Seasional variation in the condition index, meat yield and biochemical composition of the flat oyster Ostrea edulis (Linnaeus, 1758) from the Dardanelles, Turkey

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Abstract

This study was conducted in Dardanelles between October 2007 and August 2009 when condition index, meat yield, biochemical compositions and environmental parameters of seawater were investigated and the study area was found to have available conditions for cultivation. Investigation of the study area showed a positive correlation in particular among condition index, seasonal variation of temperature, protein, fat and chlorophyll-a; a negative correlation was seen between them and carbohydrate value. It was clear from the two years study that the most ideal period for oyster harvest is April and August especially when condition index was maximum followed by a winter with no oyster yield is available in terms of the related processes involving oyster cultivation.

Introduction

Turkey has an enormous potential for aquaculture activities. It has ideal geo formation with numerous sheltered bays and estuaries. Amount of economic activity is growing for with numerous sheltered bays and estuaries. Many economically important bivalve species such as flat oyster, Ostrea edulis (Linnaeus, 1758), cupped oyster, Crassostrea gigas (Thunberg, 1793), Mediterranean mussel, Mytilus galloprovincialis (Lamarck, 1819), wedge clam, Donax trunculus (Linnaeus, 1758), Mediterranean scallop, Pecten jacobaeus (Linnaeus, 1758), striped venus, Venus gallina (Linnaeus, 1758), carpet shell clam, Tapes decussatus (Linnaeus, 1758), Manila clam, Tapes philippinarum (Adams and Reeve, 1850) and warty venus, Venus verrucosa (Linnaeus, 1758) are distribution along the Turkish coastlines. However, the main production of these comes from fishing for Mediterranean mussel, Mytilus galloprovincialis, aquacultural products. The world aquaculture production was 65.19 million tons of which 4.4 million tons was oyster in 2007 (FAO, 2008). Oyster is cultivated in many regions of the world, having a wide distribution in the Aegean Sea and Sea of Marmara; however, it does not have significant aquaculture production and has only 31 tons of production via fishing (Turkish Statistical Institute, 2008).

The condition index is a rapid measure of ecophysiological state in commercially exploited bivalve and other mollusc species (Lucas and Beninger, 1985; Yıldız and Lök, 2005). It is also a very practical method used for following gametogenetic activities of bivalves (Okumuş and Stirling, 1998). Proteins, fats and carbohydrates are the basic building blocks of the living organisms. These molecules are changed by living organisms in their metabolisms, give out energy through fragmentation, and form specific synthesis products (Bayus, 1979). These molecules and condition index should be regularly monitored for successful oyster culturing. Density of oyster beds in the region, temperature, salinity, pH, amount of chlorophyll-a, amount of organic matter and environmental factors like streams and waves are significant parameters that effect biochemical compositions and condition index of oysters (Saxby, 2002; Zrncic et al., 2007; Guilian and Aguirre-Macedo, 2009). Especially temperature and the amount of food supply are considered as most important parameters in oyster culturing (Mackie and Ansell, 1993; Berthelin et al., 2000; Seguineau et al., 2001; Barraza-Guardado et al., 2009).

The purpose of this study was to determine the extent of suitability and the optimum harvest period for commercial oyster culturing in the Dardanelles. Environmental parameters that affect condition index and biochemical composition of oysters were also investigated.

Materials and methods

This study was carried out Dardanelles in the Northwestern part of Turkey (40° 22.58’N, 26° 42.24’E) (Figure 1).
dissolved oxygen, salinity were measured using an autonomous hydrolab recorder (YSI 85D, YSI Inc., Yellow Springs, OH, USA) and pH was determined using an YSI 100 pH-meter. Phytoplanktonic biomass was estimated via chlorophyll-a determinations using a spectrophotometric method (Strickland and Parsons 1972). Total inorganic matter (TIM) and total organic matter (TOM) in suspension were determined by Boyd’s (1981) methods.

Metric multidimensional scaling technique (MDS) was used to investigate relations among the environmental parameters, CI, MY and biochemical parameters of oysters. Multidimensional scaling is an exploratory technique used to visualize proximities (a proximity is a number that indicates how similar or how different two objects or variables) in a low dimensional space. MDS provides a researcher to uncover the hidden structure or relations among the variables. Each object is represented by a point a multidimensional space. Two similar objects are represented by two points close to each other, while two different or dissimilar objects are represented by two points apart from each other (Kruskal and Wish, 1978).

Results and discussion

Temperature, salinity, pH, dissolved oxygen, TIM, TOM and chlorophyll-a showed changing patterns during the study period (Figure 2). Seawater temperature, which fell in winter (with minimum 8.53°C in February 2009) started rising in spring months, and reached highest levels in summer (with maximum 24.63 oC in August 2009). Salinity, pH, and dissolved oxygen did not display significant changes while lowest values were 23.14‰, 8.11 and 7.05 mgL–1, respectively and highest values were 25.61‰, 8.88 and 9.02 µgL–1, respectively. Both TIM and TOM values reached highest levels in winter (December and February) in both two years, and followed a variable pattern in other seasons. Lowest chlorophyll-a levels (0.5832 µgL–1 and 0.7245 µgL–1) were observed in December and February, and a rapid rise was observed after April in both years of the study. Highest chlorophyll-a levels were determined in August (1.7771 µgL–1 and 1.9642 µgL–1).

In spring, both MY and CI started rising in significant levels, and this state continued during all summer. Lowest levels were observed in December and February during the study period (Figure 3).

The carbohydrate content exhibited negative relationship pattern to protein and fat. The values fluctuated between 16.84% in August 2008 and 35.06% in February 2009, with average values of 26.73%. Protein values ranged from minimum of 52% in June 2008 to maximum of 68% in August 2008 and in April 2009 during the study period. Mean of fat and ash values were 4.19% and 9.03%, respectively (Figure 4).

Relationship among environmental parameters, CI and biochemical compositions of oyster was analyzed using MDS (Stress=0.119, R2=0.834) (Table 1 and Figure 5). CI and MY were predominantly in the first dimension. Chlorophyll-a, protein and fat being at the first dimension, and bearing the same sign with CI and MY, reveal a positive relationship between them. In other words, an increase in chlorophyll-a, protein, and fat, results in an increase in CI and MY. On the other hand, a negative relation has been identified between carbohydrate and CI and MY. Similar findings can be seen in Figure 5.

CI and MY of bivalve species are affected by endogenous origin such as gametogenic cycle of animals and exogenous origin such as water character.

![Figure 1. Map of research area in Dardanelles, Northwestern Turkey.](image1)

![Figure 2. Patterns of environmental parameters during the study period. TIM, Total inorganic matter; TOM, Total organic matter.](image2)

![Figure 3. Seasonal variations in percentage condition index and meat yield of oysters. CI, condition index; MY, meat yield.](image3)

| Table 1. Contribution of the variables on each dimension. |
|-----------------|-----------------|-----------------|
| Variables       | Dimension 1     | Dimension 2     |
| Temperature     | 0.7844          | -0.8880         |
| Salinity        | -0.1176         | 1.3909          |
| pH              | 0.5171          | -1.3133         |
| DO              | -0.6426         | 1.3268          |
| TIM             | -1.7891         | -0.4974         |
| TOM             | -2.0270         | -0.4200         |
| Chlorophyll-a   | 1.0037          | -0.3785         |
| CI              | 0.9630          | -0.0915         |
| MY              | 1.0746          | 0.0511          |
| Protein         | 0.8237          | -0.5657         |
| Fat             | 0.5685          | 0.9966          |
| Ash             | 0.8152          | 0.6393          |
| Carbohydrate    | -1.9739         | -0.6284         |

DO, Dissolved oxygen; TIM, Total inorganic matter; TOM, Total organic matter; CI, condition index; MY, meat yield.
temperature (Austin et al., 1993), salinity, pH, oxygen level and food availability (Orban et al., 2002; Flores-Vergara et al., 2004). However, salinity, pH and dissolved oxygen level did not significantly effect the CI, MY and biochemical composition of oyster in the Dardanelles. This may be a result of little variation of these parameters that were in the optimum range for the oyster culture in Dardanelles. Acarlı (2005) noticed that spawning period for oysters (O. edulis) in middle of the Aegean coasts was at the end of spring and summer, and that CI were highest in March. In this study, highest CI was acquired in April and August. The one month earlier increase in CI of oyster in Aegean Sea can be attributed to the earlier increase of water temperature compared to the period water temperature increase in the Dardanelles. Water temperature in Aegean Sea rises over 15°C generally in March (Acarlı, 2005; Lök et al., 2007; Serdar et al., 2007), whereas these values are observed in Dardanelles only after April. Other environmental parameters, which are as important as the water temperature for oyster culturing, are the amount and quality of food in the region (Andersen and Nass, 1993; Rodriguez et al., 1997; Lodeiros et al., 1998; Laing, 2000; Tomaru et al., 2002; Baughurst and Mitchell, 2002; Mercado-Silva, 2005; Rebelo et al., 2005).

Numerous studies display a strong relationship specifically between chlorophyll-a and CI. Variation of reproduction rates in the oyster populations was attributed primary to changes in food amount, by taking into consideration the chlorophyll-a concentration in the environment in Spain (Ruiz et al., 1992), in Portugal (Almeida et al., 1997), in Korea (Kang et al., 2000). As in this study, it was determined that chlorophyll-a values were in high levels specially in April and August when gonads matured, and CI made a peak (Baughurst and Mitchell, 2002), and that also statistically there was a strong relation between chlorophyll-a and CI (Figure 5).

Condition index in this study varied between 1.54% and 8.8%. We can state that these values, which are in parallel to the studies carried out by Acarlı (2005) in Aegean Sea and by Dridi et al. (2007) in Tunisia, provide ideal conditions for oyster culturing. According to Okumus and Stirling (1998) fluctuations in the CI and MY have important implications for cultivation and harvesting strategy. Oysters discharge their gonads formed in their mantle cavities in spawning period; therefore significant decreases occur in the rate of their meat weight to total weight. Ren et al. (2003) stated that oysters in New Zealand lost approximately 65% of the organic substances in their body while leaving their gonads, and Cigarria (1999) found similar results in the study carried out in Spain. Harvesting in such a period is not commercially feasible. Besides, oysters use energy reserves in their body when food amount decreases in the environment. This reduces their nutritious quality, which is not favorable in terms of harvesting (Thompson, 1984; Soniat et al., 1989). In bivalve species, best term for harvesting is just before spawning period when CI is at peak (King, 1977; Peharda et al., 2007). Besides, CI and MY of oysters are also determined since they are considered very important criteria for bivalve producers. The results of MY were correlated to CI. MY values showed that oysters were suitable for consumption and of high quality in all months except December, according to The French Standardization Association (Association Française de Normalisation, 1985).
Oyster beds have significant potential in terms of oyster cultivation in the Sea of Marmara and especially in Dardanelles. The fact that no scientific study has been carried out in this region increases the importance of these results. CI, MY and biochemical parameters proved that suitable conditions existed for oyster cultivation in the Dardanelles. Most significant environmental factors determining CI, MY and biochemical factors were temperature and food amount. We can conclude that oysters enter spawning period after April and August in this region.

Conclusions

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Oyster beds have significant potential in terms of oyster cultivation in the Sea of Marmara and especially in Dardanelles. The fact that no scientific study has been carried out in this region increases the importance of these results. CI, MY and biochemical parameters proved that suitable conditions existed for oyster cultivation in the Dardanelles. Most significant environmental factors determining CI, MY and biochemical factors were temperature and food amount. We can conclude that ideal periods for oyster harvesting were April and August; and that spawning periods following these months and winter (between December and February) were not suitable for harvesting.

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