GROWTH AND SURVIVAL OF OYSTER SPAT (*CRASSOSTREA BELCHERI* SOWERBY) AS A FUNCTION OF FLOW RATES IN A RECIRCULATED UPWELLING SYSTEM

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ABSTRACT

Size, weight and survival rate of oyster spat were examined weekly for 5 weeks in a recirculated upwelling system at flow rates of 25, 50, 75 and 100 ml/min/g spat. Each upwelling tube held 5 g spat (3 replications). Growth of *Crassostrea belcheri* spat was positively correlated with increasing rate of water flow. At the end of the experiment, oyster spat had increased in size from 1.39 mm to 5.11-7.10 mm. A flow rate of 25 ml/min/g gave poor results in terms of growth and survival, significantly different from higher flow rates. Survival of spat was 34, 53, 54 and 57 % at flow rates of 25, 50, 75 and 100 ml/min./g, respectively.

INTRODUCTION

Rodhouse & Kelly (1981), Bayes (1981), and Manzi & Castagna (1989) studied the application of recirculated upwelling in nursery systems. In Thailand, limited information is available on the suitable size of bivalves which can be grown in upwelling systems and on stocking density in relation to water flow rate (Sahavatcharin 1990). Upwelling is typically created by a vertical water flow passing through a seed mass of bivalves. A screen of appropriate mesh size forms the bottom of each tube and supports the seed mass, often several cm thick. Incoming sea water passes through the mesh, accelerating rapidly as it passes through the seed mass and decelerating upon reaching the surface of the seed mass. Waste and silt are swept through the seed mass and settle as a loose layer at the seed mass surface, or leaving the system through drains near the top of the tube.

Recirculating upwelling systems apparently create conditions for rapid growth and high survival at extremely high concentrations of seed. Manzi (1986) refers to Bayes (1981) who found that as much as 1000 kg of seed can be maintained in an upwelling container with a 1.5 m^3 volume. Upwelling systems are attractive for commercial application, not only for their effective use of space and water, but also because they are relatively cheap to construct and maintain.

The aim of this study was to determine the effect of flow rate on growth and survival rate of spat. If hatchery production can be increased in Thailand, this would remedy the lack of seed and encourage more coastal people to take up seafarming of oysters.

MATERIALS AND METHODS

The study was conducted from the 1 April to 6 May 1994. Three fibre-glass tanks and two fibre-glass reservoir tanks contained the sea water. Each tank contained 4 upwelling tubes (30 x 10 cm PVC) stocked with 5 g spat, *i.e.*, approximately 6,600 seed, with an initial mean length of 1.39 mm (longest dimension). The bottom was closed with 700/900 mm bar mesh nylon screen. A 3 cm drain pipe was positioned near the top of each upwelling tube. The drain was controlled by a valve (Fig. 1). Sea water was pumped from the first reservoir fibre-glass tank (50 x 80 cm diameter) into a similar, second reservoir tank, and returned to the 3 fibre-glass tanks, passing through the upwelling tubes to the overflow pipe (Fig. 1). Flow rates were 25, 50, 75 and 100 ml/min/g oyster spat. Water (33-35 ppt) was pumped from the sea in front of the Prachuap Khiri Khan Coastal Aquaculture Development Center. It passed through sedimentation tanks and a sandfilter before storage in a concrete reservoir. This water was pumped to the laboratory and filtered through a 1 μm filter bag before use in the recirculated system. Water temperature, salinity, pH, and NH_3 were determined every time the water was changed (Table 1). Salinity was adjusted with filtered freshwater (tap) from a 50 tons storage tank.

Equal amounts of *Chaetoceros* sp. and *Tetraselmis* sp. were utilized in a combined diet. Total concentrations ranged from 50,000-150,000 cells per ml. Food was added after the water was changed in the system. The phytoplankton was checked every day, before and after sea water was drained, the density estimated, and if necessary, adjusted to the required concentration. Cultures were drained and washed with chlorine water two times per week; survival, mean size, biomass were determined weekly. Biomass was determined as the total wet weight of spat after draining. Mean size was determined from measurements of 50-100 randomly selected oysters. Survival was estimated by counts of four samples from each culture unit.

Cultures were maintained until the spat in all treatments reached a mean size of 5 mm, or until no increase in biomass occurred over a sample period. Comparisons of data were made after 35 days of each trial. Pooled data were analyzed using a one-way ANOVA, followed by a Duncan's multiple-range test.

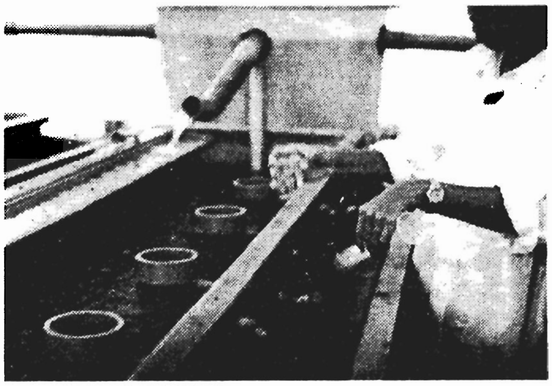


Figure 1. A recirculated upwelling system for *Crassostrea belcheri* spat

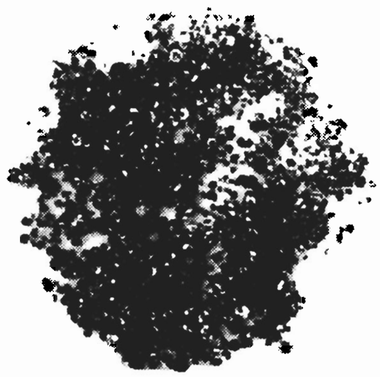


Figure 2. The spat *Crassostrea belcheri* reared for 5 weeks

Table 1. Water temperature, pH and NH_3 for each water change (twice a week) during the study period. (A) = the water quality of fresh sea water added to the system. (B) = the water quality of recirculated water before it was changed. * = The critical level for aquatic animals (> 0.02 mg/l)

Date (1994)		Temp. (°C)	pH	NH_3 (mg/l)
1 April	A	29	8.30	0.032*
5 April	B	28	8.07	0.037*
	A	29	8.14	0.024*
8 April	B	32	8.20	0.031*
	A	32	8.30	0.038*
12 April	B	32	7.89	0.014
	A	33	7.91	0.016
15 April	B	32	7.50	0.012
	A	33	7.90	0.008
19 April	B	31	8.03	0.029*
	A	32	8.15	0.032*
22 April	B	23	8.17	0.051*
	A	26	8.18	0.039*
27 April	B	24	7.90	0.036*
	A	24	8.10	0.025*
29 April	B	23	8.20	0.012
	A	26	8.30	0.006
3 May	B	24.5	8.19	0.008
	A	24	8.22	0.003
6 May	B	26	8.24	0.005

RESULTS

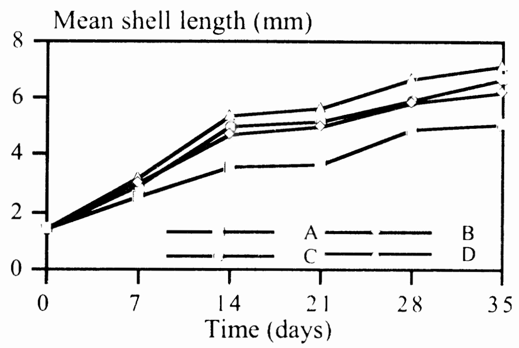
Growth

The growth was positively correlated with the rate of water flow. The smallest growth rate was found at a flow rate of 25 ml/min/g (Figs. 3,4) Growth at the flow rates 50, 75 and 100 ml/min/g were not significantly different in terms of shell length, but significantly different in terms of total weight (Figs. 3,4).

The length and weight increments generally decreased at each flow rate during the study period. However, the increments were very poor in all treatments in the third and fifth week (Figs. 5,6). At the end of the experiment, mean lengths of oyster spat were 5.11, 6.24, 6.65 and 7.10 mm, and the mean weight 45.78, 134.90, 157.77 and 202.19 mg at the flow rates of 25, 50, 75 and 100 ml/min/g, respectively.

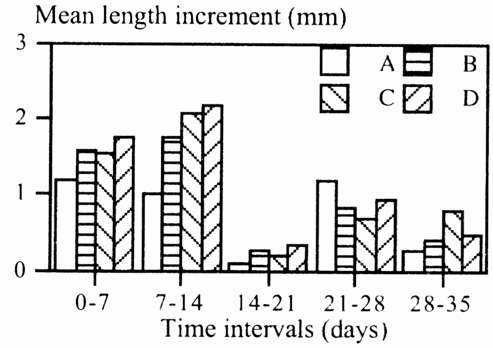
Survival

Mean survival in this experiment ranged from 34 to 56% (Fig. 7) The highest survival occurred at a flow rate 100 ml/min/g, but it was not significantly different from the flow rates of 50 and 75 ml/min/g.



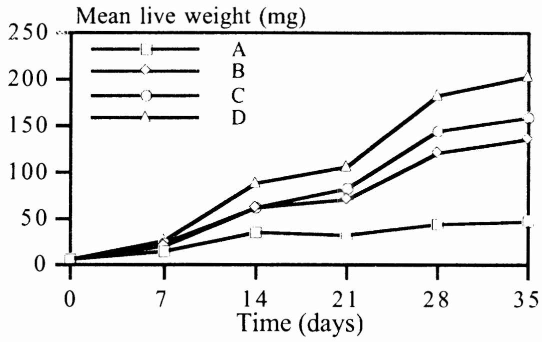
Flow rate	Time (days)					
ml/min/g	0	7	14	21	28	35
25	1.39	2.57^{b}	3.56^{b}	3.66^{c}	4.85^{c}	5.11^{c}
50	1.39	2.96^{ab}	4.72^{a}	4.98^{b}	5.82^{b}	6.24^{b}
75	1.39	2.94^{b}	5^{a}	5.18^{b}	5.87^{b}	6.65^{ab}
100	1.39	3.15^{a}	5.32^{a}	5.67^{a}	6.62^{a}	7.1^{a}

Figure 3. Growth by shell length of oyster spat at 4 different flow rates.·A: 25 ml/min/g; B: 50 ml/min/g; C: 75 ml/min/g D: 100 ml/min/g. *see NOTE for explanation of table*



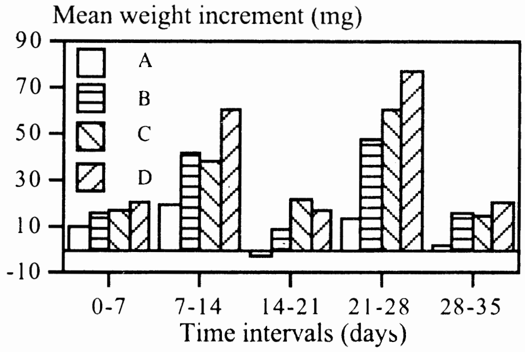
Flow rate	Time				
ml/min/g	0-7	7-14	14-21	21-28	28-35
25	1.18^{b}	0.99^{b}	0.1	1.19	0.26
50	1.57^{a}	1.76^{a}	0.26	0.84	0.42
75	1.55^{a}	2.06^{a}	0.18	0.69	0.79
100	1.76^{a}	2.17^{a}	0.35	0.95	0.48

Figure 5. Cumulative shell length increment after 7, 14, 21, 28, 35 days of culture at 4 different flow rates. A: 25 ml/min/g; B: 50 ml/min/g; C: 75 ml/min/g D: 100 ml/min/g. *see NOTE for explanation of table.*



Flow rate	Time (days)					
ml/min/g	0	7	14	21	28	35
25	5	14.5^{c}	34.2^{c}	30.8^{c}	44.1^{c}	45.8^{c}
50	5	20.6^{b}	62.2^{b}	71.2^{b}	119.4^{b}	134.9^{b}
75	5	22^{ab}	59.9^{b}	82.3^{b}	142.9^{b}	157.8^{b}
100	5	26.2^{a}	87.3^{a}	104.4^{a}	181.5^{a}	202.2^{a}

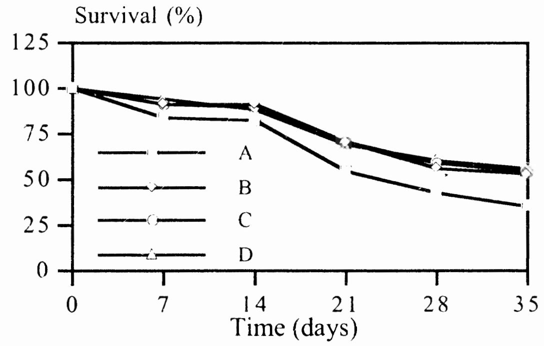
Figure 4. Growth by weight of oyster spat at 4 different flow ratesA: 25 ml/min/g; B: 50 ml/min/g; C: 75 ml/min/g D: 100 ml/min/g. *see NOTE for explanation of table.*



Flow rate	Time				
ml/min/g	0-7	7-14	14-21	21-28	28-35
25	9.5^{c}	19.7^{c}	-3.41^{b}	13.32^{c}	1.66^{b}
50	15.58^{b}	41.82^{b}	8.78^{ab}	48.17^{b}	15.55^{a}
75	16.99^{ab}	37.9^{b}	22.38^{a}	60.65^{b}	14.85^{a}
100	21.17^{a}	61.1^{a}	17.14^{a}	77.07^{a}	20.7^{a}

Figure 6. Cumulative live weight increment after 7, 14, 21, 28, 35 days of culture at 4 different flow rates. A: 25 ml/min/g; B: 50 ml/min/g; C: 75 ml/min/g D: 100 ml/min/g. *see NOTE for explanation of table.*

NOTE: Absence of letters indicates that means are not significantly different. Similar letters adjacent to means indicate trials which are not significantly different from each other (P>0.05) based on Duncan's multiple-rang test. Difference of letters indicates means which are significantly different (P<0.05) from each other.



Flow rate ml/min/g	Time (days) 0	7	14	21	28	35
25	100	83.1	81.7	53.4[b]	41.7[b]	34.4[b]
50	100	90	90	70.3[a]	55.2[a]	52.8[a]
75	100	91.2	88.8	70.4[a]	58.6[a]	53.6[a]
100	100	92.9	87.3	69.3[a]	59.4[a]	56.1[a]

Figure 7. Survival rate of oyster spat culture.at 4 different flow rates. A: 25 ml/min/g; B: 50 ml/min/g; C: 75 ml/min/g D: 100 ml/min/g.
see NOTE (previous page) for explanation of table.

DISCUSSION

The present study confirmed that flow rates influence the amounts of phytoplankton passing through the seed mass. Furthermore,wastes and silt packed over the seed mass. This caused a poor growth rate. Flow rate should not be less than 50 ml/min/g.

Environmental conditions greatly affected spat growth. Spat stocked in the second week were adversely affected by high water temperatures (> 28 °C) and high ammonia (NH_3) concentrations (> 0.02 mg/l) at all treatments.

In the third and fourth week, the high mortality occurred because the amount of phytoplankton was inadequate. Unfortunately, the range of algal concentrations fluctuated between 50,000-150,000 cells/ml. Upwelling systems are efficient for nursing bivalve spat but in this experiment we did not separate the different size of spat by grading (Fig. 2). The reduction in growth and survival rates are probably caused by competition for food and space. Grading is necessary to achieve good results.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge Mr. Songchai Sahavacharin, the Director of Prachuap Khiri Khan Coastal Aquaculture Development Center who provided site facilities. Thanks are also due to the mollusc hatchery staff especially Ms. Chaaum Sookchuay for her help in taking care of the experiment, and to Ms. Tipaporn Traitong for preparation of the manuscript.

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