EVALUATION OF THE GROWTH AND MORTALITY OF THE OYSTERS (*Crassostrea gigas*, THUNBERG, 1795) IN THE SEA FARM IN ARRAIAL DO CABO, RJ

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ABSTRACT

This study, carried out during 7 months, evaluated the growth and mortality of oyster *Crassostrea gigas* cultured at long-lines in Arraial do Cabo/ RJ at 3 initial stocking densities 500, 1,000 and 1,500 oysters / floor), maintained the pattern of density larger, medium and smaller throughout experiment. Lowest stocking density of all months displayed significant difference of greater growth than other densities. From June to September was the most representative phase of growth (11.4±5.2 mm to 51.1±11.8 mm). In October and November had low growth rate suggesting that natural reduction in final stage of development. The high mortality was observed in July and October when it presented rates of 31% and 36%. The reduction in mortality as population stoking density increase, recorded only in August and September, suggests that density was not a factor limiting in other months. Although the low upwelling events in the region this period, a satisfactory growth was reached.

Keywords*: Crassostrea gigas*; Stocking density; Growth; Mortality; Arraial do Cabo

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RESUMO

Este estudo, realizado durante 7 meses, avaliou o crescimento e mortalidade de ostras *Crassostrea gigas* cultivadas em sistema suspenso em Arraial do Cabo/RJ com 3 densidades iniciais de estocagem (500, 1.000 e 1.500 ostras / andar), mantendo o padrão de densidade maior, intermediária e menor ao longo do experimento. A menor densidade em todos os meses apresentou diferença significativa de crescimento em comparação às outras densidades. De junho a setembro houve a fase de crescimento mais representativa (11,4±5,2 mm a 51,1±11,8 mm). Foi observada maior mortalidade nos meses de Julho e Outubro, quando se registrou taxas de 31% e 36%, respectivamente. A redução da mortalidade conforme aumento densidade, observada apenas em agosto e setembro, sugere que a densidade não foi um fator limitante nos outros meses. Apesar da reduzida incidência de ressurgência no período, a região apresentou um satisfatório crescimento de *C. gigas*.

Palavras-chave: *Crassostrea gigas*, Densidade de Estocagem, Crescimento, Mortalidade, Arraial do Cabo.

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INTRODUCTION

In global terms, the aquaculture contributed in 2001, with more than 48.4 million tons, through a mean annual growth in the last decade of 9.2% against only 1.4% of fishes (FLORES-VERGARA *et al.*, 2004). The aquaculture activity has been indicated like an excellent alternative source of production and economic growth for population in some regions in the world.

The Pacific oyster, *Crassostrea gigas*, is the first species more cultured in aquaculture with several sea farms dedicate to its production around the world, such as: France (DÉGREMONT *et al.*, 2005; GANGNERY *et al.*, 2003; FRÉCHETTE *et al.*, 2003; BERTHELIN *et al.*, 2000), Italy (SARÀ and MAZZOLA, 1996), Mexico (FLORES-VERGARA *et al.*, 2004;), China (HUANG *et al.*, 2006); Australia (HONKOOP and BAYNE, 2002); Indonesia (TAYLOR *et al* 1997); Korea (NGO *et al.,* 2006), including Brazil and your native country, Japan. This culture has great economic importance around the world, with production around 4.0 million tons or the equivalent to 3.44 billion dollars in 2000 (FLORES-VERGARA *et al.*, 2004).

In Brazil, *C. gigas* adapted very well to south and southeastern coast cold waters (21°C - 24°C) and to salinity (35 psu), became the main species cultured in Santa Catarina and Rio de Janeiro. Initially, bivalves culture intended to complete the income of the fishers, but today it has been become the main source of income and creating new perspectives to these people (COSTA, 1985).

Several culture studies on bivalves species have reported that high population density creates a lower growth and a higher mortality these organisms than low density (TAYLOR *et al.*, 1997). Furthermore, high population density affects the valves form, damaging its acceptation in the market, consequently (MACCACCHERO *et al.*, 2005). Thus, to optimize the density can be a great benefit for oyster farmers, becoming possible a more profitable production. The technician use helps and scientific experiments applied to aquaculture are essential complements for the economic development of the activity.

The objective of this study was to evaluate the growth and the mortality of oysters at different densities during 7 months (April to November 2005).

MATERIALS AND METHODS

This work was carried out in the sea farm ACRIMAC, located in Forno Cove (RESEXMAR-IBAMA), between the coordinates 22˚58`05.4”S to 42˚00`21.3”W; 22˚58`08.1”S to 42˚00`19.3”W; 22˚58`09.9”S to 42˚00`22.2”W and 22˚58’07.2”S to 42˚00`24.2”W, in Arraial do Cabo city (Figure 1). In this region there were higher upwelling events during spring and summer than other seasons by fertilization of subtropical water mass South Atlantic Central Water (SACW) (VENTURA and PIRES, 2002). It becomes that region with high nutrients value and propitiates for moluscs cultive.

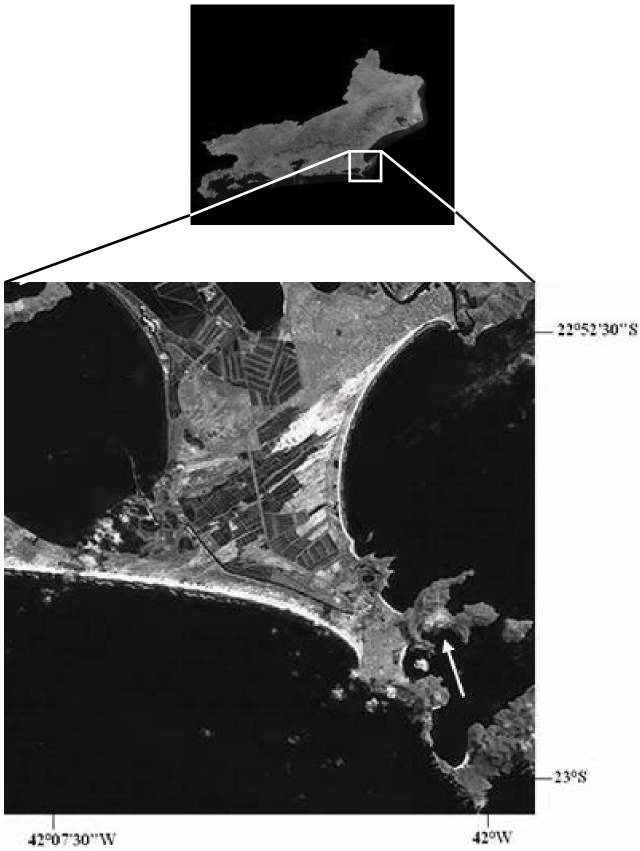

Figure 1. Location of the Forno Cove (arrow), Arraial do Cabo/RJ

From April to November 2005 the growth and mortality rates of oysters *C. gigas* were verified at different densities (a low, a medium and a high) in suspended culture long-line. The spats produced in a hatchery of Santa Catarina came in April, measuring 3mm and were placed in initial in densities of 500, 1,000 and 1,500 / floor of lantern nursery. It had 1mm mesh and was divided in 5 tiers for plastic trays with height of 30 cm between the floors. The lanterns were deployed to a depth of 7 m and the 2 m from the bottom tied to one long-line of 100 m throughout study.

The handling of oysters, lanterns and oysters cleaning and fouling detachment was made in monthly intervals. The oysters cultured were placed at 3 distinct densities to assess growth and mortality. The densities were chosen by amount of available oysters in period. The growth was evaluated by measurement of the distance between umbo and shell opposing extremity of 20 oysters / floor randomly selected of each lantern.

In May and June, the survival of the oysters was not calculated because of reduced size (about 9 mm) these organisms, therefore, the mortality started to be quantified from July. The mortality percentage of oysters was calculated by number of dead individuals and empty shells found each month in relation to the total amount of oysters (alive and died). The oysters growth was analyzed through the arithmetic mean and standard deviation of the shells length obtained for each month. The influence of the density was analyzed on the growth and mortality of oysters for each month separately.

All the data of the work were listed and represented graphically, using the *Microsoft Office Excel* program (version 2003). The statistical analysis to verify possible significant differences ($P < 0,05$) in the oysters growth among three different experimental densities was applied by statistical test ANOVA, using the *Statistica* program (Statsoft, version 7.0).

RESULTS AND DISCUSSION

The growth and mortality of *C. gigas* are two factors which more affect directly the culture productivity, coupled with the characteristics physicist-chemistries of the water and to the culture handling, represented for the high population density (POLI, 2004). Within common mistakes in culture it is high population density of oysters, loss of the lanterns due to knots badly made and lack of water circulation inside of the lanterns, due to accumulation of sediment in the opening of the mesh. Therefore, it is necessary frequent cleaning of the oysters and lanterns, elimination of the predators and, mainly, reduction of the population density as its growth. Several studies carried out with different bivales species in field have demonstrated that the growth at great densities is lower than small densities. Where as the mortality of these individuals can become higher at high densities than low densities.

July and October months presented higher mortality rates, 31% and 36%, respectively, than other months. However, in August and September, there were the lowest mortality rates (Figure 2). The high mortality in July can be coupled with oysters stress in the transport of the laboratory to the sea farm, associated with the losses not-quantified accumulation in May and June of the genetically low spats. In October, whereas the oysters loss seems to be more related to the abundance of *Cymatyum. parthenopeum*. The mean values of the length (Figure 3), in the two first months, were well similar, characterizing a beginning of growth. June to September months displayed a representative increase possibly due to better conditions of the water and reduced number of predators in this period. For the following months, however, there was a soft reduction in mean shell length around 1.5 mm, explained for high mortality of the largest oysters in this period; accented growth less in the final phases of development (BISHOP and HOOPER, 2005) or even though unexpected events which can happen in a culture, as robberies of the production and losses of the lanterns for badly made knots (POLI, 2004). This question of robberies shows the importance of guards (day/night) in the sea farms to prevent futures disruption with the loss of the production and culture equipment.

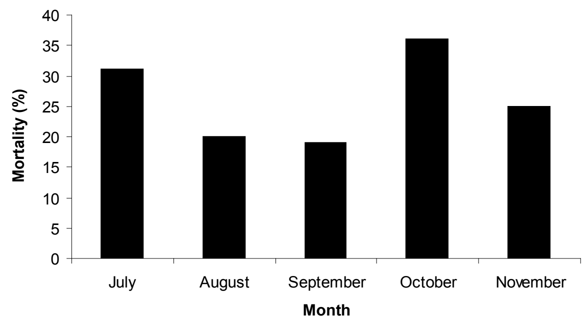

Figure 2. Monthly distribution of mortality

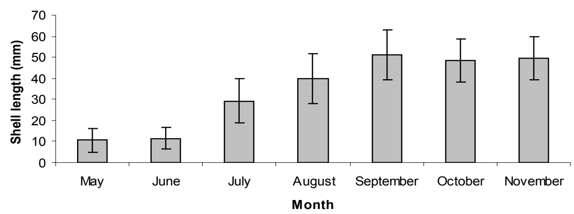

Figure 3. Distribution of the mean ± standard deviation of the shell length (mm).

This fast growth rate of *C. gigas*, in comparison with other species of oysters, was one of the main factors which have stimulated this culture around the world (POLI, 2004). In Todos Santos Bay (BA) *C. gigas* and *C. rhizophorae*, cultured in the same conditions, displayed differences in the growth rates, with *C. gigas* presenting better yield (RAMOS *et al.*, 1986). In Florianópolis (SC), *C. rhizophorae* growing in continuous immersion conditions increased only 2.2 g in 6 months, whereas *C. gigas*, under the same conditions, obtained addition of 14.8 g in its weight (OSTINI and POLI, 1990).

Analyzing growth and density by ANOVA test, there was the significant difference in the growth rates of the lowest density of each month ($P < 0{,}05$) confirmed a better growth of *C. gigas* at this density throughout the work. The idea of the highest population density / floor in the lantern to show slower growth and lower mortality due to greater competition for food and space was confirmed in 5 months of experiment, except in July and November.

In May (Figure 4), the largest oysters (shell length of 16.6±2.7 mm) were deployed at the density of 500, decreasing the shell length as increase in population density. In June, the inverse relation between oysters density and shell length were kept. At density of 200 there was a mean size of 17.2±4.0 mm, against 9.5±4.3 mm of the oysters deployed in 1000 / floor. Thereby these two first months displayed the expected relation between size and population density.

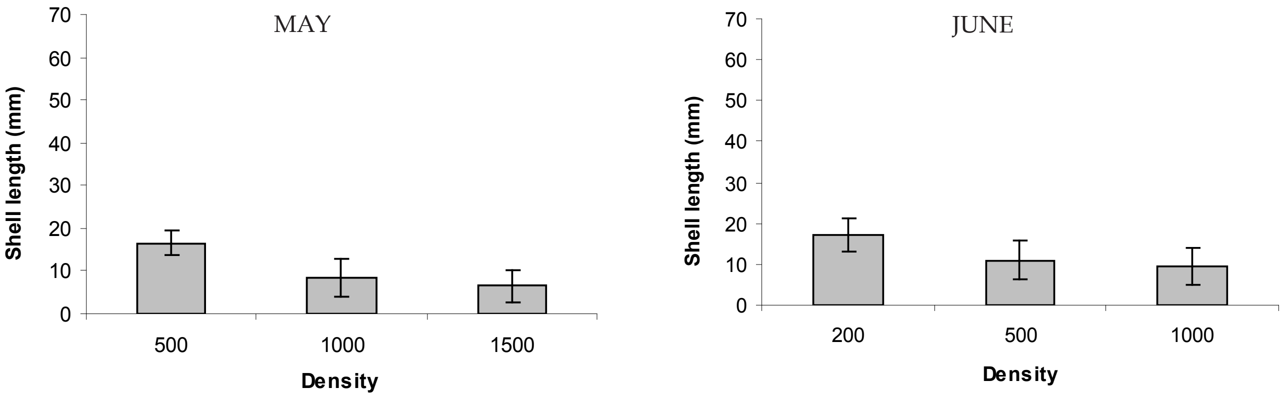

Figure 4. Mean shell length for each density in May and June

TAYLOR *et al.* (1997) reported that juveniles *Pinctada maxima* deployed at reduced density obtained faster growth, higher survival rate and smaller incidence of valves deformities than high density. In present study, in July (Figure 5), the density of 300 oysters reached higher mortality rate (16%), lower variation of oysters size, and lower mean size (18.7±4.5 mm) than other densities. However, the density of 500 obtained the lowest percentage of mortality (5%) with mean growth of 31.2±9.3 mm only. Therefore, the mean size of oysters at the lowest density can be considered greater (33.7±9.9 mm), but it did not obtain lower mortality than other densities. These data seem not to demonstrate relation of the density to the parameters growth and mortality. In this month there were the highest mortality and the lowest growth at the medium density and this can be explained by fragility of these oysters.

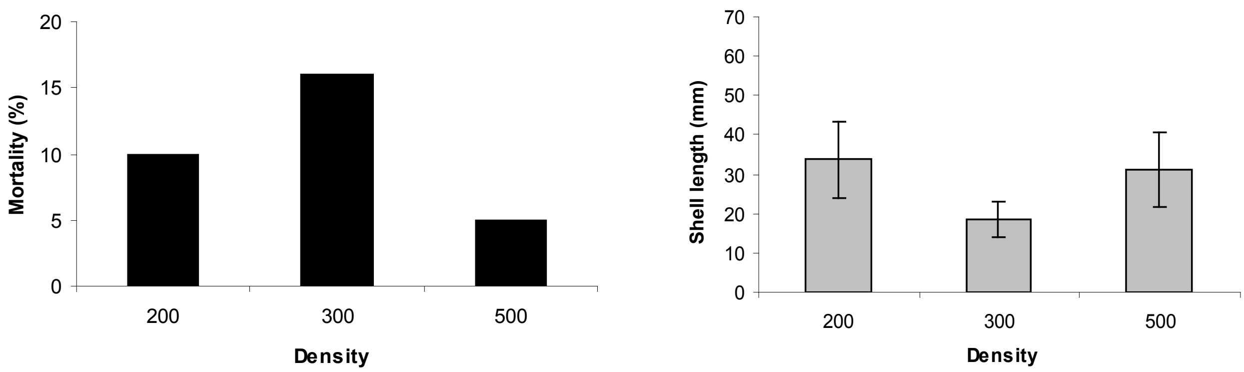

Figure 5. Mortality and mean shell length for each density in July.

In contrast with July, August and September (Figure 6) displayed a direct relation between mortality and density, when mortality rates increased as the increase of oysters amount / floor. About the oysters growth, the relation of size to density was opposite and like expected. There was a decrease of oyster size as population density increased. Therefore, the higher densities were represented by oysters of smaller size. It suggests that factor density may have influenced the growth and mortality of organisms in August and September. However, studies more detailed about growth and mortality are necessary in order to obtain data more accurate, considering water conditions like temperature, food availability and oxygen dissolved, for example.

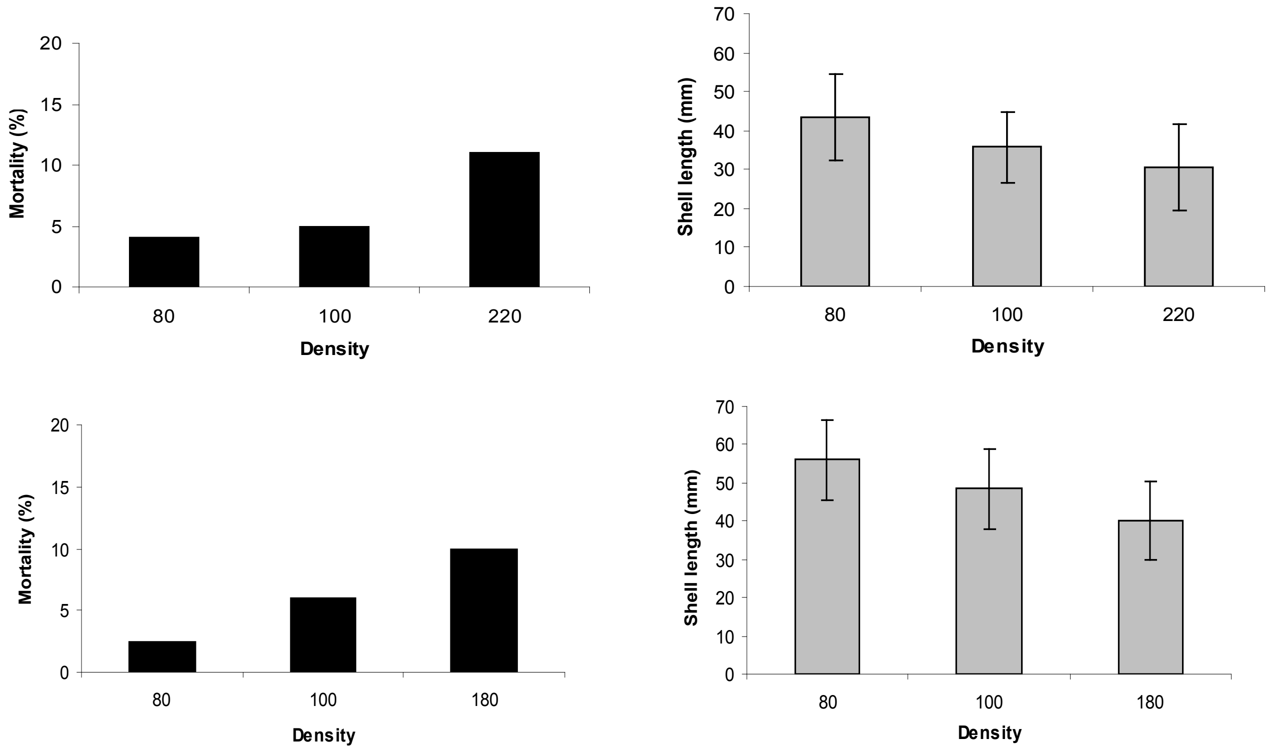

Figure 6. Mortality and mean shell length for each density in August (up) and September (down)

In October (Figure 7), this relation between density and mortality was inversed. This rate reached more 15% at the lowest density, with alive oysters obtained better growth, 57.1±8.2 mm, than other densities. It suggests that there was not the expected effect of density on growth in this month. This way, in November (Figure 8), the loss the most representative was at the lowest density with 15%, coinciding with the largest oysters (56.6±9.1 mm). About growth, an expected relation did not recorded, with the oysters placed at the densities of 40 and 50 reached growth of 43.1±7.2 mm and 48.0±7.2 mm. However, higher density displayed smaller loss of oyster (only 3%) than other densities.

Therefore, in October and November (two last months) the density did not have influence on the mortality, going against the expected. This possibly occurred owing to the highest vulnerability to the depletation by *C. parthenopeum* for the use of lanterns with larger mesh (15 mm) or even though unexpected events like robberies of the production. Although this different standard about the losses to these months the relation of the lowest density corresponding to the largest oysters was kept. We suggest that new studies, using water conditions, should be realized in order to obtain better results to explain the effect of density on growth and mortality of oysters through other factors.

This influence of the density on the mortality is much doubtful for some authors in literature, which defend the idea of the mortality rate is independent of the density in some molluscs species (HOLLIDAY *et al.*, 1991; COTE *et al.*, 1993; MGAYA and MERCER, 1995; HURLEY and WALKER, 1996; TAYLOR *et al.*, 1997a *apud* HONKOOP and BAYNE, 2002). HONKOOP and BAYNE (2002) also did not showed this influence of the density increase in to reflect in high mortality rates of the cultured organisms cultivated when studying two oysters species, *Sacrostrea glomerata* e *C. gigas*.

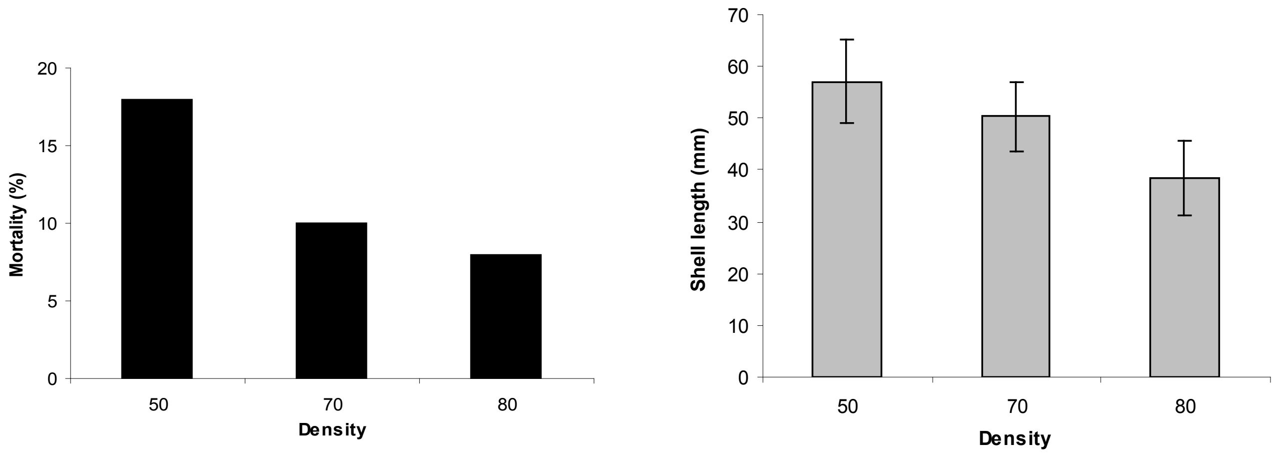

Figure 7. Mortality and mean shell length for each density in October.

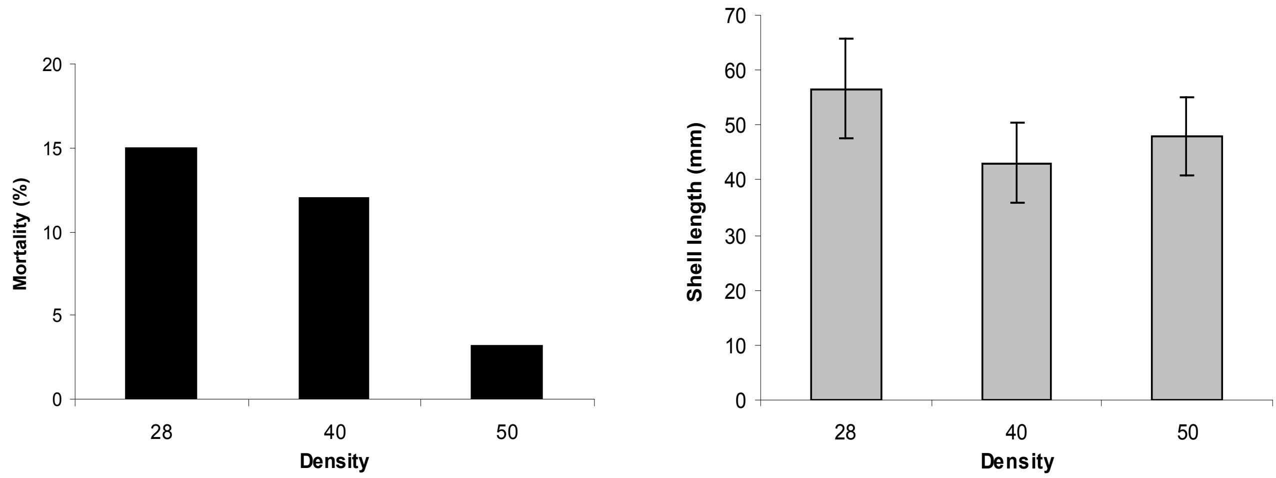

Figure 9. Mortality and mean shell length for each density in November.

The identification of the mortality causes and implementation of appropriate solutions can be well simple when these losses are coupled with the culture method and handling techniques used. For example, deaths for overpopulation can be solved with the reduction in density of organisms / floor of the lanterns; e with the certain depth casting for the culture is possible a reduced effect of the fouling and parasites.

There are also controversies about the density effect on the molluscs growth. HONKOOP and BAYNE (2002) demonstrated a relatively small existence of the density effect on the growth of *S. glomerata* and *C. gigas*. According to these authors, the growth at high densities can be limited by lower food availability, affecting the filtration and to lower physical space among individuals than low densities, damaging the shells. Thus the bivalve needs to place more energy for the repair and so reducing its growth (MACCACCHERO *et al*., 2005).

The depth chosen for the culture and, consequently, the food availability in the water are other factors of influence on the growth of molluscs. SARÀ and MAZZOLA (1997) studied culture in long-lines of oysters *C. gigas* in two depths, 7 m and 13 m. These authors found that oysters at 7 m showed greater size and weight than those at depth 13 m. It was likely owing to culture at 7 m have been more affected by phytoplankton and seasons than other depth. These effects possibly occurred with the oysters cultured in the present study. In contrast, the organisms at 13m were influenced by detrites, affecting directly the filtration mechanism, and less by phytoplankton, because of the luminosity reduction to depth.

However, in situations of high mortality, associates with environmental parameters, this readjustment of the culture methods can not be enough for an efficient solution. For example, in blooms of phytoplankton, it can be harmful through toxins for the production of the oysters (FRÉCHETTE *et al*., 2003).

We demonstrated that a satisfactory *C. gigas* growth was reached with mean size about 56mm in 5 months of culture, although the low upwelling events (Fall/Spring seasons) in the region during study. It also suggests that the culture at few densities is appropriate for all the development of *C. gigas*. For this, would be necessary greater costs to oyster farmer with lanterns, handles, more time and labor, besides high value of *C. gigas* spats. However, this apparent increase in the production cost would be compensated by a better oysters growth at reduced time and by lower mortality rate than production at high densities. So, the period between the investment and the profit would be reduced, generating income more quickly e, consequently, speeding up future productions and stimulating the activity in the place.

CONCLUSIONS

The present work appears to open new ideas with molluscs development in different periods in other sea farms of the Forno Cove. However, new approaches have to be carried out using analysis of environmental parameters. It would be possible a general vision of the areas of culture in state, the handling techniques more adequate, besides knowledge pasted to the oyster farmers of the need dedicated for the production, strengthening, this way, the aquaculture activity in the state.

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REFERENCES

BERTHELIN C.; KELLNER, K. MATHIEU, M. 2000 Storage metabolism in the Pacific oyster (*Crassostrea gigas*) in relation to summer mortalities and reproductive cycle (West Coast of France). *Comparative Biochemistry and Physiology.* Part B *12*: 359-369.

BISHOP, M. J. HOOPER, P. J. 2005 Flow, stocking density and treatment against Polydora spp.: Influences on nursery growth and mortality of the oysters *Crassostrea virginica* and *C. ariakensis*. *Aquaculture*. *246*: 251-261.

COSTA, P. F. da. 1985 Ostreicultura: Biologia e Tecnologia para o Cultivo de Ostras. Cap. 6, parte B. In: *Manual de Maricultura*, Instituto de Pesquisas da Marinha, Projeto Cabo Frio, Rio de Janeiro, p. 1-40.

DÉGREMONT, L.; EDOUARD, B.; SOLETCHNIK, P.; ROPERT, M.; HUVET, A.; MOAL, J.; SAMAIN J.F. BOUDRY, P. 2005 Relative importance of family, site, and field placement timing on survival, growth, and yield of hatchery-produced Pacific oyster spat (*Crassostrea gigas*). *Aquaculture*. *249*: 213-229.

FLORES-VERGARA, C.; CORDERO-ESQUIVEL, B.; CERÓN-ORTIZ, A. N. ARREDONDO-VEGA, B. O. 2004 Combined effects of temperature and diet on growth and bichemical composition of the Pacific oyster *Crassostrea gigas* (Thunberg) spat. *Aquaculture Research. 35*: 1131-1140.

FRÉCHETTE, M.; GOULLERTQUER, P. DAIGLE, G. 2003 Fluctuating asymmetry and mortality in cultured oysters (Crassostrea gigas) in Marennes-Oléron basin. *Aquatic Living Resources 16*: 339-346.

GANGNERY, A.; CHABIRAND, J. M.; LAGARDE, F.; GALL, P. L.; OHEIX, J.; BACHER, C. BUESTEL, D. 2003 Growth model of Pacific oyster, *Crassostrea gigas*, cultured in Thau Lagoon (Méditerranée, France) *Aquaculture*. *215*: 267-290.

HONKOOP, P. J. C. BAYNE, B. L. 2002 Stocking density and growth of the Pacific oyster (*Crassostrea gigas*) and the Sydney rock oyster (*Saccostrea glomerata*) in Port Stephens, Australia. *Aquaculture*. *213*: 171-186.

HUANG, S. C.; HSIEH, H. L. CHEN, C. P. 2006 Effects of the winter Monsoon on the growth, mortality, and metabolism of adult oysters in Kinmen Island, Taiwan. *Aquaculture*. *251*: 256-270.

MACCACCHERO, G. B.; GUZENSKI, J. FERREIRA, J.

F. 2005 Allometric growth on mangrove oyster *Crassostrea rhizophorae* (Guilding, 1828), cultured in Southern Brazil. *Revista Ciência Agronômica*, *36* (3): 400-403.

NGO, T. T. T.; KANG, S. G.; KANG, D. H.; SORGELOOS, P.; CHOI, K. S. 2006 Effect of culture depth on the proximate composition and reproduction of the Pacific oyster, *Crassostrea gigas* from Gosung Bay, Korea. *Aquaculture, 253*: 712-720.

OSTINI, S. POLI, C. R. 1990 A situação do cultivo de moluscos no Brasil. In: HERNANDEZ, R. A. *Cultivo de moluscos na América Latina*. Bogotá, 407p.

POLI, C. R. 2004 Cultivo de Ostras do Pacífico (*Crassostrea gigas*, 1852). In: POLI, C. R.; POLI, A. T. B.; ANDREATTA, E. BELTRAME, E. *Aqüicultura: Experiências Brasileiras*. Multitarefa Editora, Tubarão, p.251-266.

RAMOS, M. I. S.; NASCIMENTO, I. A. LOYOLA, J. S. 1986 The comparative growth and survival of Pacific oyster (*Crassostrea gigas*, Thunberg, *C. gigas* var. Kumamoto) and mangrove oyster (*C. rhizophorae*) in Todos os Santos Bay, Brazil. *Ciência e Cultura*, São Paulo. *38* (9): 1604-1615.

SARÀ, G. MAZZOLA, A. 1997 Effects of trophic and environmental conditions on the growth of *Crassostrea gigas* in culture. *Aquaculture. 153*: 81-91.

TAYLOR, J. J.; ROSE, R. A.; SOUTHGATE, P. C. TAYLOR, C. E. 1997 Effects of stocking density on growth and survival of early juvenile silver-lip pearl oysters, *Pinctada maxima* (Jameson), held in suspended nursery culture. *Aquaculture. 153*: 41-49.

VENTURA, C. R. R. PIRES, D. O. 2002 Ciclos de Vida de Invertebrados Marinhos. In: PEREIRA, R.C. SOARES-GOMES, A. *Biologia Marinha*. Interciência, Rio de Janeiro, p. 49-67.