Management of fishing of the Broadband Anchovy (*Anchoviella lepidentostole*) (Fowler, 1911), in south São Paulo State, Brazil

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Abstract

The broadband anchovy (*Anchoviella lepidentostole*) is one of the most important fishery resources for economic and social development of Iguape City and for the whole of the south coast of São Paulo state. Nowadays this activity involves over 2,500 fishermen. This paper aims to evaluate its fishing, and discuss how the activity is managed. In order to conduct this study, production data and catch per unit effort (CPUE) data from the 1998-2000 period have been collected, and the characterisation of the activity has also been done. A decline in broadband anchovy abundance had been observed in the region up until 2004, when a new regulation was implemented, in an attempt to recover the resource, with the establishment of closed season fishing (*defeso*) during the catch season, and adjustments in the employed fishing gear. The results have shown a recovery of the abundance of broadband anchovy throughout the 2005-2010 period, showing thus far that the measures taken for the maintenance of the resource have been successful. The activity has been managed through discussions involving people from the fishing sector in order to determine the controversial actions to be taken, that are hard to enforce. In order to achieve a more satisfactory resource management, it is necessary to keep the participatory process, with adaptive co-management, based on discussion among all the sectors involved (from government and society), and constant monitoring of the activity.

Keywords: Brazil, co-management, artisanal fisheries, marine protected areas, CPUE.

Gestão da pesca de Manjuba (*Anchoviella lepidentostole*) (Fowler, 1911) no sul do Estado De São Paulo, Brasil

Resumo

A manjuba (*Anchoviella lepidentostole*) é um dos recursos pesqueiros de maior importância econômica e social para todo litoral sul do Estado de São Paulo, com mais de 2.500 pescadores envolvidos. O presente trabalho visa avaliar sua pesca e a discutir a gestão da atividade. Para isto, foram coletados dados de produção e CPUE das capturas do período de 1998 a 2010, bem como a caracterização da atividade. Observou-se queda da abundância de manjuba na região até o ano de 2004, quando foi implementada nova normativa, na tentativa de recuperar o recurso, com o estabelecimento de período de defeso no meio da safra e ajustes nas artes de pesca empregadas. Os resultados mostraram uma recuperação da abundância da manjuba ao longo do período de 2005 a 2010, indicando, até o momento que as ações tomadas para a manutenção do recurso tem tido sucesso. Houve uma gestão da atividade através de discussão junto ao setor para determinação de ações polêmicas e de difícil implementação. Para uma gestão do recurso mais satisfatória, é necessário desenvolver melhor o processo participativo, com um co-manejo adaptativo, que tem base na discussão entre todos os setores envolvidos (governo e sociedade) e o monitoramento constante da atividade.

Palavras-chave: Brasil, co-manejo, pesca artesanal, área marinha protegida, CPUE.

1. Introduction

According to estuary ecology researchers (Day Jr. et al., 1989; Maciel, 2001), salinity is one of the main determinant variables for the distribution and occurrence of species in estuarine environments. On the Cananeia, Iguape and Ilha Comprida estuary, salinity is influenced by localised rainfall and water discharge of the Ribeira River (Paiva Sobrinho, 2001b), which is of 2 km in terms of territorial expansion. Until 1841, the original river mouth of the referred hydrographic basin was Ribeira Bar. Today, according to Bonetti-Filho and Miranda (1997), approximately 70% of the Ribeira River output flows directly in the estuary through the Valo Grande

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Channel, which was built in 1841. That channel altered the estuarine hydrodynamics, creating a salinity gradient inexistent before its construction, which today varies with Ribeira river flow. One of the effects of the entrance of waters coming from the Ribeira River into the estuary is the occurrence of the anadromous anchovy species during its reproductive season, that today enters the estuary through the Icapara Bar.

The broadband anchovy (*Anchoviella lepidentostole*) is one of the main fishing resources, being the economic base of Iguape city, involving over 2,500 fishermen, for five months a year. It is an anadroumous species, which migrates to the interior of the Ribeira de Iguape River to spawn for reproduction. The broadband anchovy has a short life span, approximately three years and four months, being ready for reproduction at around one year of age, making it highly dependent on the reproductive spawning stock and mainly on environmental conditions (Rossi-Wongtschowski et al., 1990).

This area is also under the Cananeia, Iguape, and Peruíbe Federal Protected Area (SMA, 1996), which aims to promote sustainable development, and conservation of the region. The region's main economic activity is the fishing of a variety of fish species, mollusks, and crustaceans, generating diversification in the fishing gears used by the local communities, involving around five thousand fishermen. From that total of fishermen, 90% practice artisanal fishery (Mendonça and Miranda, 2008).

Due to the broadband anchovy's importance in the economy of Iguape city, this paper aims to discuss its management in the Cananeia, Iguape, and Ilha Comprida estuary.

1.1. Fisheries management

Broadband anchovy fishery has gone through various interventions aiming at the regulation of the activity, with the application of many ordinances and regulatory instructions, as shown in Annex I.

That fishery is performed mainly in the Cananeia, Iguape, and Peruíbe Federal Protected Area (APA-CIP) - a sustainable federal conservation unit, where the use of natural resources is allowed. They have a Management Council, consisting of public agencies, civil society, and production sector representatives, who help manage the unit (Machado and Mendonça, 2007).

APA-CIP's Advisory Board is the unit's forum for the discussion, planning and management of fishing resources. In that forum they establish agreements, rules, and guidance for actions taken, aiming at the sustainability of the available resources through a participatory management process that created the current broadband anchovy fishing regulation process.

2. Methodology

This study was developed in the southern coast of São Paulo state, in Brazil; more specifically in the city of Iguape (Figure 1), during the period of 1976-2010. Data from 1976 to 2010 were used for the analysis of the landed broadband anchovy production, while monthly production and abundance index analysis were obtained from 1998- 2010 data.

The fishing fleet and gear used to capture broadband anchovy have been characterised through interviews with fishermen, and visits to fishing terminals, which helped obtain information to describe the dynamics of broadband anchovy fisheries, as well as reference information and both formal and informal meetings with the sector throughout the survey.

Production and fishing effort (fishing days) data were collected from fishing points of sale (fish markets or mid-

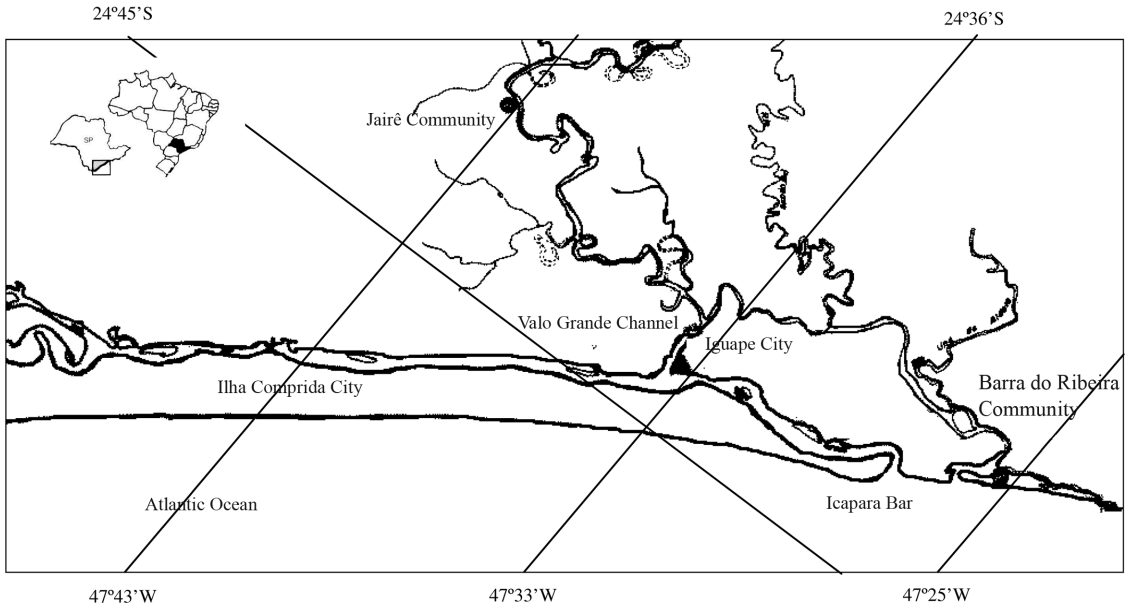

Figure 1 - The Cananéia, Iguape and Ilha Comprida Estuary, with broadband anchovy fisheries area.

dlemen) through commercial sheets. Fishing days were converted into fishing hours - an average of 8 hours a day. The Propesq® database (Ávila-da-Silva et al., 1999) from the Instituto de Pesca/SAA (Fisheries Institute) was used as well.

The Catch per Unit Effort - CPUE was used as an indicator of the state of the broadband anchovy population, as it had been used as a relative abundance index in many fisheries around the world (Gatica and Hernandez, 2003). CPUE (kilo/hour) calculations were estimated through total monthly or yearly production, divided by total effort in fishing hours of all active fishermen during the month or the year. The average annual CPUE was estimated through average monthly CPUEs. Though the species is captured with more than one type of fishing gear, surface drift gill netting captures were used for CPUE analysis, due to more consistent data and better system of data collection. Only fishing data from individual fisherman were used, without any communitarian landings data.

Analysis of variance (ANOVA) was used to verify significant differences in average annual CPUEs through logarithmised monthly CPUEs (log base 10) in order to decrease amplitude variation to a 5% significance level (α) (Callegari-Jacques, 2004).

From 1995 to 2008, capture sampling was carried out for the collection of new gender and meristic broadband anchovy data during catch periods. Analysis of variance (ANOVA) was used to verify significant differences among the landed specimens average monthly lengths for a 5% α (Callegari-Jacques, op. cit.).

3. Results

The boats operate in the estuary and in the Ribeira de Iguape River. There is a total of 428 registered boats, made of wood, fibre, or aluminum, from 5 and 10 metres in length. These vessels can be rowing boats or motor boats with 2.5 to 15 HP power. The aluminum boats are called of "*voadeiras*" ("flyers" or speed boats), and 196 units were registered, ranging from 5.5 m to 7.0 m in length, motorised, with 3.3 to 15 HP power.

The fishing arts employed in Broadband anchovy fishing are:

- *Manjubeira:* trawl net used in the water column, which presents bridle lines in its arms in order to keep it open, attached to cables that serve to tow it towards the river bank. There are floats in its upper part and sinkers in the lower part to keep the net distended (Beldazoli and Frosch, 1990). The net's length is generally between 120 and 150 metres, and it is 3 metres high. The mesh used in the bag is 18 mm, the measurement of the opposing angles of the stretched mesh. This net is stretched out with the help of a wood or fibre row boat, varying from 7 to 10 metres in length, which encircles an area of the river and then gets manually pulled to the bank. It generally takes 5 fishermen to operate each net - two to throw it, and all of them to pull it to the bank.
- *Corrico:* surface drift gillnet, which should be a maximum of 300 m in length, with 24 mm mesh (measurements of opposing angles of the stretched mesh). One or two fishermen are employed in working row or motorised wooden boats, ranging from 5 to 12 metres in length, or flyers with 3.3 to 15 HP power engines. The product caught with trawl nets has lower quality if compared to the one caught with the *Manjubeira*, because the fish entangles in the drift netting, and the handling during removal spoil the appearance of the product.
- "*Puçá*" for broadband anchovy: It is made with two bamboo sticks mounted in an "x" shape, and placed to the extremity of a raffia-style bag made out of nylon, in order to catch broadband anchovy schools which are closer to the banks (Figure 2). This device is handled by one fisherman standing on the river bank or canal - no vessel needed.

During the 1976-1989 period, average annual production was around 2,300 tones, declining after the enforcement of the protected fisheries periods as of 1990. It remained lower than 2,300 tones from then on, during the period of 1996-1997, when bumper crops occurred, with landings of over 5,000 tons. Since then, production has not exceeded 1,500 tons per year (Figure 3). The broadband anchovy fishing period generally starts in September, and extends until the end of April, when over 50 tons a month have been registered, even though there are landings of about 3 to 5 tons during the whole year.

Monthly CPUE for trawling net catches from 1998 to 2010 varied between 0.4 to 24.5 kg/hour. The highest average monthly CPUE values were registered between September and April (Figure 4). Annual CPUE values varied between 3.2 and 8.0 kg/hour, being that the highest values were found in 1998 and 2010 (Figure 5). Through analysis of variance (ANOVA), average CPUEs

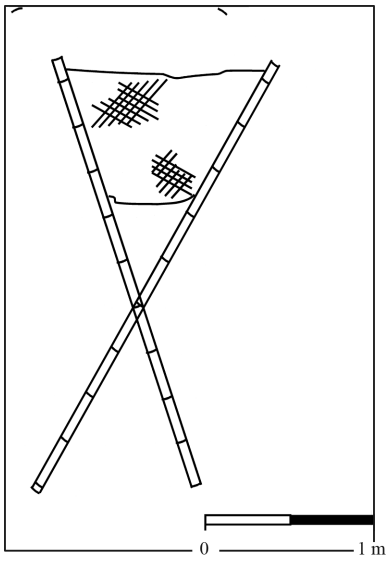

Figure 2 - Drawing of the "puçá" for broadband anchovy, in Iguape city (SP).

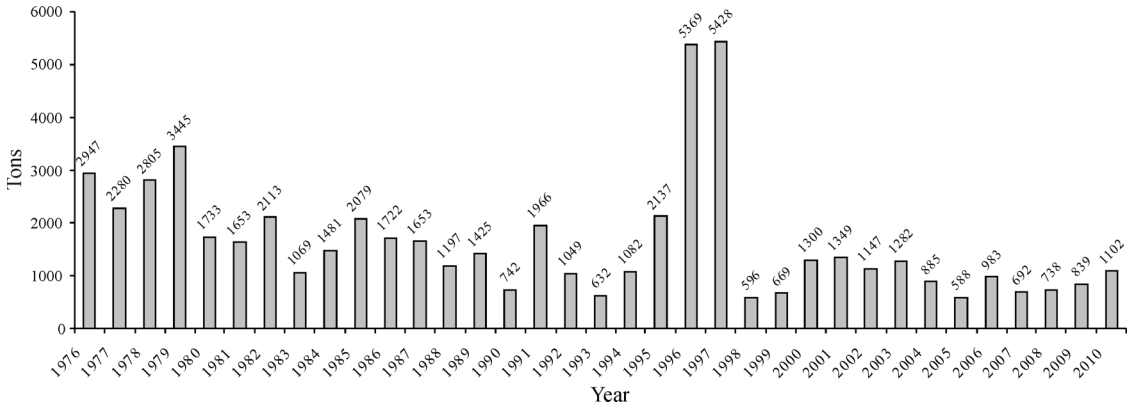

Figure 3 - Annual production of broadband anchovy landed in Iguape city (SP) in the period 1976 to 2010.

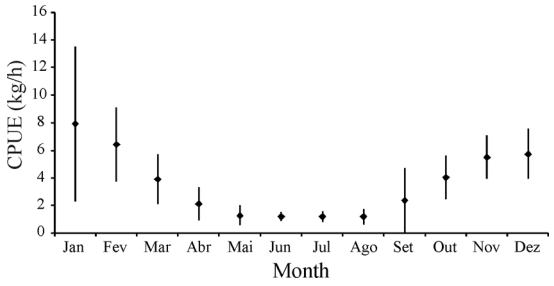

Figure 4 - Catch per unit effort (kg/hour) average monthly broadband anchovy catches with corrico in the period 1998 to 2010.

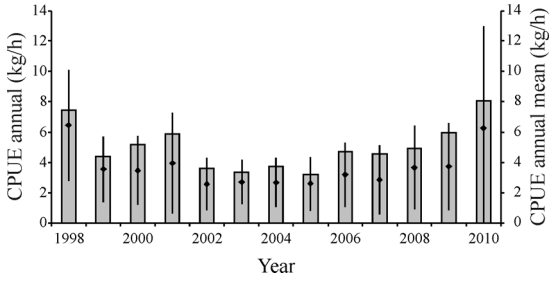

Figure 5 - Catch per unit effort (kg/hour) and annual average annual broadband anchovy caught with "corrico" in the period 1998 to 2010.

did not present significant differences ($\alpha = 0.05$) in thirteen years of study. If the analysis is divided into two periods - from 1998 to 2004 (before the enforcement of the last protected fisheries period), and from 2005 to 2010 (after the enforcement of the last protected fisheries period) - significant and antagonistic differences can be seen between the average annual CPUEs. During the first period, the abundance index presented a significant decrease as pointed to by the ANOVA, and, during the second period, an elevation in index until 2010, as shown in Figure 4. Even though the abundance index for the second period (2005 to 2010) have not presented significant differences shown by the ANOVA, ascension of CPUEs is clearly shown by the graphs.

Fishing effort (in number of fishing hours) increased throughout the study, going over 87 thousand fishing hours in 2010. Also the number of the trawling net gradually increased during the study. This increase happened for two reasons: the real increase in the number of nets in the water; and significant improvement of fishing monitoring. Due to those different reasons, it is not possible to clearly see a significant increase in effort. Until 2007, captures of various different fishermen were registered in one landing, preventing separation of individual fishermen productions. Because of that, those communitarian landings have only been considered so as to summarise production, and they have not been included in the evaluation of abundance and fishing effort indices. From 2008 on, there was a significant improvement in the collection methodology, and that made it possible to individualise the landings for each fisherman, also allowing attainment of production and effort data on fishermen captures individually. Thus, from 2008 on there was an increase in the number of fishermen and fishing hours, but not in total landing production, that does not take into consideration if the fish was landed by one sole fisherman or a whole group of them.

From 1998 to 2008, 19,219 specimens were sampled from both *corrico* and *Manjubeira* nets, in different local landings. Each year the medium length of specimens varied from 10.9 cm (± 0.4 cm) to 12.2 cm (± 0.6 cm). The average monthly length throughout the years shows that the largest specimens occurred before the beginning of the broadband anchovy crop (July - November), decreasing from the moment the crop starts, and the smallest individuals were registered in March and April (Figure 6). Average annual lengths showed a significant increase throughout 11 years (1998 -2008), showing an average of 11.6 cm (± 0.4 cm).

4. Discussion

4.1. Broadband anchovy fishing description

The life cycle of the broadband anchovy (*Anchoviella lepidentostole)* is not yet completely

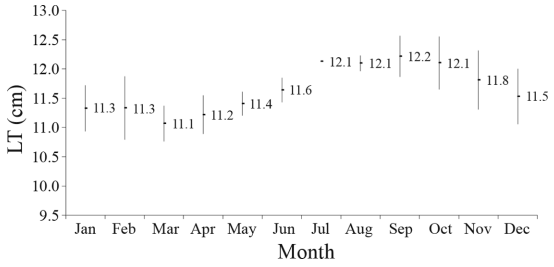

Figure 6 - Width and length of the average monthly broadband anchovy landed in Iguape in the period 1998 to 2008.

known, because the current studies have only been carried out on the fluvial areas and not on the marine migration area; as it is an anadroumous species that swims up Ribeira de Iguape River for spawning (*piracema*), which occurs mainly around Jairê (Iguape) (Giamas et al., 1990; Beldazoli and Frosch, 1990; Mendonça et al., 2000). Fishing takes place during that reproductive season, what brings concern about the sustainability of the resource.

Currently there are two main types of fishing gears used for broadband anchovy catches - the *Manjubeira* and the trawl nets. The *Manjubeira* is generally more expensive, so it is bought by businessman with greater buying power, and leased to the fishermen who undertake to deliver the fisheries harvest to the owner of the net. For those reasons there is a monopoly on the prices of the product in the region. On the other hand, the trawl nets were legally introduced in 1996 so as to detach the fishermen from the businessmen. However, the business sector acquires large quantities of trawls, and leases them to the fishermen, using the same procedure practiced with the *Manjubeira*. Thus, the fishermen remain at the mercy of the businessmen, who now monopolise the fishing activity with both types of gear. There is, however, a large number of independent fishermen in this sector, who can obtain better earnings from their activity.

Oscillation between production and productivity over time, with bumper crops (1995/1996 and 1996/1997), as well as great declines, show signs of overexploitation of the activity over the last decade, though these signs of overfishing have been previously pointed out in the 90s by Rossi-Wongtschowski (1990).

Among the factors that contributed to the oscillation of fishing productivity, a few historical facts must be highlighted. Firstly, the construction of the Valo Grande channel in August 1978, which made the species enter Ribeira de Iguape river only through the Ribeira Bar where during approximately 17 years, so in the harvest season there was a huge concentration of fishermen, lowering the chances the species had to fulfill their reproductive cycle, and causing a stock decrease (Giamas et al., 1990). The stock decrease of that species brought about the second factor: the establishment of the protected fisheries period from the months of December to January in the years from 1990 to 1994. That decrease in fishing effort aimed to recover the stock, once those months used to have the highest capture numbers, and because this time of year offers better condition for the reproduction of the species, and lower impact to the fishermen because of the Holiday season. Those facts helped the stock increase and reflected on the bumper stocks registered.

Currently, broadband anchovy fishing is still under alert, showing oscillations between crops, with total landings under 1,300 tons per crop. Data from this study at hand show significant drops in the abundance index from 1998 to 2004. That confirms the diagnosis given by Camara et al. (2001) when evaluating the stock from 1993 to 1996, which indicated a mortality coefficient per catch and operating rates value increase, suggesting that the broadband anchovy fishing effort did not increase.

From 2005 onwards, upon the enforcement of Regulatory Instruction No. 33, indexes gradually increased until 2010. That was the first indicator that the measure had an effect over the recovery of broadband anchovy abundance. Though the total production landed has not significantly increased, it is clear that fishermen are capturing more of the product throughout the crops.

Besides the encouraging data from the catches showing the recovery of the stock, the annual average length of the landed broadband anchovy showed significant increase over the studied years. That increase means that bigger specimens are present in the catches, which shows that older broadband anchovy with a higher reproductive potential are present in the schools (Giamas et al., 1990).

Although broadband anchovy abundance recovery results are satisfactory, it is important to highlight that its entrance in the Ribeira de Iguape River for reproduction depends on climatic factors, especially rainfall and temperature (Giamas, 1983; Paiva-Sobrinho and Mendonça, 2001).

The intention was to discuss the management based on adaptive management due to the intrinsic characteristics of the area of study that will be presented throughout the paper, and also because the adoption of management practices that take into consideration the relationship between the explored species stock and the environmental variables that influence its abundance and distribution. Besides the stock's maximum sustainable yield acquired under favourable environmental conditions cannot be maintained when conditions are adverse (Hoffmann and Powell, 1998). On the other hand maintaining the same fishing effort over the species in order to obtain higher production may disrupt the population, making it incapable of regrouping and resisting capture efforts even smaller than the previous ones, as well as facing environmental adversities that used to be absorbed by the species (Holling, 1973).

Adaptive management is an integrated and multidisciplinary method used for managing natural resources. It is adaptive because it recognises that the managed natural resources are always changing, that mankind must adjust it to such changes, and that surprises are inevitable. It also recognises that active learning is the way to overcome the ecological processes inherent uncertainty (Armitage et al., 2007). It further recognises that management actions must attend to social objectives, and

meanwhile, be constantly modified and flexible to adapt to surprises. However, it is structured to make learning more efficient and, in this sense, the innovative human ability is an important aspect of overcoming uncertainties (Gunderson, 2000).

It is presently believed that community involvement embedded in management work may allow fishing communities to recover control of their livelihood more efficiently (Schreiber, 2001; Domínguez-Torreiro et al., 2004). Fishermen have collective organisational capacity, and ability to discipline natural resource exploration in collective use areas, and even to standardise forms of access, prohibitions on predatory capture techniques and rules for division of the resources flow (Pereira, 2004).

For broadband anchovy fishing, adaptive management would supply the needs for spatial fishing, once the region already has in place a participative management process and capture monitoring (Machado and Mendonça, 2007). Thus, periodical evaluations of the resource must be carried out in order to support in a participative manner the discussions about broadband anchovy fishing, giving the regional fishery sector a voice, and involving managers, producers, and academics (Mendonça and Bonfante, 2011).

Furthermore, the variables with higher influence over the species production must absolutely be monitored. In the broadband anchovy fishing case, Paiva-Sobrinho and Mendonça (2001) noted a direct relationship between the Ribeira de Iguape River flow and the broadband anchovy production, so that the higher the flow of the river, the higher the species capture.

In order to relate the Ribeira de Iguape River flow to salinity, Paiva-Sobrinho (2001a) developed an expert system prototype based on fuzzy logic, with a positive relationship among the variables. The same way previous research can relate the given flow to production, or to a more appropriate variable, and build and integrated system where the monitoring and management bodies point to fishery changes, aiming at the adoption of better actions to maintain the activity's environmental, social and economic sustainability.

Management measures are not easy to apply and enforce, especially when they aim to decrease fishing effort over the resources. Generally when resource abundance improves, fishing activity rapidly intensifies, but when abundance decreases, fishing effort takes a long time to decrease, what causes a negative impact on the stocks and the economy (Steele and Hoagland, 2003). Although many actions have been taken in the past, they were very little effective because they neither decreased fishing efforts, nor had enough time to have an effect on the resource recovery due to the short duration of the instruction.

Fishing management in Brazil has seldom involved society, although the public agencies managing fishery always point to those actions (Quintas, 2002; Isaac-Nahum et al., 2006); that does not happen in practice, both because of difficulty of the approach, and because of lack of active politic will from the managing agencies to share their decisions and power of action. The creation of the Managing Council supplies this management flaw, aiming to maintain fishing resources and activity, through its dynamics of participatory spatial fishing discussion involving all sectors.

Broadband anchovy fishing management was based on co-management, that is, the resource management through discussion with users and government agencies, as defined Jentof et al. (1998) "the collaborative and participatory process of regulatory decision-making among representatives of user-groups, government agencies and research institutes", where aiming to reduce conflicts in the sectors, and achieve success in management. According to data, the management process has shown positive and encouraging results, gradually recovering fishery resources.

Thus, it is suggested that the current regulation is kept, and that the fishing effort is controlled not to exceed indices of stock sustainability of the Iguape broadband anchovy.

ANNEX 1- Ministerial Order number 34/1982 prohibits fisheries in the mouth of the Bar, e the fishing permit on the East Beach from September 15 to February 31 establishes mesh minimum size of 24 mm.

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