Charleston

CLAM-OYSTER-ABALONE LARVAL REARING

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Gerald T. Lukas
Gary G. Gibson
Fish Commission of Oregon

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CLAM-OYSTER-ABALONE LARVAL REARING

INTRODUCTION

Clam studies in the laboratory during the 1970-71 project year continued with the spawning and larval rearing of several species. Field studies were initiated utilizing laboratory-reared juvenile clams. These clams were planted in experimental plots and monitored for growth and survival. Monitoring continued on experimental clam plot studies initiated during the previous report period.

Field studies comparing growth and survival of laboratory-reared and imported Pacific and Kumamoto oysters were completed. We continued studies comparing various methods of oyster culture in Yaquina Bay. Winter survival of laboratory-reared oyster spat was determined.

Adult red abalone were obtained for spawning purposes.

During the project year, Duane Phibbs, the project biologist, resigned to go into private business. This resulted in some delay in project activities.

CLAM STUDIES

Methods

Spawning and Larval Rearing of Clams

Several clam species were spawned in the laboratory to provide juvenile clams for field studies. These included gaper (*Tresus capax*), native littleneck (*Protothaca staminea*), and Manila littleneck (*Tapes semidecussata*) clams.

Razor clams (*Siliqua patula*) were induced to spawn by using KCl and allowing the water to warm to 17-18 C (Phibbs, 1968). Razor clam larvae were reared through metamorphsis and the resultant set placed in sand. Untreated sea water, drawn from the bay, was circulated through the tank.

We attempted to spawn geoduck *(Panope generosa)* clams but the adult stock had spawned prior to our collecting them.

Field Studies

Manila littleneck clams. Juvenile Manila littleneck clams reared in the laboratory and planted in May 1970 (Phibbs, 1970) were sampled four times during the project year. These clams, with an average length of 3 mm, were planted in an 8 by 25-foot plot in upper Yaquina Bay at a density of 20 per square foot.

Native littleneck clams. In September 1970 600 juvenile littleneck clams were planted in prepared clam beds containing several types of substrate. These laboratory-reared juveniles were approximately 11 months old and had a mean shell length of 9.9 mm. They were planted at the rate of 100 per plot in 6 plots each measuring 4 by 4 feet. Five of the plots contained gravel of various sizes mixed into the substrate. One plot was left undisturbed and served as a control.

Gaper clams. Three thousand juvenile laboratory-reared gaper clams were planted in an 8 by 15-foot experimental plot in Yaquina Bay. These clams averaged 13.6 mm shell length. They were planted in Septmeber 1970 in an area which contained a natural population of adult gaper clams.

Butter clams. Monitoring of growth and survival of butter clams planted in prepared plots in Yaquina Bay continued. These laboratory-reared juvenile clams were planted in December 1968 (Phibbs, 1969).

Results

Spawning and Larval Rearing of Clams

Manila and native littleneck clams were successfully spawned and the resultant juveniles are currently being held in laboratory tanks. The

Manila juveniles will be planted in several bays which offer suitable habitat and will be monitored periodically to evaluate survival and growth in these selected areas.

The juveniles from the gaper clam spawning suffered high mortalities while being held in the laboratory due to lack of food.

The juvenile razor clams also experienced high mortalities while being held in the laboratory. Approximately 5 months after spawning only seven juveniles survived and averaged 5.2 mm in length. The high mortalities experienced by the juveniles probably resulted from extremely low salinities (2-4 o/oo) which occurred periodically during the 5-month winter period. Before further attempts are made to rear razor clams, laboratory equipment will be designed which will monitor the salinity of the incoming water and automatically shut off the water when salinity decreases to critical levels.

Field Studies

Manila littleneck clams. The survival of the Manila littleneck clams in the experimental plots varied according to the type of substrate (Table 1). During the 12-month period a river gravel substrate produced the best survival while gravel-mud substrate was poor. A mud substrate resulted in total mortality after only 3 months. The clams grew well through October 1970 but during the winter and spring period growth was curtailed. However, the total growth of 18.4 mm during the year the clams were in the plot is believed to be above average.

Native littleneck clams. The juvenile littleneck clams planted in an artificial bed containing various types of substrate were sampled for growth and survival 7 months after planting. The average length of all clams when sampled was 12.8 mm, an increase of 2.9 mm in 7 months. There

Table 1. Mean Shell Length and Percentage Survival of Manila Clams Planted in an Experimental Clam Bed

Date Sampled	Mean Shell Length (mm)	Percentage Survival River Gravel	 River Gravel-Mud	 Mud
8-18-70	12.0	12.5	10.0	0
10-28-70	19.1	12.5	15.0	0
1-7-71	19.6	7.5	2.5	0
5-14-71	21.4	4.6	0.8	0

were some differences in growth of clams between the different plots (Table 2). However, some of the plots yielded very few clams so average shell lengths of the samples may not reflect the actual average growth.

Table 2. Growth and Percentage Survival of Native Littleneck Clams 7 Months After Planting

Plot No.	Substrate Type 1/	Mean Shell Length (mm)	Percentage Survival
1	Control (unchanged)	12.5	2.0
2	Crushed Rock 3/4"-1 1/2"	12.6	42.0
3	River Rock 3/4" minus	14.0	4.0
4	Crushed Rock 3/4" minus	13.0	6.0
5	River Rock 3/4"-1 1/2"	12.0	2.0
6	Crushed Rock 1 1/2"-3"	13.7	8.0

1/ *Substrate described by Phibbs (1969).*

Only one type of substrate, 3/4-1 1/2 inch crushed gravel, had a significantly high survival rate. One problem during the 7-month interval the clams were in the plots was the deposition of silt. The results are therefore probably not conclusive as clams in the various gravel plots might have shown better survival if the plots were in an area where siltation had not occurred.

Gaper clams. The juvenile gaper clams planted in September 1970 were sampled 1 month later. No clams could be found. This planting was a second attempt to plant laboratory-reared juvenile gaper clams. The previous attempt, made in 1969 (Phibbs, 1969), also resulted in a total mortality. The probable cause was prolonged exposure during low tides and predators. The second planting was made in an area which contained a natural population of adult gaper clams and was at a lower tide level. The total mortality was believed to have resulted from predation by crabs.

Butter clams. Juvenile butter clams in the experimental plots were sampled in December 1970. They grew an average of 14.7 mm in shell length in a 9-month period (Table 3).

Table 3. Growth and Percentage Survival of Butter Clams at 15 and 24 Months After Planting

		March 25, 1970		December 9, 1970	
Plot No.	Gravel Type and Size	Mean Shell Length (mm)	Percentage Survival	Mean Shell Length (mm)	Percentage Survival
1	Control (unchanged)	26.3	0.2	1/	0.2
2	Crushed 3/4"-1 1/2"	24.2	2.0	38.6	0.7
3	River 3/4" minus	23.8	0.5	41.0	0.4
4	Crushed 3/4" minus	23.8	4.5	38.6	3.3
5	River 3/4"-1 1/2"	23.3	0.9	35.6	0.7
6	Crushed 1 1/2"-3"	22.2	2.4	38.2	2.5
Total Plot Average		23.5	1.8	38.2	1.2

1/ *Sample broken, unmeasurable.*

Survival in plot number four was the highest of all plots but mortality between March and December 1970 in plot four was greater than the average. Plot number six with the next highest survival rate did not experience any mortality during the March to December period. The increase in survival in December was the result of sample variation.

Discussion and Conclusions

Spawning and Larval Rearing of Clams

The continued success in laboratory rearing of native littleneck and Manila littleneck clams has been encouraging. An adequate supply of these juveniles is needed for field studies to determine the best size and time of year of planting for maximum survival. Although stripping the sex products from gaper clams has been successful, there is a greater chance of obtaining malformed and immature eggs. More work needs to be done on the technique of inducing the adult gapers to spawn naturally. The poor survival of juvenile razor clams was assumed to have resulted from low salinities which occurred during winter. Further attempts will be made to rear razor clams and to monitor the incoming water and prevent exposure of the juveniles to low salinities.

Field Studies

Manila littleneck clams. The juvenile Manila clams have shown good growth during the year they were in the experimental plot in upper Yaquina Bay.

The survival of 4.6% in the gravel substrate may be typical but no data are available for comparison. Additional field studies are planned.

Native littleneck clams. Juvenile littleneck clams showed exceptional survival in the substrate consisting of 3/4-1 1/2 inch crushed rock probably because water current in this area kept the plot free of silt. Growth of

2.9 mm in 7 months is probably about average for a winter period. Survival in the other plots might have been higher if silt deposition had not occurred.

Gaper clams. The planting of juvenile gaper clams will be attempted again. Screen will be used to cover the clam plot to keep predator crabs out.

Butter clams. Juvenile butter clams continued to have the best survival in a plot containing 3/4-inch minus crushed gravel which closely approximates natural habitat. Clams in crushed 1 1/2-3 inch gravel experienced good survival. These plots are part of the same habitat study as the littleneck clam study. Butter clam survival may have been affected by siltation, a factor that will be considered in future experimental clam plots.

OYSTER STUDIES

Methods

Spawning and Larval Rearing

Oyster spawning and larval rearing activities have been phased out of this program and are now being done on a routine basis by Oregon State University personnel in their pilot oyster hatchery at Newport.

Field Studies

Imported vs. Laboratory-Reared Spat. The study comparing growth and survival of imported and laboratory-reared Pacific and Kumamoto oyster spat in Yaquina Bay was completed. In May 1969 spat of Pacific oysters spawned in June-August 1968 and spat from Kumamoto oysters spawned in September-December 1968 were placed in trays suspended from an oyster rearing raft in Yaquina Bay. Imported Japanese seed was planted at the same time, place, and in the same manner. Random measurements (length and width of 40 oysters from each tray) were taken at planting and periodically until December 1970 when samples of oysters were shucked to determine oyster count per unit volume. This was done to test whether shell length-width measurements accurately indicate oyster size (meat volume). Survival was determined by gross examination of the cultch.

Tray Culture at Different Depths. Laboratory-reared oysters cultured off bottom in a stationary intertidal tray, and in suspended trays at various depths (3, 6, 9, and 12-feet below the water surface) were monitored for growth and survival. Random samples of oysters (length and width of 40 oysters from each tray) were measured every 3 months. At 21 months of age (June 1971) samples of oysters will be shucked to determine meat volume.

String vs. Tray Culture. Growth and survival experiments with Pacific oyster spat (cultch separated by 6-inch plastic pipe spacers) on wire strings was continued in Yaquina Bay. Some of these 8-foot strings were suspended from a boom log; others were draped over a wooden rack. Additional spat of the same brood were suspended from the oyster raft in a tray. Quarterly samples were taken to compare growth and survival of those animals exposed by tidal fluctuations (rack strings) and oysters continuously submerged (log boom strings and trays).

Winter Spat Survival. A study to determine winter survival of laboratory-reared oyster spat was completed in Yaquina Bay. Four broods of oyster spat, set in August-October 1970 and in January 1971, were planted in a suspended tray at various ages from September 1970 through February 1971 and counted in April 1971 to determine survival.

Results

Field Studies

Imported vs. Laboratory-Reared Spat. Mortality in all groups of Pacific oysters was negligible except among those animals from the August spawning. August spat were collected on scallop shells on which silt settled and smothered about 50% of the young oysters.

After 19 months of growth, hatchery and imported Pacific oysters averaged the same both in shell size and in meat volume (Table 4). Hatchery oysters from June's spawning were the smallest in shell size and meat volume of all groups (highest count per quart). July's spawning was the largest.

Table 4. Length and Width (mm) and Volume of Imported and Hatchery-Reared Pacific Oysters

Month Sampled	Hatchery Spawning Date			Imported Spawning Date
	6-5-68	7-29-68	8-13-68	Summer 1968
May 1969	8-7	7-5	5-4	7-5
June	18-15	19-17	12-12	18-14
September	46-33	53-39	44-40	54-34
December	61-52	66-48	61-44	67-48
March 1970	65-45	71-48	62-54	73-51
May	72-54	81-57	75-66	85-60
September	92-65	108-71	97-76	110-73
December	95-65	114-77	99-78 (Mean 103-73)	113-72
Shucked Oyster Count Per Quart	40	26	30 (Mean 32)	32

After 20 months of growth, imported Kumamoto oysters averaged slightly smaller in shell length (4.5 mm) and width (5.5 mm) than laboratory progeny but produced a 9% greater meat volume (lowest count per pint)(Table 5). Mortality was negligible in both groups.

Table 5. Length and Width (mm) of Imported and Hatchery-Reared Kumamoto Oysters

Month Sampled	Hatchery Spawning Date 9-23-68	Hatchery Spawning Date 12-17-68	Imported Spawning Date Summer 1968
April 1968	3-3	8-7	5-4
July	30-26	30-26	22-19
October	45-37	48-38	41-33
January 1970	46-38	47-39	40-32
May	48-41	53-41	43-34
September	55-43	59-45	53-40
December	56-44	59-45	53-39
Shucked Oyster Count Per Pint	91	90	82

Tray Culture at Different Depths. Shell growth of Pacific oysters 19 months after planting in Yaquina Bay was better in suspended trays than in the stationary intertidal tray (Table 6). Growth in suspended trays was nearly the same at all depths tested. Mortality in all of the trays was negligible.

Table 6. Shell Growth (Length-Width mm) of Pacific Oysters Reared in Suspended Trays, in a Stationary Intertidal Tray

Date	Suspended Trays (Depth) 3 Feet	6 Feet	9 Feet	12 Feet	Stationary Intertidal Tray
September 1969	2	2	2	2	2
October	9-7	10-9	9-8	9-8	6-5
December	15-13	18-16	16-14	17-15	--
January 1970	15-13	19-15	16-14	17-15	10-8
March	19-16	23-19	23-20	27-22	15-13
June	42-34	42-32	44-35	48-37	27-23
September	69-52	67-50	73-51	73-47	57-47
December	80-56	77-57	81-53	83-58	60-43
April 1971	85-59	88-64	85-63	89-65	62-47

String vs. Tray Culture. Shell growth, 13 months after planting, was slightly better in the suspended tray than on strings (Table 7). Oysters on the rack string were the smallest of the three groups tested.

Table 7. Shell Growth (mm) of Pacific Oysters Cultured on Strings (Rack and Boom Log) and in a Suspended Tray

Date	Rack Strings	Boom Log Strings	Tray
3-70	3.5	3.5	3.5
7-70	18.2	27.3	29.3
11-70	45.1	61.1	60.3
1-71	51.3	60.9	53.6
4-71	58.1-44.5	65.4-44.2	67.1-51.6

Winter Spat Survival. Mean overall survival of spat was 45%. Survival of the August brood was 44%; September brood 31%; October brood 59%; January brood 60%. Oyster spat survived better when planted during the months under study than September, December, and January (Table 8).

Table 8. Winter Survival of Laboratory-Reared Pacific Oyster Spat Planted at Different Ages and Times in Yaquina Bay (Sampled April 1971)

Date Planted	Age of Seed (Days)	Survival (%)
9-30-70	12	19.0
	54	13.0
11-4-70	29	55.3
	47	59.0
	89	70.7
12-4-70	59	50.0
	77	2.5
	119	37.2
1-5-70	91	46.5
	109	17.9
	151	32.5
2-11-71	35	60.1
	128	85.0
	146	57.1
	188	65.8

Discussion and Conclusions

Field Studies

Imported vs. Laboratory-Reared Spat. Because it is more practical to measure shell size than meat volume, and since shucking of oysters precludes further measurement, we wanted to determine if shell length and width measurements accurately reflect oyster size. Mean shell length times width gave a fairly accurate indication of Pacific oyster size in meat volume (Figure 1); however, this relationship was not apparent with Kumamoto oysters (Figure 2). Length-width measurements did not indicate meat volume for this species. Kumamoto oysters are quite variable in shell depth (thickness), depending on physical conditions, such as the degree of crowding during growth. Less crowded conditions in the tray containing imported Kumamoto oysters probably resulted in deeper oysters, hence the greater volume to length-width ratio. Thickness is impossible to measure while oysters are clustered or attached to cultch material.

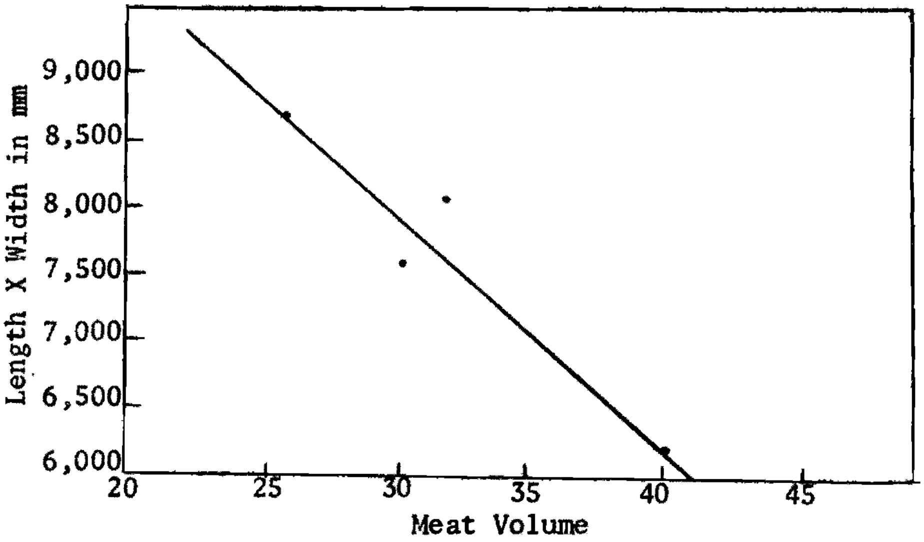

Figure 1. Mean Shell Size (Length Times Width) vs. Meat Volume (Shucked Count Per Quart) of Four Groups of Pacific Oysters

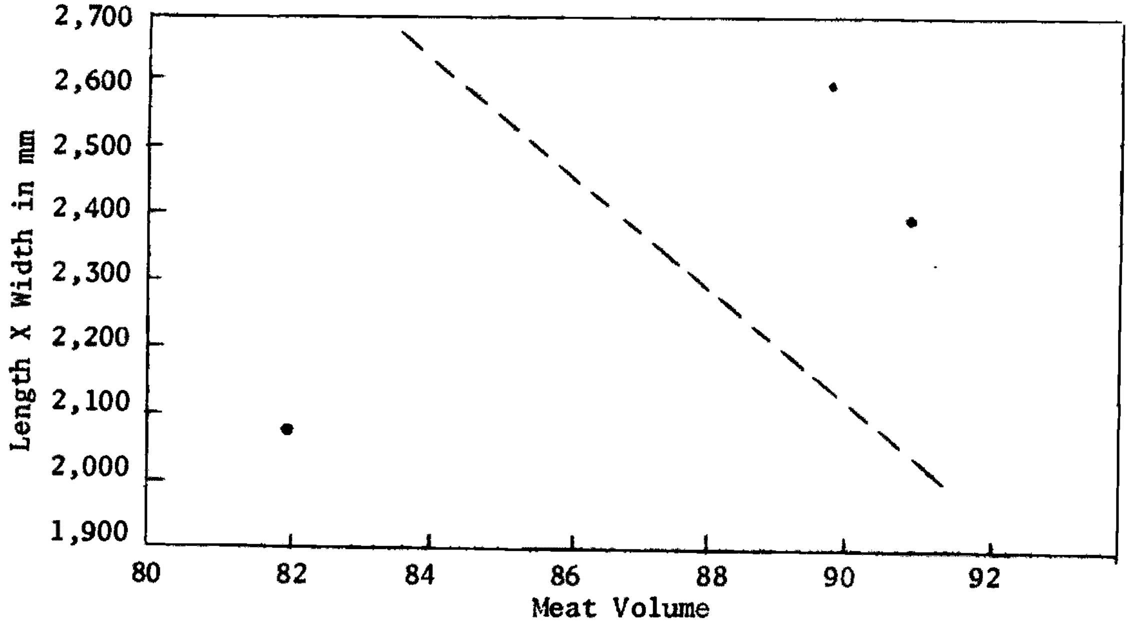

Figure 2. Mean Shell Size (Length Times Width) vs. Meat Volume (Shucked Count Per Pint) of Three Groups of Kumamoto Oysters

Tray Culture at Different Depths. Poor shell growth in the stationary intertidal tray was largely due to the high tidal level of the tray. In suspended trays growth was equal at all depths after 19 months, but growth appears much better near the surface on suspended strings (13 months after planting) being used in another study. In years of very low winter salinities, growth appears to be slightly better in deep water levels where salinities are highest; in years of less severe salinities, growth is better near the water's surface where food production is greatest.

String vs. Tray Culture. Oysters on rack strings are the smallest, probably due to their tidal exposure.

Heavy fouling by mussels on the boom log strings probably retarded oyster growth. Many oyster clusters were completely covered with mussels. Growth was also impaired by the large number of spat per cultch shell. Crowded conditions resulted in selfculling, the loose oysters being held in place by bysal threads of mussels. We recommend that cultch that has no more than 20 spat per shell be used for string culture (preferably 10-15). Thinning could be done but this would require considerable time, labor, and a place to put the culled oysters until they reach a marketable size. We also recommend that spat on strings be planted after the peak of the spring set of mussel larvae (about April 1 in Yaquina Bay).

Winter Spat Survival. The mean survival of 45% is excellent; however, some of the spat were much larger when planted than is imported seed at planting. Because of the somewhat mysterious mortality of the September-planted spat, more information should be obtained in the future during this time period. Oyster larvae in the OSU hatchery have also experienced high mortalities during September. Vitality of spat set in September may also be low since this brood reflected the lowest survival of the four broods used in this study.

ABALONE STUDIES

Methods

Adult red abalone (*Haliotis rufescens*) were obtained from the coastal waters of southern Oregon near Brookings and from Whale Cove a short distance north of Newport. These adults were used for spawning stock.

The adults were stimulated to spawn by temperature fluctuation. The water temperature was increased from 15 C to 19-20 C in a period of 6 hours. After it reached 19-20 C, it was allowed to cool. This procedure had to be repeated several times before the abalone would spawn. After spawning, the fertilized eggs were siphoned out of the spawning tray through a filter and placed in an incubation tray. After 24 hours the trochophore stage was reached and the abalone trochophores began swimming. The trochophores were siphoned out of the incubation trays and placed in clean trays with fresh sea water.

Results

The spawned eggs of the abalone obtained from southern Oregon were successfully fertilized and the resultant trochophores survived a week. The abalone trochophores became entangled in mucus strings, clumped together, and could not set. A second group of adult abalone were obtained from Whale Cove. Only the males could be induced to spawn. More adults were collected from southern Oregon but they died while being transported to the Newport Laboratory.

Discussion

Adult red abalone were successfully spawned in the laboratory but problems arose when the trochophore larvae became entangled in mucus. Before further spawnings are attempted a more extensive literature survey will be made concerning spawning techniques. Contact will be made with biologists who have successfully spawned and reared juvenile abalone. More consideration will be given to the conditions of shipment of adult red abalone to prevent mortalities such as have previously occurred.

PROGRESS TOWARD OBJECTIVES

The objectives of the Clam-Oyster-Abalone rearing project at its inception was to develop methods of spawning and rearing all native species of clams, native oyster and the exotic Pacific oyster. The long range goal of the project was to develop methods of mass culturing these animals to supplement natural reproduction and create new clam beds where adverse water currents prevent setting.

Oyster culture progressed to the point that we phased out this portion of the program. Working cooperatively with Oregon State University, techniques were developed for spawning and rearing oysters in mass culture. We conducted the last of our field testing in FY 1971. Oregon State has built a pilot oyster hatchery to demonstrate the practicality of oyster hatcheries to the industry. Our studies on field culture methods and spat survival show that hatchery seed is as good as imported seed and off-bottom culture will increase survival and growth rate of oysters.

We have spawned and reared all of the native clams to some degree The most successful have been the butter, gaper, and the native and Manila littlenecks. Razor clams and cockles need considerable work before we can consider our techniques to be of value and more refinement is needed in techniques for butter and gaper clams. While effort to broaden the time period over which gaper clam larvae can be obtained continued in FY 1971, most study was put on learning how to successfully transplant the young gaper, butter, and littleneck clams to the field. Progress has been encouraging with native and manila littlenecks. We now feel that we can mass rear the littleneck species and can contribute to our invertebrate resource. This will be field tested during fiscal 1972.

Techniques for spawning and rearing abalone are being developed.

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