Contribution to Araçá Bay management: The identification and valuation of ecosystem services

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1. Introduction

Ecosystems sustain human life and its activities through their provision of ecosystem services (Costanza et al., 1997; Daily et al., 1997; Daly and Farley, 2004; Gómez-Baggethun and de Groot, 2010; MEA, 2003). Those services represent the translation of ecological complexity and functions that benefit human beings (Gómez-Baggethun and de Groot, 2010).

However, a wide variety of human activities are seriously harming ecosystems and the provision of these services (Daily et al., 1997). The pressures on ecosystems such as predatory fishing, eutrophication, contamination and climate change effects are being reported in several parts of the world (Remoundou et al., 2009; Turner, 2000; White and Cruz-Trinidad, 1998), such as in the Araçá Bay in the coastal region of the Brazilian state of São Paulo.

This bay has been threatened over the years from unplanned land use and settlements, receiving domestic sewage, and a set of disturbances from the São Sebastião Port and the Petrobras Harbor Terminal (*Terminal Aquaviário da Petrobras* – TEBAR), such as oil spills (Amaral et al., 2016). The Araçá Bay has been physically transformed by housing construction, by dredging for the installation of a marine sewage outfall and by the construction of the São Sebastião Port. All those pressures and transformations induce to environmental degradation of the Araçá Bay (Amaral et al., 2010). The Bay also may be impacted by the expansion of the São Sebastião Port (São Paulo, 2009). Even so, the Araçá Bay still shelters a high degree of biodiversity, maintains one of the last remaining patches of mangrove vegetation on the coast of São Sebastião city and it is an important site for artisanal fishermen (Amaral et al., 2010).

The economic values of the ecosystem services are important tool to support ecosystems management (Andrade and Romeiro, 2009; Birol et al., 2006). These values can be used, for example, in environmental compensation evaluations, to highlight the importance of ecosystems (Mendelsohn and Olmstead, 2009) and to support decision-making associated to interventions in ecosystems (Costanza et al., 2014).

As 80% of ecosystem services are not transacted in markets (de Groot et al., 2010), obtaining their economic value generally depends on different methods of economic valuation (Costanza, 1994). Normally, these methods estimate the value from individual preferences related to ecosystem services or from their contribution as input in market product or service production (Motta, 1997).

However, it is not possible to convert all the contributions of ecosystems to human well-being in economic terms (Costanza et al., 2014; Jacobi and Sinisgalli, 2012), after all, for many people, ecosystems are strongly associated with historical, ethical, religious and spiritual values. These values are not fully captured by utilitarian methods, especially when ecosystems are essential for the cultural identity of people (MEA, 2003). Therefore, socio-cultural valuation methods are useful to estimate the value of ecosystem services based on people's opinion, individually or collectively (MEA, 2003; Wilson and Howarth, 2002). For example, people may be asked to rank ecosystem services according to their importance (Calvet-Mir et al., 2012), which may include economic interests or not.

The values of ecosystem services can also be estimated in ecological terms. Ecological valuation assumes that ecosystem services are physical and non-physical products generated by ecosystems, regardless of their importance to humans. Thus, ecological values are estimated on the biophysical interdependencies of ecosystems and not on human preferences. One method estimates values based on an emergy analysis, i.e., recovering the energy memory of an ecosystem resource and converting all forms of energy used during its production into solar energy equivalents (Andrade and Romeiro, 2009). Ecological valuation can also be used to attribute value to whole ecosystems using ecological indicators such as diversity and integrity (de Groot et al., 2010).

Although there are several studies about Araçá Bay (Amaral et al., 2010), none of them identified and valued its ecosystem services. Since valuation of ecosystem services can contribute to the management of the Bay, the research questions of this study were: Which are the ecosystem services of the Araçá Bay and what is their monetary value? Among those services, which are the most important for the local community?

Thus, the overall objective of the study was to identify and valuate the ecosystem services provided by Araçá Bay (São Sebastião, São Paulo) from socio-cultural and economic perspectives. We did not

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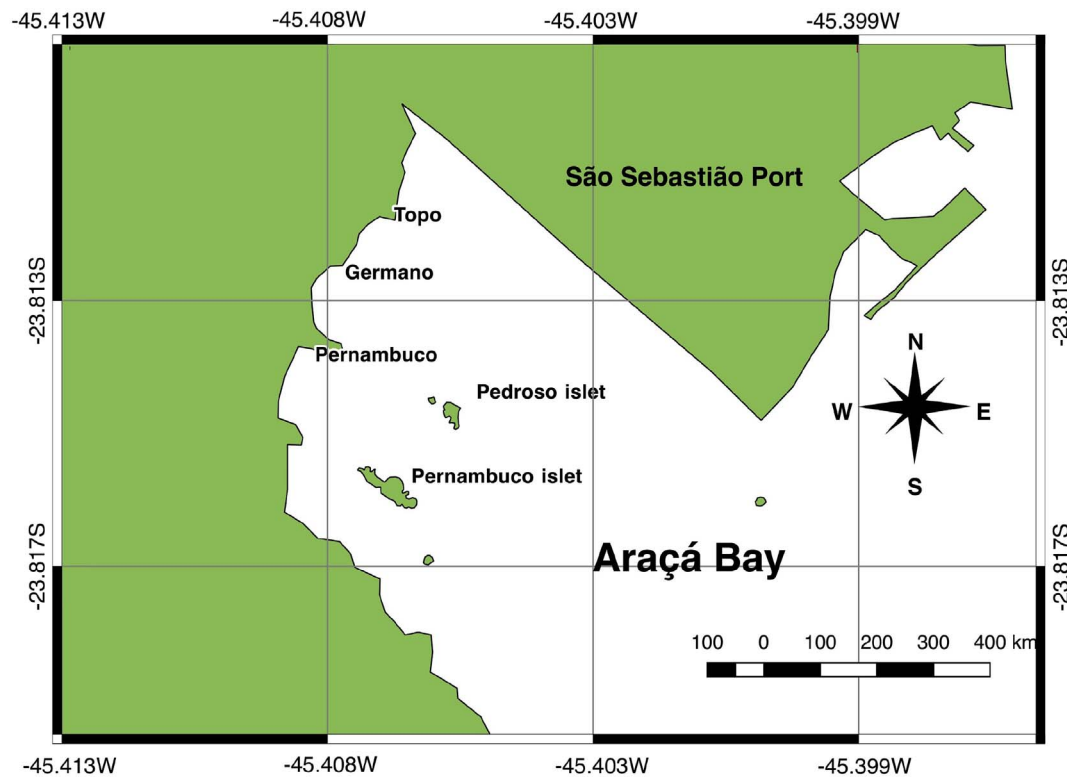
Fig. 1. The Araçá Bay and the São Sebastião port.

address the ecological values since we wanted to focus on the contributions of the Bay to human well-being.

Several other studies have identified marine and coastal services or estimated their economic value (e.g., Ahmed et al., 2007; Barbier et al., 2011; Beaumont et al., 2007; O'garra, 2012; Tuya et al., 2014; Vo et al., 2012); other studies estimated their socio-cultural values (e.g., Maynard et al., 2014; Queiroz et al., 2017); and some even estimated economic and socio-cultural values (e.g., Martín-López et al., 2014). However, to our knowledge, there haven't been any studies estimating both economic and socio-cultural values of ecosystem services in Brazil.

2. Study area

The Araçá Bay (Fig. 1) is in the municipality of São Sebastião (São Paulo, Brazil) and consists of a small cove with approximately 50 hectares (ha) (Amaral et al., 2010). It encompasses an extensive tidal flat with three distinct beaches (Pernambuco, Germano, and Topo), two islets (Pernambuco and Pedroso), patches of mangrove vegetation, two natural rocky shores and an artificial one, where the São Sebastião Port is set (Amaral et al., 2010, 2016).

Although it occupies a relatively small area when compared to other coastal bays, the bay contains a high diversity of organisms. According to Turra et al. (2016), 1364 species (taxa) have been identified at the Bay so far (56 new species and 17 are endangered species). These same authors explain that Araçá Bay presents excellent conditions for organisms to reproduce, grow and feed due to its shelter and calm waters.

The Bay's surroundings are São Sebastião urban area, exposing its environmental conditions to several kinds of anthropic activity. Given the current situation of environmental degradation, Amaral et al. (2010) argue that it is necessary to implement policies to ensure the rational use of the Araçá Bay and to take measures to achieve environmental recovery of the area and its surroundings.

3. Materials and methods

3.1. Identification of the ecosystem services

The identification of the Araçá Bay ecosystem services was done in three main steps: (i) bibliographic review on ecosystem services, especially on the marine and coastal ones (e.g., Beaumont et al., 2007; Brander et al., 2012; Cheng and Zhou, 2012; Laurans et al., 2013; O'garra, 2012; Pereira et al., 2007; Remoundou et al., 2009; Samonte-Tan et al., 2007; Vo et al., 2012; Wilson and Howarth, 2002), and also on the Araçá Bay (e.g., Amaral et al., 2010; Gubitoso et al., 2008); (ii) survey with experts (i.e., 10 Araçá Bay researchers); (iii) survey with local community (i.e., 15 residents of the Varadouro neighborhood in São Sebastião, the nearest one to the Bay).

From the bibliographic review, we have listed the ecosystem services provided by Araçá Bay and it was validated by the two consulted groups (i.e., experts and local community). The groups were asked to point out the existence or absence of the services initially identified and to indicate other services that were not identified. The specialists answered a self-administered questionnaire, while the survey with the local community was done by individual interviews.

The classification of services was based on the categories presented by the Millennium Ecosystem Assessment - MEA (2003). However, services beyond those presented by MEA (2003) were identified from the surveys with the groups. Moreover, we did not consider the support services since we understand that they represent ecosystem functions (Gómez-Baggethun and de Groot, 2010).

3.2. Economic valuation

Six of the ecosystem services identified were economically valued from direct and indirect methods based on market observation. These services were selected for valuation based on the identification of methods considered appropriate for the local context and which could be applied with available data. The economic values were estimated for