

Effect of Stocking Density on Growth Performance, Survival and Production of Silver Pompano, *Trachinotus blochii*, (Lacépède, 1801) in Marine Floating Cages

HANNIBAL M. CHAVEZ*, AMPARO L. FANG and AURELIO A. CARANDANG

Bureau of Fisheries and Aquatic Resources IVA-Regional Fisheries Research and Development Center-Freshwater Fisheries Research Station, Bambang, Los Banos, Laguna, Philippines

Abstract

The effect of stocking density on growth performance, survival and production of silver pompano, *Trachinotus blochii*, (Lacépède, 1801) were evaluated in marine floating cages. Juvenile silver pompano (12.4 ± 4.24 g – 15.65 ± 0.35 g) were stocked into HDPE cages measuring 4 m x 4 m x 3 m. Three treatments with two replicates were used: T1-25 pcs·m⁻³; T2-30 pcs·m⁻³; and T3-35 pcs·m⁻³. Silver pompano were fed twice daily with commercial pellets (48% to 44% protein) at 10%, 8%, 6% and 4% body weight for the first, second, third and fourth month, respectively. After 120 days, the best growth performances (determined in terms of average weight) were recorded in T1 (368.29 g) and T2 (368.0 g) while T3 (304.0 g) recorded the least growth. Production differed significantly among treatments ($P < 0.05$). Feed conversion ratio (FCR) of 1.67, 1.58 and 1.85 in T1, T2 and T3, respectively were not significantly different ($P > 0.05$). Feed conversion efficiency (FCE) ranged from 54.08% to 63.51%. Survival was significantly different among treatments ($P < 0.01$). Highest survival (100%) was attained in T1 with lower stocking density, followed by T2 (99%) and T3 (95%). Survival was greatly influenced by the stocking densities in all treatments. Production of silver pompano in marine floating cages was found to be technically and economically feasible.

Introduction

Marine cage culture nowadays, is gaining more attention among researchers, investors, stakeholders and commercial producers due to the decline of wild fish stocks. Most of the species being reared in this condition are marine high value species. The silver pompano, *Trachinotus blochii*, (Lacépède, 1801) is considered as a promising species for mariculture because it easily adapts to the culture environment. It readily accepts formulated feeds since it is omnivorous and has a rapid and uniform growth rate compared to other farmed fishes. Aside from these, the pompano has an attractive appearance and a firm, white and tasty meat making it a premium fish popular to high-end restaurants. The potential market for this high value finfish is enormous considering the high domestic and international market demand for premium fin fishes (Mc Master et al. 2003).

In aquaculture, growth rate, fish size and total production are the important factors that determine the price of the fish in the market. It is not surprising then, if farmers will want to

*Corresponding author. E-mail address: bfarrfrdc@yahoo.com

intensify their cage culture in order to attain higher fish production and higher market price for their fish. However, intensification of cage culture should not lead to overstocking or overcrowding of the fish which often results in a high production but smaller-sized and low quality fish. Stocking density is thus, a major aspect to consider.

Stocking density is an important factor to take into account when ranking families or progeny groups for growth performance. Fish density is a key factor affecting growth and maturation of wild and cultured fish besides food supply and its quality, genetics and environmental conditions (Smith et al. 1978; Khattab et al. 2004). In many cultured species, growth is inversely related to stocking density and this can be attributed to social interactions (Holm et al. 1990; Haylor, 1991; Miao, 1992; Huang and Chiu, 1997; Canario et al. 1998; Irwin et al. 1999, Silva et al. 2000). Ellis et al. (2002) demonstrated that rearing fish at inappropriate stocking densities may impair growth and reduce immune competence due to factors such as social interactions and deterioration of water quality, which can affect both feed intake and conversion efficiency of the fish.

Social interactions through competition for food and or space can negatively affect fish growth (Khattab et al. 2004). This study was aimed to evaluate the effects of three stocking densities on the growth performance, survival and production of pompano *T. blochii*, (Lacépède, 1801) in marine floating cages.

Materials and Methods

The study was conducted in the mariculture zone at Padre Burgos, Quezon, Philippines. Six units of high density polyethylene (HDPE) cages measuring 4 m x 4 m x 3 m were used. Silver pompano fingerlings were procured at Aquasor in General Santos City, South Cotabato, Philippines. Stocks were first acclimatized and conditioned in B-net cages until they reached juvenile size. Juvenile silver pompano (12.4 ± 4.24 g - 15.65 ± 0.35 g) were manually counted and stocked in cages early in the morning. The net cages used were made of black knotless net (Super G14) for the first 3 months and knotted black nets (mesh size 40cm) during the 4th month culture period. The experimental design comprised three stocking densities for the treatments with two replicates: T1 ($25 \text{ pcs} \cdot \text{m}^{-3}$), T2 ($30 \text{ pcs} \cdot \text{m}^{-3}$) and T3 ($35 \text{ pcs} \cdot \text{m}^{-3}$) arranged in a completely randomized design.

The stocks were fed twice a day with commercial pellets containing 48% crude protein for the 1st month, 46% crude protein for the 2nd and 3rd month, and 44% crude protein for the 4th month. Feeding rate was 10% for the 1st month and thereafter was reduced to 8% for the 2nd month, 6% for the 3rd month and 4% body weight for the 4th month.

Random sampling was done monthly wherein stocks were individually weighed and measured to determine the growth and to adjust the feeding ration. During sampling, the stocks were placed separately in an aerated basin to avoid stress. After 120 days of culture, silver pompano were harvested by hauling the bottom of the cage net to the surface and by scooping the stocks. Total

weight and number of silver pompano per treatment per cage were recorded. Daily weight gain (DWG), specific growth rate (SGR) and feed conversion ratio (FCR) were calculated as described by Watanabe et al. (1996) as follows:

$DWG = (\text{final wt} - \text{initial wt})/\Delta t$; and

$SGR (\% \text{ body weight day}^{-1}) = [(\ln \text{ final wt} - \ln \text{ initial wt}) 100]/\Delta t$, where $\ln$ = natural log.

FCR and FCE described by Yongquing et al. (1994):

$(FCR) = \text{feed intake} / \text{weight gain}$; and

$FCE = \text{total weight gain per total amount of feed} \times 100$ (Yongquing et al. 1994).

Physico-chemical parameters such as temperature, pH, dissolved oxygen and salinity were monitored monthly. Temperature and pH were measured using YSI pH10, dissolved oxygen using YSI DO meter and salinity using a refractometer.

Statistical Analysis

One-way analysis of variance (ANOVA, $P < 0.05$, 0.01) was used to determine if significant differences existed in the mean growth, survival, feed conversion ratio, feed conversion efficiency and production among treatments. Scheffe Test was used to compare the significant differences between treatments. Analyses were carried out with SPSS 13.0 for Windows.

Results

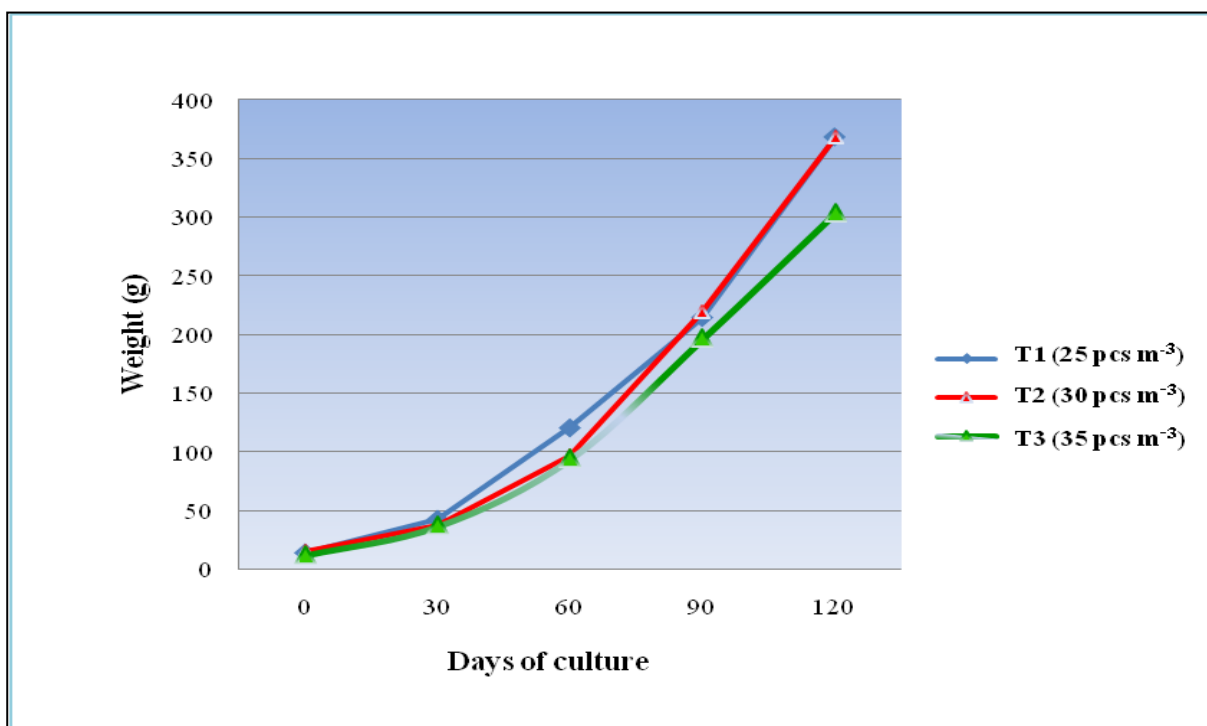
The results of the growth parameters are presented in Table 1. The growth of silver pompano at three stocking densities was not significantly different among treatments ($P > 0.05$). The best growth was attained for silver pompano with mean weights of 368.29 ± 25.39 g and 368.0 ± 16.97 g at harvest in T1 and T2, respectively. This was followed by T3 with a mean weight of 304.0 ± 2.83 g (Fig. 1). The SGR and DWG did not differ significantly among treatments ($P > 0.05$). DWG ranged from 2.43 to 2.95 g day^{-1} and SGR ranged from 2.63 to $2.72\% \text{ BW day}^{-1}$. The FCR was low ranging from 1.58 to 1.85 but were not significantly different among treatments ($P > 0.05$).

Table 1 shows that the values obtained for feed conversion efficiency were not significantly different among treatments ($P > 0.05$). It was noted that feed conversion efficiency increased in T1 and T2. Food was converted into fish biomass efficiently as indicated by the highest feed conversion efficiency of 60.41% and 63.51%, respectively. In T3, food was converted least efficiently into fish biomass at higher stocking density of 35 pcs m^{-3} , as indicated by the lowest feed conversion efficiency (54.08%).

Table 1. Growth performance of silver pompano *T. blochii*, (Lacépède, 1801) after 120 days culture in marine floating cages (mean±SD).

Parameter	T R E A T M E N T		
	T1 T1 (25 pcs·m ⁻³)	T2 (T2 30 pcs·m ⁻³)	T3 (T3 35 pcs·m ⁻³)
Initial			
Weight (g)	14.1±0.84	15.65±0.35	12.4±4.24
Length (cm)	8.8±0.14	9.05±0.07	8.05±0.35
Final			
Weight (g)	368.29±25.39	368.0±16.97	304.0±2.83
Length (cm)	27.6±0.84	28.0±0.98	25.5±0.42
SGR (% BW·day ⁻¹)	2.72±0.01	2.63±0.02	2.69±0.28
DWG (g·day ⁻¹)	2.95±0.20	2.93±0.14	2.43±0.01
Survival (%)**	100.0±0 ^b	99.0±0.71 ^{ab}	95.0±0.71 ^a
FCR	1.67±0.33	1.58±0.14	1.85±0.048
FCE (%)	60.41±12.5	63.51±6.1	54.08±2.5
Total Yield (kg)*	883.90 ^a	1,049.06 ^b	970.34 ^{b^{ab}}
Production Rate (kg m ⁻³)*	9.21±0.0 ^a	10.93±0.43 ^b	10.11±0.02 ^{ab}

Values having a different superscripts are significantly different (*P<0.05; **P<0.01)

**Fig. 1.** Growth performance of silver pompano, *T. blochii*, (Lacépède, 1801) after 120 days culture period in cages.

Production was significant among treatments ($P < 0.05$). Highest total production was obtained in T2 (1,049.06 kg), followed by T3 (970.34 kg) and T1 (883.90 kg). Survival was significantly different among treatments ($P < 0.01$). Highest survival was obtained in T1 (25 pcs·m⁻³) followed by T2 (30 pcs·m⁻³) and T3 (35 pcs·m⁻³) at 100%, 99% and 95%, respectively.

The length-weight relationship was determined using the following equation: $W_t = 0.021 L^{2.9422}$ (Fig. 2). This equation corresponds to $\log W = 1.04954 + 2.9422 \log L$ ($r = 0.9903$). The length-weight relationship exhibited a highly significant difference among treatments ($P < 0.01$). The values relate to the well being index associated to the individuals with highest weights for a given length (Castillo-Vargasmachuca et al. 2007). The asymptotic values indicate an isometric growth, that is, the length increases proportionally with its weight.

The mean values of the water parameters are shown in Fig. 3. All water quality parameters measured had no significant differences among treatments ($P > 0.05$). Mean temperature ranged from 27.0 to 28.5 °C. Concentrations of dissolved oxygen ranged from 6.07 to 7.63 mg·L⁻¹, pH from 7.54 to 8.25 and salinity from 30-35 ppt. Water parameters were within tolerable range throughout the experimental period.

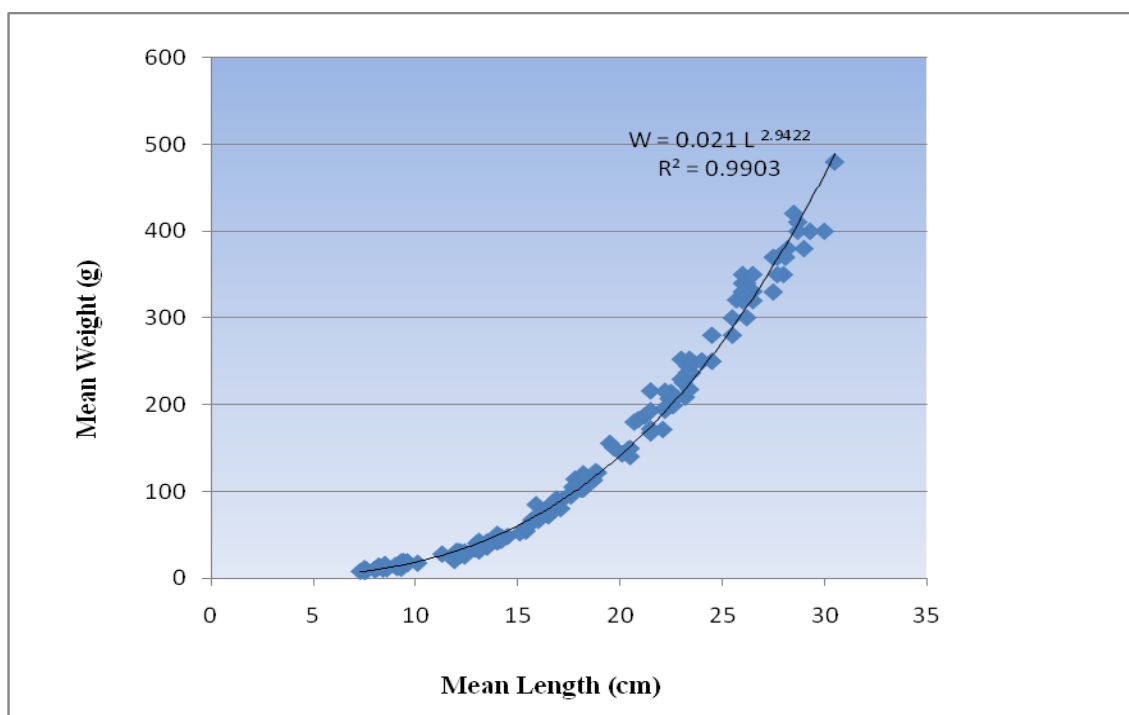


Fig. 2. Length-weight relationship of silver pompano, *T. blochii* (Lacépède, 1801) cultured at three stocking densities in marine floating cages after 120 days culture period.

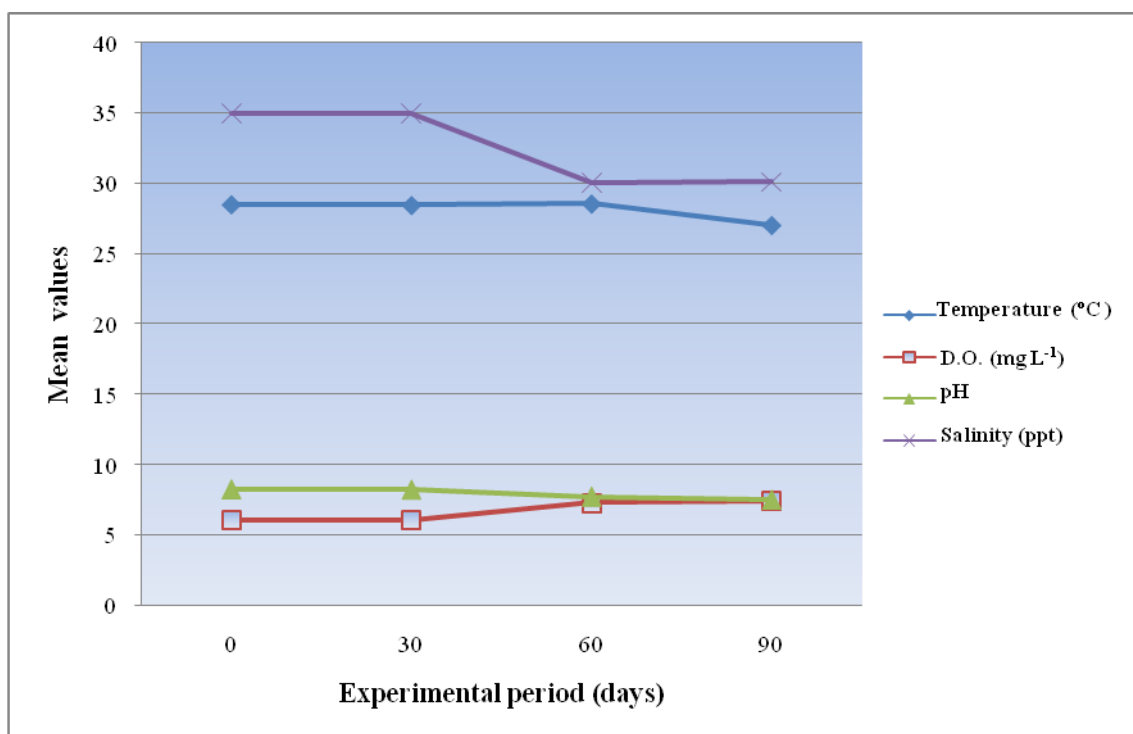


Fig. 3. Mean values of the water parameters throughout the culture period.

Discussion

Preliminary studies with pompano revealed that this species exhibits many favorable traits for aquaculture: it adapts to intensive culture systems, readily accepts pelleted feed, tolerates a wide range of salinities, and has high initial growth rates (Groat, 2002). This was also observed during the 4- month culture period in silver pompano.

Results after 120 days culture of silver pompano in marine floating cages showed no significant difference in mean weights among treatments ($P > 0.05$). Groat (2002), stressed that juvenile pompano require only two feedings per day and fish fed twice per day had the greatest mean weight gain and the highest final body weight. Highest growth and survival of silver pompano were attributed to different size and proximate composition of feed (48%-44%) and the feeding management practice from the initial stage to the end of the culture period. Several studies on stocking densities with juvenile, midwater species such as turbot (*Scophthalmus maximus*), red porgy (*Pagrus pagrus*), European sea bass (*Dicentrarchus labrax*) and gilthead sea bream (*Sparus aurata*) revealed varying results. However, European sea bass attained significantly higher growth rates when stocked at higher densities (2-4 kg·m⁻³). Studies on higher stocking densities over 15 kg·m⁻³ had been conducted in cage culture of other fish species, such as seabass (Kissil et al. 2000), salmonids (Roberts and Hardy, 2000), Japanese flounder (Min, 1995) and red sea bream (Ikenoue and Kafuku, 1992). However, experimental studies on growth utilizing lower stocking densities of 5 and 25 fingerlings·m⁻³ have been used for snappers (Benetti et al. 2002) and 1.26 to 3.24

fingerlings·m⁻³ (Castillo-Vargasmachuca et al. 2007) and this study (25 to 35 pcs·m⁻³). Maragoudaki et al. (1999) and Irwin et al. (1999) reported that juvenile red porgy and turbot exhibit higher growth rates at relatively low densities (0.7–1.1 kg·m⁻³). Silver pompano exhibit a strong schooling behavior, similar to that of European sea bass and milkfish, indicating that the growth of silver pompano could be increased at moderate to high stocking densities. However, this could induce stress and cause growth inhibition since silver pompano are extremely active fish. Lower stocking densities are sufficient to prove the technical viability of rearing pompano in marine floating cages.

The increases in the average weight of silver pompano in this study were considerably higher than the studies reported by Cremer and Jian (1999) and Cremer et al. (2001) considering the FCR, good growth indicators, good economic return and achieving marketable size over a short period of time. The commercial pellets containing 44-48% crude protein and 12-14% crude fat used in the study performed satisfactorily in terms of growth and FCR. The findings in this study also conform with the observations made in the culture of yellow tail (*Seriola quinqueradiata*) and mutton snapper (*Lutjanus analis*) which exhibited good growth rates when fed with formulated feeds (Watanabe et al. 1991; Benetti et al. 2002).

In this study, the FCR (1.58 to 1.85) is quite similar to that reported by Manomaitis and Cremer (2007) with an FCR value of 1.84, but better than those reported by Lan et al. (2007) from 2.51 to 2.59, McMaster et al. (2006) with FCR value of 3.0 and Cremer and Jian (1999) with 2.13 and 2.23 with pompano.

The decreasing values of feed conversion ratio obtained in this study with lower stocking density indicate that progressively larger portion of food was used for growth. Fish assimilated the feed consumed more efficiently at lower stocking density. The higher FCE with low stocking density indicates that a higher proportion of the food energy was utilized for growth. The FCE observed in the present study (54.08% to 63.51%) was quite similar to that reported by Groat (2002) at 63% to 81% but better than those reported from other studies with pompano. Tatum (1972) reported an FCE of 30% for pompano while Lazo et al. (1998) showed FCE values of 31% to 51%. In this study, the high FCE observed may be attributed to higher protein composition (48 to 44%) and crude fats (14-12%) of feeds used.

The survival obtained in this study was very promising (100% to 95%). Almost the same observations were also reported by Manomaitis and Cremer (2007) and Lan et al. (2007) with pompano (*T. blochii*) in cages with a survival rate of 99%. However, lower survival rate was reported by Cremer and Jian (1999) with pompano (*Trachinotus ovatus*) in cages (72%) and 42% in ponds (Mc Master et al. 2006). The high survival rate in this study can be attributed to the proper acclimatization and conditioning of stocks prior to the experiment. The use of juvenile silver pompano as initial stock size, the size and composition of feeds, feeding management, environmental conditions and the water quality in the area were within the tolerable range.

Throughout the experimental trials, the silver pompano proved to be a hardy fish, and tolerant to a wide range of environmental conditions.

Conclusion

Cage farming of silver pompano, *T. blochii*, (Lacépède, 1801) in marine floating cages showed promising results considering the FCR, survival rate, good growth indicators, and good economic returns from achieving marketable size over a short period of time. The results of the study justify the need to commercialize the technology on pompano culture which could serve as a livelihood for fisher folk and will certainly add to the fish production of the region.

Acknowledgement

We would like to thank the support of Rosa F. Macas, DFT, CESO III, Regional Director of the Bureau of Fisheries and Aquatic Resources, Region IVA, for her never-ending support and encouragement. To my staff, Marvin P. Nasino and Anna Merlinna T. Fontanilla for their technical contributions on project implementation and statistical analyses. The authors also wish to express their gratitude to the anonymous referees for their valuable comments on the manuscript.

References

- Benetti, D.D, J.A. Mattera, O.M. Stevens, J.F. Alarcon, M.W. Feeley, F.J. Rotman, Y. Minemoto, G. Banner-Stevens, J. Fanke, S. Zimmerman and L. Eldridge. 2002. Growth, survival, and feed conversion rates of hatchery-reared mutton snapper *Lutjanus analis* cultured in floating net cages. *Journal of the World Aquaculture Society* 33:349-357.
- Canario, A.V.M., J. Condeca, D.M. Power and P.M. Ingleton. 1998. The effect of stocking density on growth in gilthead seabream, *Sparus aurata* (L.) *Aquaculture Resources* 29:177-181.
- Castillo-Vargasmachuca, S., J.T. Ponce-Palafox, C.E. Ortiz and J.L. Arredondo-Figueroa. 2007. Effect of the initial stocking body weight on growth of spotted rose snapper *Lutjanus guttatus* (Steindacher, 1869) in marine floating cages. *Revista de Biología Marina y Oceanografía* 42:261-267.
- Cremer, M.C. and Z. Jian. 1999. Pompano (*Trachinotus ovatus*) growth performance in 1.5 m³ cages with soybean meal and fish meal based feed rations. Results of ASA/China, 1999. Feeding Trial 35-99-73. American Soybean Association. <http://www.aces.edu/dept/fisheries/aquaculture/pdf/documents/99PompanoLVHDTShenzhen.pdf>.
- Cremer, M.C., Z. Jian and P. Lan. 2001. Growth performance of pompano on extruded feed in coastal cages at Hainan, China. Results of ASA/China Feeding Trials 35-01-138. American Soybean Association. <http://www.soyaqua.org/pdf2/02PompanoTRHainan.pdf>.
- Ellis, T., B. North, A.P. Scott, N.R. Bromage, M. Porter and D. Gadd. 2002. The relationships between stocking density and welfare in farmed rainbow trout. *Journal of Fish Biology* 61:493-531.

- Groat, R.D. 2002. Effects of feeding strategies on growth of Florida pompano (*Trachinotus carolinus*) in closed recirculating systems. Master Thesis. Louisiana State University and Agricultural and Mechanical College. 64pp.
- Haylor, G.S. 1991. Controlled hatchery production of *Clarias gariepinus* (Burchell 1922): growth and survival of fry at high stocking density. *Aquaculture Fisheries Management* 22:405-422.
- Huang, W-B. and T-S Chiu. 1997. Effects of stocking density on survival, growth size variation, and production of Tilapia fry. *Aquaculture Resources* 28:165-173.
- Holm, J.C., T. Refstie and S. Bo. 1990. The effect of fish density and feeding regimes on individual growth rate and mortality in rainbow trout (*Oncorhynchus mykiss*). *Aquaculture* 89:3-4.
- Ikenoue, H. and T. Kofuku. 1992. Mode methods of aquaculture in Japan. Elsevier, Amsterdam. 274 pp.
- Irwin, S., J.O. Halloran and R.D. Fitzgerald. 1999. Stocking density, growth and growth variation in juvenile turbot, *Scophthalmus maximus* (Rafinesque). *Aquaculture* 178:77-88.
- Khattab, Y.A.E., M. Abdel-Tawwab and M.H. Ahmad. 2004. Effect of protein level and stocking density on growth performance, survival rate, feed utilization and body composition of Nile tilapia fry (*Oreochromis niloticus* L.). In: New Dimension in Farmed Tilapia. Proceedings of the Sixth International Symposium on Tilapia in Aquaculture. (eds. R.B. Bolivar, G.C. Mair and K. Fitzsimmons), Manila, Philippines 1:264-276.
- Kissil, G.W., A. Tandler, A. Colorni and A. Elizur. 2000. Sea bass culture. In: Encyclopedia of Aquaculture (ed. R.R. Stickney), pp. 778-784. John Wiley and Sons Inc., New York.
- Lan, H.P., M.C. Cremer, J. Chappell, J. Hawke and T. O'Keefe. 2007. Growth performance of Pompano (*Trachinotus blochii*) fed fishmeal and soy based diets in offshore OCAT Ocean Cages. Results of the 2007 OCAT Cage Feeding Trial in Hainan, China. <http://www.soyaqua.org/pdf3/07OCAT>.
- Lazo, J.P., D.A. Davis and C.R. Arnold. 1998. The effects of dietary protein level on growth, feed efficiency and survival of juvenile Florida pompano (*Trachinotus carolinus*). *Aquaculture* 169:225-232.
- Manomaitis, L. and C.M. Cremer. 2007. Performance of pompano fed soy-optimized, extruded feed using ASA-IM low volume high density cages in Vung Tau province, Vietnam. Results of ASA-IM/Soy-in-Aquaculture 2007, Feeding Demonstration Project. American Soybean International Marketing (ASA-IM).
- Maragoudaki, D., M. Paspais and M. Kentouri. 1999. Influence of stocking density of juvenile red porgy (*Pagrus pagrus*) under different feeding conditions. *Aquaculture Research* 30:501-508.
- McMaster, M.F., T.C. Kloth, J.F. Coburn and N.E. Stolpe. 2006. Florida pompano *Trachinotus carolinus* is an alternative species for low salinity shrimp pond farming. In: Aquaculture America 2006. Mariculture Technologies International Inc. <http://www.mariculturetechnology.com/MTIPompano2006.pdf>.
- McMaster, M.F., T.C. Kloth and J.F. Coburn. 2003. Prospects for commercial pompano mariculture-2003. *Aquaculture America* 2003. <http://www.mariculturetechnology.com/AquacultureAmerica03.pdf>.
- Miao, S. 1992. Growth and survival model of redbait shrimp *Penaeus pencillatus* (Alock) according to manipulating stocking density. *Bulletin of the Institute of Zoology Academia* 31:1-8.

- Min, B.S. 1995. A review of the nursery and grow-out culture techniques for flounder (*Paralichthys olivaceus*) in Korea. In: Culture of high-value marine finfish in Asia and the United States (eds. K.L. Main and C. Rosenfeld), pp. 147-152. The Oceanic Institute, Honolulu, Hawaii, USA.
- Roberts, R.J. and R.W. Hardy. 2000. Salmon culture. In: Encyclopedia of Aquaculture. (ed. R.R. Stickney), pp. 773-778. John Wiley and Sons Inc., New York.
- Silva, P.C., V.L. Souza, D.M.C. Padua, P.C. Dalacorte and D.C. Goncalves. 2000. Effect of stocking density on growth and fillet composition of tetra hybrid red tilapia, Israeli strain. In: Tilapia Aquaculture in the 21st Century. Proceedings of the Fifth International Symposium on Tilapia in Aquaculture (eds. K. Fitzsimmons and J.C. Filho), Rio de Janeiro, Brazil 2:341-345.
- Smith, H.T., C.B. Schreck and O.E. Maughan. 1978. Effect of population density and feeding rate on the flathead minnow (*Pimephales promelas*). Journal of Fish Biology 12:449-445.
- Tatum, W.M. 1972. Comparative growth, mortality and efficiency of pompano (*Trachinotus carolinus*) receiving a diet of ground industrial fish with those receiving a diet of trout chow. Proceedings of the World Mariculture Society 3:65-74.
- Watanabe, T., H. Sakamoto, M. Abiru and J. Yamashita. 1991. Development of a new type of dry pellet for yellowtail. Nippon Suisan Gakkaishi 57:891-897.
- Watanabe, W.O., J.R. Chan, S.J. Smith, R.I. Wicklund and B.L. Olla. 1996. Production of Florida red tilapia (*Oreochromis* sp.) in flow through seawater pools at three stocking densities. Conference Proceedings of the Third International Symposium on Tilapia in Aquaculture (eds. R.S.V. Pullin, J. Lazard, M. Legendre, J.B. Amon Kothias and D. Pauly). ICLARM.41:168-174.
- Yongquing, M., L.L. Yongjian, T. Ding, T. Lixia and D. Dong Fang. 1994. Studies on protein to energy ratio (DP/DE) in diets of grass carp, *Ctenopharyngodon idellus* (C. Et Val.). In: Fish Nutrition Research in Asia. Proceedings of the Fifth Asian Fish Nutrition Workshop (ed. S.S. De Silva), pp. 43-47. The Asian Fisheries Society, Manila, Philippines.