	4858
Sept. 2	6	9716
Sept. 9	6	5340
Sept. 16	6	6210
Sept. 23	6	14994
Oct. 1	6	18705
Oct. 7	6	6400
Oct. 14	6	3120
Oct. 21	6	8120
Oct. 28	6	7840
August 28	488	2635
" "	490	8675
" "	493	6293
" "	494	10441
" "	495	3180
" "	498	2160

To determine the relative numbers of each species of Copepod a large number were picked at random from the jar and about 50 of these were identified and measured.

The following table gives the percentage number of each species found in the various tows:-

	488	490	493	494	495	498
Acartia Clausi	45	35	33	30	29	35
Acartia bifilosa	25	33	25	38	36	39
Acartia longiremis	2		2			4
Tortanus discaudatus	6	2				2
Eurytemora herdmani	11	13	16	20	18	19
Temora longicornis	2	9	8	6	2	
Pseudocalanus elongatus	7	9	14	4	11	
Oithona similis	2					
Calanus finmarchicus						

Station 6	Aug. 19	Aug. 26	A.M. Sept. 1	P.M. Sept. 1	Sept. 2	Sept. 9	Sept. 16	Sept. 23	Oct. 1	Oct. 7	Oct. 14	Oct. 21	Oct. 28	Total
Acartia clausi	21	21	32	18	28	29	19	18	29	17	20	25	25	509
Acartia bifilosa	41	29	36	36	37	32	54	27	29	41	37	32	40	667
Acartia longiremis								2					2	12
Tortanus discandatus	20	19	11	33	21	21	13	14	9	14	18	16	11	230
Eurytemora herdmani	16	10	14	9	6	11	9	23	19	26	6	12	5	263
Temora longicornis		15	2		6	4		5	7		8	2	12	88
Pseudocalanus elongatus	2	4			2	2	6	7			12	9	3	92
Oithona similis		2			2									6
Calanus finmarchius						2		2	2			4	2	12

From observing the totals, it will be noted that the copepods occur in order of frequency as follows,-

Acartia bifilosa
Acartia clausi
Eurytemora hordmani
Tortanus discandatus
Pseudocalanus elongatus
Temora longicornis
Eurytemora hirundoides
Calanus finmarchius)
Acartia longiremis)
Oithona similis

The percentage numbers of the four most abundant Copepods and also the total number of Copepods in each tow were plotted against time (from August 19 until October 28). Graph (1)

It will be seen that each species shows a maximum, the total maximum occurring on October first.

Some attempt was made to account for these maxima, but so far, nothing conclusive has been discovered.

A graph was made plotting the total number of copepods against time from July 30 till December 31, 1924) and also the total number of Diatoms over the same period. Although there was not sufficient correlation to give any definite results, yet there was a suggestion that there might be some relation between the Diatom and Copepod maxima. It would be interesting to work over further data on the subject.

The vertical hauls taken at regular intervals from august 19-October 28, 1925, at Prince Station 6, were also used to determine the variation in size of the Copepods over that period of time.

About 50 specimens from each tow were identified and measured by means of a micrometer. The measurement taken was the length of the body from the tip of the head to the end of the tail furca (exclusive of tail setae).

The following table gives the average length in millimeters of the different species of Copepods.

Average length in Millimeters

Species	Aug.19	Aug.26	Sept.2	Sept.9	Sept.16	Sept.23	Oct.1	Oct.7	Oct.14	Oct.21	Oct.28
Acartia Clausi	.97	.95	.98	.90	.86	.96	.88	.89	.94	.90	.90
Acartia bifilosa	1.02	1.04	1.05	1.02	1.03	1.04	1.00	1.00	.99	1.03	.97
Tortanus discandatus	1.37	1.45	1.50	1.40	1.30	1.34	1.22	1.28	1.46	1.48	1.40
Eurytemora herdmani	1.15	1.15	1.15	1.14	1.07	1.14	1.05	1.07	1.06	1.01	195
Pseudocalanus elongatus		1.02		1.20		1.30	.90		1.12	1.10	1.05
Temora longicornis		1.00	1.24			1.15	1.19		1.19	1.40	1.22
Eurytemora hirundoides						1.00	.91				
Oithona similis		.80	.90								
Acartia Longiremis						1.00	2.80				
Calanus finmarchius		2.25	2.25							2.90	3.20

The average lengths of each of the four most abundant copepods were plotted against time.

The average length of the whole four species was also plotted against the same period of time.

It will be noticed from the graph (No. 2) that the curves of each species are similar, and also that these curves correspond to the graph of the whole four.

These maxima of size are probably due to various groups developing at different periods. But not sufficient data has been worked over to make certain of this cause.

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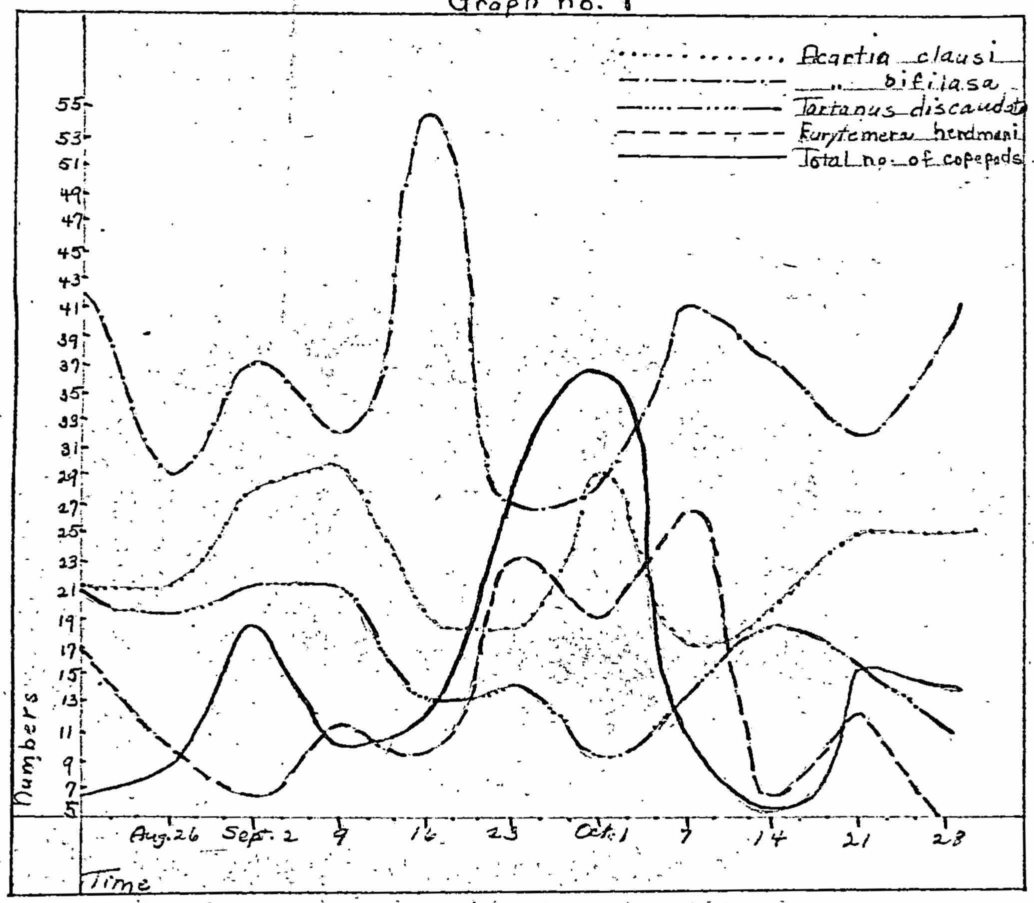
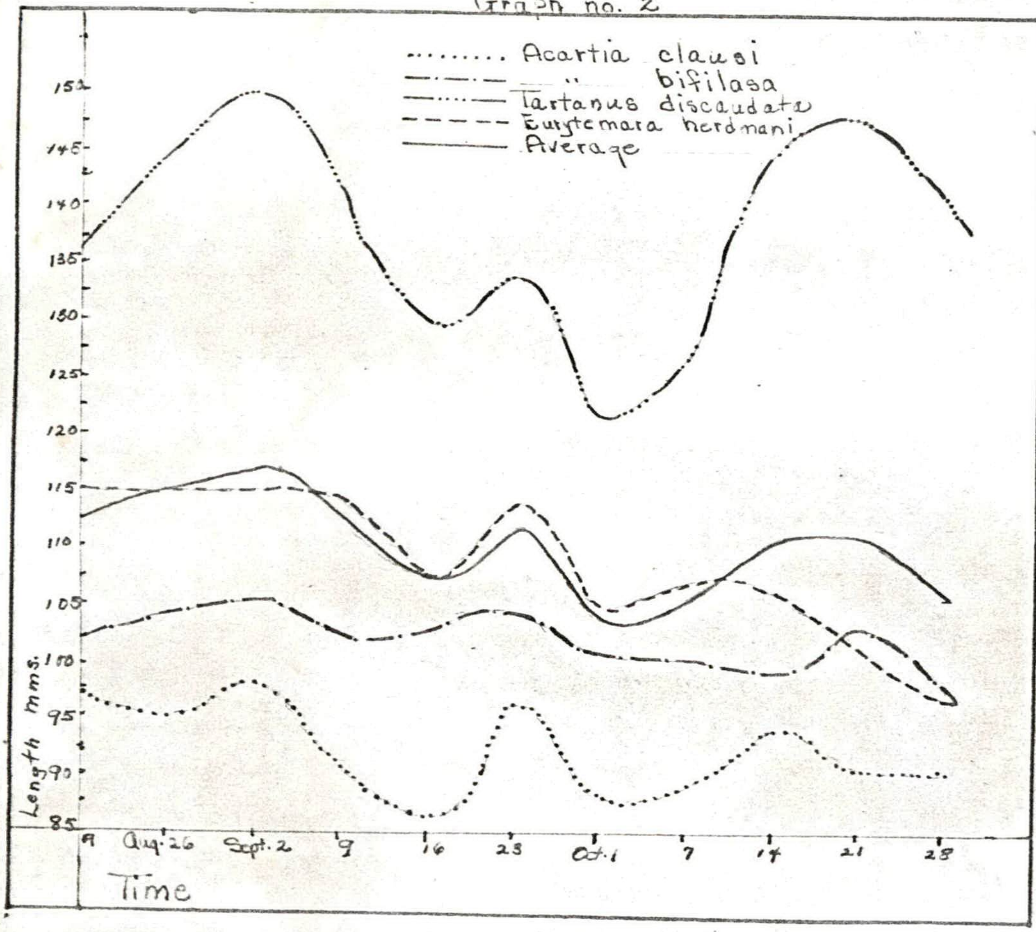
Graph no. 1



Acartia clausi
" bifilasa
Tortanus discaudata
Eurytemora herdmani
Total no. of copepods
55
53
51
49
47
45
43
41
39
37
35
33
31
29
27
25
23
21
19
17
15
13
11
9
7
5
Numbers
Aug. 26
Sept. 2
9
16
23
Oct. 1
7
14
21
28
Time

Graph no. 2


Acartia clausi
" bifilasa
Tartanus discaudata
Eurytemara herdmani
Average
152
145
140
135
130
125
120
115
110
105
100
95
90
85
Length mms.
Aug. 26
Sept. 2
9
16
23
Oct. 1
7
14
21
28
Time