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CULTURE OF *OSTREA CHILENSIS* PHILIPPI 1845 IN A NORTH CENTRAL CHILEAN COASTAL BAY

CULTIVO DE *OSTREA CHILENSIS* PHILIPPI 1845 EN UNA BAHIA DE LA COSTA NORTE-CENTRO DE CHILE

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ABSTRACT

Hatchery produced seed of *Ostrea chilensis* were cultured in Herradura Bay (30°S), Chile, employing Japanese growout technology. The oysters grew at a rate of approximately 0.17 mm per day one group reaching commercial size of about 50 mm within one year after setting. In a subsequent six months, thickening of shells occurred with small increases in shell lenght. Survival of the cultures exceeded 60% over an 18 month period. The culture was adversely affected by fisheries waste, and shell boring by *Polydora sp.* (Polychaeta: Spionidae).

Key words: oyster culture, Ostrea chilensis, *Chile mariculture.*

RESUMEN

Semillas de *Ostrea chilensis* producidas en incubadora fueron cultivadas en la Bahía Herradura (30°S), Chile, empleando tecnología japonesa de crecimiento en el ambiente. Las ostras crecieron a una tasa aproximada de 0,17 mm por día y un grupo alcanzó la talla comercial de aproximadamente 50 mm dentro de un año después de la fijación. En los 6 meses subsecuentes, ocurre un engrosamiento de las conchas con pequeños aumentos en largo de la concha. La supervivencia de los cultivos excedió el 60% en un período de 18 meses. El cultivo fue afectado negativamente por desechos de industrias pesqueras, y perforación de conchas por *Polydora sp.* (Polychaeta: Spionidae).

Palabras claves: cultivo de ostras, Ostrea chilensis, *maricultura en Chile.*

INTRODUCTION

Ostrea chilensis is a valuable marine resource in Chile. This species is commonly harvested from natural beds in the Chiloe region. Some success has been obtained in capture of seed on shell strings under managed conditions in some protected Bays in Chiloe. Although the natural range of this oyster does not extend north of Puerto Montt (41°50'S), Tomicic and Bariles (1981) produced sets of *O. chilensis* in Northern Chile (24°5'S) on shell strings in the sea under managed conditions. DiSalvo *et al.*, (1983) demonstrated the feasibility of hatchery conditioning and production of spat with this species using technology commonly in use with other oyster species in North America.

The are few data on the growth of *O. chilensis* to commercial size; oyster growers in the south of Chile assume that 2-3 years or more are required to produce a marketable crop of oysters from the time set is obtained. Walne (1963: cited by Solis, 1967) estimated that growth to 41-51 mm in shell length required 15 months near natural beds in Chiloe. Solis (1967) suggested that growth was uniform to the 60 mm size, after which growth rate diminished markedly. He used a system of growth rings to measure age of the oysters, but the chronometric use of ring formation is discounted by Tarifeño and Mena (unpub. data).

DiSalvo *et al.* (1984) demonstrated the feasibility of production of "cultchless" spat in North central Chile (30°S) with growth to an average size of 12 mm in about 3 months. Cultchless methods involve setting the oysters on small shell particles; oysters then assume a natural form and are not forced to compete with other spat fixed to the same

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substrate. These methods typically produce a more uniform product, often faster growing than oysters set on whole shell. This method avoids the need for handling shell strings, but requires special handling technology and more labor in the production process because the spat must be maintained in nets or screened trays.

Severe weather conditions in 1983 resulted in the loss of a majority of the spat produced by DiSalvo *et al.*, (1984) but an apparently representative group survived and was cultured to commercial size using Japanese methods. This report presents data obtained from this culture and some observations on *O. chilensis* produced in the cultchless condition, distant from its normal distributional range.

MATERIALS AND METHODS

Cultchless spat from a previous study (DiSalvo, *et al.*, 1984) were used for this experiment. Size distribution of a sample of these oysters is presented in Fig. 2A. Two groups of oysters were partitioned at two densities into Japanese "pearlnets" (Ise Shyokai Co., 35 × 35 cm base, 4 mm net mesh). Two replicate nets contained 180 oysters each (Group I; 0.15 indiv. cm^{-2}) and two replicate nets contained 400 oysters each (Group II; 0.33 indiv. cm^{-2}). The age of the seed at the beginning of this test was 112 days, counting from the day they were set. The pearlnets were suspended on 3 March 1983 from our laboratory pier in Herradura Bay (30°S) at a depth of approximately 3 m,

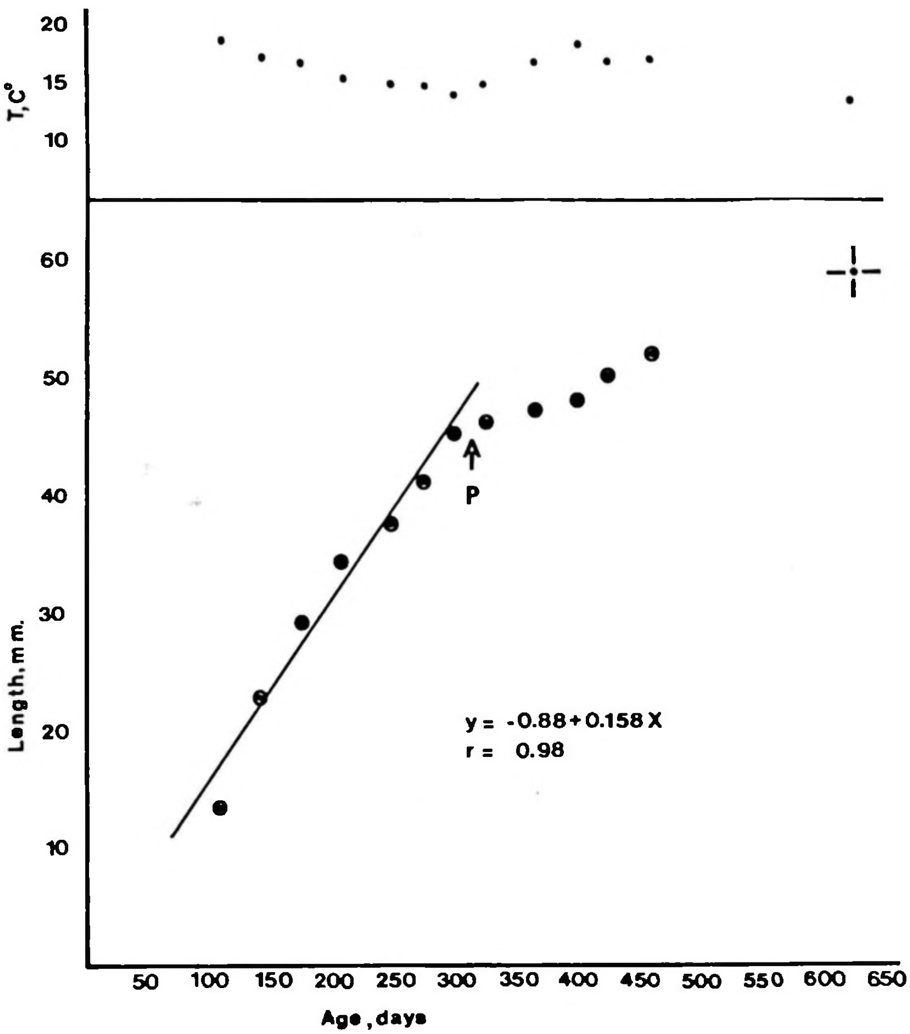

Figure 1. Growth of *Ostrea chilensis* in Herradura Bay, Chile, with sea surface temperatures included. Regression calculation made only to 301 days for reasons in text. Data points were obtained by averaging one replicate from Group I and one replicate from Group II, Table 1. The last data point (+) is the 624 day value from Group I, Table 1. Arrow at (P) indicates pollution event involving fisheries effluent (see text).

and were recovered at monthly intervals for observation and measurement. Determination of growth was made on 100 specimens taken at random from each pearlnet, measuring shell length to the nearest mm. Survivorship was determined by counting the total remaining alive, and general observations were made on the systems. Shells of the oysters were cleaned of barnacles on two occasions during the course of the culture, and shell boring Polychaetes (*Polydora sp.*) were partially controlled by immersing the oysters in fresh water for approximately 1/2 h on the days when they were measured. As the oysters grew, they were progressively transferred to pearlnets having mesh openings of 6, and them 8 mm, to facilitate water circulation. One of the replicates of Group I was lost due to inclement weather during May 1983. In August 1983 one replicate of Group II was distributed into separate pearlnets at lower population densities to determine if crowding of the oysters was impeding their growth; a (non-replicated) set of pearlnets was established, containing 20, 50, and 100 oysters each.

Two pairs of oysters having approximately the same shell size but six months difference in age were compared at the end of the experiment (August, 1984) to provide a comparative measure of change in shell weight after the major longitudinal growth phase had terminated. Dry tissue weights of oysters 640 days in age were determined for comparison with literature values. Shell and tissue samples were dried to constant weight in an oven at 60°C.

RESULTS

Growth data for the oysters are listed in Table 1. Regression analysis showed that the growth rate of the oysters maintained at lower density (Group I) was not significantly different ($P=0.01$) than the growth of those at higher density (Group II). The two complete sets of data for each group of oysters (Table 1) were therefore averaged to eliminate size differences between groups, and were plotted to show overall growth of the sample (Fig. 1). The regression calculation for this data was made to 301 days, after which the data reflected an interruption in growth introduced by occurrence of a pollution event. At this time shells of the oysters became fouled with fishery effluent (stickwater) which caused an unusual phenomenon to occur. Shells of the oysters became fouled with oily residue, and in a period of days assumed a bleached color. No mass mortality occurred, but the shell surfaces became partially dissolved, possibly due to acidic products produced by bacteria in decomposing the residue. There was no significant difference ($P=0.05$) in growth among subsets of oysters separated into lower densities in advanced stages of the culture (Table 2); these data were averaged and included as part of Replica 2, Group II (Table 1).

Distribution of sizes within the population from which the initial seed oysters were taken is shown in Fig. 2A. Figure 2B shows distribution of size among Group I oysters having a total age of 10 months, and Fig. 2C after 20 months.

After approximately one year in culture, survivorship of oysters (Table 3) was over 60% in both high and low density groups. Table 4 lists data relating wet and dry tissue weights to shell size in mid-winter 1984. Of ten specimens taken at random, 3 were males and 7 were females. All had full gonads which were partially differentiated. Males showed sperm balls with various degrees of motility and females showed eggs approaching maturation. Table 5 gives measurements on 4 oysters, comparing dry shell weights of similarly sized oysters, which differed in age by 6 months. Shells of the older oysters were significantly heavier.

DISCUSSION

Cultchless hatchery seed of *Ostrea chilensis* grew to an average length of 45 mm within 10 months of setting, and could be expected to reach the commercial size of 50 mm within one year, as suggested by the calculated regression line in Fig. 1. The pollution by fishery waste which apparently affected the growth of the oysters (Fig. 1 "P") occurred at a critical time during our measurements. Under natural conditions, increase in shell length slows nearing the 50 mm size; growth the progresses mainly as a process of shell thickening. The pollution event, occurring just prior to the oysters's attainment of the 50 mm size interfered with natural growth and prevented accurate determination of the inflection point in the

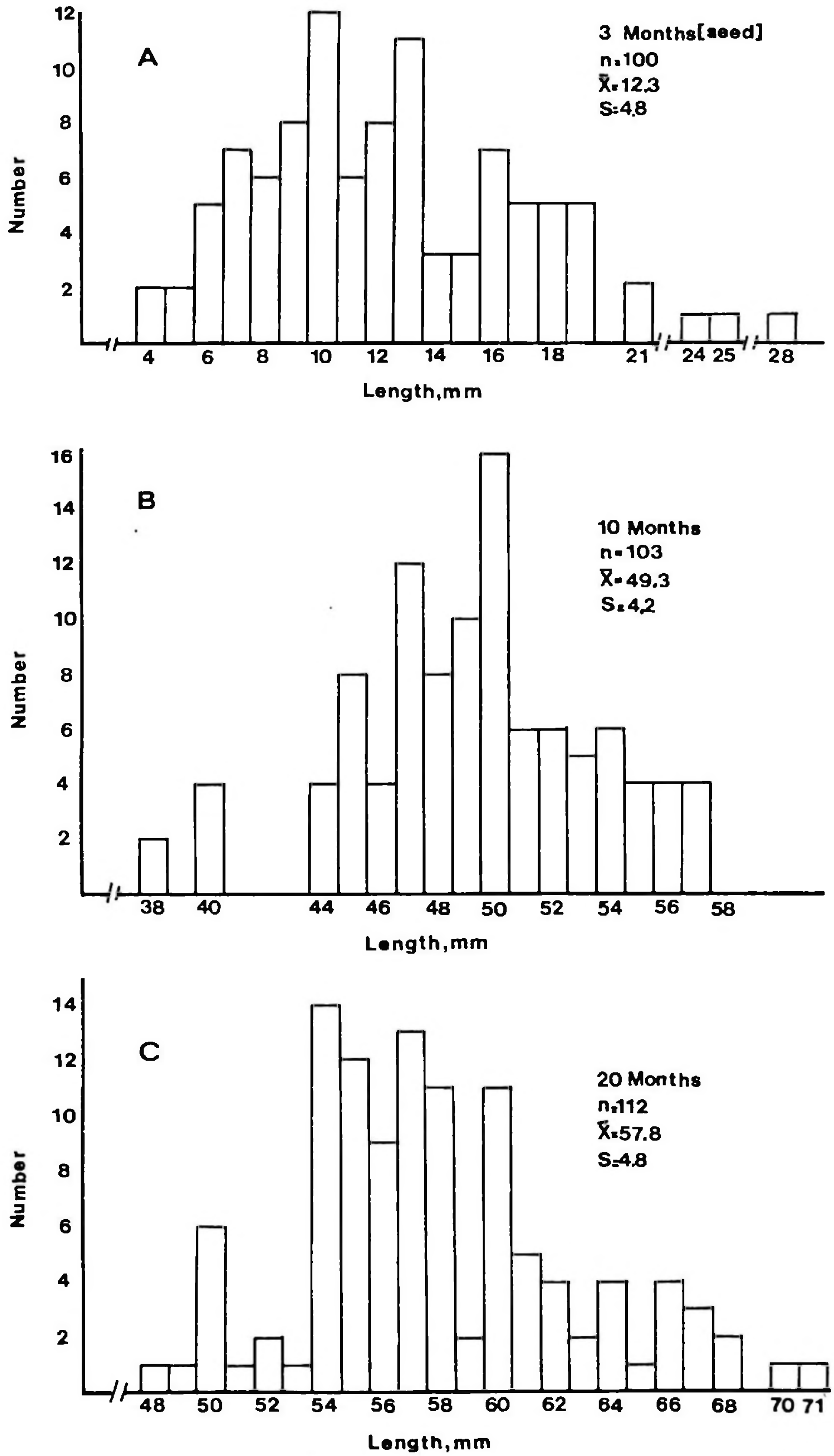

Figure 2. Size intervals among: (A) all seed *Ostrea chilensis* from which groups were selected for culture; (B) oysters of Group I, Table 1, at 10 months; (C) oysters of Group I, Table 1, at 20 months

TABLE 1

Growth data for two groups of *Ostrea chilensis* reared to commercial size in Herradura Bay, Chile (30°S)

Group I initially with 180 individuals in pearlnets (0.15 indiv. cm^{-2}). Group II initially with 400 individuals in pearlnets (0.33 indiv. cm^{-2}).

Date	Tem.[1] (C°)	age[2] (d)	GROUP I[3] Replicate 1 mm ± sd	GROUP I[3] Replicate 2 mm ± sd	GROUP II Replicate 1 mm ± sd	GROUP II Replicate 2 mm ± sd
3 III*	18.8	112	17.9 ± 2.9	17.9 ± 2.9	9.3 ± 2.8	9.0 ± 2.7
4 IV	17.4	144	27.0 ± 4.1	25.9 ± 4.1	18.3 ± 4.0	17.4 ± 3.8
8 V	16.6	178	33.5 ± 3.2	33.5 ± 3.8	25.1 ± 3.8	24.9 ± 3.9
6 VI	15.2	207	38.3 ± 3.7	Lost.	30.6 ± 5.4	30.2 ± 4.6
17 VII	14.9	246	41.0 ± 3.5	—	34.6 ± 4.5	34.4 ± 4.3
10 VIII	14.7	272	45.8 ± 3.8	—	37.1 ± 4.7	37.4 ± 4.8
8 IX	13.9	301[4]	49.3 ± 4.2	—	40.8 ± 4.8	40.6 ± 4.4
8 X	14.9	324	49.4 ± 4.4	—	42.6 ± 4.4	39.8*** ± 5.0
12 XI	16.9	365	50.8 ± 5.2	—	43.3 ± 4.1	43.9 ± 5.0
17 XII	18.2	398	51.0 ± 5.3	—	45.8 ± 6.0	46.2 ± 5.9
13 I**	16.7	423	51.8 ± 5.4	—	47.4 ± 6.2	48.9 ± 6.2
20 II	16.8	461	53.8 ± 5.4	—	50.9 ± 8.0	51.8 ± 7.3
3 VIII	13.5	624	57.8 ± 4.8	—	ND	ND

Notes:
1. sea surface
2. since day of set
3. shell length
4. Pollution event (see text).
* 1983
** 1984
ND = No data
*** Table 2

growth curve where shell length slows its increase due to normal endogenous factors. Hoyl *et al.* (1977, Figs. 6, 7) showed a marked increase in weight with only a small increase in shell length for large oysters (*c.a.* 55 mm) cultured in Chiloe.

It is common practice among oyster growers in Chiloe to remove oysters from suspended culture as they reach 40-50 mm, and place them on sand or gravel bottoms for several months to "cause the shells to harden", in preparation for marketing. We observed that six months after reaching the 50 mm size the oysters had "hardened" and were ready for market without any unusual treatment (Table 5).

Ostrea chilensis is apparently well adapted for growout under relatively crowded conditions as suggested by the lack of difference in growth between the oysters maintained at various densities in our experiment (Tables 1, 2). Previous results obtained in culturing the seed oysters showed that density was indeed important in the early stages of their growth (DiSalvo *et al.* 1984).

The main foulding organisms effecting these oysters were *Polydora sp., Piura chilensis, Megabalanus psittacus,* and *Balanus laevis*. It was observed during periodic cleaning of the oysters that biofouling of their shells was least in the pearlnets having the highest oyster densities.

Shell lengths of spat used to initiate this culture were apparently normally distributed, with positive skewness apparent at 10 and 20 months (Fig. 2). This is a favorable factor for commercial culture, noting that the minimum size at 20 months (48 mm, Fig. 2C) was of commercial size. The survivorship of all cultures not lost to storms was over 60% over the study period (Table 2), a value probably aceptable in commercial culture. This survival probably represents a minimum value due to our inexperence in handling pearlnet cultures, mortality caused by shell boring by *Polydora sp.*, and the negative impact of fishery waste on the oysters. Most of the mortality was apparently caused by *Polydora sp.* destroying the hinge area of some oysters. Losses of oysters may be minimized in the future by minimizing the effects of *Polydora sp.* by routine cleaning and treatment with fresh water.

The dry weights of oysters (Table 4) were equal to or higher than tissue weights per shell size as recorded by Solis (1967). For example, oysters with maximum shell dimension of 59-60 mm (Table 3; 6, 7, 8) had dry weights well over double those recorded by Solis (1967). It was of great interest that oysters grown in Herradura Bay showed full gonads in intermediate stages of maturity in mid-winter, suggesting absence of temperature constraints on gonadal development of these oysters in this habitat. Temperatures in natural grounds of these oyster in August are about 9°C (Ferreira, 1977), while in Herradura Bay the lowest sea surface temperature recorded during the entire period of this experiment was 13.9°C (Table 1).

Intensive culture of *Ostrea chilensis* is of interest due to its high market value, decline in natural stocks and, low efficiency and poor predictability of spat collection in its natural habitat. Culture in the north of Chile is favored by the higher growth rate and more favorable temperatures for hatchery development. This culture has the advantage over other current hatchery based oyster production systems in that larvae culture with associated high water temperatures and special water purification are not needed. Hatchery based seed

TABLE 2
Advanced growth of *Ostrea chilensis* (Table 1, Group II-2) at reduced density in pearlnets

		NUMBER PER PEARLNET											
		20				50				100			
Date	Age (d)	mm	±	sd	n	mm	±	sd	n	mm	±	sd	n
8.X.83	327	40.8	±	4.8	20	38.2	±	5.5	50	40.4	±	4.6	100
12.XI.83	365	44.1	±	5.6	16	42.7	±	5.3	41	44.9	±	4.3	96
17.XII.83	398	47.4	±	6.6	16	44.9	±	6.0	41	46.3	±	5.1	92
13.I.84	423	48.4	±	7.0	14	48.9	±	6.2	41	49.5	±	5.3	88
20.II.84	461	50.9	±	8.0	14	52.8	±	5.8	41	51.8	±	8.0	79

1. pearlnets have base dimensions of 35 × 35 cm. 2. n = total remaining = total measured.

TABLE 3
Survivorship among two Groups of *Ostrea chilensis* for which data is presented in Table 1

	GROUP I				GROUP II			
	Replicate 1		Replicate 2		Replicate 1		Replicate 2	
Age (d)	N°	% surv.	N°	% surv.	N°	% surv.	N°	% surv.
112*	180	—	180	—	400	—	400	—
144	180	100	157	87	352	88	341	85
178	167	93	157	87	330	83	310	78
207	167	93	Lost		330	83	310	78
246	167	93	—		330	83	309	77
272	167	93	—		322	81	309	77
301	167	93	—		319	80	301	77
327	160	89	—		310	78	***	
365	125	69	—		302	76	—	
398	120	67	—		300	75	—	
423	115	64	—		286	72	—	
461	112	62	—		265	66	—	
624	112	62	—		Lost		—	

*Initiation of experiment. ***Table 2.

TABLE 4
Some parameters measured for ten *Ostrea chilensis* taken from Group I, replica 1 (Table 1) after 624 days in culture.

		Shell Dimension		Tissue Weight		
N°	Sex	Length mm	Height mm	wet* g	dry** g	Humidity %
1	F	46	55	6.23	2.01	67.7
2	M	47	63	9.37	2.57	72.5
3	F	47	57	5.31	1.24	76.7
4	F	47	51	4.39	1.12	74.5
5	F	48	62	8.44	2.19	74.1
6	F	49	60	7.30	2.11	71.1
7	M	52	59	8.75	2.38	72.8
8	M	53	60	8 36	2.17	74.0
9	F	54	56	6.73	1.70	74.7
10	F	54	53	4.16	1.04	75.0

*Drained on glass. **Oven dried to constant wt. at 60°C.

TABLE 5
Shell comparisons between two pairs of similarly sized *Ostrea chilensis* differing in age by six months.

	Shell Dimensions		Shell Dry Weight	Difference
Age mo.	length mm	height mm	g	%
12	52	60	15.97	
18	53	60	18.24	+ 14.5
12	55	68	18.82	
18	54	68	23.74	+ 26.1

production of *O. chilensis* is dependent on correct management of adult animals which brood larvae internally until they are ready to set. Seed production is thus more economical and less energy intensive because it can be carried out at 18-20°C (DiSalvo *et al.*, 1983) in unsophisticated hatchery facilities.

Based on present results, hatchery based culture of *Ostrea chilensis* appears feasible, and could produce marketable crops in 18 months compared to the 2-3 years required in Chiloe. The oysters would probably be in market condition the year round and may contain larger meats than oysters cultured by traditional methods in the south. Research is now required on a pilot production scale to test this feasibility.

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