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RESEARCH ARTICLE

TRANSPLANTION OF NATIVE OYSTERS TO ENHANCE POPULATION ABUNDANCE IN MULKY ESTUARY, SOUTH WEST COAST OF INDIA

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ABSTRACT

In Mulky estuary, the oysters (*Saccostrea cucullata*) were transplanted from oyster bed areas to non oyster bed areas to study the growth and survival rate. The growth was determined in terms of increase in weight, height and length of oysters. The initial and final weight, height and length of the transplanted oysters varied from 18.05 to 30.40g, 38.90 to 48.73cm and 28.86 to 34.48cm respectively. The survival rate of transplanted oysters varied between 86.60 and 100%. The water temperature, sediment temperature, salinity, DO, pH, sedimentation rate, phytoplankton wet weight and sediment organic carbon fluctuated between 29.89-34.45 ºC, 31.60-35.20ºC, 24.20 -33.62ppt, .69-4.85mg/l, 7.18 - 7.8, 0.28 - 1.33g/m²/month, 8.86 - 58.47 mg/ m³ and 0.02 - 0.24% respectively. A significant positive correlation was recorded between average weight, height and length of transplanted oysters and water temperature, sediment temperature, salinity, DO, pH, sedimentation rate and sediment organic carbon in all the experimental cages. From the present investigation, it is well understood that large scale transplantation of oysters may be carried out to the non-oyster bed areas of Mulky estuary to enhance wild stock.

INTRODUCTION

Oysters are ecosystem engineers that influence ecological processes such as maintenance of biodiversity, population and food web dynamics, nutrient cycling and water quality maintenance (Ronaldo *et al*., 2010). Oysters have long been transplanted in new waters to support commercial cultivation or to establish a wild fishery (Newell *et al*., 2005). Oysters have been introduced worldwide to 73 countries (Alexandra *et al*., 2010). In many parts of the world, introduced oysters compose a majority of oyster harvests. Introduced oysters composed a majority of oyster harvests in many areas in USA and Europe (Cerco and Noel, 2007). Oysters may also be transplanted for the restoration of native oysters or other native species (Fulford *et al.,* 2007). Therefore, it may be important to transplant oysters in new waters or in the non-oyster bed areas of the same water to support commercial cultivation or to establish a wild fishery and also for restoration of degraded environment. Recently, a survey has been carried out to assess the distribution of oyster beds in Mulky estuary, southwest coast of India to inventory the number of oyster beds suitable for oyster exploitation and spat fall rate of oysters was also assessed (Ganapathi Naik and Gangadhara Gowda., 2013a &b)). However, in the present study oysters are transplanted to non-oyster bed areas of the same estuary in order to explore the possibilities of large scale transplantation.

MATERIALS AND METHODS

The present study has been carried out from January 2010 to May 2010. Thirty oysters (*Saccostrea cucullata*) were transplanted from oyster bed 1(OB1) to non-oyster bed 1A (NOB1A), non-oyster bed 1B(NOB1B) and non-oyster bed 1C (NOB1C) experimental cages (Plate 1). Similarly, thirty oysters (*S. cucullata*) were transplanted from oyster bed 2 (OB2) to non-oyster bed 2A (NOB2A), non-oyster bed 2B (NOB2B) and non-oyster bed 2C (NOB2C) experimental cages (Plate 2). Growth and survival rate of transplanted oysters at each experimental cage were recorded fortnightly. The water quality parameters such as water and sediment temperature, salinity, dissolved oxygen (DO), pH and sediment organic carbon were recorded according to the standard methods. Besides, sedimentation rate and phytoplankton wet weight were also estimated.

RESULTS

The growth of oysters (*S. cucullata*) transplanted from OB1 to NOB 1A, NOB 1B and NOB 1C from January 2010 to May 2010 in Mulky estuary is given in the table 1 and fig.1. The growth was determined in terms of increase in weight, height and length of oysters. At NOB1A, initial average weight, height and length of transplanted oysters were 24.48g, 45.80cm and 32.30cm respectively during January 2010. During May 2010(termination of experiment), the average weight, height and length of transplanted oysters were 30.40gm, 47.48cm and 34.48cm respectively. At NOB 1B, initial average weight, height and length of transplanted oysters were 20.19g, 41.80cm and 28.86cm respectively during January 2010. During May 2010, the average weight, height and length of transplanted oysters were 24.48gm, 42.70cm and 29.07cm respectively. At NOB 1C, initial average weight, height and length of transplanted oysters were

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23.07gm, 44.03cm and 30.84cm respectively during January 2010. During May 2010, the average weight, height and length recorded were 28.58gm, 47.07cm and 32.65cm respectively.

Table 1 Monthly average weight, height and length of oysters transplanted from OB 1 to NOB 1A, NOB 1B and NOB 1C from January to May 2010 in the Mulky estuary

Months	NOB1A			NOB1B			NOB1C		
	Av.weight	Av. height	Av.length	Av.weight	Av. height	Av.length	Av.weight	Av. height	Av.length
January 2010	24.48	45.80	32.30	20.19	41.80	28.86	23.07	44.03	30.84
February 2010	25.60	45.92	32.54	21.32	42.00	28.92	24.40	44.25	30.87
March 2010	27.36	46.46	32.82	22.81	42.16	28.94	26.94	45.80	31.58
April 2010	29.83	46.75	32.88	24.40	42.47	29.03	27.80	46.33	31.80
May 2010	30.40	47.48	33.26	24.48	42.70	29.07	28.58	47.07	32.65

Table 2 Survival rate (%) of oysters transplanted from OB 1 to NOB 1A, NOB 1B and NOB 1C from January to May 2010 in the Mulky estuary

Months	NOB 1A	NOB 1B	NOB 1C
	Survival rate (%)	Survival rate (%)	Survival rate (%)
January 2010	100	100	100
February 2010	100	100	100
March 2010	96.66	100	90
April 2010	96.66	100	90
May 2010	93.33	100	86.66

Table 3 Monthly average weight, height and length of oysters transplanted from OB 2 to NOB 2A, NOB 2B and NOB 2C from January to May 2010 in the Mulky estuary

Months	NOB2A			NOB2B			NOB2C		
	Av.weight	Av. height	Av.length	Av.weight	Av. height	Av.length	Av.weight	Av. Height	Av.length
January 2010	18.76	41.56	28.96	21.58	45.76	29.70	18.05	38.90	31.06
February 2010	21.32	42.86	29.77	22.99	46.04	29.72	19.84	43.02	32.26
March 2010	22.99	43.27	29.80	24.78	46.16	29.94	21.40	43.47	31.63
April 2010	24.61	43.64	29.85	26.89	48.19	28.72	23.09	43.76	31.66
May 2010	24.81	44.03	29.88	27.66	48.73	29.74	23.54	44.21	31.71

Table 4 Survival rate (%) of oysters transplanted from OB 2 to NOB 2A, NOB 2B and NOB 2C from January to May 2010 in the Mulky estuary

Months	NOB 2A	NOB 2B	NOB 2C
	Survival rate (%)	Survival rate (%)	Survival rate (%)
January 2010	100	100	100
February 2010	93.33	100	96.66
March 2010	93.33	96.66	93.33
April 2010	93.33	93.33	93.33
May 2010	**93.33**	**90**	**93.33**

The monthly distribution of water and sediment temperature, salinity, DO, pH, sedimentation rate, phytoplankton wet weight and sediment organic carbon at NOB 1A, 1B and 1C from January 2010 to May 2010 ranged from 30.36°C - 34.52°C, 31.99°C - 34.85°C, 24.20 - 33.24 ppt, 3.68-4.82mg/l, 7.27-7.75, 0.29-1.32g/m²/month, 8.86-58.47mg/m³ and 0.02-0.18% respectively(fig.2-4). The water temperature, salinity, DO, pH, sedimentation rate, phytoplankton wet weight and sediment organic carbon showed a significant positive correlation with average weight, height and length of oysters transplanted from OB1 to NOB 1A, NOB 1B and NOB 1C.

The survival rate of oysters transplanted from OB1 to NOB 1A, NOB 1B and NOB 1C from January 2010 to May 2010 in Mulky estuary is given in the Table 2 and fig.5. At NOB1A station, no mortality was observed during January and February 2010. During March and April 2010, the survival rate was 96.66%. The minimum survival rate 93.33% was recorded during May 2010. At NOB 1B station, no mortality was recorded during the period of experiment. At NOB 1C station, 100% survival rate was observed during January and February 2010. During March and April 2010, the observed survival rate was 90%. The minimum survival rate 86.6% was recorded during May 2010.

The monthly average weight, height and length of oysters (*S. cucullata*) transplanted from OB2 to NOB 2A, NOB 2B and NOB 2C during January 2010 in Mulky estuary is given in the Table 3. At NOB2A, initial average weight, height and length of transplanted oysters were 18.76g, 41.56cm and 28.96cm respectively during January 2010. During May 2010(termination of experiment), the average weight, height and length recorded were 24.81gm, 44.03cm and 29.88cm respectively. At NOB2B, initial average weight, height and length were 21.58g, 45.76cm and 29.70cm respectively during January 2010. During May 2010(termination of experiment), the average weight, height and length recorded were 27.66gm, 48.73cm and 29.74cm respectively. At NOB2C, initial average weight, height and length were 18.05g, 38.90cm and 31.06cm respectively during January 2010. During May 2010, the average weight, height and length recorded were 23.54gm, 44.21cm and 31.71cm respectively.

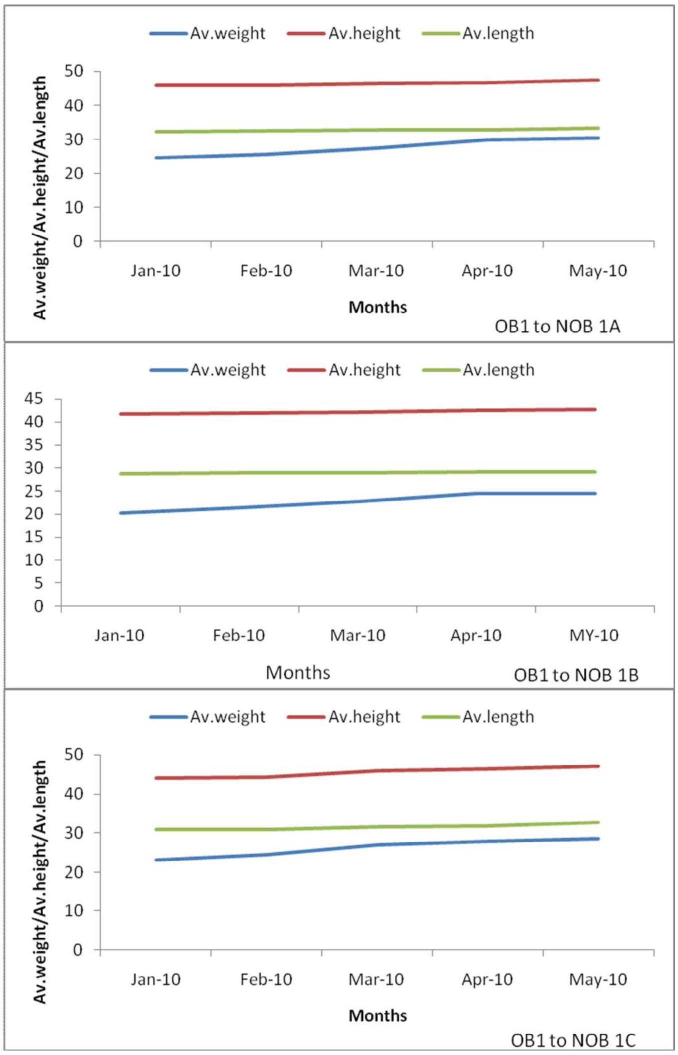


Fig.1. Monthly average weight (g), height (cm) and length (cm) of oysters transplanted from oyster bed 1 (OB1) to non- oyster bed 1A (NOB 1A), NOB 1B and NOB 1C from January to May 2010.

The monthly distribution of water temperature, sediment temperature, salinity, DO, pH, sedimentation rate, phytoplankton wet weight and sediment organic carbon at NOB 2A, 2B and 2C from January 2010 to May 2010 ranged from 29.89°C-35.12°C, 31.60°C-35.20°C, 25.57-33.62ppt, 3.69-4.85mg/l, 7.18-7.80, 0.28-1.33g/m²/month, 12.97-56.39 mg/m³ and 0.02-0.4% respectively(fig.7-9). The water temperature, salinity, DO, pH, sedimentation rate and sediment organic carbon showed significant positive correlation with average weight, height and length of the oysters in NOB 2A, NOB 2B and NOB 2C.

The survival rate of oysters transplanted from OB2 to NOB 2A, NOB 2B and NOB 2C from January 2010 to May 2010 in Mulky estuary is given in the table 4 and fig.10. During January 2010 no mortality of transplanted oysters was recorded in NOB 2A, NOB 2B and NOB 2C. At NOB 2A, during February 2010 also no mortality was recorded. The minimum survival rate 90% was recorded at NOB 2B during May 2010. At NOB 2A and NOB 2C, recorded survival rate was 93.33% during March to May 2010.

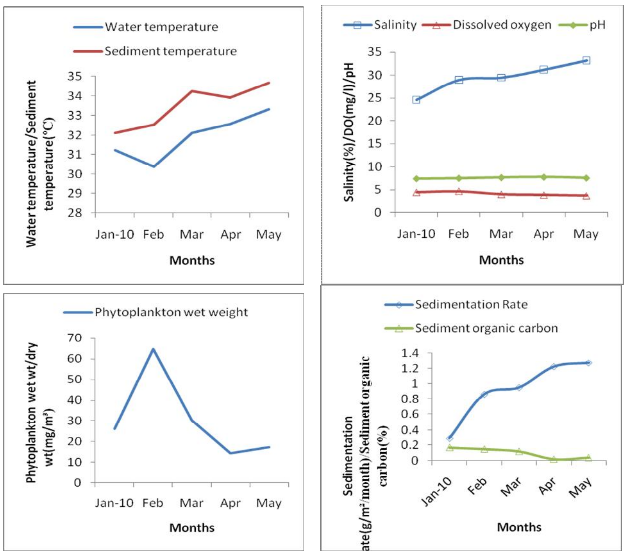


Fig 2. Monthly distribution of water temperature, sediment temperature, salinity, DO, pH, phytoplankton wet weight, sedimentation rate and sediment organic carbon at NOB 1A from January to May 2010.

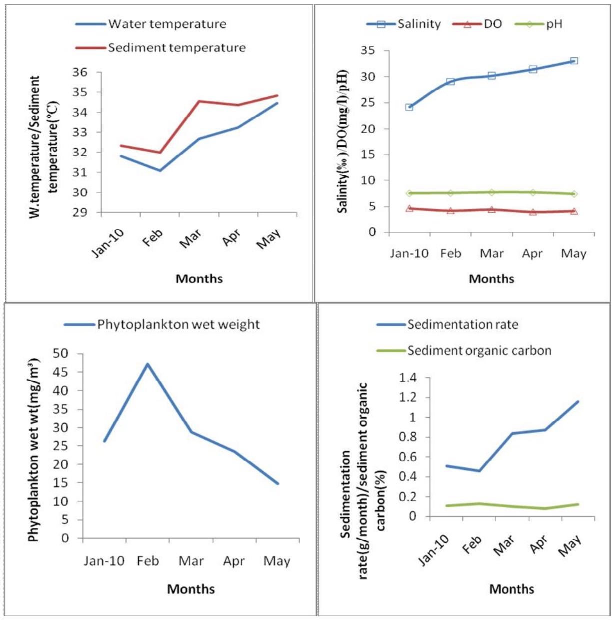
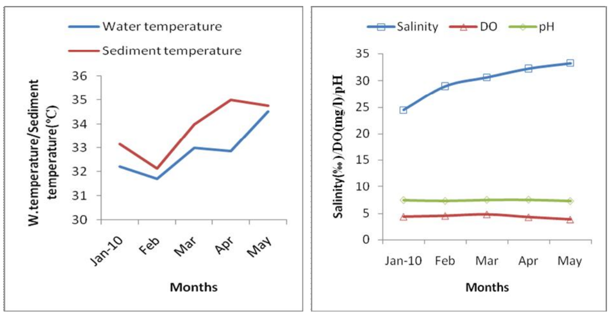


Fig 3. Monthly distribution of water temperature, sediment temperature, salinity, DO, pH, phytoplankton wet weight, sedimentation rate and sediment organic carbon at NOB1B from January to May 2010.



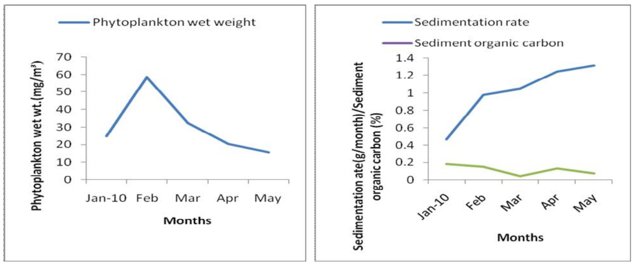


Fig. 4 Monthly distribution of water temperature, sediment temperature, salinity, DO, pH, phytoplankton wet weight, sedimentation rate and sediment organic carbon at NOB1C from January to May 2010.

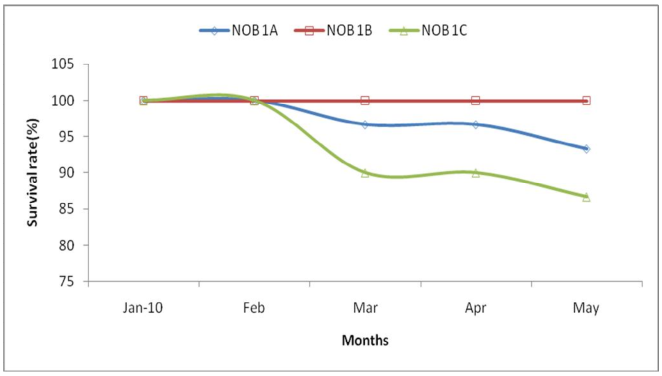


Fig.5 Survival rate (%) of oysters transplanted from OB 1 to NOB 1A, NOB 1B and NOB 1C from January 2010 to May 2010 in the Mulky estuary.

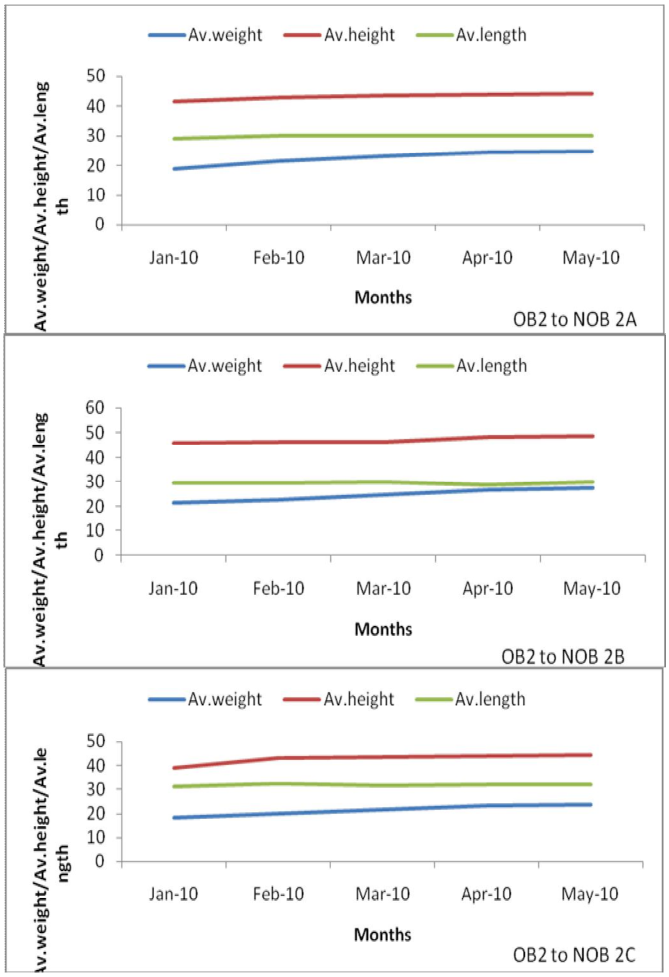


Fig. 6 Monthly average weight (g), height (cm) and length (cm) of oysters transplanted from oyster bed OB2 to NOB 2A, NOB 2B and NOB 2C from January to May 2010.

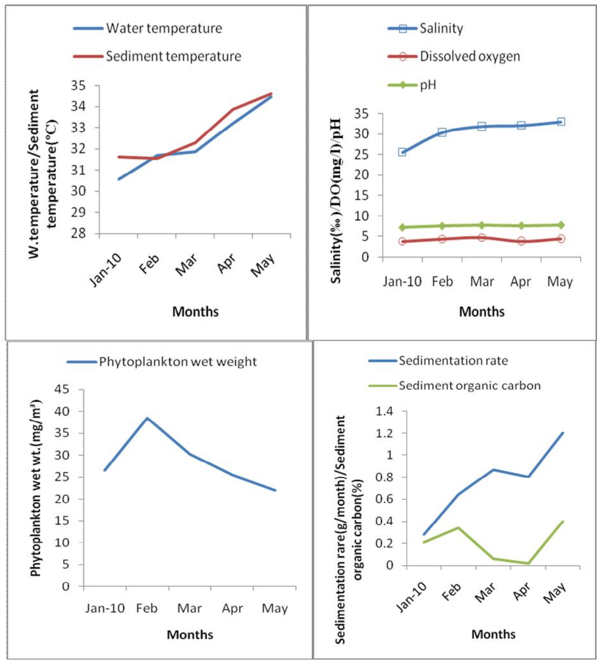


Fig.7 Monthly distribution of water temperature, sediment temperature, salinity, DO, pH, phytoplankton wet weight, sedimentation rate and sediment organic carbon at NOB 2A from January to May 2010.

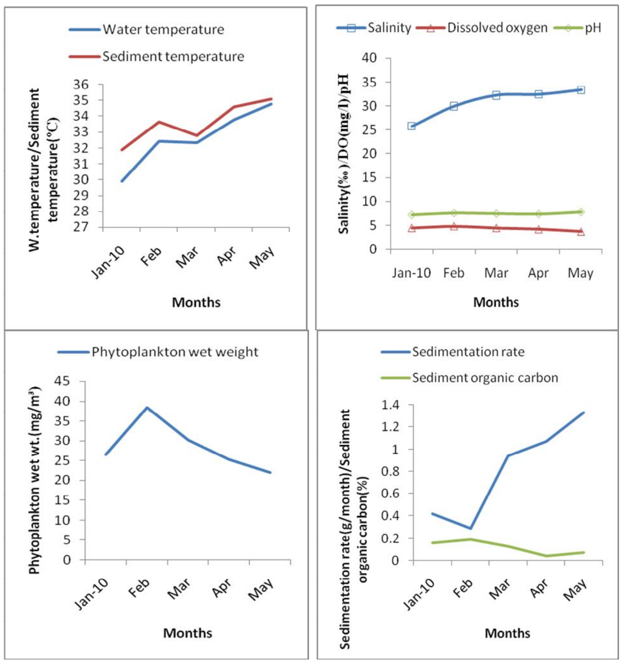
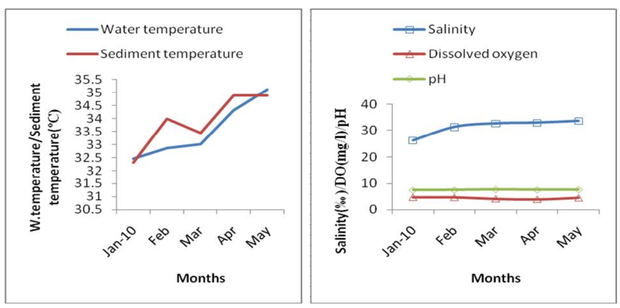


Fig 8. Monthly distribution of water temperature, sediment temperature, salinity, DO, pH, phytoplankton wet weight, sedimentation rate and sediment organic carbon at NOB 2B from January to May 2010.



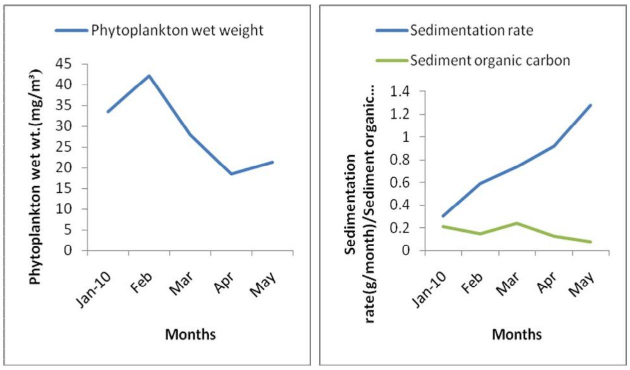


Fig.9 Monthly distribution of water temperature, sediment temperature, salinity, DO, pH, phytoplankton wet weight, sedimentation rate and sediment organic carbon at NOB 2C from January to May 2010.

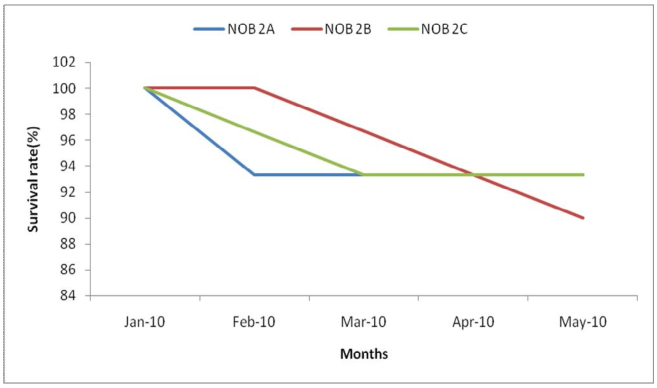


Fig.10 Survival rate (%) of oysters transplanted from OB 2 to NOB 2A, NOB 2B and NOB 2C from January 2010 to May 2010 in the Mulky estuary.

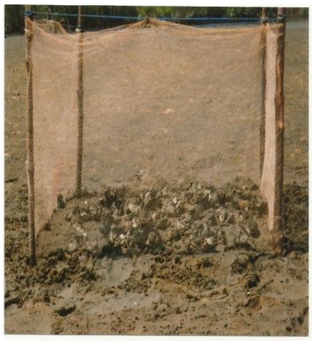
NOB 1A

NOB 1B

NOB 1C

DISCUSSION

Introductions of oysters in new waters or transplantation from oyster bed to non-oyster bed areas of the same water can greatly enhance oyster population and production (Jennifer *et al*., 2005). In the present investigation, the growth and survival of transplanted oysters were studied in Mulky estuary for the first time in India. The oysters (*S.cucullata*) were transplanted from OB1 to NOB 1A, NOB 1B and NOB 1C and also from OB2 to NOB 2A, NOB 2B and NOB 2C for five months from January 2010 to May 2010 to study the growth and survival of transplanted oysters. The initial and final weight, height and length of the transplanted oysters varied from 18.05 to 30.40g, 38.90 to 48.73cm and 28.86 to 34.48cm respectively. In all the experimental cages, weight, height and length of transplanted oysters increased gradually over the months. These results indicate the better growth of the transplanted oysters in non oyster bed areas.



NOB 2A

NOB 2B

NOB 2C

Plate 2 Experimental cages at NOB 2A, NOB 2B and NOB 2C at OB2 in Mulky estuary

The survival rate of transplanted oysters varied between 86.60 and 100%. These results clearly indicate that the transplanted oysters showed higher survival rate in the non- oyster bed areas. At non-oyster bed areas, the environmental factors such as the water temperature, sediment temperature, salinity, DO, pH, sedimentation rate, phytoplankton wet weight and sediment organic carbon varied from 29.89 to 34.45ºC, 31.60 to 35.20ºC, 24.20 to 33.62ppt, .69 to 4.85mg/l, 7.18 to 7.8, 0.28 to 1.33g/m²/month, 8.86 to 58.47 mg/m³ and 0.02 to 0.24% respectively. Thus above mentioned environmental factors may be conducive for the growth and survival of the transplanted oysters. Moreover, the significant positive correlation was recorded between growth of the transplanted oysters and above mentioned environmental factors in all the experimental cages. Cerco and Noel (2007) reported that oysters composed a majority of harvests in many areas in USA and Europe. Oysters are ecosystem engineers that influence ecological processes such as maintenance of biodiversity, population and food web dynamics, nutrient cycling and water quality maintenance (Ronaldo *et al*., 2010). The Pacific oyster, *C. gigas* was first introduced as an exotic species by oyster farmers in 1964 in the Oosterschelde estuary (SW Netherlands) (Smaal *et al*., 1997). In 1997, the Oyster

Recovery Partnership and the University of Maryland Center for Environmental Science transplanted more than 4 million Louisiana oysters in the Choptank river, Maryland, USA. Similarly, Japanese oysters were successfully introduced into Humboldt Bay, USA (Jennifer *et al*., 2005). A significant commercial aquaculture activity continued around the planting, growth and harvesting of Japanese oysters in the Humboldt Bay. The European oysters introduced in Lockhart Lake (Canada) at the end of 1990's have established a self-sustaining population in some parts of the lake (Bataller *et al.*, 2006). As they are able to reproduce naturally, it would be possible to undertake their culture without relying on hatchery reared juveniles. Moreover, the introduction of oysters with superior disease resistance (e.g, oysters from different geographical area or genetically improved strains) may be useful in restoration efforts (Buyers *et al.*,2006). Furthermore, oysters are commonly used to detect metal pollution in the marine environment. Cultured Milky oysters (*Saccostrea commercialis*) were transplanted in various sites along the North Queensland coast, Australia and analyzed for two metals of potentially anthropogenic origin (Cd, Zn)(Frederique *et al*., 2002). This study indicated that the oyster species transplanted were good bioindicators of metals.

Brumbaugh and Toropova (2008) opinied that the oysters would be successful, high-impact members of recipient ecosystems. In the present investigation, the experiments revealed that in Mulky estuary, oysters could be transplanted from oyster bed to non- oyster bed areas to enhance wild stocks of oysters that in turn beneficial for fishers for commercial harvesting to uplift their livelihoods. Since, oyster populations contribute to maintain the water quality through filtering the water, the enhanced oyster population through transplantation may also contribute in maintaining the water quality of Mulky estuary. Furthermore, oyster beds support rich biodiversity especially benthic communities, the enhanced native oyster stocks may support high level of biodiversity in the Mulky estuary that may sustain the ecosystem health. Further, oyster culture and transplantation together may substantially enhance the oyster production in Mulky estuary.

CONCLUSION

From the present investigation it is understood that large scale oyster transplantation may be done in the non-oyster bed areas of Mulky estuary to enhance the abundance of native oysters. In Mulky estuary total 25 oyster beds are found suitable for exploitation and culture (Ganapathi Naik and Ganagadara Gowda., 2013a). But most of the oyster beds are located near the barmouth region of the estuary where high water turbulence and silty mud bottom restricted the accessibility. So that if oyster transplantation is done away from the barmouth and near to the river bank that may be suitable for easy exploitation especially by fisherwomen who engaged in oyster fishing in large numbers in Mulky estuary. Therefore, large scale transplantation of oysters may be initiated in Mulky estuary to enhance the oyster population. Furthermore, oyster transplantation is also beneficial to the ecological processes such as maintenance of biodiversity, food web dynamics, nutrient cycling and water quality maintenance. However, ecosystem level consequences of oyster introductions such as impacts on flow patterns, sediment and nutrient dynamics and native bioengineering species are not well understood (Ronaldo *et al*., 2010).

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