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RESEARCH ARTICLE

ASSESSMENT OF RATE OF OYSTER SPAT FALL IN A TROPICAL ESTUARY, SOUTH WEST COAST OF INDIA

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ABSTRACT

Rate of oyster spat fall was recorded in Mulky estuary(a tropical estuary), south west coast of India from October 2009 to May 2010. The average rate of spat fall ranged from 24.96 to 1058.43 No/m². The spat fall rate was found to be higher on concave surface than convex surface of the oyster shells set for studying spat fall rate. The most suitable period for oyster spat collection in Mulky estuary is from December to January and April to May of the year. January and April appeared to be the months of peak settling. Therefore, oyster farmers may set their clutch materials during these periods to collect maximum spats for culture practices. Several environmental factors influence on the settlement of oyster spat. There was a significant positive correlation between oyster spat fall rate and water temperature, salinity, DO and pH.

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INTRODUCTION

Oysters are found worldwide in the coastal waters of temperate, subtropics and tropics (Grabowski *et al*., 2008). They generally inhabit in lagoons, estuaries and backwaters. They are sedentary with pelagic larval stages. The settling behavior of the oyster is an important factor for oyster culturists to collect the oyster seeds from wild. Most biological studies of the potential oyster culture have dealt with settling behavior of the oyster larvae. The rate of settlement of oyster spat is influenced by physico-chemical and biological factors in the habitat. The environmental factors such as water temperature, salinity, dissolved oxygen (DO) and pH influence on the rate of oyster spat settlement(Nestlerode *et al*., 2007). The biological cues to oyster larval settling are related to the fact that oyster larvae are gregarious and respond to a waterborne pheromone or metabolite released by oysters that have already metamorphosed (Hidu and Haskins, 1971). The condition of the cultch and method of exposure are the major factors for oyster settlement (Muthaiah, 1987).

The low rate of spat settlement may be due an inappropriate collection technique and /or the poor condition of the larvae. Experiments using different spat collectors showed that empty oyster shells and close meshed plastic baskets were more efficient (Reuben *et al*., 1983). In general, concave or convex substrates seem to be more attractive for spat settlement than flat or even substrates and poorly-illuminated areas are more preferred than clearly-illuminated surfaces (Doroudi and Southgate, 2002). In wild, oysters usually settle on the hard surfaces like oyster shells, rocks and sticks. Given a choice, some species of oyster prefer calcareous substrates like shell and lime stone (Walters *et al*., 2002). Different types of substrates have been used for studying settlement patterns of oyster larvae. However, the study of rate of settlement of oyster spat is important to determine the potential for oyster fisheries.

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MATERIALS AND METHODS

Study area

The Mulky estuary (Lat. 13° 05¹ N and Long. 74° 46¹ E) is located about 29 km north of Mangalore (13° 4N' 74° 17' E) was selected as the study area. The confluence of the Mulki river (also called as Shambhavi river) and Pavanje river into the Arabian Sea results in the formation of Mulky estuary. The estuary is connected to the Arabian Sea throughout the year and subjected to tidal influence to a length of 6.0 km in Mulki river and 6.6 km in Pavanje river (Reddy and Gopala 1982). The estuary has an average depth of 3m and the tidal range of about 1m. The bottom of the estuary is mostly a mixture of silt and sand. This is a typical tropical estuary which experiences wide variations in salinity. During the south-west monsoon period (June to September), the estuary is flooded with fresh water influx from the land and the estuarine waters become almost fresh. During this period, the water is very turbid throughout the estuary. During the non monsoon period, estuarine water comprises mainly of sea water as the freshwater influx is very much reduced. In this estuary, most of the productive oyster beds are distributed near the bar mouth region (Ganapathi Naik and Gangadhara Gowda., 2013).

Determination of rate of oyster spat fall

Rate of oyster spat fall was recorded fortnightly for 8 months at S1 and S3 oyster beds from October 2009 to May 2010(Plate 1). Six oyster shell strings (OSS1, OSS2, OSS3, OSS4, OSS5 and OSS6) were suspended at S1 and S3 oyster beds (Plate 2 and 3). Each oyster shell string of 1m length contained 20 oyster shells. Oyster spat settling intensity (mean number of spat per shell) on OSS1, OSS2, OSS3, OSS4, OSS5 and OSS6 oyster shell string was recorded fortnightly. Spat fall intensity on concave and convex surface of the oyster shells was also recorded. The environmental parameters such as water temperature, salinity, DO and pH were determined.

Table 1. Monthly average rate of spat fall (No/m²) on OSS1, OSS2, OSS3, OSS4, OSS5 and OSS6 oyster shell strings at S1 from October 2009 to May 2010

	OSS1			OSS2			OSS3			OSS4			OSS5			OSS6		
	Av.SA*	Av.SFR**		Av.SA	Av.SFR		Av.SA	Av.SFR		Av.SA	Av.SFR		Av.SA	Av.SFR		Av.SA	Av.SFR	
Month/Year		Cc	Cx		Cc	Cx		Cc	Cx		Cc	Cx		Cc	Cx		Cc	Cx
Oct 2009	44.42	112.46	65.31	47.12	116.08	48.62	46.90	40.63	24.96	46.40	112.68	55.36	46.57	94.90	54.51	48.47	71.98	33.67
Nov 2009	44.42	206.30	176.35	47.12	162.76	83.23	46.90	237.11	88.29	46.40	165.54	104.66	46.57	170.81	50.89	48.47	192.17	115.69
Dec 2009	44.42	540.10	312.71	47.12	516.31	224.40	46.90	642.65	302.16	46.40	651.55	166.18	46.57	629.58	394.48	48.47	678.60	381.42
Jan 2010	44.42	753.80	119.46	47.12	758.14	310.98	46.90	805.60	370.65	46.40	884.54	337.79	46.57	790.25	330.19	48.47	806.24	340.27
Feb 2010	44.42	439.17	247.79	47.12	381.27	160.21	46.90	353.22	196.87	46.40	370.92	159.15	46.57	561.78	270.80	48.47	429.42	272.76
Mar 2010	44.42	416.24	172.11	47.12	431.46	237.25	46.90	409.98	195.43	46.40	343.49	233.21	46.57	444.25	230.41	48.47	422.28	253.52
Apr 2010	44.42	893.65	472.57	47.12	850.14	342.97	46.90	925.94	512.61	46.40	907.47	434.63	46.57	831.24	460.27	48.47	967.44	614.26
May 2010	44.42	943.42	524.12	47.12	963.75	465.21	46.90	951.81	558.82	46.40	1017.44	584.55	46.57	945.47	611.98	48.47	903.34	515.62

Av.SA*- Average shell area; Av.SFR**- Average spat fall rate

Table 2. Monthly average spat fall rate (No/m²) on OSS1, OSS2, OSS3, OSS4, OSS5 and OSS6 oyster shell strings at S2 from October 2009 to May 2010

	OSS1			OSS2			OSS3			OSS4			OSS5			OSS6		
	Av.SA	Av.SFR		Av.SA	Av.SFR		Av.SA	Av.SFR		Av.SA	Av.SFR		Av.SA	Av.SFR		Av.SA	Av.SFR	
Month/Year		Cc	Cx		Cc	Cx		Cc	Cx		Cc	Cx		Cc	Cx		Cc	Cx
Oct 2009	45.77	177.80	81.18	47.75	164.88	70.18	46.55	187.52	98.03	48.15	228.70	134.16	48.50	195.39	113.87	47.40	219.88	120.16
Nov 2009	45.77	224.35	130.49	47.75	252.43	193.98	46.55	322.76	194.69	48.15	372.32	190.56	48.50	437.16	253.97	47.40	453.26	280.32
Dec 2009	45.77	935.72	461.06	47.75	860.72	444.47	46.55	831.89	463.14	48.15	652.83	390.79	48.50	776.24	478.07	47.40	890.76	545.46
Jan 2010	45.77	1056.89	595.31	47.75	1003.80	561.57	46.55	986.90	533.27	48.15	1058.43	594.23	48.50	942.37	579.30	47.40	1166.25	607.81
Feb 2010	45.77	557.79	317.56	47.75	602.45	303.73	46.55	578.72	386.83	48.15	630.95	308.49	48.50	549.20	276.02	47.40	521.81	285.04
Mar 2010	45.77	464.20	321.00	47.75	540.83	345.95	46.55	567.71	386.11	48.15	525.13	278.41	48.50	541.91	368.67	47.40	604.59	278.22
Apr 2010	45.77	1006.20	543.01	47.75	989.31	524.61	46.55	1080.83	559.84	48.15	995.68	489.76	48.50	1004.64	602.51	47.40	1002.84	555.49
May 2010	45.77	1093.71	581.53	47.75	949.66	586.49	46.55	912.62	474.57	48.15	984.79	553.98	48.50	1014.78	551.05	47.40	1020.33	588.89

RESULTS

The monthly average rate of oyster spat fall (No/m²) on OSS1, OSS2, OSS3, OSS4, OSS5 and OSS6 oyster shell strings at S1 and S2 oyster bed from October 2009 to May 2010 is given in Table 1 and 2 and Fig.1 and 2 respectively. The spat fall rate was found to be slightly higher at S2 than S1. The maximum rate of spat fall was recorded during December, January, April and May and the minimum during October (Table 1 and 2 and Fig. 1 and 2). The spat fall rate was found more on concave surface of the oyster shell than that of the convex surface (Table 1 and 2 and Fig.1 and 2). The monthly average water temperature, salinity, DO and pH at S1 and S2 from October 2009 to May 2010 is given in Fig.3 and 4. The water temperature, salinity, DO and pH ranged between 29.0-34.70°C, 9.87-33.69 ppt, 3.89-5.66mg/l and 7.14-7.84 respectively.

DISCUSSION

In the present study, at S1 and S2, the average rate of spat fall ranged from 24.96 to 1017.44 No/m² and 70.18 to 1080.83 No/m² respectively. These results clearly indicate that the spat fall rate was slightly higher at S2 compared to S1. This might be due higher population density of oysters at S2 compared to S1. In Mulky estuary, higher population density was recorded at S2 compared to S1 and also oysters were abundant during pre monsoon months compare to the post monsoon months (Ganapathi Naik and Ganagadhara Gowda, 2013). Indrasena and Wanninayake (1986) reported 17.22 No/cm² of spat fall rate on experimental plates in Crow Island area, SriLanka. The oyster spat density varied from 160 to 3010 No/m^2 in Chunnambaru estuary, Pondicherry (Rao *et al*., 1983). The same author observed oyster spat density of 300-1500 No/m^2 in the Pulicat Lake and 90-1800 No/m^2 in the Ennore estuary. Both at S1 and S2, the spat fall rate was found to be higher on concave surface than convex surface of the oyster shells. This may be due to oyster spats prefer darker surfaces to settle to avoid more illumination. Similar observations were made by Richie and Menzel (1969) on the oyster spat that preferred the dark under surface of the shells for the settlement under laboratory conditions. It was also observed that concave or convex substrates seem to be more attractive for spat settlement than flat or even substrates and poorly-illuminated areas are most preferred than illuminated areas (Alagarswami *et al*., 1983; Doroudi and Southgate, 2002).

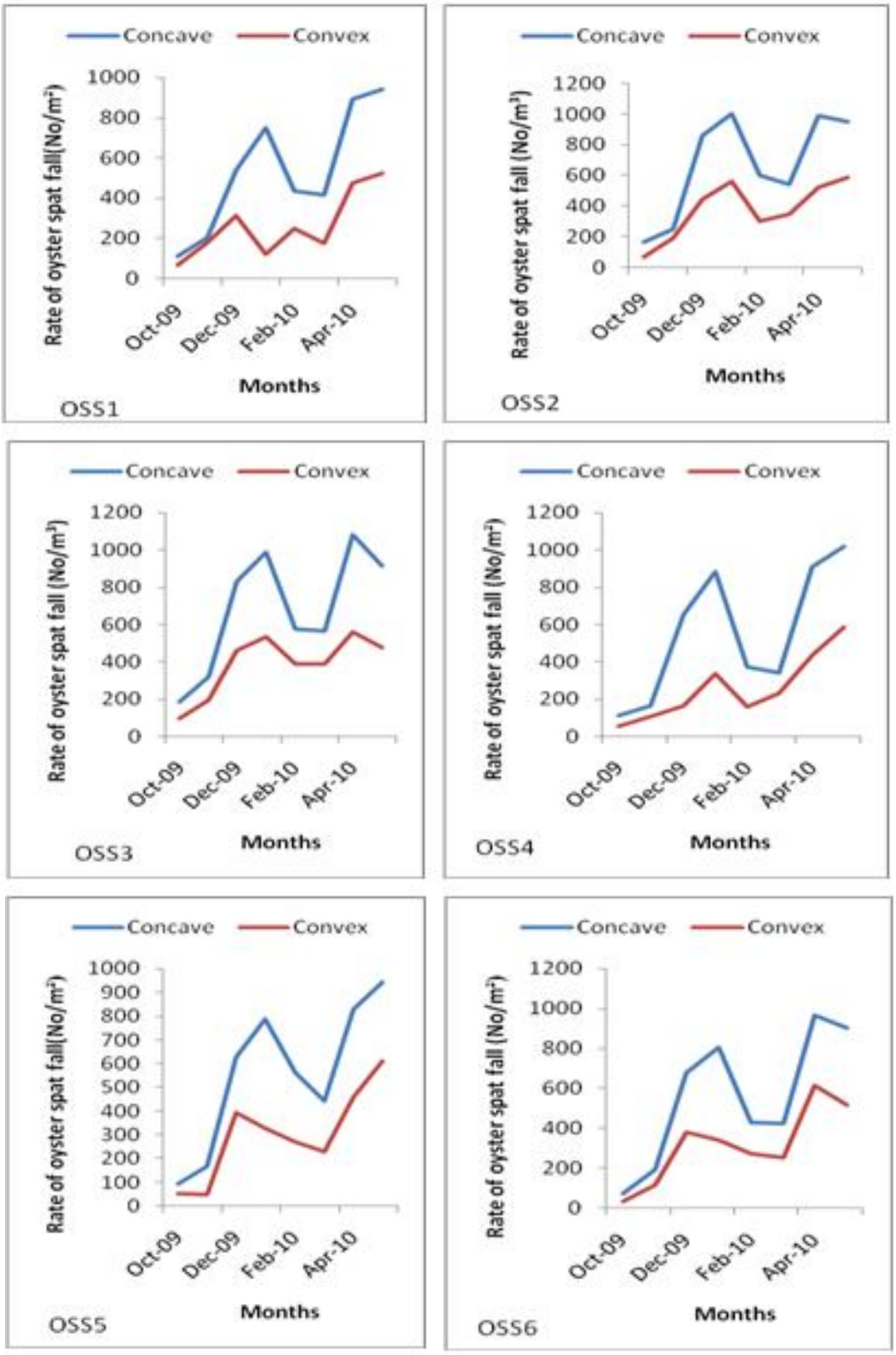

Fig.1. Monthly average rate of spat fall (No/m²) on OSS1, OSS2, OSS3, OSS4, OSS5 and OSS6 oyster shell strings at S1 from October 2009 to May 2010

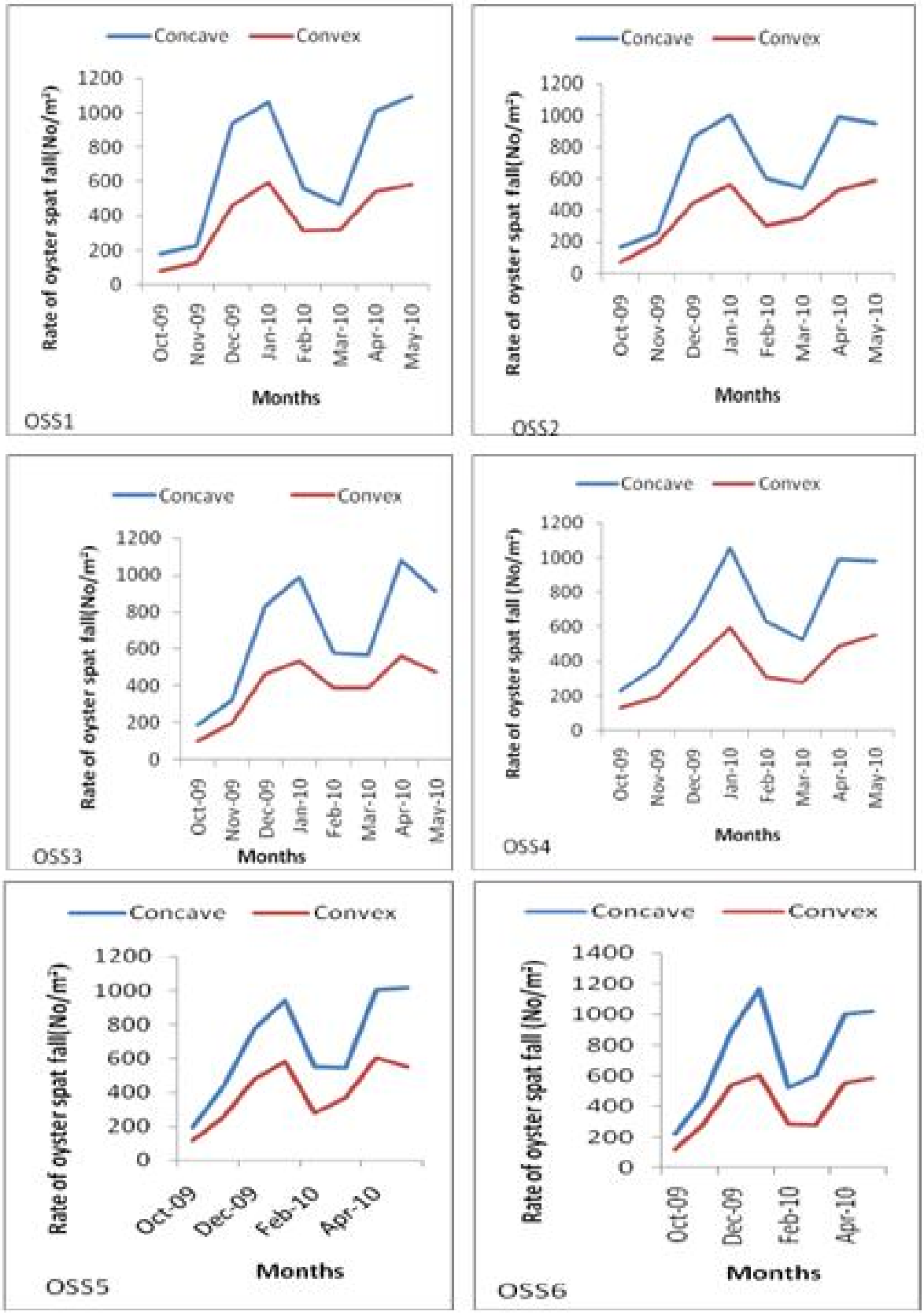

Fig.2. Monthly average rate of spat fall (No/m²) on OSS1, OSS2, OSS3, OSS4, OSS5 and OSS6 oyster shell strings at S2 from October 2009 to May 2010

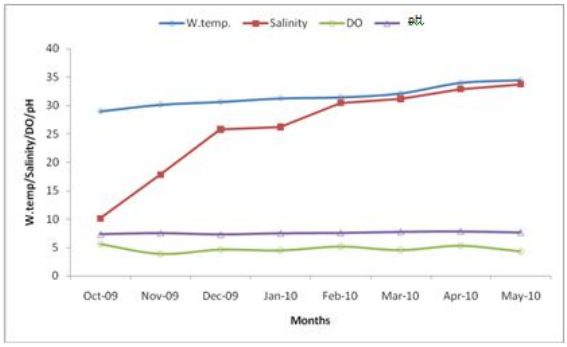

Fig.3.Monthly average water temperature (ºC), salinity (‰), dissolved oxygen (mg/l) and pH at S1 from Oct 2009 to May 2010

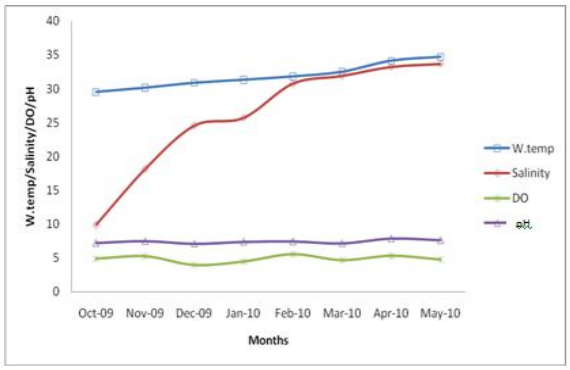

Fig. 4. Monthly average water temperature (ºC), salinity (‰), dissolved oxygen (mg/l) and pH at S2 from October 2009 to May 2010

Plate 1. Locations of oyster beds (S1&S3) in Mulky estuary

It was observed that both at S1 and S2, there was an increasing trend in rate of oyster spat fall from October 2009 onwards and there was a peak during January 2010 and again declined during February and March 2010 and again increased during April and May 2010. Two peaks were observed, one was during January 2010 and another during April 2010. However, from this experiment it is clear that ideal period for the oyster spat collection at S1 and S2 in Mulky estuary may be from October to May of the year. From this study, it was found that in Mulky estuary, oyster spat fall is continuous round the year except for the monsoon months. Reuben *et al.* (1983) also reported that settling of *C. madrasensis* spat takes place throughout

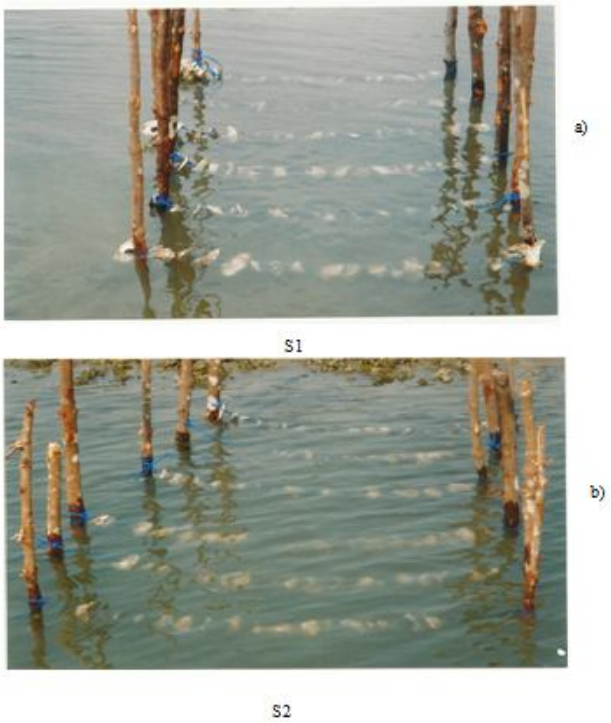

Plate 2 (a&b). The oyster shell strings at S1 and S2 in Mulky estuary

the year in Bheemanipatnam backwaters. From the present investigation, it is clear that the most suitable period for oyster spat collection (*C. madrasensis and S. cucullata*) in Mulky estuary is from December to January and April to May. January and April appeared to be the months of peak settling. Therefore, oyster farmers can set their cultch materials during these periods to collect maximum spats for culture practices. Moazzam and Rizvi (1983) reported that February-June and September-December were the suitable periods for peak collection of *C. rivularis* spats in salt water creeks near Karachi, Pakistan where March and October were the months of peak settling. Young and Travina (1983) reported that oyster spat fall (*C. iredalei)* was good in the months of July, August and September in Hemmamaylan River, Philippines. Purushan *et al.* (1983) observed settling of *C. madrasensis* commenced in July in Cochin backwaters. Rao *et al.* (1983) opined that the settling of *C. madrasensis* spat took place between January and April in Athankari estuary. Indrasena and Wanninayake (1986) reported that November-January, June and August were the peaks for the settlement of *C. belcheri* and *C. madrasensis* in the Crow Island area, SriLanka. Ahmed *et al.* (1987) observed that spat fall of *C. rivularis* in Gharo-Phitti Saltwater Creek near Karachi commenced in April and continued till October with peak settlement during April-July. The environmental factors such as water temperature and salinity greatly influence on the settlement of oyster spat. The temperature regime affects the gonad formation and spawning (Ward *et al*., 2000). After oyster gonads reach maturity in a local population, a temperature (or salinity) shock triggers the emission of sperm from one or more males. At S1, the water temperature, salinity, DO and pH ranged from 29 to 34.45ºC, 10.14 to 33.69ppt, 3.87 to 5.66mg/l and 7.28 to 7.84 respectively. In this investigation, it was observed that the maximum spat settlement occurred at the temperature range from 31.26 to 34.45ºC and the salinity range from 26.20 to 33.69ppt at S1.

At S2, the water temperature, salinity, DO and pH ranged from 29.54 to 34.70ºC, 9.87 to 33.64ppt, 3.98 to 5.52mg/l and 7.14 to 7.82 respectively. From this investigation, it was found that the maximum spat settlement observed at the water temperature range between 31.33 and 34.70 ºC and the salinity between 25.69 and 33.64ppt at S2. From these two experiments, it may be concluded that the optimum range of water temperature and salinity for the better settlement of

oyster spat is from 31.26 to 34.70ºC and 25.69 to 33.69ppt respectively. Besides, the DO and pH ranged from 3.87 to 5.66mg/l and 7.14 to 7.84 respectively that may be conducive for better spat settlement. Furthermore, the present study recorded significant positive correlation between oyster spat fall rate and water temperature, salinity, DO and pH. Kalyanasundaram and Ramamurthy (1986) found that salinities between 25-35ppt were optimum for embryonic development of *S. cucullata*. The optimum range of water temperature and salinity recorded for better spat settlement at S1 and S2 may also be the optimum range for embryonic development of oysters in Mulky estuary. Nair and Nair (1985) while studying settlement pattern of *C. madrasensis* at different habitats in and around Cochin Harbour reported that the settlement pattern was considerably influenced by the distribution of salinity. The peak settlement was recorded when salinity range was between 22.4 and 33.0ppt. Thangavelu (1988) studied the settlement of *C. madrasensis* in Pulicat Lake and found that the settlement of spat was high during May and low during November, when the salinity was high and low respectively. It was reported that the proportion of *C. gigas* larvae settling was affected by temperature, salinity, feeding levels, depth, tidal phase, water circulation rate and cultch type (Poland and Broadely, 1989). Optimum growth and settling of the larvae of *C. madrasensis* have been observed at salinities 28 to 31.5ppt and at temperatures of 25 to 27ºC (Narashiman, 2005). Aswani *et al*. (2008) reported that the growth and settling of the larvae were optimum when salinity and temperature regimes were steady (Aswani *et al*., 2008).

Conclusion

The settling behavior of the oyster is an important factor for oyster culturists to collect the oyster seeds from wild and most biological studies of the potential oyster culture have dealt with settling behavior of the oyster larvae. The most suitable period for oyster spat collection in Mulky estuary is from December to January and April to May. January and April appeared to be the months of peak settling. Therefore, oyster farmers may set their clutch materials during these periods to collect maximum spats for culture practices. Recently, for the first time, an extensive survey of oyster beds of Mulky estuary has been carried out and total 25 productive oyster beds suitable for exploitation and culture were reported (Ganapathi Naik and Gangadhara Gowda., 2013). Therefore, fishers can collect oyster spats from these productive oyster beds for culture practices and uplift their livelihoods.

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