Nie

Gary

OYSTER MORTALITY STUDY
Summary Report
1966-72

Fish Commission of Oregon
Management and Research Division
Gary G. Gibson

U. S. Department of Commerce
National Marine Fisheries Service
Contract No. N 208-0133-72

May 1974

CONTENTS

TABLES

APPENDIX TABLES

FIGURES

ABSTRACT

We monitored oyster mortality in Yaquina, Coos, and Tillamook bays from July 1966-March 1972. Pacific oyster *(Crassostrea gigas)* mortality in Yaquina Bay appears to be lower than in any other reporting area on the Pacific Coast, generally less than 2% per year. Native oyster *(Ostrea lurida)* mortality ranged from 9.6-28.2%. Low salinity stress caused over one-half of this mortality each winter. In Tillamook Bay, Pacific oyster mortality generally averaged 4% per year; mortality in Coos Bay averaged 7% a year, excluding an unexplainable mortality of 19% during the summer of 1968. Bay mussel mortality totaled 49.9% in 1970-71 and 19.3% during 1971-72. Predation by small crabs probably caused these high mortalities.

Shell growth of Pacific and native oysters in Yaquina Bay in 1968 and 1969 occurred almost entirely during April-September of each year.

During 1966-72, we sent 1,950 Pacific oysters, 2,400 native oysters, 1,400 bay mussels *(Mytilus edulis)*, 100 bent-nosed clams *(Macoma nasuta)*, 50 irus macoma clams *(Macoma irus)*, and 100 softshell clams *(Mya arenaria)* to the University of Washington and the NMFS Oxford laboratory for histological examination.

We monitored changes in hydrographic conditions (salinity, temperature, dissolved oxygen, and turbidity) in Yaquina Bay. I also collected nutrient samples (phosphate, silicate, and nitrate-nitrite).

We cooperated with the NMFS Oxford laboratory on a study to determine the nature and cause of a "neoplasm disease" of native oysters and bay mussels in Yaquina Bay.

In a laboratory study, I found native oysters tolerant to reduced salinity during the winter. Significant winter mortality in a particular area in Yaquina Bay can be expected only when salinities fall below 10 ppt for more than 3 weeks.

Bay mussels reflected high sensitivity to outboard motor effluent in a laboratory experiment. Native oysters showed a much higher tolerance to the contaminant.

OYSTER MORTALITY STUDY

INTRODUCTION

Washington and California experience periodically high Pacific oyster *(Crassostrea gigas)* mortalities, while Oregon has avoided such losses. In 1966, the Fish Commission of Oregon began an oyster mortality study as part of a coastwide program concerning Pacific oyster mass mortalities.

Primary objectives of this study included: monitoring oyster mortality; collecting hydrographic data for comparison to information from high mortality areas in other states; and supplying relatively disease-free oysters to the University of Washington and the National Marine Fisheries Service for histological comparison to animals from high mortality areas.

Other activities included: determining growth patterns of Pacific and native oysters *(Ostrea lurida)*; ascertaining seasonal condition indexes for Pacific oysters; defining the nature of a "neoplastic disease" of native oysters in Yaquina Bay; determining the low salinity tolerance of native oysters; finding out the maximum age and size of Pacific oysters and obtaining a qualitative understanding of the effects of outboard motor effluent on native oysters and bay mussels *(Mytilus edulis)*.

MATERIALS AND METHODS

Mortality Stations

Yaquina Bay. In 1966 we established seven subtidal stations in Yaquina Bay (Figure 1). At the end of 2 years, due to similarity of mortality data, I reduced the number of stations to four (stations B, C, E and G). I further reduced the number to three at the beginning of the fifth year (stations C, E, and re-established station F); only two remained during the sixth and final year (stations C and E).

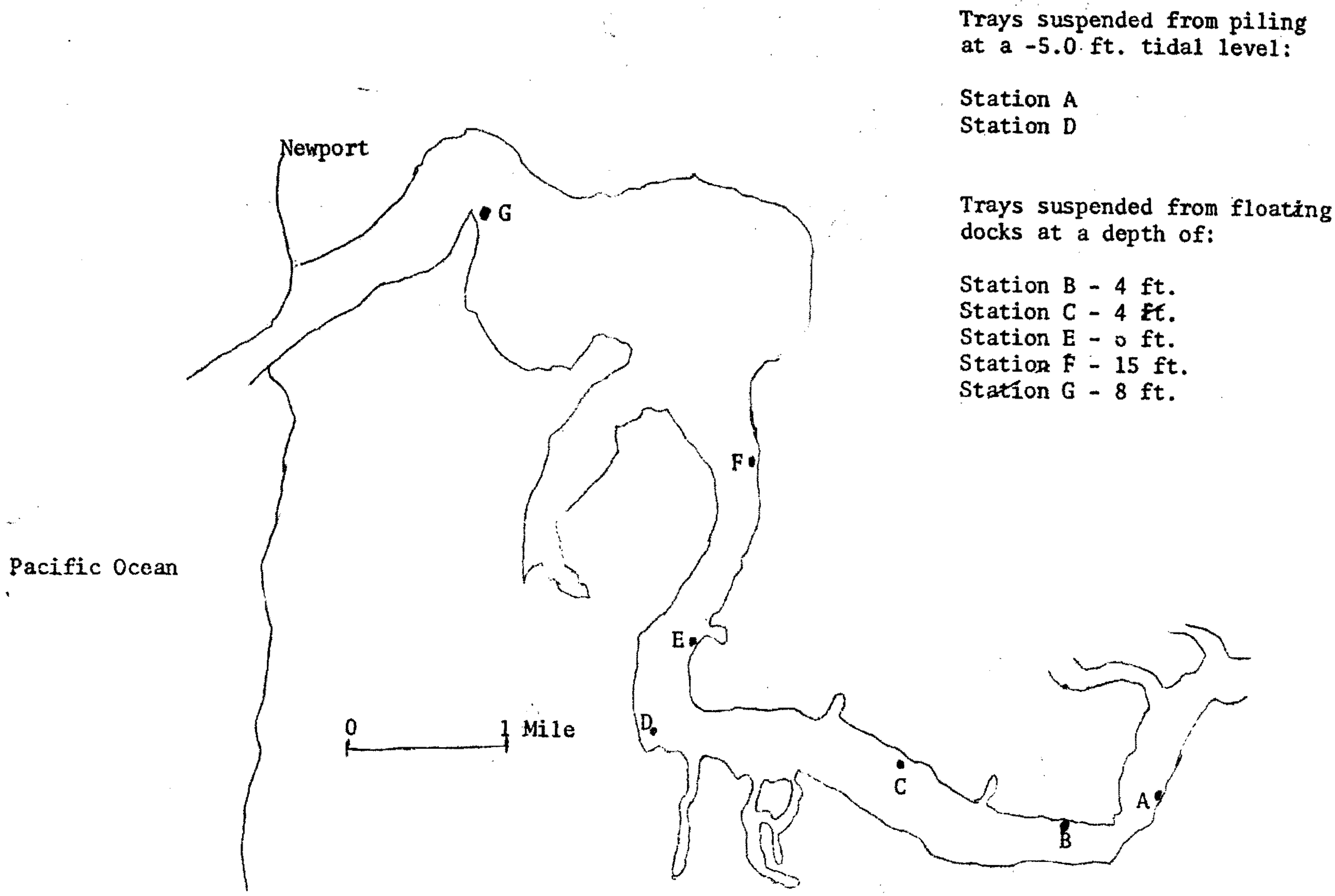

Figure 1. Locations of the Oyster Mortality Stations in Yaquina Bay.

Two suspended trays at each station contained varied numbers of Pacific and native oysters during the 6-year study. We based yearly mortality rates on a beginning population of 400-1,300 Pacific oysters, 600-2,500 native oysters, and 450-600 bay mussels (last 2 years only). We checked these animals every 2 weeks so that the effects of temporary environmental stresses could be evaluated. The Pacific oysters ranged from 1 to 2 years of age (from planting); native oysters included 1- to 5-year-old animals; only yearling bay mussels were used.

I placed an additional tray containing 500 native oyster spat from Puget Sound of the 1967 year class in Yaquina Bay at station C in November 1967. We checked these animals at irregular intervals for mortality through March 1969 to see if these animals would develop the neoplastic condition.

Tillamook and Coos Bays. Single intertidal stations within commercial oyster beds were used to indicate Pacific oyster mortality in Tillamook and Coos bays. We checked trayed oysters monthly during the first 4 years, quarterly during the last 2. Each station initially contained 50 Pacific oysters the first study year, 100 oysters the second and third years, and 150 animals the last 3 years. I used 1- to 3-year-old oysters at these stations.

Shell Growth in Yaquina Bay

Pacific Oysters. I measured the same 300 1-year-old Pacific oysters at Yaquina stations B, C, and E every 3 months from April 1968 through March 1970. The mean product of heighth (commonly termed length) and width determined shell size.

Native Oysters. One hundred native oysters of the 1967 year class were used to determine shell growth at station C in Yaquina Bay from November 1967 through March 1969. Mean shell length alone represented the size of native oysters because of their more uniform shape.

Histological Samples

Histological samples included: Pacific oysters, native oysters, bay mussels, bent-nosed clams *(Macoma nasuta)*, irus macoma clams *(Macoma irus)*, and softshell clams *(Mya arenaria)*. We sent the samples either preserved or live to the University of Washington and to the NMFS Oxford, Maryland, laboratory for histological examination. I prepared the animals by fixing them in Davidson's Solution, then transferred them first into 50% and finally 70% ethanol.

Hydrographic Data from Yaquina Bay

During the first 2 years of the study, we collected salinity, temperature, dissolved oxygen, pH, and turbidity data twice monthly at all six Yaquina Bay stations (usually at high tide).1/ During the third and fourth years, I obtained this information (no pH data) twice monthly at stations B, C, E, and G during a daily high and low slack tide. Surface, mid-depth, and bottom measurements described salinity and temperature conditions at each station; samples taken at tray level revealed dissolved oxygen values. I determined turbidity with a Secchi disc.

I began collecting nutrient samples (phosphate, nitrate-nitrite, and silicate) twice monthly in August 1971 at stations C and E during a daily high and low slack tide. I expanded this program in February 1972 to include temperature-salinity data and added stations B and G. The Oregon State University Chemical Oceanography Department analyzed these samples.

Condition Index

We determined monthly condition indexes from June 1966-March 1968 for native and Pacific oysters from Yaquina Bay (stations A-F) and for Pacific oysters from Tillamook and Coos bays (from trays and surrounding

---

1/ *Hydrographic data for June 1966-November 1967 was reported in "Hydrographic Data for Yaquina, Coos, and Tillamook Bays," Fish Commission of Oregon mimeographed report, 1967. C. Dale Snow and Gary G. Gibson.*

beds). The following formula gave us condition index values:

$$\text{Condition Index} = \frac{\text{dry weight of oyster tissue}}{\text{volume of shell cavity}} \times 100$$

We obtained dry weights by drying the oyster meats in an oven for 1 week at 194 F; we obtained shell cavity volumes by using a water displacement method.

Native Oyster Disease Study

After the identification of a "neoplastic disease" of native oysters and bay mussels from Yaquina Bay, I cooperated with the National Marine Fisheries Service in a study to determine the cause and significance of the disease. During 1969 I collected shellfish samples at irregular intervals from Yaquina Bay, and sent these live to the NMFS Oxford laboratory for histological examination. We shipped monthly samples to Oxford from January 1970-September 1971; we sent quarterly samples from November 1971-May 1972.

In January 1970, I obtained 2,500 native oysters from Puget Sound and introduced them into Yaquina Bay. I suspended a tray containing 500 oysters at each of three locations within the native oyster producing grounds. We maintained about 1,000 of these oysters in our laboratory. Before introduction we sent a sample of the Puget Sound oysters to Oxford for examination to establish that these animals did not contain the neoplastic disease. From this introduction we hoped to obtain information about the time and rate of transmission of the disease.

From May 1969-March 1970 I sampled the native oyster grounds in Yaquina Bay for mortality. From one tongful of oysters (125-350 animals) I counted the number of live oysters, gapers (entire or part of animal remaining in shell) and unfouled boxes (no part of animal remaining in a clean shell). Using the following ratio, I estimated monthly mortality rates:

$$\frac{\text{gapers + unfouled boxes}}{\text{gapers + unfouled boxes + live oysters}}$$

We sent this information to the Oxford laboratory for further evaluation and correlation with histological findings.

Salinity Tolerance of Native Oysters

To properly evaluate winter mortalities of native oysters in Yaquina Bay, we needed to determine the low salinity tolerance of these animals. In December 1968 we brought approximately 200 adult Yaquina Bay native oysters into our laboratory for conditioning at a constant temperature of 59 F for 2 weeks. While conditioning, the oysters consumed a diet of unicellular algae (*Monochrysis* sp. and *Isochrysis* sp.) totaling from 200-800 million cells per day. I then placed five groups of 40 oysters each in 1 gallon containers of water at salinities of 0, 5, 10, 15, and 30 ppt. A mixture of filtered sea water and distilled fresh water produced the required salinities. I changed the continuously aerated water in the containers every other day. At the end of 2 weeks, I placed half of the oysters from each salinity group in 30 ppt sea water and monitored them for delayed mortality. I continued daily monitoring of the oysters held at the original salinities. Oysters were considered "dead" when they gaped and could not hold their valves closed. I prepared all dead oysters for histological sectioning and sent them to the University of Washington for analysis of the internal changes caused by low salinity stress. Hopefully, pathologists could then distinguish the internal damage caused from a suspected disease, from tissue changes induced by low salinity.

Pacific Oyster Longevity Study

In 1967 Dr. Kenneth Chew, University of Washington, terminated a study in Yaquina Bay on the effects of the parasitic copepod *(Mytilicola orientalis)* on Pacific oysters. Dr. Chew gave us the remaining 2-, 3-, 4-, and 5-year-old experimental oysters which he had placed in trays at station C as 1-year-old animals in March of 1963, 1964, 1965, and 1966. Each tray initially contained 150 oysters.

This provided an opportunity to find out how long Pacific oysters live. This study was terminated in March 1970.

Outboard Motor Effluent Experiment

In March 1972 I ran an 18 horsepower outboard motor in 260 liters of raw sea water until a measured amount of mixed fuel (0.1 liter of oil and 4.8 liters of regular gas) passed through the motor. The motor consumed this amount of fuel in 100 minutes at a speed of 1,200-1,500 rpms. I repeated this procedure (using fresh sea water) six times over a 10-day period. After each run, I drew a test sample (about 250 liters) from below the unburned surface fuel layer of the water and filled a reservoir with this sample. A floating siphon device in the reservoir provided a constant flow of effluent (0.1 liter per minute) into running sea water (0.9 liter per minute) where a 10% concentration of the contaminant formed just prior to the mixture's contact with the test animals. The running sea water provided the necessary food to the shellfish.

I also pumped raw sea water into a control tank containing the same number of animals as in the test tank. One hundred native oysters and 150 bay mussels in each tank provided the experimental population. Mussels averaged 47 mm in length; oysters averaged 37 mm. Temperatures in the control tank ranged from 50-52 F; test tank temperatures averaged 0.5 F higher.

I recorded pumping and mortality data during a 10-day exposure to the effluent. I also collected mussel and oyster samples (both test and control animals) after exposure periods of 1, 5, and 10 days. I prepared some of these samples for histological examination at the NMFS laboratory in Oxford, I froze the remaining samples for the NMFS laboratory in Seattle, Washington, for chemical analysis of hydrocarbon accumulation in the tissue of the shellfish.

RESULTS AND DISCUSSION

Mortality

Yaquina Bay. We recorded few Pacific oyster mortalities from 1966 through 1972 (Table 1). Yearly mortalities generally totaled less than 2%, but higher mortalities occurred during 1969-70 and again in 1970-71. During 1969-70, I noted an unexplainable die off in one tray at station B. No oysters died in an adjacent tray less than 3 feet away. I recorded additional mortalities during February and March at two upper bay stations (B and C) where extremely low salinities killed many marine animals during the winter. The second high mortality year, 1970-71, resulted from culling damage prior to the introduction of the replacement oysters into the trays. All of the dead animals showed shell breakage, and I noticed shell repair in many of the remaining live animals. The oysters which died could not repair shell damage fast enough to prevent the invasion of marine organisms into the mantle cavities.

In conclusion, Pacific oyster mortality in Yaquina Bay appears to be lower than in any other reporting area on the Pacific Coast.

Table 1. Yearly Pacific Oyster Mortality In Yaquina Bay by Station, July 1966-March 1972 (1-and 2-Year-Old Animals)

Date	Number of Dead Oysters								
	Station								
	A	B	C	D	E	F	G	Total	Total % 1/
July 1966-June 1967	1	2	4	3	5	3	1	19	1.8
July 1967-March 1968	2	2	2	1	2	1	6	16	1.5
April 1968-March 1969	-	4	3	-	1	-	1	8	1.1
April 1969-March 1970	-	45	23	-	3	-	2	73	8.6
April 1970-March 1971	-	-	40	-	11	66	-	117	26.0
April 1971-March 1972	-	-	7	-	0	-	-	7	1.8

1/ *Total percent mortality equals 100 minus the product of monthly survival percentages.*

Yearly native oyster mortality ranged from 9.6 to 28.2% during the study period (Table 2). Over one-half of this mortality occurred at the upper bay stations (A, B, and C) each winter, where low salinities severely stressed these animals. Another significant mortality occurred almost yearly at all stations in Yaquina Bay during April and May just prior to spawning. We cannot explain the cause of this mortality. Native oysters sampled during this time do not show any abnormal structures histologically; in fact, these animals reflect a high degree of "fatness," a healthy condition prior to spawning.

Table 2. Yearly Native Oyster Mortality in Yaquina Bay by Station, July 1966-March 1972

	Number of Dead Oysters								
	Station								
Date	A	B	C	D	E	F	G	Total	Total % 1/
July 1966-June 1967	74	115	58	41	42	44	13	387	17.5
July 1967-March 1968	24	16	11	12	10	4	9	86	9.6
April 1968-March 1969	-	129	18	-	15	-	47	209	28.2
April 1969-March 1970	-	132	28	-	18	-	-	178	26.5
April 1970-March 1971	-	106	40	-	53	-	-	199	22.1
April 1971-March 1972	-	-	102	-	50	-	-	152	27.3

1/ *Total percent mortality equals 100 minus the product of monthly survival percentages.*

Bay mussel mortality totaled 49.9% in 1970-71 and 19.3% during 1971-72 (Table 3). The broken shells of many of the dead animals and the presence of small crabs in the trays indicated that crabs caused the mortality. The abundance of these crabs increased during the summer and fall; mussel mortality also increased during this time.

Table 3. Yearly Bay Mussel Mortality in Yaquina Bay, April 1970-March 1972

	Number of Dead Mussels				Total
	Station				Percentage
Date	C	E	F	Total	Mortality
April 1970-March 1971	58	60	81	199	49.9
April 1971-March 1972	47	69	--	116	19.3

Tillamook and Coos Bays. No significant Pacific oyster mortality occurred at the Tillamook Bay station during the study until the winter of 1971-72, when the intertidal trays were sanded in by storms, and many of the oysters smothered (Table 4). Yearly mortality averaged only 4% over the 5 years prior to 1971-72.

During the 6-year study, I reported a significant mortality only once at the Coos Bay station. In the summer of 1968, a 19% mortality occurred in the intertidal trays, but I noted no unusually high mortality during this time in younger oysters being cultured commercially on racks and sticks in the area. Yearly mortality, not including 1968-69, averaged 7%.

Table 4. Yearly Pacific Oyster Mortality in Tillamook and Coos Bays, December 1966-March 1972

Date	Tillamook Bay Total % 1/	Coos Bay Total % 1/
Oct. 1966-April 1967	4.0	-
Jan.-June 1967	-	12.0
July 1967-March 1968	2.4	7.3
April 1968-March 1969	4.6	27.1
April 1969-March 1970	2.1	6.9
April 1970-March 1971	7.3	6.7
April 1971-March 1972	31.3	4.0

1/ *Total percent mortality equals 100 minus the product of monthly (quarterly the last 2 years) survival percentages.*

Shell Growth in Yaquina Bay

Pacific Oysters. Shell growth in 1968 and 1969 occurred almost entirely during April-September (Figure 2). After 2 years in suspended trays, oysters at station E grew 41.5% larger than those at station B and 28.4% more than the oysters at station C. Higher salinities during winter months and intense algal blooms during spring and summer months probably contributed to rapid growth in the vicinity of station E.

Native Oysters. Mean shell length of the 1967 set native oysters increased only 1.8 mm (12.4%) during November 1967-May 1968, while rapid growth occurred during June-August 1968 (86.5%). We noted no further increase in shell sizes through March 1969.

Histological Samples

We sent a total of 2,400 native oysters, 1,750 Pacific oysters, 1,400 bay mussels, 100 bent-nosed clams, 50 *irus macoma* clams, and 100 softshell clams to either the University of Washington or the NMFS Oxford laboratory for histological examination.

Hydrographic Data from Yaquina Bay

Hydrographic conditions in Yaquina Bay change markedly between tides and between seasons (Appendix Tables A-D).

Salinity. Generally high salinities prevail within the area of oyster production between stations B and E during the summer; extremely low salinities often exist for several weeks at a time during the winter (Table A).

Layering of fresh water over salt water occurs frequently during periods of high stream flow, an example being January 8, 1969, during high tide at station C when fresh surface water overlayed salt water with a salinity of 19.2 ppt. This phenomenon often caused oyster mortality. A

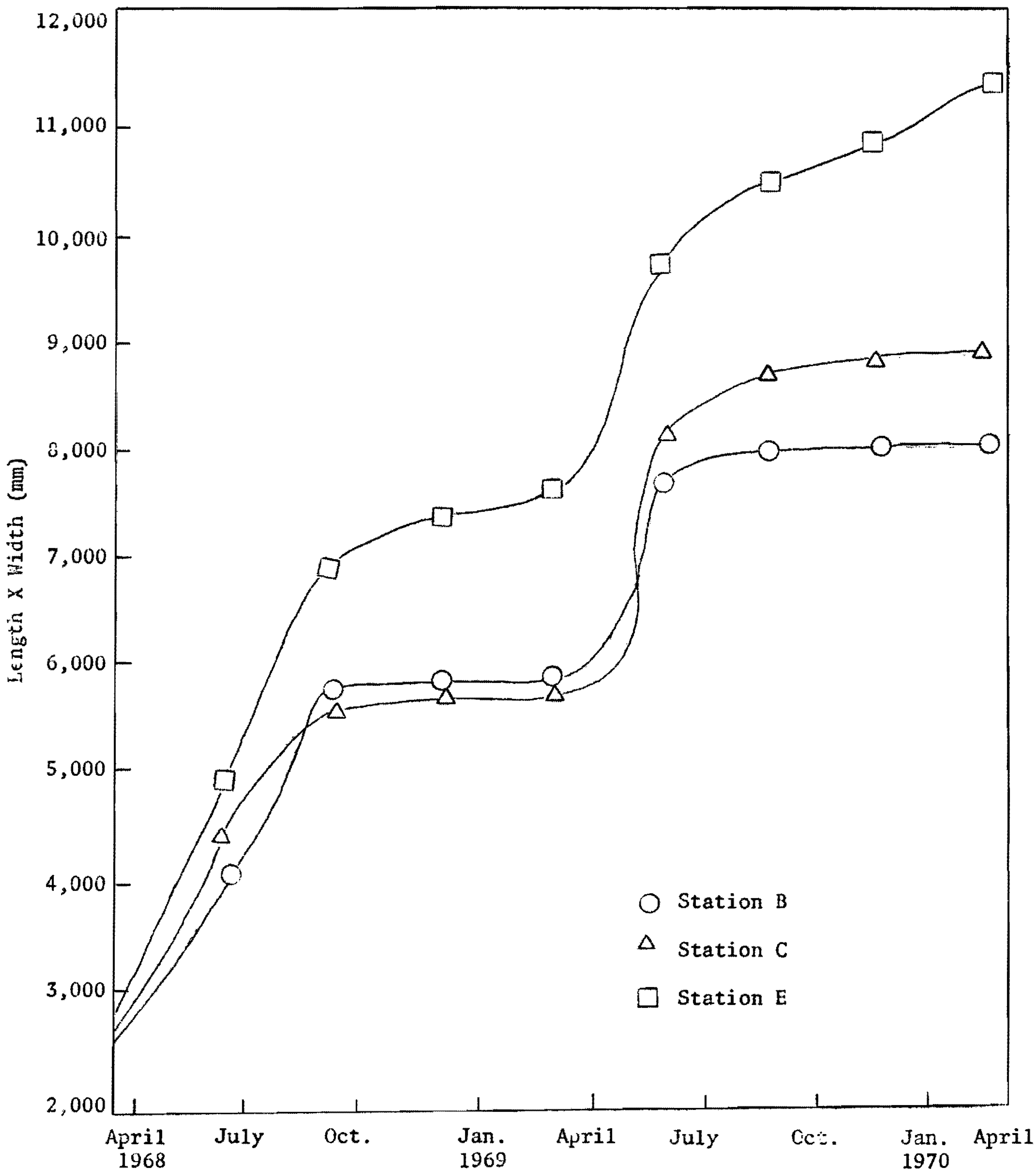

Figure 2. Average Shell Growth of 300 Yearling Pacific Oysters in Suspended Trays at Three Yaquina Bay Stations, April 1968-March 1970

high native oyster mortality occurred at station B during January-February 1969 and 1970, while I noted very few mortalities during the same time at station C, less than a mile down bay. Salinity information reveals that severe winter conditions existed at both stations at low tide, but substantially higher salinities prevailed beneath the fresh-water layer at high tide at station C than at station B.

Temperature. Temperature, like salinity, varied considerably as to area, season, and tidal cycle. Greater yearly temperature extremes occur at the upper bay stations than in the lower bay. From April 1968 through March 1970, I recorded maximum high tide summer temperatures of 67, 67, 62, and 61 F at stations B, C, E, and G, respectively, and maximum low tide temperatures of 70, 69, 65, and 61 F at the same stations. Ranges in minimum winter temperatures were generally less than 4 F between the four stations. Large differences in temperature frequently occur during the summer between stations B and G due to oceanic upwelling; for example, on July 22, 1968, I recorded a bottom temperature of 52 F at station G, and 70 F at station B.

Dissolved Oxygen. Generally high dissolved oxygen concentrations prevailed throughout the study area, but in August 1968 and 1969, at the upper bay stations, high temperatures forced readings down to 5-6 ppm. I also recorded low dissolved oxygen concentrations in July 1968 in lower Yaquina Bay when values fell to 5 ppm due to upwelling. In March 1969 an intense algal bloom at the upper bay stations caused supersaturation of dissolved oxygen.

Turbidity. Secchi disc readings ranged from 1' at station B during the winter to 11' at station G during the summer. These extremes resulted from the heavy influx of silt-laden fresh water into the head of the bay during winter freshets and the intrusion of cold, clear sea water into the lower bay during summer upwelling.

Nutrients. Phosphate, silicate, and nitrate-nitrite values for August 1971-January 1972 appear in Appendix Table E.

Condition Index

Yaquina Bay. Pacific oyster mean condition index remains fairly high throughout the year in Yaquina Bay, since spawning rarely occurs in this estuary (Table 5). Native oyster condition temporarily drops each summer due to spawning. Young Pacific and native oysters which replaced older animals in our trays, reflected low condition indexes during January-March 1968 as expected for immature oysters.

Table 5. Monthly Mean Condition Indexes for Native and Pacific Oysters in Yaquina Bay and for Pacific Oysters in Tillamook and Coos Bays, June 1966-March 1968

Date	Yaquina Bay		Tillamook Bay	Coos Bay
	Native	Pacific	Pacific 2/	Pacific 2/
June 1966	12.1 1/	19.7 1/	-	-
July	9.6	14.7	-	-
August	13.6	16.2	-	-
September	17.4	16.2	16.9	-
November	15.5	15.3	-	-
December	14.3	14.4	14.0	9.6
January 1967	15.5	14.1	13.0	7.3
February	14.9	12.2	14.1	9.4
March	13.8	13.3	13.3	8.1
April	14.9	13.8	-	-
May	13.5	17.1	-	14.7
June	-	-	12.9	-
July	9.3	16.8	-	-
August	9.6	16.8	-	-
September	10.2	15.5	14.4	12.0
October	18.5	14.6	15.7	7.6
November	15.0	13.9	-	11.2
December	-	-	12.9	13.2
January 1968	11.9	7.2	12.8	10.7
February	10.1	10.0	14.2	8.9
March	9.3	10.2	-	9.4

1/ Oysters before being placed in trays.
2/ Includes oysters from tray and surrounding beds.

Tillamook and Coos Bays. Pacific oyster mean condition index remained at a constant level at the Tillamook Station (Table 5). Coos Bay oysters exhibited more variable "fatness," but generally reflected lower condition indexes than oysters in Yaquina and Tillamook bays.

Native Oyster Disease Study

The NMFS Oxford laboratory publishes separate pathology reports concerning shellfish samples which we submit to them. One such report, describing a neoplasm disease, stated that "histological examination disclosed a 40% incidence of this disorder in native oysters collected from Yaquina Bay during October 1969."

I noted generally low mortality in the monthly samples which I collected on the native oyster bed in Yaquina Bay from May 1969-March 1970 (Table 6). The 10% mortality recorded in February 1970 probably resulted from extremely low salinities that occurred over the native oyster beds for several weeks.

Table 6. Native Oyster Mortality (%) on a Natural Oyster Bed in Yaquina Bay from May 1969-March 1970

Date	Mortality	Date	Mortality
May 1969	2.6	November	0.6
June	6.7	January 1970	0.0
July	3.0	February	10.1
September	1.1	March	1.2
October	0.0		

Salinity Tolerance of Native Oysters

I found native oysters to be tolerant to low salanities during the winter. Better survival in distilled water than in 5 ppt salinity, indicates that low salinity (5 ppt or less) may be as lethal as fresh water (Table 7).

Table 7. Survival of Adult Native Oysters in Different Salinities at 59 F

Salinity (ppt)	Percentage Survival After: 7 days	14 1/ days	21 days	28 days	35 days	42 days	49 days
0	100	95	65	20	0	0	0
5	98	85	50	15	0	0	0
10	100	93	87	82	62	10	0
15	98	98	98	88	88	83	83
30	100	97	97	97	97	97	97

1/ *One half of oysters removed at the end of 14 days.*

The threshold of survival appeared to be somewhere between 5 and 10 ppt salinity for 2-3 weeks at 59 F. Similar experiments with other oyster species have shown that low salinity tolerance increased as temperature decreased. Since winter temperatures nearer to 50 F (compared to the experimental temperature of 59 F) prevail in Yaquina Bay over the native oyster beds, significant mortality can be expected when salinities fall below 10 ppt for more than 3 weeks. These conditions occasionally occurred during winter freshets on the native oyster grounds, and subsequent mortalities were observed.

Native oysters held at low salinities (0, 5, 10, and 15 ppt) for 2 weeks, then maintained in 30 ppt saltwater, experienced no significant delayed mortality (Table 8).

Table 8. Delayed Mortality of Native Oysters after Being Held in Reduced Salinities for 14 Days, then Held at 30 ppt Salinity

Initial Salinity (ppt) for 14 Days	Percentage Survival in 30 ppt Saltwater After: 7 days	14 days	21 days
0	78	78	78
5	100	94	94
10	100	89	89
15	95	95	95
30	100	100	100

A preliminary experiment indicated that native oysters may tolerate reduced salinity less during the summer.

Pacific Oyster Longevity Study

Table 9 shows the survival of four year classes of Pacific oysters planted in Yaquina Bay.

Table 9. Survival and Growth of Four Age Groups of Pacific Oysters in Yaquina Bay (Data Taken March 1970)

Year Placed in Tray	Year Planted in Yaquina Bay	Survival %	Size (mm) Mean Length	Mean Width
1966	1965 (1964 year class)	47	150	89
1965	1964 (1963 year class)	36	148	81
1964	1963 (1962 year class)	37	161	92
1963	1962 (1961 year class)	13	154	100

Low salinity stress probably caused the generally poor survival, since I noted and removed most of the mortalities just after periods of low salinity each year. Growth data reveal only small differences in size among the four groups

Outboard Motor Effluent Experiment

After a 24-hour exposure to the outboard motor effluent, almost all mussels showed stress (gaping). I noted no gaping oysters, although none of them appeared to be pumping. After the 24-hour exposures I placed all of the bay mussels in clean running seawater; the oysters remained in the contaminant. At the end of 45 days, delayed mussel mortality totaled 76% (Table 10). At the end of 10 days in the effluent, native oyster mortality (allowing for sampling) totaled 14% (Table 11). During the experiment I noted only one mussel mortality and one oyster death in the control tank.

Table 10. Cumulative Delayed Mortality of Bay Mussels in Running Seawater after an Initial 24-Hour Exposure to a 10% Solution of Outboard Motor Effluent

Day No.	Cumulative Mortality %
3	12
9	61
10	66
45	76

Table 11. Cumulative Native Oyster Mortality during a 10-Day Exposure to a 10% Solution of Outboard Motor Effluent

Day No.	Cumulative Mortality %
3	2
4	3
7	10
10 1/	14

1/ All oysters dead or sampled at the end of 10 days.

The high sensitivity of the bay mussels to the effluent suggests that very small amounts of outboard motor wastes may adversely affect these animals. Concentrations of outboard motor effluent in bays and estuaries probably never reach the level used in our experiment, but by comparing our observations on mortality with histopathological (tissue damage) and histochemical (accumulated hydrocarbons) information, we should obtain a clearer picture of the qualitative effects of outboard motor contamination to shellfish.

APPENDIX TABLES

Table A. Salinities (ppt) from Yaquina Bay,
April 1968-March 1970 1/

Date	Station			
	B	C	E	G
4-16-68	4.2	5.2	12.6	23.1
Low tide	2/	5.6	14.1	23.5
	4.8	5.8	20.9	25.2
4-16-68	18.8	24.6	25.8	31.4
High tide	18.7	24.3	30.7	32.3
	22.0	24.6	31.0	31.9
4-30-68	10.3	11.4	17.9	26.0
Low tide	10.3	11.2	18.3	27.6
	9.9	11.0	27.3	28.8
4-30-68	22.2	23.9	24.4	32.4
High tide	22.9	25.9	30.0	33.4
	25.0	26.3	31.4	32.5
5-13-68	24.8	25.9	17.9	27.7
Low tide	2/	2/	2/	28.1
	2/	26.7	21.7	29.1
5-13-68	28.0	29.0	29.1	32.8
High tide	28.6	31.0	32.1	33.2
	29.0	31.1	32.4	33.2
5-31-68	8.9	10.2	16.1	21.7
Low tide	2/	10.3	17.1	23.9
	8.9	10.5	22.6	24.0
5-31-68	17.5	19.9	19.9	27.3
High tide	19.0	20.0	25.0	27.4
	20.6	21.7	25.9	27.7
6-19-68	16.0	17.0	19.7	26.5
Low tide	16.0	17.1	24.3	27.2
	16.5	21.7	28.1	30.7
6-19-68	16.6	18.0	22.1	29.5
High tide	19.6	21.7	28.4	32.5
	25.8	26.4	30.0	33.0
7-8-68	22.5	24.6	29.0	31.9
Low tide	22.2	25.0	30.3	33.4
	22.9	26.5	31.5	33.6
7-8-68	28.0	29.3	31.2	32.4
High tide	28.4	30.6	32.9	33.7
	28.9	30.8	33.7	33.8
7-22-68	24.6	26.4	30.3	34.2
Low tide	24.6	26.3	31.9	34.4
	25.2	26.7	32.3	34.6
7-22-68	27.2	26.8	30.2	32.0
High tide	27.2	27.4	31.6	34.2
	27.3	27.3	32.3	34.4
8-5-68	26.3	27.8	30.4	33.6
Low tide	26.1	27.8	31.5	33.4
	27.2	29.4	32.8	34.0
8-5-68	29.4	32.0	33.0	34.9
High tide	29.7	32.5	34.9	35.1
	30.3	33.3	35.1	35.4
8-28-68	17.4	19.7	25.9	33.0
Low tide	17.3	19.6	25.8	33.2
	18.2	20.6	28.2	33.4
8-28-68	28.0	29.0	32.7	32.7
High tide	28.6	30.0	32.8	33.0
	29.4	32.0	32.9	33.2
9-11-68	20.6	23.1	27.7	33.6
Low tide	21.0	23.5	28.4	34.0
	22.1	25.0	32.7	33.6
9-25-68	17.8	19.6	24.6	32.8
Low tide	18.3	20.1	25.5	33.0
	18.6	21.4	28.2	33.2
9-25-68	27.7	31.9	33.3	33.2
High tide	31.2	32.7	33.7	33.8
	32.4	32.5	34.0	34.0
10-9-68	21.4	23.3	26.8	33.6
Low tide	21.7	23.5	29.7	33.2
	24.2	23.9	31.9	33.2

1/ *Measurements are for surface, mid-depth, and bottom positions, respectively.*

2/ *Insufficient depth to make a difference in values.*

Table A (cont'd)

Date	Station B	C	E	G	Date	Station B	C	E	G
10-9-68	29.1	31.4	32.3	33.4	2-7-69	6.3	10.1	17.5	24.0
High tide	29.9	32.4	33.8	33.8	High tide	17.8	18.0	23.9	31.2
	31.8	32.7	33.7	34.0		22.2	22.2	26.0	31.1
10-31-68	9.8	11.9	18.6	24.6	2-21-69	2.5	4.5	9.4	18.4
Low tide	9.6	11.6	19.9	25.4	Low tide	2.6	4.5	11.4	18.4
	9.7	13.7	21.3	27.6		2.9	4.6	15.8	24.4
10-31-68	16.6	20.5	22.6	31.1	2-21-69	12.8	16.2	19.4	20.9
High tide	20.1	24.3	29.8	32.7	High tide	17.1	20.3	25.4	32.3
	22.7	25.5	31.2	32.7		18.2	22.1	26.3	32.1
11-14-68	2.1	4.8	6.0	9.2	3-21-69	3.8	5.8	12.0	20.5
Low tide	2.1	5.1	7.3	11.9	Low tide	3.2	5.8	12.6	22.6
	3.9	11.1	26.3	27.8		5.0	7.5	17.6	25.5
11-14-68	6.2	5.4	6.7	9.9	3-21-69	18.4	22.1	24.8	29.8
High tide	8.4	8.1	25.4	30.7	High tide	18.7	22.6	27.3	32.5
	19.6	23.7	27.3	31.1		19.6	23.3	30.6	33.0
12-12-68	0.0	0.0	2.9	4.6	4-7-69	9.3	10.8	10.7	25.5
Low tide	0.0	0.0	3.3	5.8	Low tide	10.8	10.7	17.4	26.7
	0.4	0.1	8.6	19.6		11.6	10.7	23.8	27.2
12-12-68	0.5	0.5	1.1	3.9	4-7-69	20.6	23.5	26.3	28.8
High tide	0.0	0.8	8.5	20.8	High tide	20.1	23.9	27.1	30.3
	0.9	12.4	24.6	27.8		21.6	25.6	28.8	30.7
1-8-69	0.0	0.0	0.8	6.6	4-21-69	10.2	11.6	16.0	24.0
Low tide	0.0	0.0	3.2	8.1	Low tide	10.5	11.9	17.0	25.2
	0.0	0.0	5.2	14.2		10.6	12.2	22.2	27.2
1-8-69	0.0	0.0	18.2	21.4	4-21-69	20.5	22.5	25.5	29.8
High tide	0.0	0.4	18.0	28.4	High tide	21.2	24.0	27.6	30.6
	9.4	19.2	25.4	30.8		21.8	24.8	28.2	30.7
1-21-69	2.1	4.5	8.0	20.6	5-12-69	15.4	17.0	21.7	29.4
Low tide	2.5	4.6	11.5	23.9	Low tide	15.4	17.0	23.4	32.4
	5.0	5.2	19.1	26.9		15.6	17.0	25.9	32.9
1-21-69	12.8	16.2	19.4	20.9	5-12-69	23.5	25.2	28.4	31.9
High tide	17.1	20.3	25.4	32.3	High tide	23.9	27.4	31.8	34.1
	18.2	22.1	26.3	32.1		24.4	28.2	32.5	34.5
2-7-69	3.2	4.7	9.4	18.4	5-28-69	19.4	21.6	25.9	29.4
Low tide	3.0	4.8	11.2	20.9	Low tide	19.1	21.3	25.9	29.1
	3.5	5.2	15.3	25.1		20.9	22.6	28.0	29.1

Table A (cont'd)

Date	Station B	C	E	G	Date	Station B	C	E	G
5-28-69	24.7	26.4	28.1	31.1	9-16-69	31.0	31.1	32.3	32.8
High tide	24.8	27.2	28.9	31.6	High tide	31.0	31.6	32.5	32.8
	25.6	27.4	30.8	31.5		31.5	32.1	32.9	32.8
6-10-69	18.7	20.6	25.8	31.0	10-6-69	25.0	25.8	29.1	30.6
Low tide	19.0	20.5	26.5	30.7	Low tide	2/	25.6	28.9	30.7
	21.7	23.4	29.0	31.4		25.1	26.7	29.5	31.1
6-10-69	24.6	26.0	28.1	29.3	10-6-69	27.3	27.8	29.1	30.4
High tide	24.6	26.7	29.1	31.2	High tide	26.9	28.4	29.3	31.4
	25.6	27.6	29.5	31.6		27.1	28.9	30.2	31.9
6-26-69	17.0	19.0	23.5	31.1	10-21-69	20.3	22.1	25.9	28.5
Low tide	17.3	19.0	25.6	31.5	Low tide	20.4	22.2	26.9	30.7
	18.2	22.0	27.6	31.6		20.6	27.2	28.9	31.2
6-26-69	23.1	23.4	28.2	28.2	10-21-69	27.3	28.9	30.2	31.2
High tide	23.7	25.4	28.9	30.7	High tide	27.6	29.5	31.0	31.6
	25.2	26.4	29.5	30.6		28.0	28.0	31.4	31.8
7-25-69	23.1	25.1	28.4	31.2	11-18-69	12.6	15.6	20.8	27.8
Low tide	23.0	24.7	29.4	31.5	Low tide	2/	16.1	21.0	28.9
	23.3	25.9	30.3	32.7		2/	16.7	24.6	29.3
7-25-69	25.9	29.3	30.7	32.4	11-18-69	24.0	24.6	28.9	29.0
High tide	26.7	29.9	31.4	33.7	High tide	24.0	25.1	29.1	31.2
	26.9	29.5	32.3	33.6		24.6	27.6	29.4	31.4
8-15-69	20.9	21.1	28.6	31.2	12-5-69	18.4	18.4	23.4	28.6
Low tide	21.3	22.2	28.2	31.6	Low tide	2/	18.3	24.7	28.6
	21.2	22.2	29.4	31.8		2/	18.3	26.0	29.0
8-15-69	30.3	30.4	32.4	32.8	12-5-69	25.2	27.2	28.9	30.4
High tide	30.3	31.4	32.8	33.0	High tide	25.2	27.1	29.1	30.4
	30.8	31.5	32.8	33.2		25.6	27.2	29.4	31.2
8-29-69	22.7	23.8	28.5	31.4	12-30-69	5.6	7.2	11.2	14.9
Low tide	22.9	23.8	28.5	31.6	Low tide	2/	7.2	13.2	19.1
	23.0	24.0	28.8	31.8		2/	7.5	23.9	26.0
8-29-69	31.2	31.5	32.3	32.0	12-30-69	5.5	5.6	12.0	16.1
High tide	31.4	31.9	32.1	32.3	High tide	5.9	8.1	21.3	24.8
	31.4	31.9	32.3	32.3		7.9	22.0	25.4	30.8
9-16-69	25.6	27.2	31.5	32.8	1-28-70	0.0	0.0	1.6	3.3
Low tide	25.6	27.2	32.0	32.8	High tide	0.0	0.0	16.0	21.4
	26.1	28.2	32.1	32.8		0.0	6.0	18.4	27.6

Table A (cont'd)

Date	Station B	C	E	G
2-9-70	0.9	0.3	5.5	16.9
Low tide	2/	0.4	6.3	18.2
	2/	0.4	11.0	19.6
2-9-70	11.6	12.6	20.0	23.8
High tide	12.8	21.8	25.5	29.0
	14.8	22.0	27.3	29.4
2-24-70	6.4	7.1	12.7	21.2
Low tide	2/	7.3	14.6	22.4
	6.3	11.5	17.1	24.2
2-24-70	14.5	15.4	23.5	25.8
High tide	16.7	21.6	26.3	29.5
	17.8	24.8	24.0	31.1
3-10-70	4.5	6.0	14.4	24.6
Low tide	2/	6.4	15.2	25.5
	2/	7.7	19.7	26.1
3-10-70	19.7	23.7	26.1	30.3
High tide	21.3	25.8	29.5	30.4
	22.5	26.0	29.7	30.4

Table B. Temperatures (°F) from Yaquina Bay, April 1968-March 1970 1/

Date	Station B	Station C	Station E	Station G
4-16-68	53	52	52	51
Low tide	2/	52	51	52
	52	52	50	52
4-16-68	53	53	53	52
High tide	53	52	51	51
	53	52	50	50
4-30-68	58	58	58	55
Low tide	58	58	57	55
	58	58	55	54
4-30-68	59	58	58	54
High tide	58	57	54	53
	57	57	54	53
5-13-68	57	57	57	54
Low tide	2/	2/	2/	54
	2/	57	56	53
5-13-68	56	55	53	53
High tide	55	54	53	53
	54	54	56	53
5-31-68	64	64	63	61
Low tide	2/	64	62	60
	64	64	61	60
5-31-68	62	60	60	56
High tide	60	60	57	55
	60	59	56	55
6-19-68	67	67	66	61
Low tide	67	66	62	61
	66	65	59	55
6-19-68	66	65	63	56
High tide	65	64	58	52
	62	61	57	50
7-8-68	70	69	62	57
Low tide	70	69	60	55
	69	67	59	51
7-8-68	64	62	60	58
High tide	64	60	55	50
	63	60	52	50
7-22-68	70	69	63	54
Low tide	70	69	62	53
	70	68	62	52
7-22-68	67	67	62	60
High tide	67	66	61	52
	67	66	61	51
8-5-68	68	68	65	60
Low tide	68	67	62	57
	67	65	61	55
8-5-68	65	63	62	58
High tide	64	62	58	55
	64	61	56	54
8-28-68	64	64	63	60
Low tide	64	64	62	60
	64	64	62	60
8-28-68	64	63	61	61
High tide	64	62	61	61
	62	62	61	60
9-11-68	65	64	62	58
Low tide	65	64	62	58
	64	63	60	58
9-25-68	63	63	62	58
Low tide	63	63	61	57
	63	62	60	56
9-25-68	64	60	58	58
High tide	62	59	57	55
	60	59	56	54
10-9-68	57	56	56	52
Low tide	56	56	55	51
	56	56	54	51

1/ *Measurements are for surface, mid-depth, and bottom positions, respectively.*

2/ *Insufficient depth to make a difference in values.*

Table B (cont'd)

Date	Station B	Station C	Station E	Station G	Date	Station B	Station C	Station E	Station G
10-9-68	56	55	54	52	2-7-69	44	44	44	46
High tide	55	54	52	51	High tide	44	44	45	46
	54	53	52	51		45	45	46	46
10-31-68	54	54	55	55	2-21-69	47	47	47	47
Low tide	54	54	55	55	Low tide	47	47	47	47
	54	55	55	54		47	47	47	48
10-31-68	53	53	53	53	2-21-69	47	48	48	48
High tide	54	54	53	53	High tide	47	48	48	48
	54	54	53	53		47	48	48	49
11-14-68	50	50	50	49	3-21-69	51	51	50	50
Low tide	50	50	50	50	Low tide	51	51	50	50
	50	51	53	53		51	51	50	50
11-14-68	50	50	49	48	3-21-69	52	52	51	51
High tide	50	50	53	52	High tide	52	52	51	51
	52	53	53	53		52	51	50	50
12-12-68	49	49	49	48	4-7-69	55	54	54	53
Low tide	49	49	49	48	Low tide	55	54	54	53
	49	49	49	50		56	55	53	53
12-12-68	48	48	49	49	4-7-69	54	54	54	54
High tide	48	48	49	50	High tide	54	53	52	52
	48	49	50	51		54	53	52	52
1-8-69	47	47	47	48	4-21-69	57	57	56	55
Low tide	47	47	47	48	Low tide	57	57	56	55
	47	47	48	48		57	57	55	54
1-8-69	47	47	48	48	4-21-69	57	57	56	54
High tide	47	47	48	49	High tide	56	56	54	54
	48	49	49	50		56	55	54	54
1-21-69	43	43	44	45	5-12-69	64	64	62	57
Low tide	43	43	44	45	Low tide	64	64	60	55
	44	44	46	47		64	64	60	54
1-21-69	45	46	47	48	5-12-69	60	59	56	53
High tide	46	47	48	49	High tide	60	58	54	49
	47	47	48	49		60	57	54	49
2-7-69	43	43	43	44	5-28-69	63	63	60	58
Low tide	43	43	44	45	Low tide	63	63	60	58
	43	43	44	45		62	62	59	57

Table B (cont'd)

Date	Station B	C	E	G
2-9-70	50	50	50	50
Low tide	2/	50	50	50
	2/	50	50	50
2-9-70	52	52	52	53
High tide	52	52	53	53
	52	52	53	53
2-24-70	49	49	50	50
Low tide	2/	49	50	50
	50	50	50	50
2-24-70	52	53	52	53
High tide	52	53	52	53
	52	53	53	53
3-10-70	51	50	51	52
Low tide	2/	50	51	51
	2/	50	51	51
3-10-69	53	53	53	53
High tide	52	52	53	53
	52	52	53	53

Table C. Dissolved Oxygen Values (ppm at Tray Level) from Yaquina Bay, April 1968-March 1970

	Station					Station			
Date	B	C	E	G	Date	B	C	E	G
4-16-68 Low tide	10.0	10.4	9.5	8.8	8-28-68 Low tide	5.4	5.4	6.0	7.0
4-16-68 High tide	10.2	8.9	9.0	9.0	8-28-68 High tide	6.4	6.5	8.2	8.5
4-30-68 Low tide	9.4	9.4	8.3	8.3	9-25-68 Low tide	6.4	6.4	6.8	7.0
4-30-68 High tide	8.8	8.2	9.1	10.0	9-25-68 High tide	7.0	7.5	7.4	7.3
5-13-68 Low tide	6.9	6.9	7.0	7.8	10-9-68 Low tide	7.3	7.5	8.0	7.8
5-13-68 High tide	8.0	8.0	10.2	10.8	10-9-68 High tide	8.2	8.4	8.4	8.8
5-31-68 Low tide	7.5	7.4	7.0	7.6	10-31-68 Low tide	8.5	8.6	8.7	9.2
5-31-68 High tide	8.2	8.2	8.0	8.2	10-31-68 High tide	8.4	8.4	8.5	8.6
6-19-68 Low tide	8.2	8.8	9.1	9.6	11-14-68 Low tide	9.6	9.4	9.4	9.3
6-19-68 High tide	7.5	7.5	6.6	6.0	11-14-68 High tide	9.2	9.3	8.6	8.9
7-8-68 Low tide	7.5	7.8	6.5	6.5	12-12-68 Low tide	10.2	10.3	10.0	10.2
7-8-68 High tide	6.9	6.4	5.6	5.0	12-12-68 High tide	10.3	10.5	10.0	9.9
7-22-68 Low tide	7.9	8.1	7.1	6.2	1-8-69 Low tide	10.6	10.6	10.3	10.2
7-22-68 High tide	6.8	6.4	6.7	5.4	1-8-69 High tide	10.7	10.7	10.0	9.6
8-5-68 Low tide	6.2	6.6	7.6	10.7	1-21-69 Low tide	10.7	10.7	10.1	9.5
8-5-68 High tide	6.3	6.5	9.0	9.7	1-21-69 High tide	10.2	9.9	9.2	9.0

Table C (cont'd)

Date	Station B	C	E	G	Date	Station B	C	E	G
2-7-69 Low tide	11.1	11.2	10.7	10.2	6-26-69 High tide	8.9	8.0	8.3	8.8
2-7-69 High tide	10.8	10.9	10.1	10.2	7-25-69 Low tide	8.6	9.4	9.0	9.2
2-21-69 Low tide	10.6	10.7	10.2	9.6	7-25-69 High tide	8.5	8.6	8.0	6.2
2-21-69 High tide	10.4	10.3	9.8	9.8	8-15-69 Low tide	5.9	5.8	6.8	6.4
3-21-69 Low tide	10.9	11.2	11.1	10.1	8-15-69 High tide	7.2	6.7	6.4	6.2
4-7-69 Low tide	8.9	9.0	9.4	9.2	8-29-69 Low tide	5.4	5.5	6.4	8.0
4-7-69 High tide	9.4	9.3	9.5	9.8	8-29-69 High tide	8.0	8.2	8.4	8.8
4-21-69 Low tide	9.0	9.1	8.7	8.6	9-16-69 Low tide	6.4	6.6	7.1	6.0
4-21-69 High tide	9.1	8.6	8.9	9.6	9-16-69 High tide	7.6	7.4	6.9	7.0
5-12-69 Low tide	8.9	9.0	8.6	7.4	10-6-69 Low tide	8.2	8.0	8.4	9.6
5-12-69 High tide	8.2	7.6	6.8	5.3	10-6-69 High tide	7.6	7.9	8.3	8.7
5-28-69 Low tide	7.4	7.5	8.1	8.8	10-21-69 Low tide	8.2	8.0	8.4	9.0
5-28-69 High tide	8.2	8.0	7.7	9.0	10-21-69 High tide	8.1	8.6	8.8	8.9
6-10-69 Low tide	7.6	7.6	7.4	8.0	11-18-69 Low tide	9.2	9.2	9.0	9.2
6-10-69 High tide	7.0	6.7	7.2	7.8	11-18-69 High tide	8.3	8.8	9.2	9.1
6-26-69 Low tide	8.9	10.2	9.1	9.0	12-5-69 Low tide	9.6	9.4	9.0	9.2

Table C (cont'd)

Date	Station B	C	E	G
12-5-69 High tide	8.5	8.8	8.9	9.0
12-30-69 Low tide	10.2	9.9	9.4	9.1
12-30-69 High tide	10.0	10.1	8.9	8.8
1-28-70 High tide	10.4	10.4	9.6	9.2
2-9-70 Low tide	10.0	10.1	9.7	9.4
2-9-70 High tide	9.6	9.2	9.1	9.0
2-24-70 Low tide	10.2	10.2	9.4	9.0
2-24-70 High tide	9.3	9.0	9.3	9.0
3-10-70 Low tide	9.7	8.9	9.4	8.6
3-10-70 High tide	8.9	8.7	9.0	9.4

Table D. Secchi Disc Readings (ft) from Yaquina Bay, April 1968-March 1970

Date	Station B	C	E	G	Date	Station B	C	E	G
4-16-68 Low tide	1/	2.0	2.5	4.0	8-5-68 Low tide	4.0	4.0	5.0	7.0
4-16-68 High tide	4.0	4.5	4.5	5.5	8-5-68 High tide	4.0	5.0	5.0	7.5
4-30-68 Low tide	3.5	3.5	4.5	4.5	8-28-68 Low tide	3.5	3.5	4.0	6.0
4-30-68 High tide	4.5	5.0	5.0	6.5	8-28-68 High tide	4.5	5.0	7.0	10.0
5-13-68 Low tide	1/	2.5	2.5	2.5	9-11-68 Low tide	5.0	5.0	5.0	8.0
5-13-68 High tide	2.5	3.0	3.5	5.5	9-25-68 Low tide	4.0	3.5	4.0	5.5
5-31-68 Low tide	3.0	3.0	3.5	4.0	9-25-68 High tide	5.0	5.5	7.0	7.5
5-31-68 High tide	3.5	4.0	4.5	10.0	10-9-68 Low tide	4.5	4.5	6.0	8.5
6-19-68 Low tide	3.5	4.0	4.0	5.0	10-9-68 High tide	5.5	6.0	6.5	10.0
6-19-68 High tide	4.0	4.0	4.5	7.0	10-31-68 Low tide	5.0	5.0	6.0	7.0
7-8-68 Low tide	3.5	3.5	4.0	8.0	10-31-68 High tide	6.0	6.0	5.5	6.5
7-8-68 High tide	3.5	4.0	4.0	11.0	11-14-68 Low tide	3.0	3.0	3.5	3.0
7-22-68 Low tide	3.0	3.5	4.5	10.0	11-14-68 High tide	3.0	3.0	3.0	4.5
7-22-68 High tide	3.5	4.0	4.5	6.0	12-12-68 Low tide	1.0	1.0	1.0	1.5

1/ *Insufficient depth to obtain reading.*

Table D (cont'd)

Date	Station B	C	E	G	Date	Station B	C	E	G
12-12-68 High tide	1.0	1.0	1.0	1.5	5-28-69 Low tide	4.0	4.5	5.0	6.5
1-8-69 Low tide	1.0	1.0	1.5	2.5	5-28-69 High tide	4.0	4.0	4.5	6.5
1-8-69 High tide	1.5	1.5	2.0	3.5	6-10-69 Low tide	4.0	4.5	5.0	8.0
1-21-69 Low tide	3.0	3.0	3.5	6.0	6-10-69 High tide	5.0	5.0	7.5	11.0
1-21-69 High tide	5.0	5.5	5.5	8.0	6-26-69 Low tide	4.5	4.0	5.5	7.0
2-7-69 Low tide	4.0	4.5	5.0	7.5	6-26-69 High tide	4.0	5.0	5.5	7.0
2-7-69 High tide	5.0	5.0	6.5	8.5	7-25-69 Low tide	4.0	4.5	5.5	9.0
2-21-69 Low tide	4.0	4.5	4.5	6.5	7-25-69 High tide	4.5	5.0	5.0	11.0
2-21-69 High tide	6.0	6.0	7.5	8.5	8-15-69 Low tide	3.0	3.5	4.0	6.0
3-21-69 Low tide	3.5	3.5	3.0	7.0	8-15-69 High tide	4.0	4.5	7.0	8.0
3-21-69 High tide	5.0	6.0	7.0	9.5	8-29-69 Low tide	3.0	3.5	3.5	4.0
4-7-69 Low tide	1/	1/	6.0	5.5	8-29-69 High tide	4.0	4.0	6.5	6.5
4-7-69 High tide	7.0	7.0	3.5	8.0	9-16-69 Low tide	4.5	5.0	4.5	7.5
4-21-69 Low tide	1/	4.0	5.5	6.0	9-16-69 High tide	5.5	5.5	7.0	11.0
4-21-69 High tide	4.5	5.0	6.5	8.0	10-6-69 Low tide	1/	6.0	5.5	8.5
5-12-69 Low tide	4.0	4.0	4.0	8.0	10-6-69 High tide	5.0	6.0	6.0	8.0
5-12-69 High tide	5.0	5.5	7.0	9.5	10-21-69 Low tide	5.0	6.5	6.5	10.0

Table D (cont'd)

Date	Station B	C	E	G
10-21-69 High tide	5.0	6.5	7.5	8.5
11-18-69 Low tide	1/	6.0	6.0	6.5
11-18-69 High tide	5.0	5.0	5.0	7.0
12-5-69 Low tide	1/	5.0	7.0	5.0
12-5-69 High tide	6.0	7.0	8.5	10.0
12-30-69 Low tide	1/	5.0	5.0	5.0
12-30-69 High tide	1/	5.0	5.0	6.0
1-28-70 High tide	1.5	1.5	1.5	1.5
2-9-70 Low tide	1.5	2.0	2.0	2.0
2-9-70 High tide	3.0	3.5	3.5	6.0
2-24-70 Low tide	1/	4.5	5.0	4.0
2-24-70 High tide	4.0	4.0	5.0	8.5
3-10-70 Low tide	1/	4.0	5.0	5.0
3-10-70 High tide	4.0	6.0	6.0	9.0

Table E. Nutrient Values (uM) from Yaquina Bay, August 1971-January 1972

Date	Tide (ft)	Depth (ft)	Station-Sample No.	Phosphate1/ (uM)	Silicate (uM)	Nitrate + Nitrite (uM)
8-10-71	- 0.5	0	A 1	1.21	49.4	6.2
		3	A 2	1.66	49.8	8.2
		0	B 1	1.46	36.9	3.4
		7	B 2	1.62	32.2	2.7
	8.4	0	A 3	1.39	18.3	1.5
		11	A 4	1.14	13.4	0.8
		0	B 3	0.79	15.8	0.7
		15	B 4	0.62	10.1	1.4
8-24-71	0.7	0	A 5	1.31	41.1	6.1
		4	A 6	1.51	40.5	6.0
		0	B 5	1.48	26.4	3.7
		7	B 6	1.87	33.4	3.2
	7.5	0	A 7	1.14	28.6	2.7
		11	A 8	1.00	23.8	1.6
		0	B 7	0.83	17.8	1.2
		15	B 8	0.91	13.9	1.3
9-9-71	1.6	0	A 9	1.31	58.4	10.5
		5	A10	1.54	60.9	10.7
		0	B 9	1.19	45.2	6.8
		8	B10	1.63	31.8	4.4
	8.9	0	A11	1.48	29.1	4.1
		13	A12	1.12	25.3	3.8
		0	B11	0.97	20.0	4.3
		17	B12	1.19	17.9	4.7
9-24-71	3.1	0	A13	1.15	57.0	12.3
		6	A14	1.65	54.3	12.4
		0	B13	1.42	52.5	12.2
		10	B14	1.27	61.3	11.6
	7.7	0	A15	1.08	46.1	11.2
		11	A16	1.15	40.2	10.6
		0	B15	0.95	38.5	9.4
		15	B16	0.59	20.5	3.5
10-7-71	2.1	0	A17	1.25	66.0	10.9
		5	A18	1.35	63.7	10.4
		0	B17	1.51	44.1	6.8
		9	B18	1.26	30.2	5.7
	9.5	0	A19	1.02	22.4	7.0
		13	A20	1.34	28.6	3.6
		0	B19	1.01	20.6	7.7
		17	B20	1.26	21.4	9.0

1/ PO_4's probably within ±0.10 or so. Samples had a lot of silt and detritus which affected the PO_4 analysis.

Table E. (cont'd)

Date	Tide (ft)	Depth (ft)	Station-Sample No.	Phosphate1/ (uM)	Silicate (uM)	Nitrate + Nitrite (uM)
10-21-71	3.2	0	A21	0.80	36.1	6.2
		7	A22	1.57	57.1	10.8
		0	B21	1.14	58.6	11.0
		10	B22	1.28	31.8	7.9
	8.5	0	A23	1.25	59.9	11.1
		11	A24	1.13	28.3	7.5
		0	B23	1.17	28.8	7.3
		15	B24	1.09	15.4	6.0
11-11-71	7.1	0	A25	0.84	80.0	28.0
		11	A26	0.99	38.0	11.0
		0	B25	0.87	62.0	0.0
		14	B26	1.04	32.0	9.0
	- 3.0	0	A27	0.74	116.0	39.0
		6	A28	0.89	64.0	30.0
		0	B27	0.77	94.0	33.0
		10	B28	0.84	54.0	16.0
11-29-71	9.4	0	A29	0.69	138.0	83.0
		11	A30	1.06	60.0	30.0
		0	B29	0.61	132.0	71.0
		15	B30	0.77	44.0	17.0
	- 2.4	0	A31	0.84	107.0	80.0
		6	A32	0.74	96.0	78.0
		0	B31	1.14	123.0	65.0
		10	B32	1.47	103.0	59.0
12-13-71	8.2	0	A33	0.54	91.0	70.0
		10	A34	0.90	94.0	39.0
		0	B33	0.89	37.0	59.0
		13	B34	0.76	50.0	17.0
	- 0.8	0	A35	0.68	130.0	78.0
		4	A36	0.72	94.0	79.0
		0	B35	0.67	127.0	67.0
		7	B36	0.99	119.0	61.0
12-30-71	10.0	0	A37	0.64	154.0	59.0
		12	A38	1.03	46.0	17.0
		0	B37	0.96	77.0	28.0
		15	B38	1.05	35.0	14.0
	- 1.6	0	A39	1.36	133.0	57.0
		2	A40	1.32	135.0	60.0
		0	B39	1.19	121.0	54.0
		5	B40	2.41	46.0	41.0

Table E. (cont'd)

Date	Tide (ft)	Depth (ft)	Station-Sample No.	Phosphate1/ (uM)	Silicate (uM)	Nitrate + Nitrite (uM)
1-28-72	9.2	0	A41	1.36	62.0	22.0
		10	A42	0.57	149.0	51.0
		0	B41	0.89	101.0	40.0
		15	B42	1.47	45.0	17.0
	- 1.0	0	A43	0.78	126.0	58.0
		2/	A44	2/	2/	2/
		0	B43	1.83	65.0	40.0
		5	B44	1.59	84.0	46.0

2/ *Insufficient depth to make a difference in values.*