A Pre-Fertilization Benthic Survey of Ostrea Lake, N. S.

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General Background

Ostrea Lake, Fig. 1, which lies near the mouth of the Musquodoboit River, NS is a salt water pond with limited tidal exchange through a permanent opening to Musquodoboit Harbour. The lake which consists of two connected ponds has long had a population of oysters (*Crassostrea virginica*). In the past, these were fished on a commercial scale but at present stocks are very low. According to local residents stocks declined about 40 years ago. Before that time oysters were abundant on the rocks in the lake from where they were fished by means of dip-nets with blades at the rim. These were also apparently fished from the bottom in two limited areas, one in the south pond and one in the main pond near the outlet. Local opinions regarding the reason for the decline of the oyster population vary but include overfishing and the appearance of an algal scum rendering rocks unsuitable for settlement. A further possibility is that a second transitory entrance to outside water through South Pond, which is separated from open water only by a barrier beach, could have produced an unsuitable temperature regime for a considerable period. It also seems possible that Malpeque Disease was introduced and caused heavy mortality. Although the tidal range in the area is about 7 ft, tides in Ostrea Lake are very slight due to a sill near the entrance which prevents emptying. Tidal range in the lake is only a few inches.

Background to this Survey

The Nova Scotia Department of Fisheries has selected Ostrea Lake as a site for an experiment on the effects of fertilization on the production of oysters. The background to this experiment and the first years results have been presented by MacLeod (1968). Oysters are being held on suspended trays, bottom culture is not contemplated.

In 1967 fertilizer was introduced into the lake and the associated changes in chemical oceanography and oyster growth monitored. Oysters for the experiment were introduced from Bideford, PEI and will therefore carry and are resistant to Malpeque Disease.

As such large scale fertilization will affect the whole biota of the lake, it was decided that a general survey of the bottom combined with a quantitative sampling of the benthos at several selected stations should provide data which could be compared to similar data collected at intervals following fertilization.

Methods

Qualitative transects were swum across the lake at chosen points using SCUBA apparatus. On transects, specimens of common fauna and flora were collected and detailed descriptions of bottom conditions made.

Quantitative samples were collected using a diver operated suction dredge modified from a design by Brett (1964) discharging through a 3 x 5 mm mesh bag. Most of the fauna smaller than this size was, therefore, lost.

In the laboratory, samples were sorted to species, each species counted and weighed. Weights were taken of the whole animals in normal condition and after drying for 16 hrs. at 100°C. In the case of species with calcareous shells, an additional wet weight was taken after shucking or chemical decalcification. Results have all been calculated to represent samples of one square meter. Actual sample areas varied from 0.33 m^2 to 1 m^2.

Sampling Locations

Approximate locations of transects and quantitative samples are shown in Figure 1. Exact locations were recorded on a detailed map by using prominent landmarks and sextant angles to fix positions.

Qualitative Results

Observations recorded on each transect are listed in Table 1.

In general, the North Arm in which transects I, II and III were run had a bottom of extremely soft fine mud with a fauna dominated by the deposit feeding bivalve Tellina agilis. There was little associated fauna but two predators were common. Asterias vulgaris (common starfish) were present at over $1/m^2$ and were feeding on T. agilis. Pseudopleuronectes americanus (winter flounder) were common. One of the latter captured with a knife had the gut packed with T. agilis. The bottom in this arm is completely unsuitable for oysters due to the soft fine mud, made worse by the presence of an almost continuous mat of filamentous algae. The only live oysters seen were attached to rocks and were quite old. Large rocks frequently had a surrounding pile of dead oyster shell; in some cases several feet thick. The matted filamentous algae also shrouded rocks whose surface appeared quite unsuitable for oyster settlement. No small oysters were seen.

The matted algae characteristic of the North Arm and also occurring in other locations was a mixture of species. Sphacelaria britannica was abundant and Polysiphonia arctica and Ceramium rubrum were also present.

Near the outlet of the lake where transect IV was located, the bottom was much sandier and firmer than in the North Arm but exhibited similar scattered rocks. On the bottom at this location, loose oyster shells were found and it could well once have been an oyster bed. No live oysters were encountered but the cleaner bottom suggested it as a possible site for bottom rearing.

In South Pond where the fifth transect was run, the bottom on the south side had a high proportion of sand, soft mud only being encountered in the central portions. Mya arenaria were abundant in the sand and muddy sand and appeared to have a good growth rate. Additionally, dense populations of maldanid worms suggested good general productivity. T. agilis was again dominant in mud but starfish (A. vulgaris) were not common.

The sixth transect run across the southern portion of the main pond showed a bottom essentially similar to the North Arm. However, fouling algae were less abundant. No live oysters were encountered but shells were occasionally seen on rocks. Table 2 summarizes conditions found on transects as they relate to oyster biology.

Quantitative Results

Summarized general quantitative results from stations 1 to 6 are presented in Table 3, detailed results are in Appendix 2. Table 4 presents details on the three species ranking highest in decalcified dry weight at each of the three stations and on their numbers and weights.

At the three stations in the North Arm (1 to 3) T. agilis was clearly dominant since it comprised 38, 53 and 95% of the total faunal biomass at stations 1 to 3 respectively. The fauna of this area and probably of most of the lake may be classified as a T. agilis community. The decreasing presence of Macoma balthica at stations 1 to 3 is no doubt a reflection of an increasing salinity regime in this area. M. balthica and T. agilis are both deposit feeders but T. agilis is characteristic of more saline waters.

At station 4 near the outlet the very low total faunal biomass made selection of a dominant species impossible. The area sampled had a low standing crop.

Stations 5 and 6 both in South Pond showed quite different fauna consequent upon their different bottom types. The sample from Station 5 in mud showed Asterias vulgaris to be dominant. However, this is a large species which was shown by observation not to be abundant in this area. The nereid worm Nereis pelagica is probably more characteristic. Again at this station T. agilis were common. Station 6 in muddy sand showed the highest faunal biomass of the stations sampled. The total of 19.62 g/m^2 is relatively high for this type of locality, and since many of the constituents are short lived, probably reflects a good benthic productivity. The community was characterized by Mya arenaria and T. agilis.

The main feature of the benthic flora was the large amount of filamentous algae at stations 2 and 3 in the North Arm. Such a biomass of algae is most unusual for oyster growing areas.

Discussion

Ostrea Lake is evidently thermally suitable for oyster culture (MacLeod, 1968) but the extremely soft muddy bottom over much of its area prevents normal methods of bottom culture. Additionally, the presence of large amounts of blanketing filamentous algal growth on bottom and rocks in many locations makes the liklihood of a natural spatfall of any size remote.

The South Pond area appears more productive than the main lake and additionally the bottom is, in places, quite suitable for bottom culture of oysters. As long as the seaward entrance to this pond remains shut, it would appear to provide a better area for oyster culture experiments than does the North Arm. Additionally, at the time of this survey the density of star fish, which may be significant predators of young oysters, was much less in South Pond than in the main lake.

Ostrea Lake by virtue of its almost landlocked form and small tidal exchange attains much warmer summer temperatures than the adjacent Nova Scotia coast. This coastal water was not always as cool as it is today and there is evidence that during the post-glacial hypsithermal period many species now typical of more southern waters were able to colonize this coast, and also to spread into the Gulf of St. Lawrence. When the coastal water again cooled, much of this warm water fauna disappeared but isolated populations remained in locations where summer water temperatures were suitable. Bousfield (1960) discusses the fauna of this area in detail. Ostrea Lake is one of these locations retaining southern components in its fauna. Others are the Bras D'Or Lake in Cape Breton Island and many sheltered shallow bays and estuaries in the southern Gulf of St. Lawrence. Species which are found in Ostrea Lake and are typical of more southern waters are the molluscs Volsella demissa, Crassostrea virginica, Bittium alternatum, Retusa canaliculata, Haminoea solitaria, Crepidula fornicata and Odostomia sp., the crustaceans Corophium insidiosum and Ampelisca vadorum and the hemichordate Saccoglossus kowalevskii. Although it is possible that C. virginica was introduced by man, the evidence provided by the presence of other warm water species and the fact that the species occurs in other sheltered bays even further to the north, suggest that it has been present since the hypsithermal period.

The numerical and weight dominance of the deposit feeding bivalve Tellina agilis at stations in the North Arm is unusual. Many similar locations in this general area are dominated, at least in weight, by Yoldia limatula and usually have some Venus mercenaria (M.L.H. Thomas, unpublished data). These latter two species have not, however, been observed in Ostrea Lake. *T. agilis* is a rapidly growing bivalve with a short life history. Consequently, its production may be quite high in relation to its standing crop. Observations in Ostrea Lake showed that *T. agilis* was the main item of the diet of the winter flounder (*Pseudopleuronectes americanus*) in the lake. One specimen that was caught and opened had a gut packed with this clam and small piles of shells in the faeces of this species were a conspicuous feature of the bottom. *T. agilis* was also the prey of all starfish that were feeding when observed.

Table 5 is an attempt to classify members of the benthos at each station by their trophic relationships. Figures may not be fully correct due to poor knowledge of the feeding habits of some species and because some species may use more than one feeding method. It must also be remembered that the samples would not include large active predators on the benthos such as *P. americanus*, which observations showed to be common in the area. Predators are, therefore, underestimated. Suspension and deposit feeders were also underestimated because the method of sampling allowed the escape of organisms less than 3 x 5 mm in cross section. Probably, however, the method retained most of the biomass (Reish, 1959). The ratio of about 1:10 between predators and prey shown in Table 5 is probably realistic. The great preponderance of benthic macro-algae among primary producers is most unusual, as is the high proportion of primary producers in the total benthos. This situation may arise due to some peculiarity of Ostrea Lake.

The large quantity of filamentous algae as a blanket on the bottom in the North Arm is inherently dangerous to the benthic fauna. Such growths on dying would almost certainly produce an anaerobic layer over the bottom. The proposed fertilization may well aggravate the problem if it encourages the growth of these species. If such an anaerobic layer does build up at intervals, it would explain the absence of long-lived sedentary benthos from parts of the lake. The presence of such a growth certainly precludes the possibility of bottom culture of shellfish in parts of the lake.

ACKNOWLEDGEMENTS

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TABLE 1

Observations on Transects across Ostrea Lake, N.S.

May 31 - June 2, 1967.

Transect #	Location	Comments
1	North Arm	From N. shore scattered large rocks occur for about 150 ft. On rocks _M. edulis_ was abundant and oysters occasional. The central portion was of very soft sandy mud with _T. agilis_ the dominant fauna with little associated fauna. Predators on _T. agilis_ included _A. vulgaris_ ($1/m^2$) and _P. americanus_. The 250 feet up to the south shore consisted of very soft organic mud with little fauna but _Ruppia maritima_ was common. Filamentous algae were common throughout but especially on the rocks. Eelgrass occurred in scattered patches and was about 30" in length. Maximum depth 7'.
2	North Arm	Large rocks were present but scattered for about 150 feet on both shores. Oyster shells were common on rocks and around rocks on the bottom but no live specimens were seen. In the centre and between rocks the bottom was of fine silty mud of very soft nature. _T. agilis_ was dominant with predators as on transect #1. _M. edulis_ was dominant along the shores. Additionally the bottom was 80% covered by a layer of filamentous green algae. Maximum depth 10'.
3	North Arm	The bottom was very similar to that on transect #2. _Haminoea solitaria_ and _Syngnathus fuscus_ were observed. Maximum depth 10'.
4	Near outlet	Scattered rocks occurred across the transect with some areas of sand between rocks. In places there were considerable quantities of old dead oyster shells. The area could well once have been an oyster bed. Loose _Laminaria_ sp. were common on the bottom. Maximum depth 20'.
5	South Pond	The S. shore at this location is of sand. _M. arenaria_ were common down to about 5 feet deep. Many were quite large and appeared to be fast growing. Moving into deeper water the proportion of mud in the sediment increased until in the central portion it was slightly sandy mud. Eelgrass was common to about 5' and below it _T. agilis_ were abundant. _A. vulgaris_ were rare. In places Maldanid worms were abundant. No live oysters were encountered but shells were scattered. Maximum depth 9'.
6	S. part of Main Pond	From the W. shore rocks were scattered for 150 feet giving way to soft sticky mud. _A. vulgaris_ and _T. agilis_ were abundant. Oyster shells occasional on rocks. Maximum depth 10'.

TABLE 2

Summary of Transect Observations

Transect #	General Bottom Type	Suitability for Oysters on Bottom	Suitability for Natural Spatfall
1	Sandy Mud	Nil	Negligible
2	Mud	Nil	Nil
3	Mud	Nil	Nil
4	Muddy Sand	Possible	Locally Possible
5	Sand to Mud	Good on Sand or Muddy Sand	Fair
6	Mud	Nil	Nil

TABLE 3

Summarized Results of Quantitative Benthos Samples from Ostrea Lake, N.S. - June 1, 1967

(Weights and Numbers per square meter)

Sta. No.	Area Sampled cm^2	Total dry wt. g/m^2	Total dry wt. fauna g/m^2	Total dry wt. flora g/m^2	No. live Fauna/m^2	Dry wt. fila. algae[5] g/m^2	Dominant fauna & dry wt. g/m^2
OL 1	5,000	9.55	8.98	0.57	1688	0	T. agilis (1) 3.44
OL2	3,330	207.71	1.42	206.29	354	206.16	T. agilis 0.75
OL3	3,330	257.91	1.30	256.61	739	256.53	T. agilis 1.24
OL4	10,000	1.03	0.08	0.95	39	0	C. septemspinosus (2) 0.03
OL5	10,000	0.99	0.93	0.06	96	0	A. vulgaris 0.56 (3)
OL6	5,000	20.38	19.62	0.76	752	0	M. arenaria 10.20 (4)

(1) Tellina agilis. Mollusca. Pelecypoda.

(2) Crangon septemspinosus. Crustacea.

(3) Asterias vulgaris. Echinodermata. Common Starfish.

(4) Mya arenaria. Mollusca. Pelecypoda. Soft shell clam.

(5) Filamentous algae containing Sphacelaria britanica, Polysiphonia arctica and Ceramium rubrum.

TABLE 4

Main faunal constituents of the Benthos at Quantitative Stations in Ostrea Lake, N.S. - June 1, 1967

(Nos. and wts. per m^2)

Station	Dominant Species			Second Species			Third Species		
	Species	No.	Dry wt.g	Species	No.	Dry wt.g	Species	No.	Dry wt.g
OL 1	T. agilis[1]	838	3.44	M. balthica[5]	30	1.72	A.americana[7]	2	1.26
OL 2	T. agilis[1]	291	0.75	C. septem-spinosus[2]	6	0.44	M. balthica[5]	3	0.12
OL 3	T. agilis[1]	665	1.24	M. elongata[6]	3	0.03	P. gouldii[9]	17	0.02
OL 4	C. septem-spinosus[2]	2	0.03	A.americanus[7]	1	0.02	L. rapax[10]	32	0.01
OL 5	A. vulgaris[3]	3	0.56	N. pelagica[8]	13	0.13	L. littorea[11]	8	0.12
OL 6	M. arenaria[4]	32	10.20	T. agilis[1]	377	3.00	M. edulis[12]	4	2.57

1. Tellina agilis. Mollusca: Pelecypoda.
2. Crangon septemspinosus. Crustacea: Decapoda.
3. Asterias vulgaris. Echinodermata.
4. Mya arenaria. Mollusca: Pelecypoda.
5. Macoma balthica. Mollusca: Pelecypoda.
6. Madanopsis elongata. Polychaeta: Maldanidae.
7. Anguilla rostrata. Fish.
8. Nereis pelagica. Polychaeta: Nereidae.
9. Pectinaria gouldii. Polychaeta: Pectinariidae.
10. Leptochelia rapax. Crustacea: Tanaidacea.
11. Littorina littorea. Mollusca: Gastropoda.
12. Mytilus edulis. Mollusca: Pelecypoda.

TABLE 5

Decalcified dry weights (g) and percentages of total dry weight of various trophic groups at Stations in Ostrea Lake

Station	Primary Producers	Browsers	Suspension Feeders	Deposit Feeders	Predators
OL 1	0.571 5.98%	0 -	0 -	7.003 73.3%	1.981 20.75%
OL 2	206.193 99.4%	0 -	0 -	1.247 0.60%	0.066 0.03%
OL 3	256.606 99.5%	0 -	0 -	1.296 0.50%	0.004 <0.01%
OL 4	0.945 92.0%	0	0.005 0.05%	0.056 5.45%	0.022 2.14%
OL 5	0.064 6.44%	0.121 12.19%	0 -	0.245 24.7%	0.563 56.7%
OL 6	0.757 3.72%	0 -	14.620 71.9%	4.761 23.4%	0.239 1.17%
Totals	465.136 93.60%	0.121 0.02%	14.625 2.94%	14.608 2.94%	2.875 0.58%

(Browsers + Suspension Feeders + Deposit Feeders, bracketed:) 29.354
5.90%

APPENDIX 1

List of species collected and/or observed in Ostrea Lake, N.S.

A. Fauna

Polychaeta

Nereis pelagica
Maldanopsis elongata
Clymenella torquata
Pectinaria gouldii
Scoloplos fragilis
Eteone lactea
Notomostus latericeus

Mollusca: Gastropoda

Retusa canaliculata
Haminoea solitaria
Littorina littorea
Littorina saxatilis
Bittium alternatum
Odostomia spp.
Lacuna vincta
Melampus lineatus
Crepidula fornicata

Mollusca: Pelecypoda

Crassostrea virginica
Mytilus edulis
Volsella demissa
Macoma balthica
Tellina agilis
Petricola phaladiformis
Mya arenaria

Crustacea

Leptochelia rapax
Ampelisca vadorum
Crangon septemspinosus
Corophium insidiosum

Echinodermata

Asterias vulgaris

Hemichordata

Saccoglossus kowalewskii

Fish

Anguilla rostrata
Apeltes quadracus
Pseudopleuronectes americanus
Syngnathus fuscus

B. Flora

Chlarophyta

Ulva lactuca

Phaeophyta: *Laminaria* sp.

Sphacelaria britannica

Rhodophyta

Ceramium rubrum
Chondrus crispus
Gracilaria verrucosa
Lomentaria baileyana
Phyllophora interrupta
Polyides caprinus
Polysiphonia arctica

Angiosperms

Ruppia maritima
Zostera marina

APPENDIX 2

Numbers and Total Weights of each Species[1] per square meter at each quantitative station in Ostrea Lake

Species	No.	Rough Weight g	Decalcified wet weight g	Decalcified dry weight g
		STATION OL 1		
M. elongata	2		0.60	0.072
P. gouldii	10		1.64	0.047
M. balthica	30	44.20	8.92	1.723
T. agilis	838		10.32	3.435
A. vadorum	788		6.98	0.624
C. septemspinosus	12		5.95	1.102
A. vulgaris	4	5.07	3.49	0.672
A. americana	2		6.68	1.261
A. quadracus	2		0.17	0.048
U. lactuca	-		1.42	0.097
L. bailayana	-		2.84	0.345
Z. marina			1.09	0.129
Totals	1688 (12 spp.)		50.10	9.554
		Fauna	44.76	8.984
		STATION OL 2		
M. elongata	6		0.02	0.005
P. gouldii	6		0.32	0.025
S. fragilis	3		0.14	0.007
E. lactea	3		0.02	0.003
R. canaliculata	6		0.01	0.003
M. balthica	3	2.48	0.68	0.116
T. agilis	291		4.24	0.751
A. vadorum	18		0.05	0.006
C. septemspinosus	6	2.16	1.76	0.440
A. vulgaris	12	0.57	0.27	0.063
U. lactuca	-		0.06	0.033
Filamentous algae	-		2433.39	206.160
Totals	354 (12 spp.)		2441.61	207.705
		Fauna	7.51	1.418

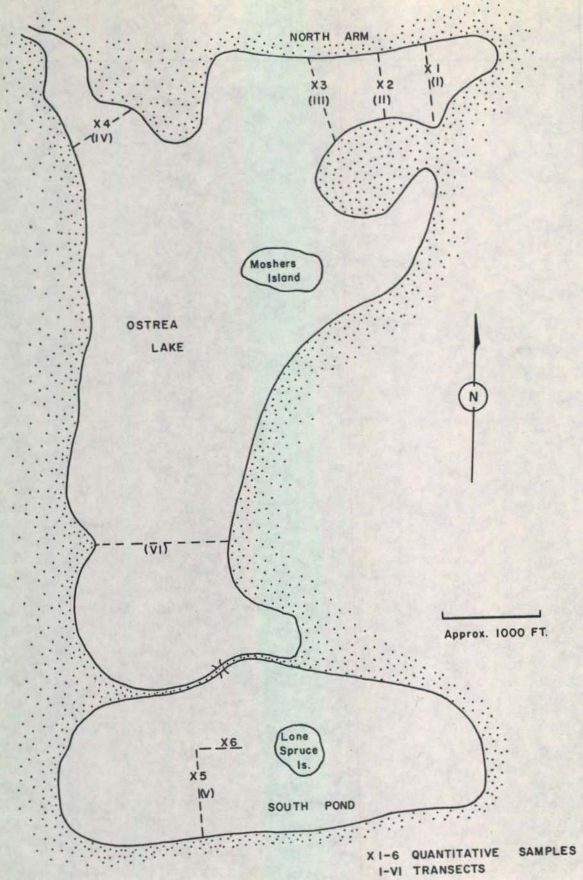
1) Order of species and names as in Appendix 1.

APPENDIX 2 (continued)

Species	No.	Rough Weight g	Decalcified wet weight g	decalcified dry weight g
		STATION OL 3		
M. elongata	3		0.35	0.032
P. gouldii	17		0.15	0.016
R. canaliculata	27		0.01	0.004
T. agilis	665		8.13	1.244
L. rapax	27		0.01	0.004
C. crispus	-		0.53	0.076
Filamentous algae	-		2631.84	256.530
Totals	354 (7 spp.)		2641.02	257.907
		Fauna	8.65	1.300
		STATION OL 4		
M. elongata	1		0.01	<0.001
P. gouldii	1		0.09	0.007
M. edulis	1	0.13	0.03	0.005
T. agilis	1	0.02	0.01	0.001
L. rapax	32		0.03	0.013
C. septemspinosus	2		0.11	0.035
A. americanus	1		0.08	0.022
U. lactuca			0.02	0.002
L. baileyana			0.71	0.228
P. caprinus			1.89	0.668
Z. marina			0.14	0.047
Totals	39 (11 spp.)		3.10	1.028
		Fauna	0.34	0.082

APPENDIX 2 (continued)

Species	No.	Rough Weight g	Decalcified wt. weight g	Decalcified dry weight g
		STATION OL 5		
N. pelagica	13		1.54	0.126
P. gouldii	18		0.22	0.021
S. fragilis	3		0.07	0.007
E. lactea	22		0.11	0.014
N. latericeus	3		0.06	0.007
R. canaliculata	1	0.01	<0.01	<0.001
L. littorea	8		0.51	0.121
T. agilis	16		0.21	0.063
A. vadorum	2		0.04	0.005
C. insidiosum	7		0.01	0.002
A. vulgaris	3	5.46	2.83	0.563
L. baileyana			0.06	0.035
Z. marina			>0.04	>0.029
Totals	96 (13 spp.)		5.69	0.993
		Fauna	5.59	0.929
		STATION OL 6		
M. elongata	202		5.38	1.225
C. torquata	63		0.75	0.141
P. gouldii	10		0.73	0.337
S. fragilis	24		0.22	0.033
E. lactea	2		0.04	0.006
R. canaliculata	18		0.06	0.011
C. fornicata	2	8.19	2.11	0.728
M. edulis	4	59.73	18.42	2.569
M. balthica	2	0.22	0.07	0.021
T. agilis	377		8.98	2.998
P. pholadiformis	10	18.40	5.60	1.120
M. arenaria	32	127.87	46.77	10.203
A. vulgaris	4	1.02	0.54	0.121
A. quadracus	2		0.31	0.107
Z. marina			5.19	0.757
Totals	752 (15 spp.)		95.17	20.376
		Fauna	89.99	19.619



Figurel. Sketch map of Ostrea Lake showing approximate location of Transects and Quantitative benthos samples. 1967.