Journal of Aquatic Biology & Fisheries | 2021 | 9 | pp. 165-170
ISSN 2321–340X

Effect of Feeding Frequencies on Growth and Profit of Asian Seabass (*Lates calcarifer*) in Cage Culture Systems

Priya, N.P.[1,2*], Shoji J.[1], Ajithkumar, P.B.[1,2], Sunithakumari, K.[1,2] and Smina, M.S.[1,2]

[1]*ICAR- Central Marine Fisheries Research Institute, Post Box No. 1603, Ernakulam North P.O, Kochi-682018, Kerala, India*
[2]*Cochin University of Science and Technology, South Kalamassery, Kochi, Kerala 682022*
**Email: priyanvnraj@gmail.com*

Abstract

Cage culture is one of the most advanced aquaculture production systems where fishes are held in floating enclosures like net cages, moored in the open water systems, and allow free water flow. The open water cages developed by Central Marine Fisheries Research Institute (CMFRI) during the last decade are becoming very popular in coastal waters. One of the major problems faced by farmers at all stages of culture is fish feed and feeding. A suitable feeding strategy is important to improve fish growth and reduce feed costs and environmental pollution. The study was conducted to investigate the effect of feeding frequency from sea bass cultured in cages on water quality, growth parameters, survival rate, economic return and bottom characters in Moothakunnam (N10011.478' E076011.901'+ 4m) in Ernakulam district. Water and sediment samples and growth parameters were collected and analyzed monthly from inside and outside of the cages for a period of one year. Significant differences were found in growth parameters like weight gain (1.04±0.03-1.78±0.008), Specific growth rate (1.2±0.03-1.48±0.005), Survival rate (40%-61.53%) and FCR (4.3-4.56). The water quality parameters DO, Nitrate, Nitrite, Ammonia and Orthophosphate in the cage and reference sites did not show many significant variations indicating a healthy growth condition in the cages. Therefore it could be concluded that the growth performance of sea bass is increasing by feeding frequency, but the economic analysis indicated that net profit is negatively related to feeding frequency.

Keywords: Cage culture, Feeding frequency, Growth parameters, Water quality, Economic analysis

1. Introduction

Cage culture is an aquaculture production system where fishes are held in floating enclosures like net cages. Factors such as increasing consumption of fish, declining wild fish stocks and poor farm economy have produced a strong interest in fish production in cages. A primary concern among aquaculturists is to deliver feeds that meet the nutritional requirements of the fish. The major portion of the production cost lies in feed. However, developing a fish culture at a commercial level is important to establish an appropriate feed management strategy. The amount and timing of feeding strategy play an important role in growth, feed utilization efficiency and knowledge about the optimum feeding is important not only for regulating the feed intake, growth and chemical composition of fish but also for preventing water quality deterioration as a result of over feeding. On the other hand, over feeding of fish can be an overload to the stomach and intestine, leading to decreases in digestive efficiency and reduction in feed utilization. Thus the diet amount fed each time, or feeding frequency, may influence diet utilization.

The most important factor is feed and feeding while culturing in fish cages, and so these are the critical factors that determine the economic viability of commercial cage culture. The direct influence on growth rate in terms of feeding intensity, feeding time, food rations are the economic considerations.

Lates calcarifer (Asian sea bass) is an economically important food fish in the tropical and subtropical regions in the Asia-Pacific. Because of its relatively high market value, it has become an attractive commodity for both large to small – scale enterprises. Sea bass is a relatively hardy species that tolerate crowding and has wide physiological tolerance, including high turbidity, varying salinities and temperature. In addition, they are fast-growing with a growth rate of approximately 1 kg in 8 months can reach marketable size (350 g – 5kg) in 6 – 24 months.

2. Materials and Methods

The experiment was carried out in a brackish delta formed by the Periyar River at Moothakunnam (N10^{0}11.478' E76^{0}11.901'+4m) with an average depth between 5 – 9 m in Ernakulam district of Central Kerala.

GI cages with a size of 4×4 m and with two enclosure nets, inner and outer nets, were used for culture. The Mesh size of the net depends on the culture species and the initial size of the seed. Juveniles of Sea bass obtained from Rajiv Gandhi Centre for Aquaculture, Kochi were transported to experimental sites and stocked in cages. The length and weight were measured, and fingerlings with weight 8±2 gm and length 6.5±1.5 cm were stocked. Equal numbers of juveniles (2000 fingerlings/cage) were stocked in triplicates of three treatments in a completely random manner. Fresh and clean chopped Trash fishes were used as fish feeds in these experiments. After each sampling, the amount of feed given was adjusted according to the biomass in the cage. Chopped trash fish were given in the morning 08.00 hrs, afternoon 12.00 hrs and evening 17.00

Received on: 11-06-2021; Revised on: 30-07-2021; Accepted on: 31-07-2021

hrs at the overall rate of 10% of the total biomass in the first three months of the culture, and the remaining months feeding is reduced at the rate of 7- 8% of the total biomass. The experiments were conducted with three feeding frequencies of one (T1), two (T2) and three (T3) times a day were evaluated as treatment in triplicate for a period of 2019 February to January 2020.

Samples were collected every month (February to January) and water samples were collected from inside and outside (Reference site) of the cages. 20 fishes from each treatment were collected for growth analysis. Water quality parameters, growth parameters and economic productivity were analyzed. Water temperature was measured with thermometer, concentration of dissolved oxygen and pH were measured by titrimetric method (Winklers method Strickland & Parsons 1968) and pH meter. Salinity by Refractometer and Nitrite, Nitrate, Ammonia, Phosphate by spectrophotometric methods (Strickland & Parsons ,1968). Fingerlings are stocked in the hapa with a mesh size of 10 mm at the early stages. In this case, fishes have to be graded every week to avoid cannibalism depending on the species. According to the size of the fish, grow out nets with a mesh size of 18 mm, 24 mm, 26 mm, 28 mm and 30 mm were used throughout the culture. Bio fouling on cages is a serious problem in the experimental site because it is very nearer to the sea. So the nets are mechanically cleaned regularly to prevent fouling organisms. The net exchange was done once in a month for facilitate water exchange and to avoid bio fouling.

Growth performance and feed utilization were calculated in terms of weight gain, daily growth rate (DWG), specific growth rate (SGR), Feed Conversion Ratio (FCR), survival rate (SR). Weight and length of fishes were recorded for each cage and dead fish were removed and recorded. The fish weight and length were measured using measuring board and digital balance.

- DWG=(mean final weight - mean initial weight) / rearing duration in days
- SGR = [(ln final weight - ln initial weight) / rearing duration in days]×100
- FCR = total feed intake/ total biomass gain
- Survival = (number of fish harvested/number of fish stocked)×100
- Weight gain = [(final mean body weight - Initial mean body weight)/ Initial mean body weight]×100

At the end of the experiment fishes were harvested, counted, length and weight were measured. Production input costs were recorded throughout the treatment. After the termination of the experiment, an economic analysis were performed to estimate the net return and benefit - cost ratio on the basis of different feeding frequency of Asian sea bass. Various indicators were used for profitability analysis including: variable costs (VC), Fixed Costs (FC), Total Costs (TC), Total Revenues (TR), and Benefit-cost Ratio (BCR) (Yuan *et al.*, 2017). Fixed cost include cage cost, equipment and tools etc. The costs of feeds, fingerlings, security, maintenance, operational cost and harvest including in the variable costs. Prize of the fish is the total revenue generated from the culture. The economic feasibility and efficiency of the culture system was assessed by using the equations;

$$TC = VC + FC$$

$$BCR = \frac{TR}{TC}$$

3. Results and Discussion

In the present observation, Growth performance of Asian sea bass was significantly affected by feeding frequency. Weight gain, Daily growth rate, Specific Growth rate and survival rate of the fish fed with thrice daily were higher than compared to one and two times daily.

The observations are similar with the results obtained by Wang *et al*., 1998, Lee *et al*., 2000, Dwyer *et al*., 2002, Harpaz *et al*., 2005, Kikuchi *et al*., 2006, Booth *et al*., 2008 and Wang *et al*., 2009.

Feeding rate, frequency of feeding and time of feeding are important factors to be considered in cage farming. Feeding rate and frequencies are related to age and size of fish. Larval fish and fry need to be fed on high protein diet more frequently. As fishes grow bigger, feeding rate and frequencies can be reduced. Feeding is labour intensive, so frequency has to be adjusted to become economically viable. Growth and feed conversion increases with increase in feeding frequency. Feeding of fish also influenced by the time of the day, season, water temperature, dissolved oxygen level and other water quality parameters (Rajesh *et al.*,2020).

According to Ranjan *et al*., 2016, the fish should be fed at least twice per day once in the morning and then evening. However, at the earlier stage, feeding frequency of more than two times is suggested for better growth.

Table 1 shows growth evaluation of the fish fed with different feeding frequencies. The mean weight gain of the fishes increased about 1.78 ± 0.008 kg fed thrice daily than those fed twice 1.44 ±0.03 and one time per day 1.03 ± 0.03 . Average daily growth was 3.9 ± 0.005 and Specific Growth rate is 1.48 ± 0.005 in the cages where feeding was thrice, also showed all these values to increase with feeding frequency. But the FCR recorded was relatively high in fish with twice feeding frequency compared to one time and three times feeding per day. The best survival rate (61.53%) was obtained in cages were the fish fed thrice in a day. The net yield was also highest at this feeding level.

Table 1. Effect of different feeding rate on growth performance and survival of Asian sea bass under cage culture system

Growth parameter	Feeding Frequency No. of feedings /day		
	1 time/day	2 times/day	3 times/day
Initial mean weight(g)	8.0 ± 0.01	8.0 ± 0.01	8.0 ± 0.01
Final mean weight(kg)	1.01±0.03	1.16 ±0.02	1.8 ± 0.003
weight gain(kg)	1.03 ± 0.03	1.44 ± 0.03	1.78 ± 0.008
Average daily growth rate(g)	1.82 ± 0.05	2.15 ± 0.05	3.9 ± 0.005
Specific growth rate	1.2 ± 0.02	1.3 ± 0.03	1.48 ± 0.005
Survival rate %	40	45	61.53
Feed Conversion Ratio	4.4	4.56	4.3

This study revealed that growth in terms of final length and weight and other weight related indices, like Daily Growth Rate, Survival rate and Specific Growth Rate in Sea bass could be improved when they were cultured with feeding provided for three times compared to one time and two times daily. Water quality parameters were not significantly different between treatments and were within the acceptable ranges for Asian sea bass.

Success of a commercial aquaculture operation largely depends on the growth and survival of the fish under culture. As feed is the single most significant cost involved, it is emphasized to carry out farming with its maximum conversion into fish growth in a cost-effective management approach. Considering these facts, this study suggests that in brackish water net cage rearing, Asian sea bass can achieve maximum growth, survival and better feed conversion when they are fed with three times feeding daily.

Feeding frequency affected the survival in sea bass with fish fed three meals daily exhibiting the highest survival. Significantly lower survival was found in fish groups fed at one time feeding per day. Present observation of feeding frequency influencing survival was in accordance with the conclusions of Chua and Teng (1978).

The influence on feeding frequency on feed intake is also variable among different fish species. For feeding frequency, Kyano *et al.*,1990 studied on young red spotted grouper (*Epinephelus akaara*) reported that high frequency led to high growth rate, high feed conversion efficiency and high survival rate. Increasing feeding frequency from one to four times daily significantly improved body weight gain and feed utilization, but unchanged at feeding frequency over four.

The experiment by Ganzon-naret, 2013, concluded that increasing feeding frequency in sea bass resulted in a better growth performance, body composition and survival rates under controlled laboratory condition after 60 days of feeding trial. The success of sea bass depends on effective feeding frequency. A feeding frequency of six times a day compared to other experimental groups is suggested to be optimum for achieving optimum growth, feed conversion efficiency and high survival rates among *Lates calcarifer*. The results of the Suresh Kumar Mojjada *et al.*, 2013 study showed that high stocking density (up to 2000 nos. m-3) with proper feeding rate, feeding frequency and water quality can help to reduce cannibalism and to obtain maximum survival rate and growth in sea bass. The technique can be used to produce large numbers of sea bass juveniles for open sea cage farming of Asian sea bass.

A simple economic analysis was developed to estimate the profitability in each treatment. The cost of cage, feed, fingerlings and total revenue generated from harvest were estimated. In the present study, production economics was affected by feeding frequencies of Asian sea bass. Benefit-cost ratio of each treatment was determined on the basis of input costs of fish, cage materials, feed and returns from fish sale. Total cost of inputs in T3 was higher than that in T1 and T2. A highest Net profit was also obtained in T3 followed by T1 and T2. But Benefit-cost ratio (BCR) was highest in the T2 (2.06) and lowest in T1(1.44). From the observations, comparison of the net profit (Table.2) of three treatments (T1,T2,T3) indicates that T3 is more profitable than T1 and T2, even though the operational cost is more.

During the study period, water quality parameters were monitored and found within the ranges that provide good growth for Asian Sea bass in cage culture (Kailasam *et al.*, 2006). There was not much marked variations observed in temperature, pH, dissolved oxygen, nitrate, nitrite, ammonia, phosphate, biological oxygen demand and dissolved oxygen from inside and outside of the cages throughout the experimental period.

Water temperature, salinity and pH parameters were found similar in cage site and reference site (Fig.1a, 1b, 1c). Salinity changes was mainly due to the seasonal variations (Saha *et al.*, 2001). Statistical analysis of the present study indicated that there were significant differences in the water quality parameters ($p<0.05$) like nitrite (Fig.1d) nitrate (Fig.1h), ammonia (Fig.1e), and phosphate (Fig.1f) between reference site and cage site. According to Nyanti *et al.*, 2012 ammonia was higher at fish culture site due to excretory products released by the fish. Karnatak and Kumar (2014) reported that the high fish densities, along with the high feeding rates, often reduce dissolved oxygen

Table 2. Cost – Turn over Analysis of Cage culture

	T1	T2	T3
Total no. of fish stocked	6000	6000	6000
No. of fishes harvested	2466	2714	3700
Total quantity produced (Kg)	2568	3137	6714
Total cost of production	711234	739454	1625000
Total turn over	1027200	1530415	2985000
Net profit	315966	790961	1360000
Total feed used (Kg)	11226	14400	30000
Total feed cost	275261	356045	745000
Feed cost/ kg	24.52	24.72	24.83
Average price / kg	400	487.94	444.59
Benefit-cost ratio	1.44	2.06	1.8

Fig. 1. Graphs showing the water quality parameters of cage site and reference site; a. Temperature, b. Salinity, c. pH, d. Nitrite, e. Ammonia, f. Orthophosphorous, g. Dissolved Oxygen and Biological Oxygen Demand, h. Nitrate.

and increase ammonia concentration in and around the cage, especially if there is no water movement through the cage. The primary route by which phosphorous enters the aquatic environment from cage farming is through the feed administrated to the fish (Gavine *et al.*, 1995). A large number of cages in area can exceed the carrying capacity of the aquatic environment, which may cause problems by high levels of phosphorous (Mallasen *et al.*, 2012). But Cornel and Whoriskey observed that the same levels of ammonia, nitrate and orthophosphate in both cage site and reference site. The observations from the present study, dissolved oxygen and biological oxygen demand is similar in the cage and reference site (Fig.1g) La Rosa *et al.*, 2002 reported that cage farming activity has comparatively lower impact on water environment than on the sediment. The influence of aquaculture on the benthic environment is due to the deposition of organic loads such as uneaten feed and dead fish (Wu *et al.*, 1994; Wu, 1995)

Bottom sediments were collected by using Van Veen Grab (0.05m2) and analyzed. There is no significant difference in pH and salinity inside and outside of the cage site (Fig 2a & 2b). D. Prema *et al.*, 2010 also reported the similar findings. But the organic contents were slightly higher inside the cages (Fig. 2b). White, P., 2013 reviewed that total organic carbon under salmon cages in Atlantic Canada was 40% higher than at reference site. Accumulation of carbon depends on the composition and quantity of waste material, sedimentation rate and site characteristics.

The results of the present study indicate that increasing feeding frequency and water quality can help to obtain

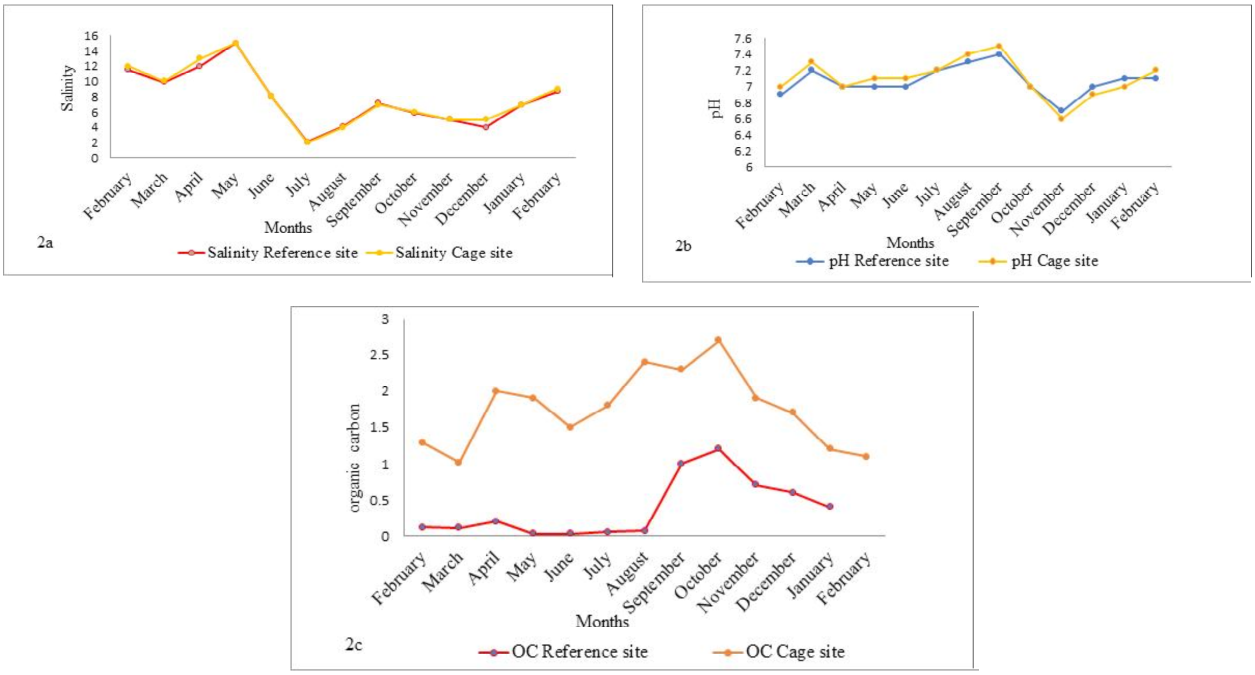

Fig. 2. Graphs showing the sediment parameters in cage site and reference site; a. Salinity, b. pH, c. Organic Carbon.

maximum survival rate and growth in sea bass. In consideration of economic analysis, net profit from three treatments indicates that T3 is more profitable than T1 and T2. Therefore feeding frequency of three times per day could be recommended for the successful cage culture of Asian sea bass. The findings of the current study have practical significance, for sustainable and cost effective sea bass cage culture in brackish water environment.

Acknowledgements

The authors express their gratitude to Dr. Gopalakrishnan, Director CMFRI, for providing all the facilities and the Scientists & technical staff, Mariculture Division, CMFRI, Kochi for the helps rendered in the present study. We also express our sincere thanks to CSIR for their financial support.

4. References

Bascinar, N., Cakmak, E., Cavdar, Y., and Aksungur, N. 2007. The effect of feeding frequency on growth performance and feed conversion rate of black sea trout (*Salmotrutta labrax Pallas*, 1811). *Turkish J. Fish. aquat. Sci*., 7:13– 17.

Booth, M.A., Tucker, B.J., Allan, G.L., and Fielder, D.S. 2008. Effect of feeding regime and fish size on weight gain, feed intake and gastric evacuation in juvenile Australian snapper *Pagrus auratus*. *Aquaculture*, 282, 104–110.

Cornel, G.E., and Whoriskey, F.G.1993. The effects of rainbow trout (*Ornchorynchus mykiss*) cage culture on the water quality, zooplankton, benthos and sediments of Lac du Passage. *Quebec*, *Aquaculture*, 109:101-117.

Daudpota, A.M., Abbas, G., Kalhoro, I.B., Shah, S.S.A., Kalhoro, H., Hafeez-ur-Rehman, M., and Ghaffar, A. 2016. Effect of feeding frequency on growth performance, feed utilization and body composition of juvenile Nile tilapia, *Oreochromis niloticus* (L.) reared in low salinity water. *Pakistan Journal of Zoology*, *48*(1).

Devi, P.A., Padmavathy, P., Aanand, S., and Aruljothi, K. 2017. Review on water quality parameters in freshwater cage fish culture. *International Journal of Applied Research*, *3*(5), pp.114-120.

Dwyer, K., Brown, J.A., Parrish, C., Lall, S.P. 2002. Feeding frequency affects food consumption, feeding pattern and growth of juvenile yellowtail flounder. *Aquaculture*, 213, 279–292.

Ganzon-Naret, E.S. 2013. Effects of feeding frequency on growth, survival rate and body composition in sea bass (*Lates calcarifer*) juveniles fed a commercial diet under laboratory condition. *Animal Biology & Animal Husbandry*, *5*(2), pp.175-176.

Gavine, F.M., Phillips, M.J., Murray, A. 1995. Influence of improved feed quality and food conversion ratios on phosphorus loadings from cage culture of rainbow trout, *Oncorhynchus mykiss* (Walbaum), in freshwater lakes. *Aquaculture Research*, 26:483-495.

Harpaz, S., Hakim, Y., Barki, A., Karplus, I., Slosman, T., Eroldogan, O.T. 2005. Effects of different feeding levels during day and/or night on growth and brush-border enzyme activity in juvenile *Lates calcarifer* reared in freshwater re-circulating tanks. *Aquaculture*, 248, 325–335.

Kailasam, M., Thirunavukkarasu, A.R., Sundaray, J.K., Abraham., Mathew., Subburaj, R., Thiagrajan, G., Karaiyan, K. 2006. Evaluation of different feeds for nursery rearing of Asian seabass, *Lates calcarifer* (Bloch). *Indian J. Fish*, 53, 185–190.

Karnatak, G., and Kumar, V. 2014. Potential of cage aquaculture in Indian reservoirs. *IJFAS*. 1(6):108-112

Kikuchi, K., Iwata, N., Kawabata, T., Yanagawa, T. 2006. Effect of feeding frequency, water temperature, and stocking density on the growth of tiger puffer, *Takifugu rubipes*. *J. World Aquac. Soc*. 37, 12–20.

La Rosa, T., Mirto, S., Favaloro, E., Savona, B., Sara, G., Danovaro, R., and Mazzola, A. 2002. Impact on the water column biogeochemistry of a Mediterranean mussel and fish farm. *Water Res*., 36: 251–259.

Lee, S., Hwang, U., Cho, S.H. 2000. Effects of feeding frequency and dietary moisture content on growth, body composition and gastric evacuation of juvenile Korean rockfish (*Sebastes schlegeli*). *Aquaculture*, 187, 399–409.

Mallasen, M., Barros, H.P., Traficante, D.P., and Camargo, A.L.S. 2012. Influence of a net cage tilapia culture on the water quality of the Nova Avanhandava reservoir, Sao Paulo state, Brazil. *Acta Scientiarum Biological Sciences*, 34(3):289-296.

Mojjada, S.K., Dash, B., Pattnaik, P., Anbarasu, M., and Imelda, J. 2013. Effect of stocking density on growth and survival of hatchery reared fry of Asian seabass, *Lates calcarifer* (Bloch) under captive conditions. *Indian Journal of Fisheries*, *60*(1), pp.71-75.

Nyanti, L., Hii, K.M., Sow, A., Norhadi, I., and Ling, T.Y.2012. Impacts of Aquaculture at different Depths and Distances from cage culture sited in Batang Ai Hydroelectric Dam Reservoir Sarawak, Malaysia. *World Applied Sciences Journal*, 19(4):451-456

Prema, D., Sobhana, K.S., Laxminarayana, A., Imelda, J., Joseph, S., Ignatius, B., Jeyabaskaran, R., Nandakumar, A., Khambadkar, L.R., Anilkumar, P.S., and Shylaja, G. 2010. Observations on selected characteristics of water and sediment at the open sea cage culture site of Asian seabass, *Lates calcarifer* (Bloch) off Cochin, south-west coast of India. *Indian Journal of Fisheries*, *57*(4), pp.53-59

Rajesh, N., and Ignatius, Boby., and Imelda, Joseph .2020. *Introduction to mariculture techniques: Cage farming*. *In:* The Blue Bonanza: *A Manual for on the job Training,* 17-22

Ranjan, R., Behera, P.R., Dash, B., and Chinnibabu, B. 2016. Different aspects of cage culture management for sustainable fish production. *Training Manual Series No*. 10 .

Saha, S.B., Bhattacharyya, S.B., Choudhury, A., 2001. Impact of sedimentation on the hydrobiology in relation to shrimp culture of two tidal ecosystems in Sundarbans of West Bengal. *Trop. Ecol*, 42, 251–258.

Teng, S.K., and Chua, T.E. 1978. Effect of stocking density on the growth of estuary grouper, *Epinephelus salmoides Maxwell*, cultured in floating net-cages. *Aquaculture*, *15*(3), pp.273-287.

Teng, S.K., Chua, T.E., and Lim, P.E. 1978. Preliminary observation on the dietary protein requirement of estuary grouper, *Epinephelus salmoides Maxwell*, cultured in floating net-cages. *Aquaculture*, *15*(3), pp.257-271.

Wang, N., Hayward, R.S., Noltie, D.B. 1998. Effect of feeding frequency on food consumption, growth, size variation, and feeding pattern of age-0 hybrid sunfish. *Aquaculture*, 165, 261–265.

Wang, N., Xu, X., and Kestemont, P. 2009. Effect of temperature and feeding frequency on growth performances, feed efficiency and body composition of pikeperch juveniles (*Sander lucioperca*). *Aquaculture* ,289, 70–73.

White, P., 2013. Environmental consequences of poor feed quality and feed management. *FAO Fisheries and Aquaculture Technical Paper*, *583*, pp.553-564.

Wu, R.S.S. 1995. The environmental impact of marine fish culture: towards a sustainable future. *Mar. Pollut. Bull*, 31: 159– 166.

Wu, R.S.S., Lam, K. S., MacKay, D. W., Lau, T. C. and Yam, V. 1994. Impact of marine fish farming on water quality and bottom sediment : a case study in the sub-tropical environment. *Mar. Environ. Res*, 38 : 115–145.

Yuan, Y., Y. Dai., and Y. Gong. 2017. Economic profitability of tilapia farming in China. *Aquaculture International*, 25 (3):1253–64. doi:10.1007/s10499-017-0111-8.