Physical-Chemical Parameters of Seawater Mollusc Culture Sites in Santa Catarina - Brazil

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ABSTRACT


In Santa Catarina, the production of marine mollusces, mainly Crassostrea gigas and Perna perna, has increased considerably during the last decade. In order to conduct a seawater characterization of culture sites a monitoring program has been developed in five different locations along Santa Catarina's coast (27°23' and 27°55' S; 48°40' and 48°20' W). From August 1998 to December 2002 data was collected on physical-chemical parameters, chlorophyll a, and suspended matter. It was not possible to notice any significant trends of temporary variation for the different factors in the same location. The major differences observed were related to comparisons among the different parameters at different times of the year in the different places of study, which reflected the local environmental and seasonal variations. In the Northern bay of Santa Catarina's island, we found a larger chlorophyll a concentration compared to the Southern bay, 3.7 and 2.7 µg.L⁻¹, respectively. The concentration of total suspended matter was also larger in the Northern Bay than in the Southern Bay, 21.7 and 10.7 µg.L⁻¹, respectively. Outside the bay chlorophyll a averaged 1.5 µg.L⁻¹ and the total suspended matter 8.9 µg.L⁻¹. Data indicates a relatively larger abundance of food for the molluscs in the Northern bay; however, that food is less available because it demands larger energy efforts for its selection and metabolism. We strongly need a more rigorous follow up of the production of marine mollusces in relation to the sites used for their cultivation.

ADDITIONAL INDEX WORDS: Mollusc culture, environmental parameters, mariculture.

INTRODUCTION

On Santa Catarina's coastal areas the production of seawater mollusces, mainly Crassostrea gigas oysters and Perna perna sea mussels, has considerably increased during the last decade. There is a significant lack of data in relation to water column characteristics in the Bay of Florianópolis. It is essential to know the ecosystem where this activity is being developed, since cultivated seawater molluscs operate as filters of suspended matter. Taking this fact into consideration we should say that their production characterizes itself by the use of the natural environment as a source of energy. DAME (1996) claimed that high populations of bivalves in estuaries and coastal ecosystems frequently represented the largest functional component consuming big amounts of primary producers, and serving as a connection between the bentonic environment and the water column.

According to TAIT (1970), although the interactions between animal and vegetable populations are difficult to elucidate, the feeding rate of herbivorous zooplantonic is one of the elements that regulates the size of phytoplankton's permanent population influencing the mollusc production rate.

Spacial variation of bivalves in the natural environment is caused by the interaction of several environmental parameters, related to the site's hydrodynamics, food availability, as well as the specific abilities of each species to survive in different habitats (DAME, 1996). Taking this into account, when the adequate environment for molluscs cultivation is modified by the introduction of a large biomass it can become inadequate for the development of bivalves. Monitoring the physical chemical variables of the water column is a potential tool that can be used to indicate the viability of a culture in a certain area, as well as to reflect possible alterations caused to the environment by the introduction molluscs cultures.

The marine ecosystem is extremely dynamic. There are permanent water molecule exchanges, transportation of suspended matter, oceanic currents brought about by tidal variations that provoke sediment resuspension, winds and geomorphologic factors (NAVARRO and IGLESIAS, 1993). The alterations that might take place in this adaptable ecosystem will depend on the specific characteristics of each culture site.

Some case studies try to understand the energetic balance in the marine environment, but they overlook many interactions that are part of the food chain. Therefore, when measurements are conducted for a certain period of the year, the values obtained should not be taken as exact for they are based on little real information (TAIT, 1970). Following up parameters during a long period of time, provides a general vision of the analyzed variables seasonal behavior.

The present case study was implemented with the purpose of characterizing the water column in bivalve mollusc culture sites, identifying parameters that could be used as indicators of the animals' development in these cultures, and observing the possible environmental impacts in relation to the examined parameters.

It is extremely important to conduct an environmental characterization in order to size up and manage the cultures. Environmental data becomes a useful tool for the rational management of sites where cultures have already been introduced.

The management or implantation of a mollusc culture must have the goal of using the natural environment, without depleting its energy reserves impairing other species and threatening water quality. It should bring forth balance to the ecosystem, generating social, economical, and environmental sustainability.

METHODS

Monitoring was conducted in the Bay of Florianópolis where there are seawater mollusc cultures between latitudes 27°23' and 27°55' S, longitudes 48°40' and 48°20' W. The Bay of Florianópolis is an elongated body of water located in the north-south direction; it separates the Island from the mainland (SALLES, 2001). Ocean currents in this part of the Atlantic flow towards the North (N).

The bay area is divided into the Southern Bay and the Northern Bay, which are connected by a narrow channel. This....
outside the bay. The bar represents 5 Km.

Sampling sites: 1, 2 - Northern Bay; 3, 4 - Southern Bay; 5 - America; B - State of Santa Catarina; C - Island of Santa Catarina.

Figure 1. Locations of sampling sites. A - Brazil in South America; B - State of Santa Catarina; C - Island of Santa Catarina. Sampling sites: 1, 2 - Northern Bay; 3, 4 - Southern Bay; 5 - Outside the Bay. The bar represents 5 Km.

case study has been performed at four different locations within the bay. Two locations are in the Southern Bay and another two are in the Northern Bay, plus one more site close to the southern entrance outside the bay (Figure 1). Rivers, mangroves, estuaries flow into the bay and the coast is very irregular. All these elements contribute to differentiate one site from another. The ocean currents that flow into and out of the bay are strongly influenced by the winds and the tides.

The sites under study are different from one another due to their environmental, geomorphologic and water flow characteristics, as well as in relation to the culture characteristics, yield, adopted densities and cultivation systems (Table 1). The sites under study are different from one another due to their environmental, geomorphologic and water flow characteristics, as well as in relation to the culture characteristics, yield, adopted densities and cultivation systems.

Determining Physical-Chemical Parameters

The data was collected every fortnight, between August 1988 and December 2002. Physical-chemical parameters, chlorophyll a and particulate matter in suspension in the water column were analyzed. The sampling was conducted at two different depths: 0.30 m from the surface and 0.50 m from the bottom.

In order to determine variables such as temperature, pH, salinity and dissolved oxygen (DO) a multiparameter Multiline P4 WTW equipment was used. All determinations were performed in loco. Total particulate matter (TPM), particulate organic matter (POM), particulate inorganic matter (PIM), and chlorophyll a were determined in the lab. A Nisky bottle was used to obtain water samples.

Particulate matter (TPM, POM and PIM) was evaluated adapting the methodology described by STRICKLAND and PARSONS (1972). Samples were filtered through a 230 μm mesh in order to retain larger particles, which were then filtered using a 0.45 μm porosity glass fiber filter and finally washed with distilled water to remove salts. Later on filters were dried at 60°C for 48 hours, weighted and burnt again at 450°C for two hours to determine the organic and inorganic fraction of the total particulate matter.

Chlorophyll a was determined using the fluorimetric method by extraction (STRICKLAND and PARSONS, 1972; LITTLEPAGE, 1998). After collecting the water - taking care not to cause degradation to chlorophyll a - 100 ml of seawater were filtered through a 0.45 μm glass fiber filter. The chlorophyll was extracted keeping samples in the dark for approximately 20 hours in 90% ketone. Afterwards they were centrifuged and a reading with an AU 10 Turner Designs Fluorimeter was taken. In all the cases were conducted three repetitions for each sample.

All data showed normal distribution patterns and variance homogeneity. Using a 5% significance level to analyze data, the multiple variance (ANOVA) was employed, followed by a comparison test of averages according to Turkey (for data with different N) whenever necessary.

RESULTS

Data related to salinity, DO, pH (table 2) and chlorophyll a does not present any significant differences between surface and bottom in the five locations. No significant differences either were observed in Ribeirão and Pinheira comparing data between surface and bottom for TPM, PIM and POM. In the other locations the data obtained for TPM, PIM and POM were statistically different. The P values were 0.00002, 0.000004 and 0.003731 in Sambaqui; 0.000589, 0.001864, 0.0049575 in Santo Antônio; and 0.002007, 0.00372 and 0.00877 in Enseada.

Seasonal changes were reflected (Figure 2) in chlorophyll a values revealing a significant difference among locations. In Sambaqui and Santo Antônio, chlorophyll a values were higher during summer and autumn, both with P = 0.000001. Enseada (P = 0.012102) and Ribeirão (P = 0.000122) had their highest averages recorded during the summer and Pinheira (P = 0.001268) in the spring.

TPM, PIM and POM seasonal averages (Figure 3) did not register any significant difference in Sambaqui, Santo Antônio and Enseada. In Ribeirão and Pinheira P values for TPM were 0.004183 and 0.003492 respectively; PIM and POM showed the same trend. In Sambaqui (P = 0.00564), Santo Antônio (P = 0.010274) and Pinheira (P = 0.000003) seasonal variations in salinity were noticed. Meanwhile in Enseada and Ribeirão.

Table 1. Sites’ description.

<table>
<thead>
<tr>
<th></th>
<th>Sambaqui (1)</th>
<th>Santo Antônio de Lisboa (2)</th>
<th>Ribeirão da Ilha (3)</th>
<th>Enseada do Brito (4)</th>
<th>Pinheira (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth (m)</td>
<td>2.5 to 3.5</td>
<td>1.5 to 2.5</td>
<td>3.0 to 4.0 m</td>
<td>1.0 to 2.0</td>
<td>4.0 to 5.0</td>
</tr>
<tr>
<td>Circulation</td>
<td>Intermediated</td>
<td>low</td>
<td>Intermediated</td>
<td>low</td>
<td>high</td>
</tr>
<tr>
<td>Cultivation system</td>
<td>Long-lines</td>
<td>fixed</td>
<td>Long-lines</td>
<td>fixed</td>
<td>Long lines</td>
</tr>
<tr>
<td>Location</td>
<td>faces the W</td>
<td>faces the NW</td>
<td>faces the NW</td>
<td>faces the E</td>
<td>outside the bay</td>
</tr>
<tr>
<td>Bottom</td>
<td>muddy</td>
<td>muddy</td>
<td>sand</td>
<td>muddy</td>
<td>sand</td>
</tr>
<tr>
<td>Influent Wind</td>
<td>North (N)</td>
<td>North (N)</td>
<td>South (S)</td>
<td>Northeast (NE)</td>
<td>South (S)</td>
</tr>
</tbody>
</table>
Table 2. Yearly averages and (sd) of Physical-chemical parameters of seawater mollusc culture sites in the 5 studied locations.

<table>
<thead>
<tr>
<th></th>
<th>Sambaqui</th>
<th>Santo Antônio</th>
<th>Ribeirão</th>
<th>Enseada</th>
<th>Pinheira</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp. (°C)</td>
<td>22.69</td>
<td>22.83</td>
<td>21.81</td>
<td>22.51</td>
<td>20.50</td>
</tr>
<tr>
<td>pH</td>
<td>8.05</td>
<td>8.00</td>
<td>8.05</td>
<td>7.94</td>
<td>8.04</td>
</tr>
<tr>
<td>O2 (mg/L⁻¹)</td>
<td>7.03</td>
<td>6.75</td>
<td>7.24</td>
<td>6.57</td>
<td>7.38</td>
</tr>
<tr>
<td>Sal. (%w)</td>
<td>31.51</td>
<td>31.54</td>
<td>31.54</td>
<td>31.94</td>
<td>33.32</td>
</tr>
</tbody>
</table>

salinity did not suffer seasonal changes.

Comparative analysis among the different sites showed that chlorophyll a values were different for all of them, except in Ribeirão and Enseada (Sambaqui and Santo Antônio P=0.0043; Sambaqui and Ribeirão P=0.000567; Sambaqui and Enseada P=0.002351; Sambaqui and Pinheira P=0.000017; Santo Antônio and Ribeirão P=0.00017; Santo Antônio and Enseada P=0.000017; Santo Antônio and Pinheira P=0.000017; Ribeirão and Pinheira P=0.000021).

TPM was different in Sambaqui and Santo Antônio P=0.000167 and between Sambaqui and the other locations P=0.000017; between Santo Antônio and the other locations P=0.000017; and between Ribeirão, Enseada and Pinheira there was no significant difference.

DISCUSSIONS

The data collected during the period of study (table 2) is compatible to the patterns described about other places found in international literature (TAIT, 1970; NAVARRO et al., 1995). Some parameters present a wide range of variation. This is probably related to the fact that these areas are close to the coast and therefore, not very deep. DAY et al. (1989) remarked that most estuarine ecosystems are open and variable. Physical processes dominate and support them causing a great exchange of biotic and abiotic materials including water, salts, nutrients, sediments and organisms with neighboring systems. This situation might be the one taking place in our studied locations.

GRANT et al. (1993) stated that a high biomass of cultivated animals could produce a negative feedback to the local environment, brought about by the increase of the organic load and anacorobic conditions, which can potentially cause the culture environmental degradation. No increasing or decreasing trend was observed in the assessed parameters during this period indicating that maximum production (support capacity) of these places has not been achieved yet. This information is similar to the data supplied by SUPILCY et al. (2003), who applied ecological modeling to assess the support capacity of culture sites in Santa Catarina.

TPM, PIM and POM values recorded a significant difference between surface and bottom. The highest values for the bottom were recorded in Santo Antônio, Enseada and Sambaqui all of these places have low water circulation. This could be happening as a consequence of sedimentation of suspended matter, provoked by weak currents and the muddy bottoms. In the Southern Bay there are 3 to 5 meter bathimetric curves, which set the boundaries of shallow areas and separate larger depths into which tidal currents from the southern channel come and leave. These currents avoid shallow areas in Enseada do Brito. The same happens in the Northern Bay, where water flows through corridors into the Northern Channel spreads along coastal indentations and once it gets there takes the direction of the blowing wind. Meanwhile currents avoid shallower bottoms as the one in Santo Antônio (CRUZ, 1998).

Figure 2. Chlorophyll a (µg L⁻¹) seasonal variation in the different sampling locations

Recorded DO and pH values do not reveal any differences between surface and bottom. They show that sedimentation caused by bivalve cultures is not reaching the layer next to the sediment, where in general organic matter accumulates. DAY et al. (1989) verified that the reduction of DO at the bottom of estuaries was almost certainly the result of decomposed algae cells and organic matter resulting from debris and other sources.

In environments where there is little water movement, over 50% of primary production sediments through the water column. As a result most of the particulate organic matter mineralizes in the sediment, and the products of its decomposition end up returning to the water column (CURTIUS et al., 2003). It could be said, that water circulation in the studied locations is strong enough to keep phytoplankton in suspension, since chlorophyll a remains homogenous throughout all the spots in the water column. DAY et al. (1989) interpreted this trend in non-stratified locations as an indication of temperature’s strong influence on the recycling process of nutrients and on the planktonic growth.

Chlorophyll a varies spacially and seasonally. There are many factors responsible for the productivity of a certain site, but no pattern could be identified in relation to temperature and the other analyzed parameters. Although there is a trend indicating more primary productivity in the warmer seasons, there is little seasonal previsibility in tropical systems whose productivity may be associated to river water influx, rainfalls, nutrient availability, circulation and irradiation. Models as a consequence may vary a lot. BAYNE (1993) hold that mussels react in different ways to environmental alterations in food.

Chlorophyll a values in the Northern Bay were higher, first of all in Santo Antônio followed by Sambaqui. The other sites exhibited the same seasonal trend: having higher chlorophyll a in the summer and autumn months (Figure 2), as well as larger TPM. This may be happening as a result of the contribution of coastal waters and the proximity to the mangroves. The Bay has several mangrove areas that are known to play an important role in relation to the coastal ecosystem. (MELO et al., 1999). In Sambaqui TPM’s high values are an indication of water turbidity, which may be blocking solar radiation reducing the production of phytoplankton as described by DAY et al. (1989).

TPM values were also different between de Bays (Figure 3). Sambaqui displayed the largest amount of suspended matter, followed by Santo Antônio. In the Southern Bay, Ribeirão and Enseada did not reveal any significant differences, they were almost the same as well as Pinheira, the site located outside the Bay. The differences between the two Bays are the result of interactions among many factors. MELO et al. (1999) described the differences between currents in the bays. The Southern Bay has more channels and it is connected to the ocean by a narrow entrance, while the Northern Bay is broader and its connection to the ocean is very wide. On the other hand, the Southern Bay has a very asymmetric tidal flux and it is mainly influenced by the interaction of factors such as wind, tidal variations, and oceanic currents.
increases abruptly in diets with low content of organic matter, especially in the presence of high seston concentrations. NAVARRO and IGELEIAS (1993) remarked that when the concentration of POM increased as a result of resuspension, it produced a huge reduction in the quality of the measured particles in relation to their organic or energetic content. Nevertheless, DAME (1993) concluded that bivalves' particle selection mechanism and their capacity to filter suspended matter needed to be adequately worked out not only by the organisms, but by the ecosystem too.

According to CURTIS et al., (2003) considering that total particulate matter is mostly formed by inorganic material, means that these locations offer further possibilities for aquaculture activities. Nevertheless, shallow coastal areas with no significant currents to stir intense and constant water movement may face difficulties in the future.

CONCLUSIONS

The environmental impact of suspended matter from the cultures of filtering molluscs is different in each location. Although the production of marine molluscs has increased 6,000 % between 1991 and 2002, no increasing or decreasing trend has been observed during this period indicating that the carrying capacity of these sites has not been reached yet.

There is a real need for a strict follow up of the production of marine molluscs in relation to their cultivation sites, management and quantities. The environmental function played by these cultures could be compared to the function of natural stocks.

As it happens in the natural environment producers must take advantage of spacial and time management strategies to optimize the productive system.

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LITERATURE CITED


