THE EXPLOITATION OF THE CLAM, *Tapes decussatus* (MOLLUSCA: BIVALVIA), IN SANTO CRISTO LAGOON, SÃO JORGE, AZORES.

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An analysis of the exploitation of the clam, *Tapes decussatus*, in the coastal lagoon of Santo Cristo on São Jorge Island (Azores) is presented from 1991, when a new regime of controlled exploitation was implemented, to 1998. During these years about 6.8 t of clams were caught, with a maximum of 1.75 t in 1993. Annual landings, mean shell length, and catch per unit effort (CPUE – kg/hour) have been decreasing since 1994 (when a maximum of 1.6 kg/hour was reached). In 1998 the annual mean shell length was the lowest since 1991 (47.0 mm). These facts indicate a decrease of the population, at least in the more exploited areas of the lagoon, and/or the inefficiency of the present management model. Alternative management models are discussed.

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INTRODUCTION

The clam *Tapes decussatus* (Linnaeus, 1758) (syn. *Venerupis decussatus*, *Ruditapes decussatus*) occurs in the north-eastern Atlantic, distributed from SE-W England to NW Africa (Morocco to Senegal), including the Iberian Peninsula and the Mediterranean (Tebble 1976). The species lives buried in muddy-gravel bottoms from the intertidal to a few metres depth in the subtidal (Poutiers 1987; Poppe & Goto 1993).

In the Azores, the clam *T. decussatus* is confined to a unique habitat: the Santo Cristo lagoon on the N. coast of S. Jorge island, which has an area of 0.9 km². Moreover, this occurrence constitutes the westernmost locality in the geographical range of this species. Several authors have published general descriptions of the Santo Cristo coastal lagoon and its biological communities (e.g. Morton 1967, Santos & Martins 1988, Fonseca et al. 1995, Morton et al. 1998). The work of Santos et al. (1990) was focused mainly on the clam population. Santo Cristo lagoon is the only true marine coastal lagoon in the Azores archipelago and was declared as a protected natural reserve in 1989 (Special Ecological Area - DLR 6/89/A, July 18).

*T. decussatus* is believed to have been introduced in Santo Cristo lagoon by man (Morton 1967). The genetic studies of Willems et al. (1995) suggested that the Santo Cristo population has been isolated from those of the continent only recently.

The clams constitute a small resource that has been traditionally exploited by the local residents. This exploitation was uncontrolled until 1984, when the inhabitants objected to the unregulated harvesting. This led to the prohibition of catches from 1984 until 1989. A new regulated exploitation period begun in 1990 following recommendations by Santos & Martins (1988). Ten exploitation licences, allowing a monthly catch of 50 kg, are issued annually by the Regional Directory of Fisheries (DRP). A seasonal closure (from 15 May to 15 August) and a minimum catch size (shell length) of 30 mm was fixed. The resident warden of the reserve...
administered this new regime and filled in the catch control forms.

The exploitation of *T. decussatus* in Santo Cristo lagoon is normally carried out in the intertidal margins of the lagoon and in the upper subtidal using rakes. The rakes have 3 to 4 m long handles and a minimum of 3 cm gap between the teeth.

The number of licences was raised to 13 in 1994, and to 14 from 1995 to 1997. Annual reports of exploitation, based on these forms, were produced by the Department of Oceanography and Fisheries (DOP) of the University of the Azores, as well as recommendations for the next year's activity (GONÇALVES & MARTINS 1991; GONÇALVES 1992, 1993, 1994; GONÇALVES et al. 1995, 1997; FERRAZ & GONÇALVES 1997, 1998).

The clam biomass was estimated in 1988 to ca. 9.4 t. in the intertidal zone and to 36.6 t. in the subtidal (SANTOS et al. 1990). In 1992, clam biomass was estimated to 4.1 t. in the intertidal and to 15.1 t. in the subtidal (GONÇALVES 1994).

In this paper we review the clam exploitation during an eight year regime that ended in 1998.

**METHODS**

The reserve warden recorded each catch by the licensed harvesters on appropriate forms. The forms contain the identification of the harvester, total weight per catch, the area of the lagoon where the clams were caught, the number of hours of activity and the characteristics of the tool used. Measurements of a sub-sample of 50 clams (shell length to the nearest mm) from the total catch were also included. The logbooks were sent every month to DOP where the data were introduced in a computer database (Microsoft Access®).

The following parameters were analysed: annual and monthly catches, catch per unit of effort (CPUE – kg/hour), mean shell length, and length frequency histograms (5 mm size classes).

**RESULTS**

1. **LANDINGS**

The total declared clam weight increased substantially from 1991 to 1993, which could be due to the increase of the number of licences attributed, and also to a more efficient use of them. Since 1993, the annual catches have decreased slowly (with small oscillations) in spite of an increase in the number of licences. In 1995 and 1997 the landings were the lowest since 1991. The 1998 value consists only of catches from the first four months (Fig. 1) since the resident warden of the reserve resigned from May 1, 1998.

The monthly variation of landings tends to increase from January to April, followed by a subsequent decrease to November, and rising again in December (Fig. 2).

The exploitation was concentrated in certain zones of the lagoon: C, D, F and I, mainly in C and D. (Fig. 3).

2. **CATCH PER UNIT OF EFFORT (CPUE - KG/HOUR)**

From 1991 until 1994 the mean annual CPUE tended to increase. After 1994, when the highest value was reached (1.6 kg/hour), the CPUE decreased slowly. The high variability of the means is indicated by the high standard deviations (Fig. 4).

3. **SHELL LENGTH**

The mean shell length has always been close to 50 mm, with a slight tendency to decrease since 1994. The smallest mean (47.0 mm) was recorded in 1998 (Fig. 5).

The shell length shows a decrease in the predominant size classes since 1991 (modal value of 60 mm) to 1998 (modal value of 35 mm) (Fig. 6).
DISCUSSION

The landings of clams (*T. decussatus*) from Santo Cristo lagoon (< 2 t. annually from 1991 to 1998) are very small when compared with other regions (e.g. POUTIERS 1987), even when compared with other artisanal Azorean fisheries (see SANTOS et al., 1995). However, these figures should be considered in the context of the small area of the lagoon. The importance of these clams should not be disregarded as they, and the lagoon, in which they occur, are highly relevant in the Azorean context, especially for the island of S. Jorge. The main reason for declaring the Santo Cristo lagoon as a natural reserve (Special Ecological Area) was the presence of clams.

The general pattern of decrease in landings during the period of regulated exploitation (from 1991 to 1998), indicate a reduction of the stock. The number of catch permits increased slightly during the same period, while the CPUE decreased. Also, the slight decrease in the annual mean shell length as well as the decrease in size of the modal class, support this view. However, it is to be expected that average size should decrease with time in an under-exploited or a new fishery (KING 1997). MORTON & CUNHA (1993) mentioned that the lack of large empty shells in the lagoon is a typical sign of a managed fishery. The average size of *T. decussatus* recorded from Santo Cristo, however, is relatively high when compared with the common catch size on the Portuguese mainland (SANCHES 1992).

The increase of landings and CPUE during the first years (before 1994) of regulated exploitation...
Fig. 3. Annual landings from the main exploited areas in the lagoon.

Fig. 4. Annual means of catch per unit of effort (CPUE – kg/hour). Vertical bars represents standard deviation.
Fig. 5. Variation of annual mean shell length. Vertical bars represent one standard deviation.

Fig. 6. Histograms of shell length of *Tapes decussatus* in 5 mm size classes, from the Santo Cristo lagoon for the years 1991-1998.
could be due to a higher availability of the resource and/or to an improved efficiency while the effort remained the same. In some cases CPUE's can increase while the resource is already declining (King 1997).

However, it should also be noted that the decline in landings could be an artefact as undeclared catches could have occurred, making an interpretation of the fishery difficult. As the catch limit is restricted to 50 kg per month, under-declaring or not declaring catches are ways to avoid control. The exploitation of clams was concentrated in a few areas of the lagoon (C, D, F, I - see Fig. 3). There are two main reasons for this. These areas are more accessible for exploitation and they also benefit from the seawater inflow. The type of sediment seems to be less important as various sediment types occur in these areas (Fonseca et al. 1995). Although the density of T. decussatus in Santo Cristo lagoon might be higher on the intertidal shore, the biomass is higher in the subtidal, due to the presence of bigger and heavier clams (Santos et al. 1990; Gonçalves 1994).

The accumulated landings of the last 8 years (ca. 6.8 t.) represents 40% of the biomass estimation for clams larger than 30 mm (intertidal + subtidal = 17 t.) estimated by Gonçalves (1994), which is less than the estimation by Santos et al. (1990). However, both biomass estimations should be considered with caution, as the sampling of subtidal clams was insufficient, due to the difficult access.

Camacho (1980) refers that 6-7 years is needed by T. decussatus in Ria Arosa (NW of Spain) to achieve an average size of 5 cm. The growth rates reported by Santos et al. (1990) for the Santo Cristo clams are higher, at least for smaller size classes. This is not surprising since the water temperature in this Azorean lagoon is higher, all year round, than in the Spanish localities. (cf. Santos & Martins 1988; Santos et al. 1990; Morton & Cunha 1993; Camacho 1980). Unfortunately there are no data on the lagoon's productivity, neither primary or from the clams, to be compared with other regions.

The current regime of controlled exploitation of the clams in Santo Cristo lagoon has now ended, since there is no resident warden to control the catches after April 1998, and it has been very difficult to find a substitute. For 1999 a modification in the management regime was introduced and 9 catch permits were issued. These licensed harvesters will self-register the data from their own catches. If this new exploitation regime does not work, it has to be changed.

As an alternative regime we suggest the implementation of a total allowed catch (TAC) per year based on assessment and productivity studies. The annual TAC might be exploited by licensed fishermen or completely free to be exploited by anyone. The only fixed rules might be the minimum catch size (30 mm) and an exploitation ban during the reproductive season (15 May to 15 August). Monthly analysis of the landings will follow closely the evolution of the exploitation. When the TAC is achieved the exploitation will be stopped. This means that the end of the season might be different from year to year. To implement this model it will be necessary to have a good knowledge of the stock (biomass estimation and productivity) and trustworthy landing data. In this case it will be irrelevant if the fishermen have permits or not. However, it is easier to regulate licensed fishermen, as they will tend to control each other. Another possibility is to use the same system as for limpet exploitation where two kinds of permits are used (Ferraz et al. 2001). The first, for the general public only for self-consumption, without the issuing of licences, and restricted to a small amount. This will satisfy an old demand from the local inhabitants. The second category, for commercial catches, would need the issue of temporary (annual) permits, in which case the catches should be declared for statistical purposes. The problem with these management models is that it will be necessary to perform annual biomass estimations, which represent an additional cost.

Leaving this resource uncontrolled and overexploited would certainly lead to its destruction and possibly extinction. The area of the lagoon is very small and the high fecundity of clams could be insufficient to counteract the high exploitation. The clams could also become extinct in the Azores if the natural conditions of the lagoon change. A decrease of seawater inflow caused by enclosure of the main channel to the
open sea could modify the salinity and other important parameters. The opposite might happen if the seawater entrance is enlarged, which will destroy the sheltered environment. In both cases the environment might be inappropriate for the clams as well as other species.

Another aspect that should be considered is the harvesting method. At present only rakes are allowed. However, this instrument has the disadvantage of digging in the bottom and leaving it disturbed. This action might in fact have adverse impacts on other biological bottom communities, which are also unique and need to be protected (MORTON et al. 1998). Other lesser damaging methods (e.g. snorkelling) should be considered in the future, if really advantageous.

Whatever the model of exploitation, the enforcement and control will always be necessary to ensure the implementation of the regulations. This enforcement should not only be focused on the catch in the lagoon but also elsewhere where the clams are traditionally sold to the public (restaurants, snackbars, etc.).

From a pure conservation perspective for the overall lagoon and its biological communities, the best solution would be to ban the exploitation of clams altogether. However, this will mean the end of an old gastronomic tradition in São Jorge Island, and should be considered.

For a better management of this resource in the future it will be necessary to improve the research as several aspects of the population dynamics of the clams are still unknown. Growth parameters, maturation, mortality, in relation to age and size, as well as biomass estimation are some of the biological parameters that need to be studied.

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