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Observations on variations in physico-chemical water parameters of marine fish cage farm off Karwar

K. K. PHILIPOSE, S. R. KRUPESHA SHARMA, JAYASREE LOKA, DIVU DAMODARAN, G. SYDA RAO*, NARAYAN G. VAIDYA, SONALI S. MHADDOLKAR, NARASIMHULU SADHU AND PRAVEEN DUBE

Karwar Research Centre of Central Marine Fisheries Research Institute, P. B. No. 5, Karwar - 581 301, Karnataka, India
**Central Marine Fisheries Research Institute, Kochi - 682 018, Kerala, India*
e-mail: kkphilipose@gmail.com

ABSTRACT

An investigation was undertaken to study the fluctuations in the water quality parameters in a marine fish cage culture site off Karwar during the period 2009-2011. Two stations *viz.*, one from cage site (Station 1) and the other away from the cage site (Station 2) were selected for the study. Water samples were collected at weekly intervals. Temperature of Station 1 varied from 28.5 ± 0.89 °C to 32.5 ± 1.04 °C during the first crop of Asian seabass culture in 2009-10 and it ranged between 26.7 ± 0.83 to 32.5 ± 0.79 °C during the second crop of seabass culture in 2010- 11. The salinity was minimum during July 2010 and maximum in May 2010. There was no significant difference observed between the water quality parameters of the two stations ($p>0.05$). However, difference in salinity was significant between the two culture periods in Station 1 ($p<0.05$). No significant difference was observed in the nutrient levels of the cage and reference sites and also between the two crops. No significant difference was observed between the mean weight of the fish and temperature of both the sites and periods. A positive correlation was observed between the weight gain of fish and salinity of water at cage site.

Keywords: Asian seabass, *Lates calcarifer*, Marine fish cage farm, Physico-chemical water parameters

Introduction

Culture of many fish species in cages has been practised for several years in different countries worldwide. In mariculture, water quality plays a major role in the growth and health of the fish. Any deviation in water quality causes stress to fish and affect the growth and production (Ponce Palafox *et al*., 1997; Papoutsoglou *et al*., 1998). Drastic changes in water quality parameters may lead to infection by opportunistic pathogens causing mass mortalities (Arulampalam *et al*., 1998). The main physico-chemical parameters that need to be considered in culture systems include water temperature, salinity, dissolved oxygen, pH and ammonia levels (Wu *et al*., 1999). While most of the studies on the quantity of nutrients released to the environment from aquaculture activities have been theoretically calculated, only a few of them are based on field studies (Molina–Domínguez *et al*., 2001). Pichavant *et al*. (2001) conducted experimental studies on the interaction between environmental oxygen concentrations, feeding and growth of juvenile turbot and European seabass. Pitta *et al*. (1999) and Karakassis *et al*. (2001) made a detailed study on seasonal changes in environmental variables in marine cage culture. Kikuchi *et al*. (2002) stated that nitrogenous waste levels affect water temperature. For a profitable production system, nitrogenous wastes, temperature and stocking density are key biological parameters (Qiang *et al*., 2011). From India, few reports are available on the water and sediment quality of marine cage farms (Anil *et al*., 2010; Imelda *et al.,* 2010; Philipose *et al*., 2010; Prema *et al*., 2010). The present investigation was undertaken to study the variations in the water quality at the marine cage site culturing Asian seabass, *Lates calcarifer* and at a reference site, at Karwar during two culture periods 2009-10 and 2010 - 11 and also to analyse the effect of water quality on growth of fish.

Materials and methods

The present study was carried out in the marine farm of the Central Marine Fisheries Research Institute at Karwar (lat. 14^0 49' 914"; long. 74^0 06' 002") comprising 14 floating cages (diameter: 6 m; volume: 142 m^3). The depth of the water column at the cage site was 12 m and 10 m during high and low tides, respectively. Stoking density of seabass during 2009-10 was 3000 fish $cage^{-1}$ and 5000 $cage^{-1}$ during 2010-11. The fish were fed with fresh chopped oilsardine (*Sardinella longiceps*) at the rate of 10% of biomass. Fish were fed four times per day (at 0600, 1200, 1700 and 0000 hrs).

For the present investigation, two sampling stations were chosen to study the water quality. Station 1 represented cage culture site where the Asian seabass were reared and Station 2 represented the reference site without any cage culture activity, one km away from the cage site towards south. Water samples were collected from the two selected sites from two different depths, *i.e.*, near the surface (1 m) and from bottom of the cage (6 m). Water quality parameters like temperature, salinity, pH, dissolved oxygen (DO), total ammonia, nitrite and nitrate were analysed at weekly intervals following standard procedures (APHA, 1984). Length and weight of fish were also measured at weekly intervals. Weight gain of fish was calculated using the standard formula (final mean body weight - Initial mean body weight) / Initial mean body weight. Data were subjected to statistical analysis using SPSS software to determine whether there is any significant difference between the parameters and between the periods employing ANOVA and correlation analysis.

Results

Mean water temperature, salinity, pH, DO, ammonia, nitrite and nitrate did not vary significantly ($p>0.05$) between the two stations during the two crops. Variations in the physico-chemical water quality parameters of cage site and reference site are represented in Fig.1 and 2.

Mean water temperature of cage site in Station 1 varied from 28.5 ± 0.89 °C to 32.5 ± 1.04 °C during 2009-10 and 26.7 ± 0.83 °C to 32.5 ± 0.79 °C during 2010- 11. At station 2, the temperature varied from 28 ± 0.5 °C to 32.5 ± 0.2 °C and 27.9 ± 0.32 °C to 32.5 ± 0.24 °C during 2009-10 and 2010-11, respectively. Highest temperature was observed during the month of May 2010. There was no significant variation in mean temperatures during the two culture periods ($p>0.05$). Salinity of the cage site during 2009-2010 varied between 21.5 ± 0.5 to 32.8 ± 0.8 ‰ and between 16 ± 2.5 to 32.5 ± 0.2 ‰ during 2010-11. There was no significant difference in salinity values between stations during the two crop periods ($p>0.05$). Minimum DO recorded at Station 1 was 3.1 and 2.42 mg l^{-1} during 2009-10 and 2010-11 respectively and was recorded in July during both the crops. Maximum DO values were noticed during May 2010. No significant difference was observed between two stations during the experimental period ($p>0.05$).

Minimum value of pH was noticed in December 2010 (7.1) and maximum during May of 2011 (8.1) at Station 1. Although fluctuations were observed in the pH levels throughout the culture period, there was no significant variation between stations as well as between culture periods ($p>0.05$). Total ammonia levels of Station 1 varied between 0.02 to 0.03 mg l^{-1} in Station 1 during the period 2009-10 whereas the levels were comparatively more (0.04 to 0.08 mg l^{-1}) during 2010-11. There was no significant difference in the levels of total ammonia between stations except for a high value during July 2011 ($p>0.05$). The difference in the ammonia values was significant between the two culture periods ($p<0.05$). Nitrite levels of Station 1 (cage site) varied between 0.1 to 0.45 mg l^{-1} and 0.2 to 0.6 mg l^{-1} during the first and second crop, respectively. Nitrate values ranged between 1.2 - 2.8 mg l^{-1} during the

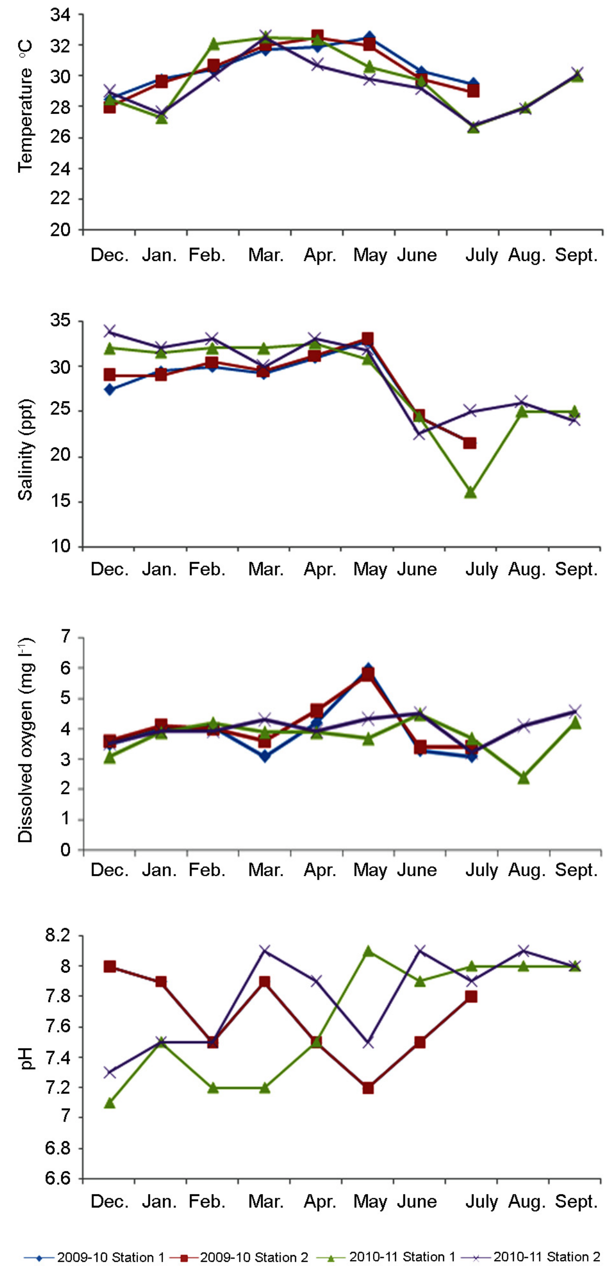

Fig. 1. Variations in the physico-chemical water parameters of floating cage site and reference site during 2009-10 and 2010-11

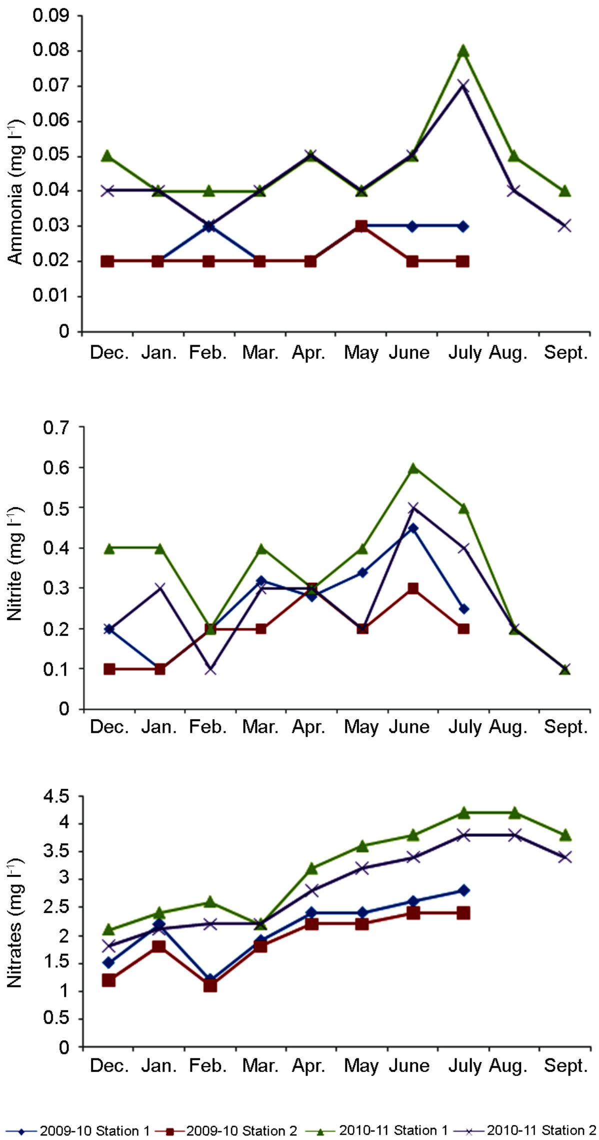

Fig. 2. Variations in the physico-chemical water parameters of floating cage site and reference site during 2009-10 and 2010-11

first crop and 2.1 to 4.2 mg l^{-1} during the second crop. Positive correlations were observed in temperature (r = 0.72, 0.8), DO (r = 0.75, 0.83) and pH (r = 0.9, 0.76) between the samples collected from surface and bottom.

Weight gain of seabass was minimum (0.45 g) during July 2010 and was maximum during May 2010 (3.08 g). Whereas, the weight gain was low during the period 2010-11 with a maximum of 2.8 g (Fig. 3). Maximum weight gain of 3.08 g was observed in seabass when the salinity of the cage site was 32.8 ‰ during the period 2009-10 and during 2010-2011 the weight gain was maximum (2.8 g) in the month of April, when the salinity was 32.5 ‰ (Fig. 4-6).

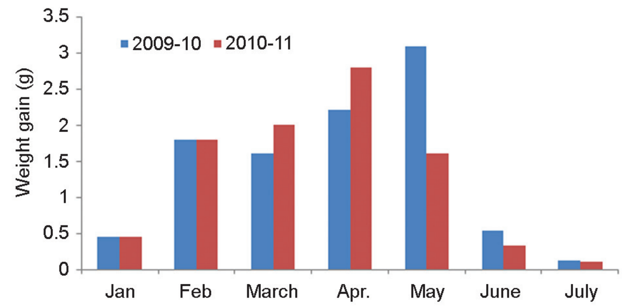

Fig. 3. Weight gain (g) of Asian seabass cultured in cages at Karwar during 2009-10 and 2010-11

A reduction in weight gain was observed during June and July 2011 when the salinity and DO values of water decreased (Fig. 4-6)). Mortalities were recorded in cages during June (2%) and July (5%) 2011 when there was a sudden fluctuation of salinity and DO levels.

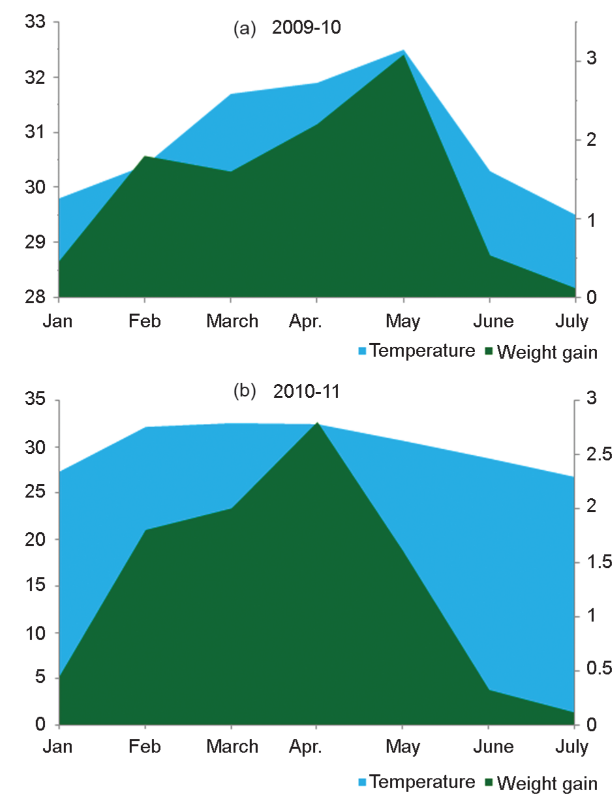

Fig. 4. Water temperature (°C) and weight gain (g) of fish at cage site during 2009-10 (a) and 2010 – 11 (b)

Discussion

Water quality forms one of the important factors governing the health of fish under culture environment (Leong, 1989). Due to the conservative nature of the marine environment and the large water volume and exchange, water quality variables such as total alkalinity, total hardness, pH, DO, nitrogenous compounds and hydrogen

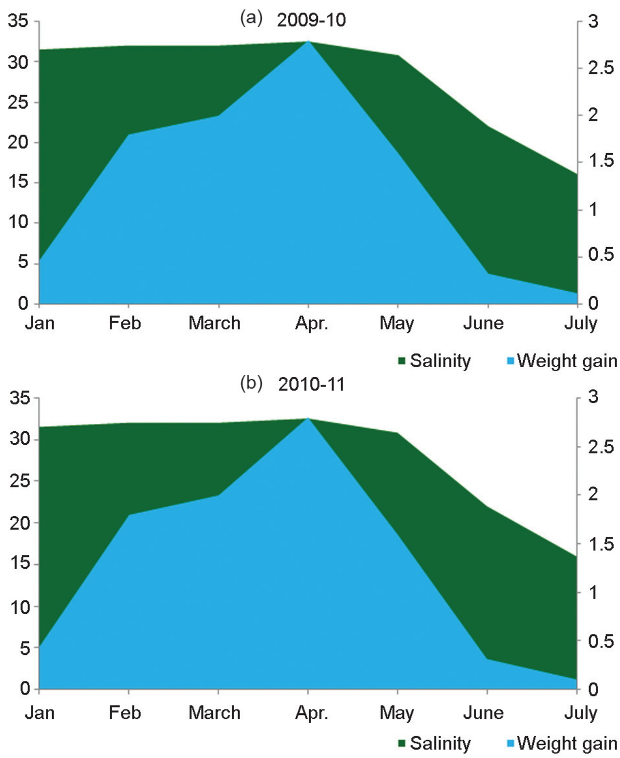

Fig. 5. Water salinity (‰) and weight gain (g) of fish at cage site during 2009-10 (a) and 2010 – 11 (b)

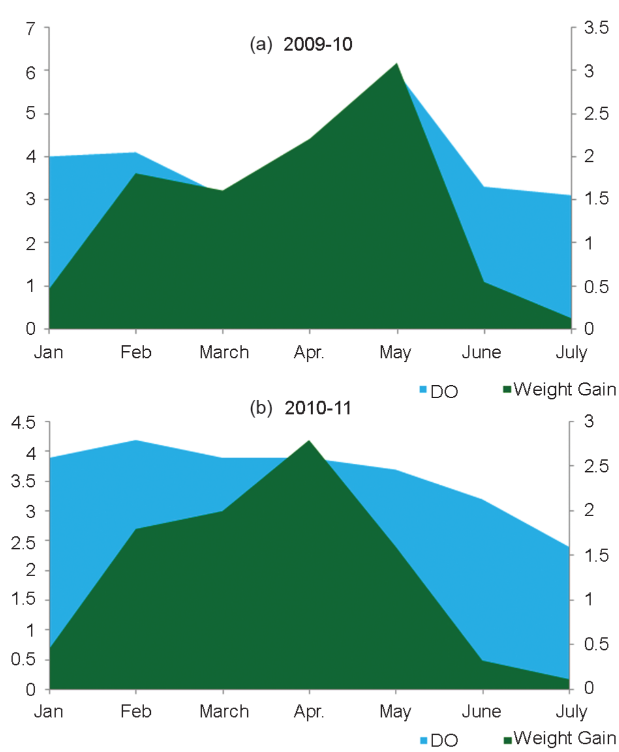

Fig. 6. DO (mg l^{-1}) and weight gain (g) of fish at cage site during 2009-10 (a) and 2010 – 11 (b)

sulphide were considered of little importance (Perez *et al*., 2005). Vargas-Machuca *et al.* (2008) stated that long period of cultivation may lead to variations in pH, transparency, DO, ammonia, nitrites, nitrates, phosphorus and sulphates. No significant variation was observed in the mean values of water temperature, salinity, pH and, DO, between the cage and reference sites during the present investigation.

In seabass culture, optimum temperature for growth and food conversion ranged between 26-32 °C (Kungvankij *et al*., 1984). Tucker *et al*. (2002) mentioned that seabass has an extremely wide thermal tolerance range (15–40 °C) and they are cultured at temperatures from 22 to 35 °C. In the present investigation, weight gain was maximum when the temperature of cage site was 32.5 °C during both the culture periods. Highest growth rate was recorded during May 2010 when the highest temperature was recorded during the culture period. Mackinnon (1989) reported that little or no growth occurred at about 20-22 °C, and increase in general activity and feeding was noticeable with each degree of increase at temperatures around 25 °C. In the case of juvenile seabass, growth was optimised at temperatures from 27 to 36 °C and they have a much wider range for maximum growth efficiency (Katersky and Carter, 2005).

The variations in DO, ammonia, nitrites and nitrates due to the long period of cultivation may affect the growth and health of fish (Vargas-Machuca *et al*., 2008). During the present investigation, 2 to 5% of fish mortalities in cage were observed during the months of June and July 2011, and the salinity and DO of water at cage site were observed to be 16 ‰ and 2.42 mg l^{-1}, respectively. The decrease in salinity and DO values and increased levels of ammonia might have resulted in increase of bacterial loads of water and occurrence of mortality of fish during June and July 2011. Vargas-Machuca *et al*. (2008) stated that the nutrient levels of water at cage site and reference sites did not show any significant variation ($p>0.05$). But they observed a significant correlation between the nitrite and nitrate values with bacterial loads of water. The increase in *Vibrio* spp. and other harmful bacterial counts may lead to occurrence of diseases. Vargas-Machuca *et al*. (2008), Baross and Liston (1977) as well as Arumlampalam *et al*. (1998) also reported that the nutrient in the water column increased the bacterial growth especially *Vibrios* which may lead to the spread of diseases. Leong (1989) reported occurrence of 'red boil disease' in groupers when the water was turbid with suspended particles. In the present study, values of ammonia, nitrites and nitrates varied between two crops. Higher values were recorded during 2010-11 when compared to 2009-10. Lower values of DO and higher values of ammonia might have lead to the attack of opportunistic bacteria, which further lead to mortalities.

Arumlampalam *et al*. (1998) suggested use of pelleted feed for cage cultured fish in order to maintain good water quality. Fluctuations were observed in the nutrient levels of the water samples collected from cage site during the two crop periods which were statistically not significant ($p>0.05$).

Poor water quality conditions due to high fish densities are known to affect fish growth by reducing feed intake and or feed conversion ratios (Ellis *et al*., 2002; Person Le Ruyet *et al*., 2003; Lemarie *et al*., 2004; Bjornsson and Olafsdottir, 2006; Santos *et al*., 2010). During the present study, stocking density of seabass was 3000 per cage during 2009-10, whereas, the stocking density was 5000 per cage during 2010-11. The higher stocking density and fluctuations in salinity as well as DO levels might be the reason for the decrease in the average weight of fish after seven months of culture period during 2010-11. Further studies on water, sediment and feed quality are needed to understand the influence of these on growth patterns and also to develop management strategies for attaining maximum production in cages.

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References

Anil, M. K., Santhosh, B., Jasmine, S., Saleela, K. N., Rani Mary George, Jose Kingsly, H., Unnikrishnan, C., Hanuamnta Rao, G. and Syda Rao, G. 2010. Growth performance of the seabass *Lates calcarifer* (Blotch) in sea cage at Vizhinjam Bay along the south-west coast of India. *Indian J. Fish.,* 57(4): 65-69.

APHA 1984. *Standard methods for the examination of water and wastewater*, 15th edn., Washington D. C., American Public Health Association, 1134 pp.

Arulampalam, P., Yousoff, F. M., Shariff, M., Law, A. T. and Srinivasa Rao, P. S. 1998. Water quality and bacterial population in a marine tropical cage culture farm. *Aquacult. Res.,* 29: 617-624.

Baross, J. and Liston, J. 1970. Occurrence of *Vibrio parahaemolyticus* and related haemolytic *Vibrio* in Marine environments of Washington State. *Appl. Microbiol.,* 20: 179-186.

Björnsson, B. and Ólafsdóttir, S. R. 2006. Effects of water use, water quality, blood physiology and growth rate of juvenile cod (*Gadus morhua). Aguaculture,* 256: 255-263.

Ellis, T., North, B., Scott, A. P., Bromage, N. R., Porter, M. and Gadd, D. 2002. The relationships between stocking density and welfare in farmed rainbow trout. *J. Fish Biol.,* 61: 493–531.

Funan, L. A. and Ottey, D. R. 1993. Temperature effects on spontaneous behavour of larval and juvenile red drum *Sciaenops ocellatus* ad implications for foraging, *Fish. Bull.,* 91: 23-35.

Imelda-Joseph, Shoji Joseph, Boby Ignatius, Syda Rao, G., Sobhana, K. S., Prema, D. and Molly Varghese 2010. A pilot study on culture of Asian seabass *Lates calcarifer* (Bloch) in open sea cage at Munambam, Cochin coast, India. *Indian J. Fish.,* 57(3): 29-33.

Karakassis, I., Tsapakis, M., Hatziyanni, E. and Pitta, P. 2001. Diel variation of nutrients and chlorophyll in sea bream and sea bass cages in the mediterranean. *Fresenium Enviroment. Bulletin* 10(3): 278-283.

Katersky, R. S. and Carter, C. G. 2005. Growth efficiency of juvenile barramundi, *Lates calcarifer*, at high temperatures. *Aquaculture,* 250 (3-4): 775-780

Kikuchi, K., Iwata, N. and Takeda, S. 2002. Production of Japanese flounder in closed recirculating aquaculture system. *Fish. Sci.* 68: 851–854.

Kungvankij, P., Pudadera, B. J. Jr., Tiro, L. B. and Potestas, I. O. 1984. Biology and culture of seabass (*Laces calcarifer). NACA Training Manual Series*, 3: 67 pp.

Lemarié, G., Dosdat, A., Covés, D., Dutto, G., Gasset, E. and Person-Le Ruyet, J., 2004. Effect of chronic ammonia exposure on growth of European seabass (*Dicentrarchus labrax*) juveniles. *Aquaculture,* 229: 479–491.

Leong, T. S. 1989. Marine fish diseases. Malaysian experience. In: Cheah, S. H. and Saidin, T. H. (Eds.), *New Technologies in Aquaculture.* Occasional Publication No. 6, Malaysian Fisheries Society, Serdang, p. 91-101.

Mackkinnon, M. R. 1989. Status and potential of Australian *Lates calcarifer* culture. *Advances in Tropical Aquaculture*, Tahiti, Feb 20 - March 4, 1989. *AQUACOP IFREMER Actes de Colloque,* 9: 713-727.

Molina-Domínguez, López, L. G., Vergara, J. M. and Robaina, L. 2001. A comparative study of sediments under a marine cage farm at Gran Canaria Island (Spain). Preliminary results. *Aquaculture,* 192: 225-231.

Papoutsoglou, S. E., Tziha, G., Vrettos, X. and Athanasiou, A. 1998. Effects of stocking density on behavior and growth rate of European sea bass (*Dicentrarchus labrax*) juveniles reared in a closed circulated system. *Aquacult. Eng.,* 18: 135–144.

Perez, O. M., Telfer, T. C. and Ross, L. G. 2005. Geographical information systems-based models for offshore floating marine fish cage aquaculture site selection in Tenerife, Canary Islands. *Aquacult, Res.,* 36: 946-961.

Person-Le Ruyet, J., Lacut, A., Le Bayon, N., Le Roux, A., Pichavant, K. and Quemener, L., 2003. Effects of repeated hypoxic shocks on growth and metabolism of turbot juveniles. *Aquat. Living Resour*., 16: 25–34.

Philipose, K. K., Krupesha Sharma, S. R., Sadhu, N., Vaidya, N. and Syda Rao, G. 2010. Some aspects of nursery rearing of the Asian seabass (*Lates calcarifer,* Bloch) in indoor cement tanks. *Indian J. Fish.*, 57(4 : 61-64.

Pichavant, K. K. 2001. Comparative effects of long-term hypoxia on growth, feeding and oxygen consumption in juvenile turbot and European sea bass. *J. Fish Biol.,* 59: 875–883.

Pitta, P., Karakassis, I., Tsapakis, M. and Zivanovic, S. 1999. Natural vs. mariculture induced variability in nutrients and plankton in the Eastern Mediterranean. *Hydrobiologia*, 391: 181-194.

Ponce-Palafox, J., Martl´nez-Palacios, C. A. and Ross, L. G. 1997. The effects of salinity and temperature on the growth and survival rates of juvenile white shrimp, *Penaeus vannamei*, Boone, 1931. *Aquaculture,* 157: 107–115.

Prema, D., Sobhana, K. S., Laxminarayana, A., Imelda-Joseph, Shoji Joseph, Boby Ignatus, Jeyabaskaran, R., Nandakumar, A., Khambadkar, L. R., Anilkumar, P. S., Shylaja, G. and Syda Rao, 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 J. Fish.,* 57(4) : 53-59.

Qiang Jun, Xu Pao, Wang Haizhen, Li Ruiwei and Wang Hui. 2011. Combined effect of temperature, salinity and density on the growth and feed utilization of Nile tilapia juveniles (*Oreochromis niloticus*). *Aquacult. Res.*, doi: 10.1111/j.1365-2109.2011.02938.x

Santos, G. A., Schrama, J. W., Mamauag, R. E. P., Rombout, J. H. W. M. and Verreth, J. A. J. 2010. Chronic stress impairs performance, energy metabolism and welfare indicators in European seabass (*Dicentrarchus labrax*): The combined effects of fish crowding and water quality deterioration. *Aquaculture,* 299: 73–80

Tucker, Jr., Russel, D. J. and Rimmer, M. A. 2002. Barramundi culture: a success story for aquaculture in Australia. *World Aquacult.,* p. 53–59.

Vargas-Machuca, S. C., Ponce-Palafox, J. T., Arredondo-Figueroa, J. L., Chávez-Ortiz, E. A. and Vernon-Carter, E. J. 2008. Physico-chemical water parameters variation in the floating cages of snappers (*Lutjanus peru* and *L. guttatus*) farmed in tropical sea. *Revista Mexicana de Ingeniería Química,* 7(3): 237-242

Wu, R. S. S., Shin, P. K. S., MacKay, D. W., Mollowney, M. and Johnson, D. 1999. Management of marine fish farming in the sub-tropical environment: a modelling approach. *Aquaculture,* 174: 279–298

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