~~Report to~~

Oregon Department of Fish and Wildlife

Abundance of gaper clam larvae in lower Yaquina Bay, Oregon from 12 January to 12 March, 1976

submitted by

M. Joan Flynn

~~School of Oceanography~~
~~Oregon State University~~
~~Corvallis, Oregon, 97331~~

19 May 1976

ABSTRACT

Analysis of January to March samples of gaper clam larvae from Yaquina Bay, Oregon have established four hypotheses for further testing 1) gaper clams have an approximately lunar cycle of spawning intensity with maximum production of larvae at the periods of greatest tidal amplitude,2) the time required for development from 'straight-hinge' to 'umbo' stage is two to three weeks; 3) younger larvae are about evenly distributed through the lower estuary, except that they are less common over the tidal flats of the south shore; and 4) gaper clam larvae are found throughout the water column but are consistently most abundant in near surface depths.

METHODS

A sampling program to study the gaper clam larvae in Yaquina Bay, Oregon was conducted over a nine week period from 12 January to 17 March 1976.Samples were collected by hydraulic pump on high tide at seven stations (Figure 1,2). Six cubic meters of water were filtered for each sample. Five midbay stations extend across the channel from Sally's Bend shore to Idaho Flat shore, #1, #3, #5, #7 and #9. Two stations, #10 and #11, are located just seaward of the Yaquina Bay Bridge. The two mid-channel stations, #5 and #10, were sampled for surface and near bottom depths. Other stations were sampled near the bottom.

A total of 74 quantitative samples were counted and numbers per cubic meter have been determined. The counting procedure involved diluting each sample to 100 ml and then removing either 5 or 10 separate aliquots with a 1 ml stempel pipette. Larvae were separated into younger 'straight-hinge' and older 'umbo' groups for counting and length measurements. Larvae were measured in each sample to establish the size range. Larvae of at least two clam species other than gapers were present in low varying numbers in the samples and were included in the gaper larvae counts. Positiv identification has not been established. The numbers of these species were too low to have influenced the conclusions about gaper clams. Two types of very round larvae were found in the samples which are definitely not gapers. Both 'straight-hinge' and 'umbo' stages of this type were combined into one separate category termed 'round larvae'. Sixteen samples of the various larval sizes and types have been separated into vials for identification by specialists at the University of British Columbia.

RESULTS

The densities of gaper clam larvae in the straight-hinge and umbo developmental stage classes are summarized for all stations and dates in Tables I and II. Four hypotheses can be formed from these data: 1) gaper clams are cyclic spawners with maximum production of larvae during periods of greatest tidal range; 2) they develop in the field approximately according to the schedule predicted from laboratory rearing studies at comparable temperatures; 3) straight-hinge larvae are found in approximately constant density over the sampling area except for low densities at the Idaho Flat shore station, while umbo larvae tend to be most abundant over the channel (stations 4, 5, 6, 10, and 11); and 4) in deeper water near-surface samples give consistently higher estimates than near-bottom samples. Each of these hypotheses will be discussed in detail.

Spawning Cycle

The density estimates for straight-hinge larvae on each date (Table I) were ranked separately at each station. The ranks were then summed for each date, producing the following sums of ranks:

Sampling Date	Sums of Ranks
12-13 Jan	67.5
20-22 Jan	24
27-28 Jan	23.5
3- 6 Feb	43
11-13 Feb	47
18-19 Feb	12
1- 2 Mar	55.5
11-12 Mar	51.5

A concordance estimate, W, was calculated from these sums. $W = 12\Sigma D^2/R^2(C^3-C)$, where D is the difference between each observed sum and the expected sum under the null hypothesis that the ranks are random, R is the number of rankings, and C is the number of items ranked in each ranking. The result was W = 0.73, whose probability under the null hypothesis is less than 0.0001 (See Tate and Clelland, 1957). This implies that the stations are strongly concordant about which dates have high and which dates have low densities.

The dates with highest densities, (lowest sums of ranks) are 27-28 January and 18-19 February. Both of the sampling periods followed immediately after a period of maximum tidal amplitude. It is well known that populations of may intertidal invertebrates have lunar periodicities in their spawning intensity, and it is important to find this may be the case for the gaper clam. Confirmation of this result will require data from at least one additional year.

Development Rate

The existence of cycles in abundance of the early straight-hinge larval phase leads to the expectation of a cycle in abundance of later larval phases that lag in time by the periods necessary for development. Cycles do exist in the abundance of the umbo stage clams. The data (Table II) were ranked in the same fashion as the straight-hinge stage data. The sums of ranks were:

Sampling Date	Sums of Ranks (Umbo)	Sums of Ranks (Straight-hinge) (for comparison)
12-13 Jan	66.50	67.5
20-22 Jan	29.5	24
27-28 Jan	21	23.5
3- 6 Feb	55.5	43
11-13 Feb	30.5	47
18-19 Feb	32.5	12
1- 2 Mar	64.5	55.5
11-12 Mar	24	51.5

The concordance value is W = 0.71 ($p<.0001$). The peak periods (indicated by low sums) were 27-28 January, 11-13 February, and 11-12 March. A suggested development time is indicated by the arrows. The 27-28 January peak probably derives from a spawning preceding the sampling period. For the 27-28 January peak in straight-hinge larvae the period to the 11-13 February peak in umbo larvae is 15 to 16 days. For the 18-19 February straight-hinge peak the period to the 11-12 March umbo peak is about 22 days. Considering that the actual peaks do not necessarily fall on the sampling dates, and the uncertainty about temperature variations in the field, these intervals are consistent with the 19 day period expected from laboratory rearing studies at 8-11° C.

Measurement data presented in Table I can be summarized for straight-hinge larvae by mean shell lengths as follows:

Sampling Date	Mean shell length (μm)	Numbers measured
20-22 Jan	122	105
27-28 Jan	125	77
3- 6 Feb	119	23
11-13 Feb	135	48
18-19 Feb	117	99
1- 2 Mar	130	21
11-12 Mar	123	31

Almost all of the larvae on 18-19 February were very close to 116µm (84 of 99 individuals), and since this date is at the strongest maximum of the spawning cycle, this is close to the size of the youngest straight-hinge larvae. On dates like 11-13 February, at maximum time after a spawning peak but before the next peak, the mean length of straight-hinge larvae has increased to 135µm. Smallest umbo clams are much larger than this, 182µm, which implies that, despite spawning peaks, a large fraction of straight-hinge clams are early in that phase at all parts of the cycle.

Distribution of larvae in the bay

Rankings of Tables I and II were performed for each date according to the order of the abundance estimates at the various stations. These ranks were then summed for each station. Dates with large numbers of zeros were dropped, and surface values were used for stations 5 and 10. The sums were:

Station	Sums of Ranks (Straight-hinge)	Sums of Ranks (Umbo)
1	28	30
3	27.5	29.5
5 (surface)	19	17
7	20	18.5
9	41.5	31
10 (surface)	31	17.5
11	29	24.5
	$W = 0.241$	$W = 0.235$
	$p = 0.20$	$p = 0.20$

While the statistical significance of the deviation of the sets of sums from sets that might be expected under the null hypothesis (no agreement between dates about the ranking of the stations) is only at the 20% level, the direction of the deviations is in accord with a clear alternate hypothesis in each case. Younger larvae tend to be in lowest abundance at station 9, above the tidal flats across the bay from the principal gaper clam beds. Station 9 is the only sampling site deviating consistently from the others. Umbo stage larvae are most abundant at stations over the channel (5 surface, 7, 10 surface, 11) and least abundant at stations over the flats (1,3, and 9).

Vertical distribution

Surface and bottom samples were analyzed for stations 5 (mid-channel in mid-bay) and 10 (mid-channel near the bridge). The results extracted from Tables I and II were:

Number per cubic meter

Sampling Date	Umbo #5 Surface	Umbo #5 Bottom	Umbo #10 S	Umbo #10 B	Straight-hinge #5 S	Straight-hinge #5 B	Straight-hinge #10 S	Straight-hinge #10 B
12-13 Jan	120	3	0	2*	293	10	0	0*
20-22 Jan	130	53	237	77	1130	397	110	90
27-28 Jan	153	55	293	273	920	70	510	257
3- 6 Feb	17	7	7	3	205	77	17	3
11-13 Feb	403	118	87	3	197	30	153	37
18-19 Feb	180	17	90	77	1193	430	1250	703
1- 2 Mar	0	3*	0	20*	3	38	0	27*
11-12 Mar	217	---	380	333	57	---	170	93

If the date-station-stage combinations with very low densities (indicated by an *) are eliminated, 24 of 25 date-station-stage combinations showed higher abundance at the near-surface depth. Gaper clam larvae live throughout the water column, but are somewhat more abundant near the surface.

Larvae of species other than gaper clams

Density estimates of 'round larvae' are presented in Table III. The concordance between the stations about which dates had low and high densities was W = 0.49, which is lower than the values for gaper larvae, but still highly significant ($p > .001$). The dates with highest densities at most stations were the same (27-28 January and 18-19 February) as the dates of maximum spawning intensity of the gapers. The singly highest value, 473 per cubic meter at station #11 on 11-12 March, did not occur in agreement with this schedule. The other animals in that sample (*Calanus marshallae* Frost, for example) were characteristic of the coastal ocean well offshore, so it is likely the sample represents spawning by another species or population located in the ocean. No consistent spatial pattern is evident in the data for 'round' larvae.

Discussion

This study has resulted in several important discoveries about the larval life of the gaper clam. Coincidence of maximum spawning with the period of maximum tidal range certainly has adaptive significance. The larvae could achieve an improved retention within the bay from this, provided that spawning is coincident with return of the water after very low tides. The flood tide would then carry the larvae to the maximum distance upstream, minimizing subsequent losses from the bay to the ocean. Establishment of the timing of spawning within the daily tidal cycle is thus an obvious next step for this research.

The approximate agreement between the observed time required in the field for transformation of straight-hinge larvae to the umbo stage and the time required in the laboratory suggests that the laboratory rearing is a realistic way to evaluate larval growth processes.

It is surprising to have found the maximum densities of both age groups of larvae to be near the surface. This should produce more flushing of larvae from the bay than concentration near the bottom, where net transport should be upstream. The fact, however, is quite strongly established.

Acknowledgement

I wish to thank Charles B. Miller of the School of Oceanography for assistance with the statistical analysis and preparation of the manuscript.

References

Tate, Merle W. and Richard C. Clelland. 1957. Nonparametric and Shortcut Statistics. The Interstate Printers and Publishers, Inc. Danville, Illinois. 171p.

Figure 1.

Location of Plankton Sampling Stations

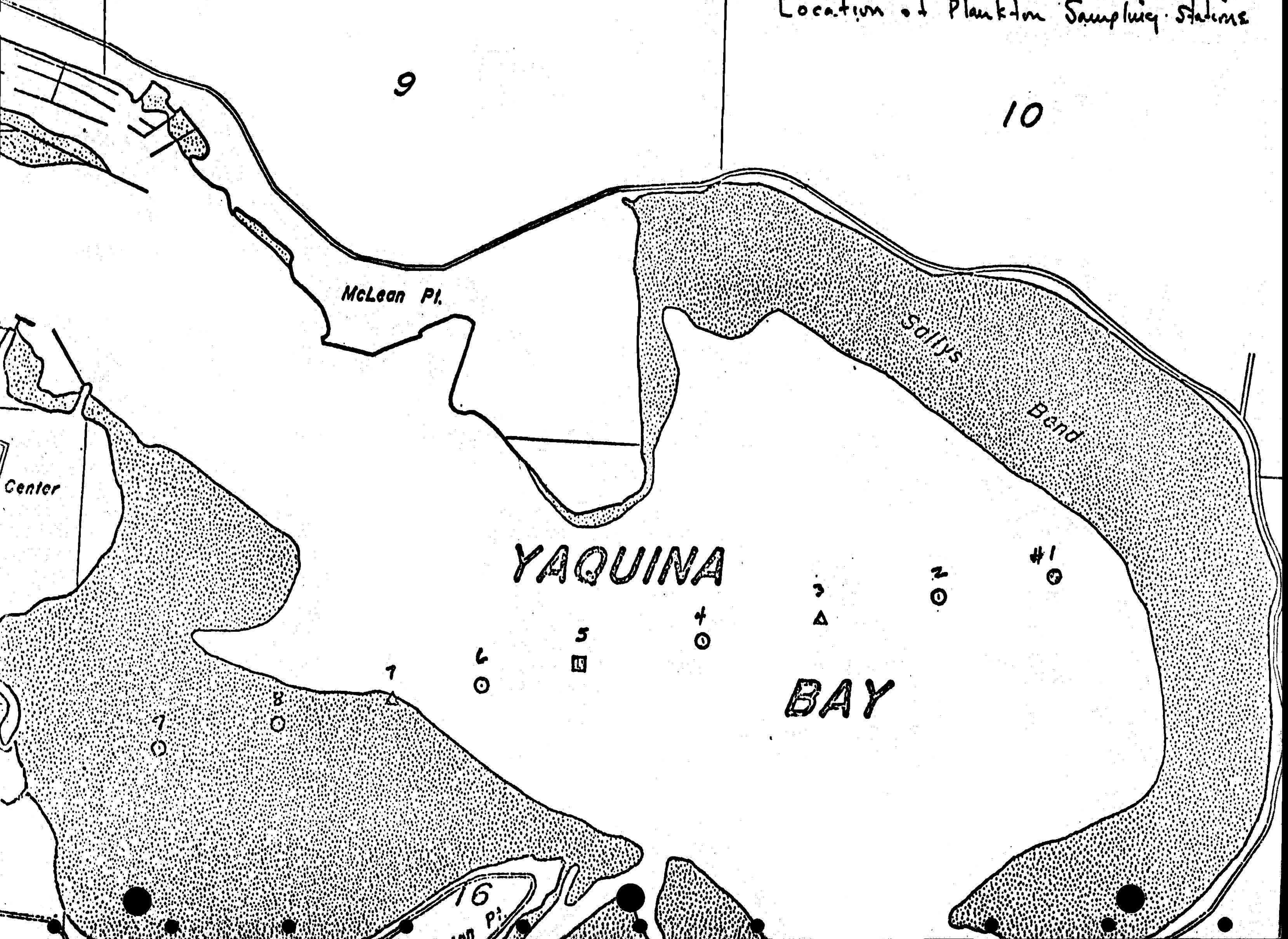

Figure 2.

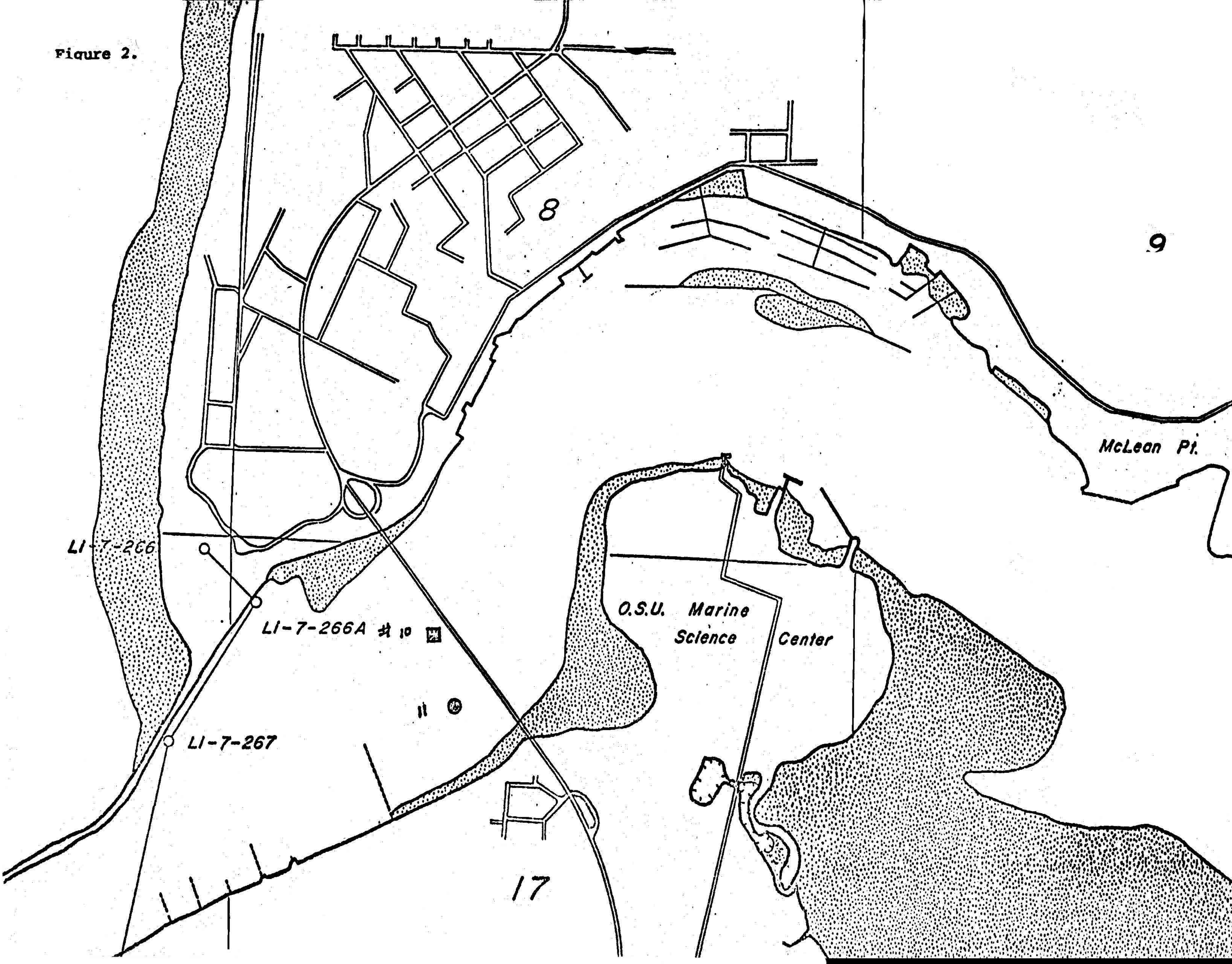
8
9
McLean Pt.
LI-7-266
LI-7-266A #10
11
LI-7-267
O.S.U. Marine
Science Center
17

Table I. Number per cubic meter of 'straight-hinge' larvae.

Date	Station								
	#1	#3	#5S	#5B	#7	#9	#10S	#10B	#11
12-13 Jan	3	0	293	10	2	0	0	0	7
20-22 Jan	353	157	1130	397	1237	700	110	90	190
27-28 Jan	915	586	920	70	1407	85	510	257	88
3- 6 Feb	38	73	205	77	87	7	17	3	148
11-13 Feb	23	133	197	30	113	—	153	37	80
18-19 Feb	2555	1330	1193	430	1200	393	1250	703	688
1- 2 Mar	35	43	3	38	3	3	0	27	88
11-12 Mar	7	3	57	—	140	3	170	93	20

Table II. Number per cubic meter of 'umbo' larvae.

Date	Station								
	#1	#3	#5S	#5B	#7	#9	#10S	#10B	#11
12-13 Jan	3	0	120	3	0	2	0	2	0
20-22 Jan	110	27	130	53	287	353	237	77	57
27-28 Jan	263	90	153	55	183	45	293	273	147
3- 6 Feb	10	23	17	7	0	5	7	3	27
11-13 Feb	13	227	403	118	617	—	87	3	35
18-19 Feb	32	77	180	17	77	65	90	77	90
1- 2 Mar	7	0	0	3	0	0	0	20	20
11-12 Mar	55	10	217	—	1990	17	380	333	107