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A SECOND REPORT ON STARFISH WITH REFERENCE TO THE OYSTER

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A SECOND REPORT ON STARFISH WITH REFERENCE TO THE OYSTER.

A report of work at
Prince Edward Island
Biological Station.
Summer 1935.
Winter 1936.

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University of Toronto.
March 20, 1936.

Mar 25/36

The material of this report is the work of summer 1935 and two weeks in February 1936, on starfish with reference to oyster culture. The work was done at the Prince Edward Island Biological Station at Ellerslie, P.E.I. under Dr. A.W.H. Needler. Thanks are also due to Professor A.F. Coventry, of the University of Toronto, for many suggestions.

The problem was begun in the summer of 1934. On the first summer's work a report has already been submitted. For the most part the work of 1935 was a continuation of the observations and experiments initiated in 1934. Therefore the report herein contained does not form a unified whole, but is rather in the nature of an amplification, extension, and in some points a revision of the previous report.

Spawning of Starfish and Settling of Larvae.

In 1934 the attempt to determine the spawning period of Starfish failed because work was begun too late in the season. In 1935 the work was begun the last week in May.

In this part of the work three methods were employed. The gonads were examined to estimate to what extent spawning had taken place. Plankton tows were taken to trace the development of the larvae, and microscope slides were suspended in the water to estimate the time of the major settling of starfish larvae.

The following are the data from the examination of gonads. ø is in this report the mean diameter of the starfish in centimetres.

Date.	Place	Temp.	ø	Gonads small	Gonads medium	Gonads large
23/5/35	Martin Landry Bed.	10.7°C	16			1
			8			1
			6			1
			5			1
23/5/35	McKay's Point	10.5°C	13			1
			10			1
			8			1
			6½			1
			6			1
			4			1
25/5/35	Cooper Bed	11.1°C	2½		3	3
			3			1
			3½		3	11
			4		2	15
			4½		3	7
			5		1	6
			5½		2	5
			6		1	3
			7			2
			7½		1	

Date.	Place	Temp.	Ø/	Gonads small	Gonads medium	Gonads large
27/5/35	Wharf Bed	13.1°C	2½	1	1	2
			3	1	1	4
			3½	1	1	20
			4		2	7
			4½			6
			5			1
			5½	1		
			6			4
			6½			1
			7½			3
			8			1
			9			1
			10			1
30/5/35	Lane shell Bed	15°C	4			3
			4½			2
			5			2
			5½			1
			6		1	7
			6½			3
			7			11
			8			5
			9		1	2
			10½			3
~~30/5/35~~ 5/6/35	Cooper Bed	17.7°C	5½		1	
			6	1		1
			8	1		1
5/6/35	Claude Hayes' Bed	19.5	10			1
			7	1		
7/6/35	Wharf Bed		3		11	17
			4	9	40	32
			5	12	40	27
			6	6	30	32
			7	5	21	15
			8	1	6	7
			9	1	3	1
			12		2	1
11/6/35	Bar Bed	18	5	1		1
			6	3		2
			7	3	1	6
			8		1	3
			8½	3		
			9	1	1	1
			10	2		
			11	2		
			12	1	1	
			13		2	
			14	1		

Date	Place	Temp.	Ø	Gonads small	Gonads medium	Gonads large.
21/6/35	Totten Bed	18	2	6		1
			3	27	2	
			4	30	7	
			5	36	7	3
			6	27	6	
			7	16	7	2
			8	7		2
			9	5	1	
			10	1		
			12	1		
			14	2		
			18	1		

These data show that spawning was taking place during the first week in June in Bideford River P.E.I. It is seen that starfish as small as 2½ and 3 cm. have mature gonads. As will be seen later, these individuals are probably just one year old.

For comparison, the gonads of starfish collected at St. Andrews N.B. and sent to the Biological Station at P.E.I., by the courtesy of Dr. Leim, were examined. At St. Andrews, two species of starfish, Asterias vulgaris and A. forbesi, occur together near low tide mark. It is only the former species, however, that is found in Malpeque Bay P.E.I. The data are presented below.

Condition of Gonads

Starfish collected at Atlantic Biol. Sta. Wharf, St.Andrews N.B.

	May 30				June 27			
Ø	vulgaris		forbesi		vulgaris		forbesi	
	large	small	large	small	large	small	large	small
under 5	1					7		
5 -10	1	6		3	10	10	11	4
over 10	11	3	5	1	7		4	

	July 2				July 17				Aug 16			
Ø	vulgaris		forbesi		vulgaris		forbesi		vulgaris		forbesi	
	L.	S.	L.	S.	L.	S.	L.	S.	L.	S.	L.	S.
under 5						10				1		
5 -10	5	3	4		2	19	9	4		10		6
over 10		1	13	4		1				5		7

These figures are not so definite as those for Malpeque Bay but two observations may be made on them. The data indicate that A. vulgaris spawns earlier than does A. forbesi at St.Andrews. This is to be expected since A. forbesi is a more southerly form than A. vulgaris. A. vulgaris is found in colder waters than A. forbesi, occurring up the Labrador Coast. A. vulgaris spawns much earlier in Malpeque Bay than does this species at St.Andrews. This is doubtless due to the much earlies warming up of the water in Ma lpeque Bay

To follow larval development a series of plankton tows was made during the last part of May, all of June and the first part of July. The significant data are given below in tabular form.

Plankton Tows 1935.

Date	Tow No.	Place	Depth	Net	Larval Stage.
June 5	35-11	Indian Island	Surface	18	Gastrulae
"	35-12	" "	24 ft.	5	Gastrulae
"	35-13	Cooper Bed	S	18	Gastrulae, young bipinnaria
"	35-14	Claude Hayes'Bed	S	18	young bipinnaria
June 6	35-15	2001	S	18	" "
" 7	35-16	Black Buoy	S	5	" "
"	35-17	Shipyard Point	S	5	" "
June10	35-18	Cooper Bed	S	5	" "
"	35-19	Claude Hayes'Bed	S	5	" "
June13	35-20	2001	S	5	Brachiolaria
" 14	35-24	Cooper Bed	5 ft.	5	young & old bipinnaria
"	35-25	" "	S	5	young bipinnaria
"	35-22	2004	20 ft.	5	bipinnaria
"	35-23	2004	S	5	"
June 21	35-26	2004	S	5	Bipinnaria, brachiolaria
"	35-27	2004	20 ft.	5	" "
July 2	35-32	Cooper Bed	Bottom	5	old bipinnaria

Slides were set out to catch settling larvae if possible. The slides were suspended vertically in racks in various parts of Bideford River where larvae were known to occur. Some racks were suspended at the surface and others near the bottom. The slides were changed and examined periodically. In only three ca ses were larvae obtained.

Microscope Slides

Set out	Taken up	Place	Position	Starfish
June 20	July 3	Station Stage	Low tide level	550-750 microns
June 21	July 4	Claude Hayes' Bed	Bottom	770 "
July 4	July 8	Cooper Bed	Bottom	780 "

Apparently the ma jor settling took place between June 20 and July 4.

Discussion.

The information from these three methods checks very well. The gonads showed that the major spawning took place during the first week in June. The first larvae were obtained on June 5 being free swimming gastrulae. From this date to June 21, progressively later larval stages appeared in the plankton until after July 2. Metamorphosed larvae were obtained between June 20 and July 4. The temperature of the water during the first week in June was roughly 16°C, but rising rapidly. This temperature is in excess of the temperature at which this species spawned at St.Andrews. The explanation is possibly that the temperature was rising so rapidly that spawning was not well under way until the temperature was much higher than the minimum necessary for spawning. The larval life of the starfish was about three weeks in these warm waters.

Size Constitution of a Population, Population Density and Growth.

Measurements of samples of Starfish population begun in 1934 were continued. The population constitution according to size for Cooper Bed on several dates and for Fred England Bed on one date, for comparison, is given below. Ø is mean diameter in centimetres.

Starfish Size Distribution

	Cooper Bed										Fred England	
	Oct.23/34		June 27/35		July 26/35		Sept. 21/35				Sept. 16/35	
Ø	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1	3	.6	5	.7			1	.2				
1½	9	1.9	33	4.8	10	2.0	6	1.1				
2	75	15.5	80	11.7	69	14.5	30	5.4				
2½	93	19.2	159	23.2	88	18.5	67	12.0				
3	76	15.6	136	20.0	90	19.0	85	15.3				
3½	61	12.6	76	11.1	41	8.6	86	15.4				
4	49	10.1	71	10.4	34	7.1	72	12.9			4	.7
4½	30	6.2	35	5.1	30	6.3	38	6.8			1	.2
5	24	5.0	25	3.7	37	7.8	35	6.3	466	32.0	16	2.8
5½	15	3.1	18	2.6	20	4.2	21	3.8			25	4.3
6	13	2.7	19	2.8	16	3.4	26	4.7	385	26.5	50	8.6
6½	9	1.9	4	.6	10	2.0	24	4.3			49	8.5
7	8	1.7	5	.7	9	1.9	15	2.7	275	18.9	70	12.0
7½	2	.4	1	.1	3	.6	7	1.3			75	13
8	4	.8	4	.6	4	.8	12	2.2	156	10.7	69	12.
8½			1	.1	1	.2	6	1.1			55	9.5
9	1	.2	1	.1	3	.6	3	.5	69	4.8	53	9.2
9½	5	1.0	2	.3	2	.4	3	.5			32	5.5
10	1	.2	3	.4	4	.8	3	.5	48	3.3	29	5.0
11	3	.6	3	.4	4	.8	4	.7	16	1.1	24	4.1
12			2	.3			5	.9	14	1.0	9	1.6
13	1	.2					1	.2	6	.4	7	1.2
14	1	.2	1	.1			1	.2	5	.3	4	.7
15							1	.2	4	.3	4	.7
16			1	.1			2	.4	4	.3	1	.2
17							2	.4	5	.3	1	.2
18									1	.1	1	.2
19									1	.1		
Total	484	99.7	685	100.0	475	99.8	556	100.0	1455	100.1	579	100.2

It was brought to notice in the 1934 report on this work that the size distribution of the starfish in this region was unimodal. Irregularities in the distribution of larger sizes were noticed however. These might represent all that remained of secondary modes or might be irregularities due to the small number of individuals. ~~of sizes~~.. It may be seen from the above table

for Cooper Bed on Sept. 21, 1935, that only 30.9% of the starfish are larger than 4½ centimetres in diameter. 1455 starfish larger than 4½ cm were measured to the nearest centimetre. These two sets of measurements are therefore the equivalent of measuring a sample of 4700 specimens. The irregularities in size distribution had entirely disappeared. There is therefore no indication of year classes shown by this method of attack.

It may be seen that over winter the mode of the size distrib--ution did not shift for Cooper Bed, but during the summer there was a slight increase. The small growth of starfish on Cooper Bed is to be associated in all probability with the great density of of population of starfish, which will be mentioned later, and the relative scarcity of food suitable for small starfish. It has been shown by Mead that starfish may exist for a considerable time without any food.

The greater size of the starfish on the Fred England Bed probably has a similar explanation. There was here a greater abundance of food which was in the form of small spat planted on the bed at the beginning of the season. This is a similar case to Martin Landry Bed reported in 1934. These observations are in accordance with the view put forward in the previous report, that the size of the starfish is not a measure of the age but an indication of the availability of food.

The total catches of starfish taken from the Department of Fisheries' Beds, during the course of routine mopping to remove these pests, were counted. This was an attempt to obtain an estimate of the starfish population densities. Mopping operations ceased on a particular area when catches became small. The writer

is of the opinion that in this process 75 or 80% of the starfish on the area at the time were removed.

Starfish Population Estimate Bideford River

Place(Bed)	Date	Days Mopping	Number	Area
Totten Bed	June 17-22	5	5133	
Bar Bed	June 22-24	1	1400	
Shipyard Pt.	June 24-29	2½	5084	
Fred England	Sept.15-17	3	5470	
Cooper			42400	

The size of the starfish on Cooper Bed and Fred England Bed were contrasted earlier in the report. In the case of Cooper Bed the starfish were for thr most part, too small to eat the oysters. The starfish are concentrated on the bed, however, presumably attracted there by the oysters which proved to be too large to open. Other food on the bed is apparently enough to keep this large population alive, at least for the most part, but insufficient to permit much growth. Under these delicately balanced conditions, the starfish are an asset to the oyster bed, since they keep the population of oyster competitors, such as mussels, at a low level. From the oyster's point of view the small starfish is a very different animal from the large starfish. The small starfish is an ally but the large starfish is an enemy. Three points are to be carefully considered however. The starfish must be too small to open the oysters and no oysters that are small enough to be opened should be planted on the bed. The population of starfish must be so large that food is so scarce that appreciable growth of the starfish cannot take place. If the starfish population were decreased or the food increased, either in the form of small oysters or other food, the population of starfish would be expected to increase in the size of the indivi-

which would then be able to open the large oysters. The oyster bed must not rely on the natural set of spat as these would be eaten by the starfish, but should be a bed that is stocked with oysters already above the size that can be opened by the starfish. Under these narrow conditions it would be an asset to oyster culture to have a large population of small starfish on an oyster bed.

The estimation of growth rate from size (diameter) analyses of a population at different times is subject to several possible errors. The position of the peak of the curve is not only influenced by rate of growth of individuals of the population, but a differential mortality would have a marked effect. There is no certainty that the population at one place is constant. Indeed, as will be shown, there is a definite seasonal mass movement of starfish. It is not necessarily to be expected that the number of starfish from each size class, leaving a definite area at one time, will be proportional to the number of starfish in the size class.

In an attempt to obtain a better measure of growth, starfish were placed in cages with an abundance of mussels as food, and sunk near the bottom of the river under the station stage. One tray was left floating for comparison

The diameters of starfish are given below in centimetres.

	Tray I			Tray II			Tray III		
	Floating near Stage			Sunk			Sunk		
	Sept.4	Sept.26	Oct.12	Sept.4	Sept.26	Oct.12	Sept.4	Sept.26	Oct.12
	4.7	5.6	6.2	3.3	4.2	4.6	4.8	6.0	5.6
	4.8	5.7	6.4	3.6	4.7	4.8	5.0	5.5	6.3
	4.9	6.3	6.9	4.0	4.6	5.2	5.2	6.6	6.5
	5.9	6.8	7.2	4.0	5.1	5.6	5.1	6.8	7.0
	6.4	7.0	7.9	4.1	5.3	6.0	5.4	6.4	7.2
	6.9	7.6	8.0	4.1	5.6	6.0	5.5	6.8	7.7
	7.0	7.5	8.4	4.6	5.6	6.3	6.0	7.1	7.1
	7.0	7.4	9.0	4.7	6.0	6.8	6.5	7.6	8.2
	7.1	8.3	9.0	4.8	5.6	6.9	6.6	7.7	8.2
	7.7	8.7	9.2	4.5	6.2	7.3	6.0	6.6	7.2
verage	6.24	7.09	7.82	4.17	5.29	5.95	5.61	6.71	7.10

	Tray IV. sunk				Tray V. sunk			
	Sept.4	Sept.26	Oct.12/35	Feb.10/36	Sept.4	Sept.26	Oct.12/35	Feb.10/36
	7.0	8.2	8.3	8.4	8.3	7.5(?)	9.0	
	7.1	7.5	7.6	8.5	8.4	8.3	9.2	all dead
	7.4	8.0	8.2	9.5	8.8	8.6	9.2	
	7.4	7.6	7.8	9.2	8.8	10.0	9.4	smothered
	7.5	9.0	8.9	10.0	8.9	9.2	9.4	
	7.6	9.2	9.0	10.0	8.9	9.1	10.0	by
	7.9	9.2	9.0	10.2	9.0	9.2	10.2	
	8.0	9.1	9.6	10.4	9.1	10.5	11.0	mussels.
	8.2	9.0	9.6	10.4	9.6	10.6	11.0	
	8.2	8.5	10.1	10.5	10.0	10.8	11.6	
verage	7.63	8.53	8.81	9.71	8.98	9.32	10.00	

The diameter of the starfish was measured while the starfish was extended and walking across the bottom of the pan. It was observed that great care must be taken to be sure that the starfish is in the same state for successive measurements as they can change their diameter considerably (about 1 cm in the case of large specimens.) At the beginning of the experiment each starfish was measured and notes made of the individual colour characterictics. The cages used were shallow boxes with screen bottoms. Thus the starfish were in darkness during the experiment. At the time of the second measurement not all the

starfish could be recognized by comparison with notes regarding colour and size. By the third measurement very few individuals could be recognized as such. The bright colours of all specimens tended to become dull and dark blueish or greenish greys or browns.

The figures obtained for the growth in the above table show that with sufficient food, growth may be rapid. This evidence is in agreement with the hypothesis that Fred England Bed starfish were large on account of better food supply mentioned earlier in this report. It should perhaps be mentioned here that an earlier experiment was attempted between July 6 and August 17. All the trays were floating. In this case all but a few of the starfish died and these showed no growth. At the time the writer was of the opinion that the continual motion of the floating boxes was the source of the trouble. However, tray I in the above experiment was one of these same trays. The only difference that the writer could see between the earlier experiments and the later was the date of the experiment. In a report on Starfish and Oysters, A.W.H.Needler reports that his trapping experiments were not very successful during the middle of the summer. Thus there is some evidence, though far from conclusive, that during the warmest part of the summer the starfish are not so active as during the Spring and Fall. A certain amount of evidence that may be interpreted as pointing in this direction may be found later in this report under the discussion of mass movements. Feeding experiments were tried on the starfish in Tray IV in February 1936. This tray was suspended near the bottom under the ice. The temperature was below $0^{o}C$

Feb. 10, 1936, 5.00 P.M. 60 spat from 2 to 4½ cm in diameter placed in tray with 10 starfish.

Feb. 12, 1936, 12.00 noon. No spat opened but starfish clinging to them.

Feb. 26, 1936, 10.30 A.M. No spat opened. All spat and starfish present and apparently healthy.

Thus it appears that the starfish are almost inactive under the ice.

In an attempt to estimate the age of the starfish, specimens of various sizes from various localities were dried. It was hoped that the grinding down of the ossicles to thin sections would reveal under the microscope some differences in structure of different regions, which might be interpreted as annual rings. For comparison specimens of Strongylocentrotus and Echinarachnius were also dried. Moore has shown the presence of annual rings of pigment in the plates of Echinus (1935). The writer found similar rings in the plates of Echinarachnius and Strongylocentrotus but the ossicles of the starfish showed no difference in pigmentation or visible structure. The starfish ossicles contained no pigment. The ocular ossicle was tried first since it is as old as the starfish. Apical ossicles were also tried. Ambulacral ossicles are of diminishing age as the tip of the arm is approached. All cases gave negative results. Further work on this material will be done.

Distribution, Mass Movements, and Temperature as a Factor limiting Distribution and affecting Mass Movements.

The following table is a summary of observations on the abundance and distribution of starfish at selected stations in Malpeque Bay. The time of mopping was in all cases ten minutes. Map position refers to the place as indicated on the map published by the Department of Fisheries for the plotting of oyster leases.

Date	Place	Map Position	Bottom	No. of Starfish	Diam. in cm. of Mode
27/6/35	Cooper Bed	192-E	Oyster Bed	685	2½
"	Sharp's Bed	213-O	" "	580	3
"	Indian Island	188-U	Mud	71	3½
"	Bird Island	190-R	Sand	145	3
"	Hog Island	174-A	Rock	12	4
"	Low Point	178-M	Sand	291	3½
"	Malpeque Bay	144-O	Mud	11	7
28/6/35	Curtain Island	106-I	Shell	475	4
"	" "	49-U	"(?)	107	4
"	" "	120-Q	Sand	68	7
"	Ram Island		Shell	21	3½
"	Princeton	144-O	Mud	11	7

Although mud bottom supports a very small starfish population, the starfish on this type of bottom are large, relatively. Probably the difference in density of population merely indicates a difference in food abundance. On a mud bottom the food is probably quite scarce and the starfish are few, but those few apparently find enough food to grow to a relatively large size. The great concentration on oyster beds may indicate that starfish move to these areas by sense of smell. Further evidence favouring this possibility is given below.

More observations were made on starfish in the "Rivers" near the Biological Station than elsewhere. Paugh's Creek is an arm of Bideford River used extensively by the Biological Station for collecting Spat. Along the shore of this creek in the summer of

1935 there were two small areas where one year old spat were set out. These areas are reffered to in this report as Upper and Lower Paugh's shell beds. There was a similar area on Smelt Creek, (also an arm of the Bideford River) about ~~80~~ 200 yards up stream from the Biological Station, near the warehouse, and a fourth area about 300 yards downstream from the Station near the lane, called in this report ,Warehouse Shell Bed, and Lane Shell Bed. Starfish observed were removed at the time unless otherwise stated.

A Observations at Paugh's Shell Beds.

31/5/35.	No starfish observed.	
13/6/35.	Lower Shell Bed	
	Off the east of bed at 25 yards	19 starfish
	On bed	4
	Between upper and lower beds	1
	On upper bed	3
18/8/35	On beds	0
	50 yards downstream	3
	Temperature 28°C	
20/8/35	Mopping 25 yards off lower bed	2
	One was 1935 set.	

B. Warehouse Shell Bed

30/5/35	On bed	3
27/7/35	" "	0
16/8/35	" "	0

C. Lane Shell Bed.

30/5/35	On and near bed	40 starfish
	removed and 20 specimens placed 20 feet west of bed at 12.00 noon.	
31/5/35	12 noon, On bed	15 "
	less than 9 feet from bed	3 "
	20 starfish placed 20 feet west of bed.	
2/6/35	3.00 P.M. On bed	17 "
	Within 48 feet of bed	4
	offshore 10 feet of bed	5
	within 40 feet east of bed	20
	4.00 P.M. 25 starfish placed 40 feet west of bed	
	22 " " 40 " east " "	
	all other starfish removed.	
4/6/35	4.00 P.M. on bed, several, could not be counted on account of rough water.	
6/6/35	Mr. Forbes removed 52 starfish from the Bed and from within a few feet of the bed.	
10/6/35	Mr. Forbes removed all the starfish (number?) from the bed and vicinity	

13/6/35 Mr. Forbes removed 132 starfish from the Bed and vicinity
16/6/35 166 starfish removed from Bed,
those not on bed not removed.
19/6/35 181 starfish removed from Bed
66 " " " within 30 feet east
15 " " " " " " west
12 " " " " 12 feet offshore
24/6/35 30 " " " Bed. Not all as water was muddy
25/6/35 25 " " " " " " " " " "
29/6/35 30 " " " " " " " " " "
4/7/35 14 on Bed, none within 20 feet.
15/7/35 27 on Bed
0 westward
few scattered eastward
16/8/35 Many on Bed
several near bed
2 dead, temperature 24.5°C.
Starfish were not removed.
17/8/35 Outer 8 sq.yds. of Bed 155 alive 6 dead
Shoreward part of Bed 57 " 3 "
Within 50 feet west 22 " 8 "
" 50 " east 66 " 5 "
Temperature 27°C.
All removed
30/8/35 65 on Bed
108 within 90 feet east
48 " 90 " west
Temperature 20.5°C All removed
3/9/35 On Bed 224
Temperature 19.5

D. Claude Williams' Creek.

Claude Williams' Creek is a small creek emptying into Bideford River. The creek is protected by a sand bar across its narrow mouth. At no time were large starfish found here but the physical conditions are admirable for raising of small oysters. However, on Sept. 13 a tow was made here with a No. 0 net. This tow must have scraped the bottom since several small starfish about 1½ cm were brought up. The next day some baskets of spat were lifted that had been resting on the bottom for about two weeks. These baskets also contained some of these small starfish. On Oct. 11, 34 small starfish were obtained from this place by using two mops on the end of a pole. The mode was 2.2 cm. and the largest 2.9 cm. in diameter. These are certainly all starfish of 1935 set.

E. Upper Paugh's and Smelt Creeks

20/8/35. Small Starfish were obtained from these two places.

All specimens were between 7 and 14 mm. in diameter.

Winter Observations on Distribution.

Stations were selected and examined in the Fall and examined again in February, through holes made in the ice. The data obtained were as follows. In all cases the starfish in this part of the work were obtained with two mops on the end of a pole.

Mud Digger Point Bed. Depth 4 feet.

9/ 10/35. Starfish present. Ø 5½, 6, 6, 6, 6½, 6½, 7, 7, 7½, 8, 8, 8½, 9, 9½, 9½, 10, 10, 10, 10, 11.

3/2/36. 10 A.M. Ice 2 feet thick. Salinity, surface 4.3‰, bottom, 29.3‰. No starfish found.

7/2/36 2.25 P.M. Low tide. Salinity, bottom 29.5‰.

Two starfish, Ø 5, 5½.

50 yards south, 10° west. 11½ ft deep. Ice 2 feet thick.

2.35 P.M. Low tide. Bottom salinity 29.8‰

8 starfish present. Ø 3, 5, 5, 6, 6, 7, 7, 10.

Totten Bed.

9/10/35 No starfish found.

4/2/36 No starfish found.

Pulpit Bed.

9/10/35 Starfish found. Ø 3½, 4, 4½, 4½, 5½, 5½, 5½, 6, 6½, 7, 8, 8, 8, 8, 8½, 8½, 9, 9, 10.

4/2/36 Starfish found Ø 3, 3½, 6½, 7, 7, 9½.

Wharf Bed

9/10/35 No starfish found.

4/2/36 Starfish found Ø 3½. 3½, 3½, 4, 5, 5, 7, 8½, 9½.

cut down to a low density every, or nearly every summer, as will be shown later for the summer 1935. If, however, food is near, the starfish will move towards it. This fact is well known by lobster fishermen and has also been observed at the Lane Shell Bed and in Claude Williams' Creek on Sept. 14 when small starfish clustered on a basket of spat. The spread of starfish upstream does not continue uniformly throughout the summer. From the observations on Land Shell Bed it would appear that the movement was at a maximum about the middle of June. By the end of July, the upstream movement had apparently practically stopped. The writer feels confident that the reason for the diminished upstream movement is temperature, which at this time was well above 20° at the place under consideration.

On August 17 a temperature of 27°C was measured on the Lane Shell Bed, and several starfish were found dead. This would seem to indicate a very high mortality, since dead starfish are completely removed in a few hours by scavengers. On this date about 200 starfish were removed from the bed, but no starfish had been removed for more than one month previous. At the height of the movement in the Spring, about 60 starfish a day could be removed from the area. On Sept. 23, 224 starfish were removed from the area. These had come since Aug. 30. At this time the temperature was down to about 20°C.

The mortality of starfish in warm water (above 25°C) is completely in accord with the thermostat experiments reported upon in 1934. In these experiments it was shown that in the laboratory under the conditions of the experiments, the starfish would not live in water above 25°C, but it was also shown that very small starfish, in the thermostat experiments, were much more resist ant

Claud Williams' Creek. Depth 4 feet.

11/9/35 Starfish found. Ø 1.6, 1.6, 1.7, 1.7, 1.7, 1.8, 1.8 1.8, 1.9, 1.9, 1.9, 2.0, 2.0, 2.0, 2.0, 2.0, 2.1, 2.1, 2.1, 2.1, 2.1, 2.2, 2.2, 2.2, 2.2, 2.2, 2.2, 2.3, 2.4, 2.4, 2.4, 2.4, 2.6, 2.8, 2.9,

4/2/36 Depth 4 feet, ice 18 inches. Bottom salinity 24.3‰. Starfish found, Ø 2.6, 2.6, 2.7, 3.0 3.0

Cooper Bed.

12/9/35 Starfish found, Ø 3, 3½, 3½, 5, 6½, 6½, 9½, 9½, 10½.

5/2/36 Depth 9 feet, ice 2 feet. Bottom salinity 30.5‰. Starfish found Ø 2½, 2½, 2½, 2½, 2½, 3½, 3½, 3½, 5½.

8/2/36 Shallow part of the Bed. Depth 5 feet, ice 2 feet. Starfish found Ø 2½, 2½, 3, 3½, 3½, 4½ 4, 4, 4, 5, 5,7, 7½.

Lane Shell Bed.

11/2/36 (a) Near shore, depth 3½ feet, ice 2 feet, Bottom salinity 25.9‰. Starfish not found.

(b) 30 yards off shore from (a) Depth 15 feet, ice 1½ feet. Mud bottom. 14 starfish found.

12/2/36 (c) Half way between (a) and (b) Depth 8 feet. 5 starfish found.

Discussion.

The repeated observations of Lane Shell Bed show that there is a movement of starfish upstream in the Spring. That starfish will move directly towards oysters has been shown for a distance of at least 20 feet. The writer does not think that the movement from great distances is directly towards oysters or other food, but that the population movements are more in the nature of diffusion from regions of greater starfish population density. As a result it appears that starfish are migrating up towards the head of the inlets in the Spring. The upstream population is quite possibly

This has also been confirmed by field observations, Small starfish were found in Claude Williams' Creek and in Upper Paugh's and Smelt Creeks. It now appears that the large starfish are not found here because the temperature conditions in the summer are too rigorous. The writer has no observational evidence, as yet, that the starfish may move toward deep water when the shallow water becomes too warm. O'Donoghue, however, presents some evidence to support this view.

The winter distribution of starfish was somewhat different from that in the summer. The starfish population density on shallow areas was lower than in deeper water. Near the shore the starfish could not be found. The writer is of the opinion that this difference will be accentuated by the fresh water at the Spring thaw. These conditions would leave the upstream and shallow areas comparatively free from starfish. The evidence on this point is incomplete, but that on hand all points in the same direction. The picture at present is, therefore, that during the winter under the ice, and in the summer when the temperature is high, the starfish population on shallow water areas and upstream is reduced, but in the Spring and Fall the movements of the starfish tend to increase the population on these areas.

Parasites.

During the examination of starfish gonads to estimate spawning time, several ovaries were observed that contained an astomate Holotrichidan parasite. Only the ovaries, as a rule, were examined under the microscope, since it was comparatively easy to determine whether or not the eggs were ready to be shed, but a similar observation on sperms in a testes masceration would be considerably more troublesome. On June 11, 1935, 17 females from Bar Bed were examined. The ovaries of four of these were infested by the protozoan. Individuals infested appeared to be healthy.

Cépède described an astomate Holotrichidan from the testis of Asterias rubens, which he named Orchitophyra stellarum. Of over 6000 specimens examined only 3 males were found to be infested. On this basis he remarked that this parasite is very rare and is confined to the males, this latter view being put forward also in the generic name. Other observations of Cépède were that this protozoan causes castration of the male, and that although parasitic only in starfish gonad, and not found free living, this protozoan does not die, nor is it injured by being placed directly in sea water.

From the writer's observations, he thinks that the protozoan found in the ovaries of Asterias vulgaris is identical with Orchitophyra stellarum Cépède. During the summer of 1934 some starfish eggs were fertilized in the laboratory and one of the females used happened to be infested with Orchitophyra, After a week the culture was discarded and at this time the protozoa were quite active.

The writer differs from Cépède, however, with regard to sex specificity and abundance of the parasite. It remains to be estimated to what extent these parasites may be useful in controlling starfish

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