Proposal for creation of a “zoning with regulation of use in the Cananéia estuarine-lagoon complex” aiming the conservation of the estuarine dolphin, *Sotalia guianensis* (van Bénéden) (Cetacea, Delphinidae)

GISLAINE DE FATIMA FILLA\(^1,2\), ANA CAROLINA GREGÓRIO ATEM\(^1\), TATIANA LEMOS BISI\(^1\), LISAVASCONCELOS DE OLIVEIRA\(^1\), CAMILA DOMIT\(^1,2\), MAURA GONÇALVES\(^1\), LIISA HAVUKAINEN\(^1,3\), FERNANDO OLIVEIRA\(^1\), RENATO GARCIA RODRIGUES\(^1\), FERNANDO CÉSAR WEBER ROSAS\(^1,4\), ANA RITA DOS SANTOS-LOPES\(^1\), EMYGDIO LEITE DE ARAUJO MONTEIRO-FILHO\(^1,5\)

\(^1\)Instituto de Pesquisas Cananéia. Rua Tristã Lobo, 199. CEP 11990-000 – Cananéia, SP, Brasil. www.ippecpesquisas.org.br
\(^2\)Pós-graduação em Zoologia – UFPR.
\(^3\)Pós-graduação em Psicobiologia – UFRN.
\(^4\)Instituto Nacional de Pesquisas da Amazônia, INPA.
\(^5\)Departamento de Zoologia – UFPR.

Authors’ e-mails: gica_filla@yahoo.com.br, ana.atem@gmail.com, tbisi@yahoo.com.br, lisa.oli@uol.com.br, cadomit@gmail.com, maura_goncalves@hotmail.com, liisabio@yahoo.com.br, botocinza@uol.com.br, renato_garcia@gmail.com.br, frosas@inpa.gov.br, anasantos_lopes@yahoo.com, elamf@ufpr.br

Abstract. The increase in human activities in the coastal region has affected the stability of certain cetacean populations. In the Southeastern Brazilian coast, the populations of estuarine dolphins, *Sotalia guianensis* (van Bénéden, 1864) suffer strong pressure as a result of long exposure to pollution, reduction of habitats, by-catch and tourism. Since 1981, the Instituto de Pesquisas Cananéia (IPeC) studies the biology and ecology of the estuarine dolphin in the Cananéia-Paranaguá estuarine-lagoon complex. Since then, we have obtained information on group structure, population density, reproduction, foraging, behavior, acoustics, video identification and interactions with other species, including the local human community. These data indicate that the traffic of fishing boats does not interfere in the activities of the estuarine dolphin. However, small boats with outboard motor may interfere physically; through collisions with dolphins or stressing them, and also may interfere in their acoustic behavior. Therefore, with the intention of acting effectively in the conservation of the estuarine dolphin, without excluding human activities we formulated a proposal for creation of an area of “zoning with regulation of use” which consists in outlining sectors of greater density of dolphins in the Cananéia estuarine-lagoon complex.

**Key words:** Boats, tourist activities, human impact, acoustics, behavior, conservation.

Resumo. Proposta de criação de “zoneamento com regulamentação de uso no Complexo Estuarino Lagunar de Cananéia” visando à conservação do boto-cinza, *Sotalia guianensis* (van Bénéden) (Cetacea, Delphinidae). O aumento de ações humanas na região costeira tem afetado a estabilidade das populações de cetáceos. Nas baías da costa sudeste, as populações de boto-cinza, *Sotalia guianensis* (van Bénéden, 1864) vêm sofrendo forte pressão por estarem expostas à poluição, diminuição dos habitats, captura acidental e ao turismo. Desde 1981, o Instituto de Pesquisas Cananéia (IPeC) estuda a biologia e ecologia do boto-cinza no Complexo Estuarino Lagunar Cananéia/Paranaguá. Durante este período, obtivemos diferentes informações sobre estrutura de grupo, densidade populacional, reprodução,
alimentação, comportamento, acústica, videoidentificação e interações com outras espécies, incluindo comunidade local. Estes dados denotam que o tráfego de embarcações pesqueiras não interfere nas atividades do bato, mas que pequenas embarcações com motor de popa, podem interferir tanto impactando fisicamente os animais, estressando e colidindo com os mesmos, quanto no seu comportamento acústico. Assim, com o intuito de atuar efetivamente na conservação do bato-cinzento, sem contudo, excluir atividades humanas, formulamos uma proposta de criação de uma área de “zoneamento com regulamentação de uso” que consiste na delimitação de setores de grande densidade de botos no Complexo Estuarino Lagunar Cananéia.

Palavras-chave: Atividades turísticas, embarcações, impactos humanos, acústica, comportamento, conservação.

Introduction

Over the past decades, environmental questions have become the central focus of great world-wide discussions given that they are directly related to the maintenance of basic conditions of survival in our planet. Basic research must be the starter for such discussions. In Brazil, basic studies involving cetaceans have gained new perspectives with the publication of the Action Plan for Aquatic Mammals of Brazil (IBAMA 1997, 2001). Although the species Sotalia fluviatilis is classified in the category “data deficient” in this Action Plan, it is under strong anthropogenic pressure, such as pollution, loss of habitat, by-catch and intentional harassments by tourism and leisure boats (Siciliano 1994, Di Benedetto et al. 1998, Rosas 2000, Kajiwara et al. 2004, Kunito et al. 2004). The confirmation of two species of the genus Sotalia is recent (Monteiro-Filho et al. 2002, Cunha et al. 2005, Caballero et al. 2007) and the status of conservation of S. guianensis until now was not evaluated by the IUCN (IUCN 2007).

In the Cananéia estuary, southern coast of São Paulo State, the estuarine dolphin S. guianensis (van Bénéden, 1864) is seen in a positive way by the local community. Especially considering the interaction displayed during foraging activities, in which the dolphin conducts shoals of fish to the “cerco-fixo” (a local traditional fish trap), helping the fishermen to capture the fish (Monteiro-Filho 1995). The species is also seen as a great tourism attraction in the region, which constitutes of an important source of income for the community. Although dolphin-watching tourism may promote economic benefits (IFAW 1995); it may disturb the balance in dolphins’ populations if it is not regulated (Coscarella et al. 2003). The EMBRATUR National Tourism Project (1992 apud Becker 1995) considers the southern coast of São Paulo State as one of the greatest areas of potential increase in nautical facilities, with the possibility of implantation of marinas in the coast.

A team of 33 researchers has been investigating the estuarine dolphin in that area for the past 26 years, which enabled an effective monitoring of different aspects of the biology and ecology of this dolphin population. This kind of research is of fundamental importance so that we can suggest conservation proposals in the region where dolphins are present all year round; mating, nurturing their calves and feeding, including during the night. It is worth stressing that a good part of the studies developed by us follow the suggestions stated in the item “Projetos e Ações Prioritárias” (Projects and Priority Actions) from the Action Plan for Aquatic Mammals from Brazil (IBAMA 2001).

Considering this reality, and the fact that in the Cananéia estuarine-lagoon complex, the estuarine dolphin has been suffering impacts by human action, such as possible collisions with high speed boats; noise interference generated by boats (Gonçalves 2003, Rezende 2008), organochlorine contamination (Kajiwara et al. 2004, Kunito et al., 2004), by-catch (Rosas 2000) and by the increase of the local tourism (Filla 2008); a proposal of zoning with regulation of use was elaborated aiming the protection and conservation of the population of estuarine dolphins inhabiting this area.

Material and methods

Study area

The Cananéia Estuarine-Lagoon Complex (Fig. 1) is located in the southern coast of São Paulo State. The region has 110km of extension, consisting of a protected channel (Mar Pequeno), a bay (Baía de Trapandé) and three islands (Ilha Comprida to the east, Ilha do Cardoso to the south and Ilha de Cananéia to the west), with narrow coves to the north (Barra do Icapará) and to the south (Barra de Cananéia). This estuarine system represents one of the most preserved ecosystems in the Brazilian coast and since it is part of a State and Federal Area of Environmental Protection, the complex is legally protected (Schaeffer-Novelli et al. 1990).
Research Procedures

The different studies regarding the biology and ecology of the estuarine dolphin were gathered with the intention of formulating a proposal of an area for the protection of the estuarine dolphin in the region of Cananéia. These studies are already available in different scientific journals and were carried out by the team of researchers working in the Estuarine Dolphin Project from 1981 to 2007.

Having all the data mentioned above and based on the present Brazilian legislation, we are contacting the Brazilian governmental agency responsible for the environmental policies (IBAMA-Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis) to make possible that the rules proposed herein can be implemented in the Estuarine region of Cananéia.

Results

During the 26 years of estuarine dolphin research in Cananéia, many studies were carried out. The main results of the studies regarding the estuarine dolphin biology and ecology are shown in Table I.

After putting together the data collected and having contacted the IBAMA; it was possible to elaborate the “Proposal of zoning with regulation of use” for the Cananéia estuarine-lagoon complex (Table II), where the sectors with greater densities of estuarine dolphins in the region are considered priority for the conservation of this species. In addition, the human activities occurring in these sectors should be monitored.

Discussion

According to the Action Plan for Aquatic Mammals of Brazil (IBAMA 2001), the main threats that affect the genus are related directly to the destruction of habitats within its distribution area, including pollution resulting from industrial waste, toxic substances used in agriculture, river dam for both electricity production and irrigation, as well as the deforestation of riverbanks, lakes and mangrove areas. The increase of boat traffic and urban development in the coastal areas along with the mangroves and estuaries are gradually affecting the stability of dolphin’s populations. In coastal bays along the Brazilian Southeast region the Sotalia populations are under severe human pressure resulting in exposition to the synergic effects of pollution, habitat loss, bycatch and intentional molesting by leisure and tourist boats. In the state of Santa Catarina, for instance, the unorganized and non regulated practice of cetacean observation tourism is also a threat to the local population (IBAMA 2001).
**Table I.** Themes developed during several studies on the biology, ecology and conservation of the estuarine dolphin, *S. guianensis*, in the Cananéia estuarine-lagoon complex, southern coast of São Paulo State, Brazil, with the respective sampling periods and results that contributed to the elaboration of the proposal of zoning with regulation of use in Cananéia.

<table>
<thead>
<tr>
<th>Study Theme</th>
<th>Sampling Periods</th>
<th>Contribution for the proposal</th>
</tr>
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<tbody>
<tr>
<td>Individual Identification</td>
<td>Two sampling periods: From 06/2001 to 08/2002; From 08/2004 to 08/2005.</td>
<td>48 individuals with natural marks on the dorsal fin, on the head and on the back were identified (De Oliveira &amp; Monteiro-Filho <em>in press</em>).</td>
</tr>
<tr>
<td>Density estimation</td>
<td>Two sampling periods: From 01/2001 to 09/2001; From 05/2003 to 05/2004.</td>
<td>Besides the estimation of the dolphin population, it was also possible to observe a difference in use and in spatial and temporal distribution by the dolphins (Bisi 2001, Havukainen 2004).</td>
</tr>
<tr>
<td>Reproductive biology</td>
<td>From 04/1997 to 10/1999</td>
<td>Size and age of sexual maturity, length of birth, time of gestation and lactation, fetal growth rate, reproductive cycle and observation of senescent ovaries in females above 25 years, were estimated. Promiscuous reproductive systems, with sperm competition were also observed (Rosas &amp; Monteiro-Filho 2002, Rosas &amp; Barreto <em>in press</em>).</td>
</tr>
<tr>
<td>Pollution</td>
<td>From 04/1997 to 10/1999</td>
<td>Organochlorine values (DDT and PCBs) in the bubbler and hepatic concentrations, especially Cu and Zn, were detected in similar levels to what was found in dolphins from highly industrialized regions (Kajiwara <em>et al.</em> 2004, Kunito <em>et al.</em> 2004).</td>
</tr>
<tr>
<td>Behavior</td>
<td>Two sampling periods: From 1981 to 1991 From 01/2004 to 07/2005.</td>
<td>The behavioral studies demonstrated the great importance of the Cananéia estuary for the performance of elaborated and complex foraging strategies, with many different patterns performed individually or in associations (Monteiro-Filho 1992, Rautenberg &amp; Monteiro-Filho <em>in press</em>).</td>
</tr>
<tr>
<td>Infant’s Behavior</td>
<td>From 1981 to 2005.</td>
<td>The results demonstrated that calves have great variation of behavioral patterns in different ages. They occur in different frequencies and were grouped in eleven categories (Domit 2002, 2006, Monteiro-Filho <em>et al.</em> <em>in press</em>).</td>
</tr>
<tr>
<td>Group Structure</td>
<td>From 1984 to 1999</td>
<td>Describes the category &quot;family&quot; as the most frequent grouping in the estuarine dolphin in Cananéia (Monteiro-Filho 2000).</td>
</tr>
<tr>
<td>Strandings on beaches in the region</td>
<td>Since 1981</td>
<td>Information collected since the beginning of the project. The specimens are deposited in the collections of the Museum of Natural History of UNICAMP (ZUEC) and at Instituto de Pesquisas Cananéia (IPeC).</td>
</tr>
<tr>
<td>Skull morphometric analysis</td>
<td>From 1998 to 2001</td>
<td>The data collected in this study support the description of two species for the <em>Sotalia</em> genus (Monteiro-Filho <em>et al.</em> 2002).</td>
</tr>
<tr>
<td>Ethnic knowledge</td>
<td>From 2001 to 2006</td>
<td>Diagnosis of specific traditional knowledge about the species, as well as, the local communities’ socio-environmental needs (Oliveira &amp; Monteiro-Filho 2006, Oliveira <em>et al.</em> <em>in press</em> b).</td>
</tr>
<tr>
<td>Interaction with local fishermen community</td>
<td>From 1982 to 1990</td>
<td>Description of the interactions between dolphins and fishermen, especially close to the “cercos-fixos” (traditional fish trap) (Monteiro-Filho 1995).</td>
</tr>
<tr>
<td>Acoustics</td>
<td>From 1989 to 1998</td>
<td>Four categories of sound emissions were described (Monteiro-Filho &amp; Monteiro 2001).</td>
</tr>
<tr>
<td>Impact of touristic activities</td>
<td>From 12/2004 to 03/2007.</td>
<td>Just as the acoustics, preliminary results about the impact of tourism show that small (and high speed) boats with outboard motors cause immediate reaction by the dolphins (Filla 2008).</td>
</tr>
</tbody>
</table>
Table II. Items that compose the "Proposal of zoning with regulation of use" in the Cananéia Estuarine-Lagoon Complex, submitted to the IBAMA (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis).

<table>
<thead>
<tr>
<th>Item</th>
<th>Proposal</th>
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<tr>
<td>Boat Traffic</td>
<td>Aluminum boats with outboard motor should transit in low speed whenever a dolphin is seen from a distance of 500 m, therefore, reducing the impact generated by the noise of the engine, and allowing the boats to be sighted from certain distance. All boats should keep a minimum distance of 50 meters from the animals and if/when the animal are being watched, they should keep the engines on neutral so that their presence and localization are easily noticeable by the animals. Never, under any circumstances, should the animals be separated from the group, especially calves from their mothers.</td>
</tr>
<tr>
<td>Nautical Sports</td>
<td>Jet-ski and water-ski should be avoided in the region, and totally forbidden in the areas of major occurrence of estuarine dolphins, which should be marked with signalizing buoys.</td>
</tr>
<tr>
<td>Tourism</td>
<td>Avoid changing direction of the boats when aiming to get closer or to follow an animal or group. The total time of observation of the same group of dolphins is limited to a maximum of 30 minutes. A maximum of 03 boats can stay close (less than 100m) to the same group of dolphins at the same time.</td>
</tr>
<tr>
<td>Scientific studies</td>
<td>Exceptionally, scientific research involving estuarine dolphins is allowed. Approaching cetaceans with boats and aircrafts can be done exclusively with scientific purposes. Invasive scientific research or biopsy techniques that perforate or remove living animal tissues without contention should be avoided at all costs and can only take place with official authorization from the Conservation Unit corresponding to the Federal Office in charge (IBAMA).</td>
</tr>
<tr>
<td>Responsibilities</td>
<td>The responsibility for breaking the rules must be attributed to the conductors of the boats and their owners.</td>
</tr>
<tr>
<td>Monitoring</td>
<td>A continuous monitoring of all nautical activities in the region should occur and the results of this monitoring should be forwarded to the local environmental authorities.</td>
</tr>
</tbody>
</table>

Continuous efforts which enable the monitoring, in an effective way, of different biological and ecological aspects of the estuarine dolphin populations, are of fundamental importance so we can base conservation proposals. This is the case of the Cananéia region where the dolphins are present throughout the year. The animals use the area to breed, feed and nurture their calves, and are very active including during the night (Monteiro-Filho 1992, Rosas & Monteiro-Filho 2002, Atem & Monteiro-Filho 2006, Monteiro-Filho et al. in press, Oliveira et al. in press a, Rautenberg & Monteiro-Filho in press, Rosas & Barreto in press). In this area, the estuarine dolphin also interacts with the traditional local communities (Monteiro-Filho 1995).

Regarding the impact evaluation, studies involving acoustic and monitoring of the tourism activities in the region point out to a negative impact when small sized boats with outboard motors are present in the area. The noise emitted by this kind of boat has been shown to make the dolphins swim away from the boat (avoidance reaction) or even cause change in the acoustic niche (Gonçalves, 2003, Rezende 2008). Moreover, the increase in boat traffic is of great concern in some regions across the Brazilian coast (Valle & Melo 2006, Santos-Jr et al. 2006) since it may cause serious damage to the dolphin populations and may push the dolphins to abandon the area such as already has happened on other locations in the world (Watkins 1986 Richardson et al. 1995, Ritter 2002, Magalhães et al. 2002, Coscarella et al. 2003, Lusseau 2003, Ng & Leung 2003).

Studies concerning population density in different places have shown alarming rates of abandonment of area for certain cetacean species. For S. guianensis, two records of abandonment of area are reported. The first one was within the northern limit of its geographic distribution (Edwards & Schnell 2001) and the other nearby the southern limit (Filla 2004). In both cases the most likely cause for the abandoning of the area was the increase in human activities, especially the increase in boat traffic. Recent studies with this species, such as those carried out by Gonçalves (2003) and Rezende (2008), in Cananéia (SP) and Keinert (2006) Ilha das Peças Island (PR), have shown that not only the exaggerated proximity of the boats is damaging, but also the sound
produced by their engine can be harmful to the dolphin’s population. The above-mentioned studies analyzed boats with central engine (diesel) and boats with outboard motor (petrol), showing that the acoustic emissions registered are within the *S. guianensis* acoustic range. As a result the increase in traffic may cause serious damage to the dolphins’ population and force them to abandon the area.

One of the most serious consequences of the interaction of cetaceans with high speed boats is the possibility of collision. According to Ana Rita dos Santos Lopes (personal observations) 17.26% of the estuarine dolphins found in the beaches along the Cananéia region, over the past six years, showed evidences of crash with boats (scars, recent cuts and/or bruises and bleeding).

One way of protecting marine habitats is to create small protection areas, with special attention to particularly valuable places for certain species which offer great benefits for the local communities. The planning for marine protected areas should contain initiatives that have influence in the decisive processes within the society. In that sense, it is necessary to motivate the government, the people from the local communities, and national and international organizations to conserve the biological diversity and the cultural integrity (IUCN 2002).

Hence, an area of protection of zoning with regulation of use in the region of Cananéia is proposed herein following the orientations of the IUCN (1999) guide for marine protection areas. This work is a concrete and ethically consistent proposal to conserve the species, and does not exclude the human activities (Filla et al. 2002, Filla & Monteiro-Filho 2006), avoiding conflicts and bad utilization of the conservation areas such as those reported by Wedekin et al. (2002) in the Santa Catarina State and by Silva & Silva Jr. (2002) in the Fernando de Noronha Arquipelago.

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