ABUNDANCE ESTIMATES OF *SOTALIA* DOLPHINS: A REVIEW.

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Introduction

Population abundance estimates can be considered as one of the most important ecological parameters for conservation purposes. When considering top predators which usually can be found in larger ecosystems, such estimates should be one of the priorities to be reached. However, the scenario for *Sotalia* dolphins is still far from it should be. Marine and freshwater *Sotalia* dolphins inhabit areas which have been critically impacted by human activities (*e.g*. habitat destruction and overfishing) in the last 20 years. Considering the relatively broad range of the distribution of *Sotalia* dolphins, there is still a few studies on abundance estimates. Thus, regarding a review on the state of the art, it turns necessary to discuss what has been accomplished, to list a few steps to find better ways to improve further studies, and to list the priorities in a near future for conservation purposes.

Objectives

Gather the available information on *Sotalia* abundance estimates, present an updated and summarized table on such surveys (e.g. survey date and place, employed technique, reached estimates, and source of information), and list a few aspects to be discussed to improve further studies.

Results

The results on this first review can be found summarized on table 1. Documents in which data was not presented were left with question marks "?".

From all studies conducted up to now, and considering only the ones which showed results, around 24 documents were presented in scientific meetings as abstracts, in universities as thesis or dissertations, and were published in peer-reviewed journals. Most of these documents were abstracts and a few others were presented as requisites to take under-graduation, masters and doctorate degrees. Six publications in peer-reviewed journals are available: three with freshwater and three with marine *Sotalia*. Probably because of the broader distribution of marine *Sotalia* along South and Central Americas, as well as their closer proximity to research centers along coastal areas and in bigger cities, most studies were conducted with *S. guianensis*. These studies were conducted in a few places. In Brazil, all marine *Sotalia* abundance estimates were conducted in Rio de Janeiro (Guanabara and Sepetiba bays), São Paulo southern and Paraná northern estuarine waters (Cananéia – Paranaguá estuary), and Santa Catarina (Babitonga bay). There is also information available for Nicaragua (Cayos Miskito reserve) and Colombia (Golfo de Morrosquillo). Around 60% of these studies were based on distance sampling, and the rest were based on mark-recapture estimators using the photo-identification technique. Those studies have been conducted since 1983.

Regarding *S. fluviatilis*, the few studies available were conducted in the Brazilian, Colombian and Peruvian Amazon basin. The interesting point is that, because of the habitat heterogeneity in the Amazon ecosystem, all surveys used a mixture of methods including line and strip transect, as well as cue counting. Those studies have been conducted since 1993.

Discussion

Different field techniques and estimators can be used as tools to reach dolphin abundance estimates. The choice for each depends on the characteristics of the surveyed species, features of the habitat, and the interest of gathering other populational parameters (*e.g*. survival rates). All require specific survey designs for data analyses, which generally need to respect assumptions. Maybe one of the most important and delicate issues for researchers is to avoid violations of previous assumptions when choosing a specific technique and/or survey design. A few authors contributed with a discussion on this issue (e.g. Vidal *et al*., 1997; Campos *et al*., 2004; Martin *et al*., 2004). Thus, one of the major aspects to be discussed by *Sotalia* researchers should be "survey design and shortcomings".

Another interesting issue presented by a group of authors that deserves attention was about the significant effect of leaving observers in the back of boat-based platforms when conducting line transect surveys (see Vidal *et al*., 1997; Marques *et al*., 2002). This may be interesting to estimate the fraction of animals which may be missed during transects. This issue comes from the difficulties in observing *Sotalia* dolphins in their element as they are usually found in brackish waters, generally avoid boat approaches, and are considered small when comparing to other Delphinids.

Also considering survey designs, it would be interesting to discuss if the ones who have been working with *S. guianensis* using line transects should try to conduct surveys based on a combination of techniques like previous investigations conducted with *S. fluviatilis* (see Vidal *et al*., 1997; Martin *et al*., 2004). In most estuarine environments, features like big rivers, lagoons, bays and tributaries resemble closed areas usually found in the Amazon basin.

An important aspect to be discussed by the ones who have been using the photo-identification technique is related to the adaptation on the use of new technologies. Digital cameras drastically reduced the cost of photo-identification surveys, and improved the quality of analyzed photographs. It is easier to prepare and compare new photos to cataloged ones. However, it would be interesting to change experiences on which equipments have been used, how researchers have been organizing their catalogs, how they have been comparing new photos to old ones, and if any of them tried to use any software to compare photos. One of the main shortcomings regarding *Sotalia* photo-identification comes from the difficulties in getting good quality shots on a relatively small dorsal fin of a shy dolphin species, as well as those problems which come from false positives when including individuals in a catalog with less conspicuous notches on the edge of their dorsal fin.

Probably these first presented aspects can lead to further important discussions to improve *Sotalia* population estimates, an important parameter for conservation purposes.

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Table 1. *Sotalia* abundance estimates with emphasis to places where surveys took place, sampling period, area or length of survey, technique used, gathered results and source of information.

Place: Basin/Country/State	Sampling Period	Área/Length of Survey	Technique(s)	Estimates	Source (se
Amazon/Peru, Colombia, upper Brazilian Amazon river	5-26 June 1993	120 km	line; strip transect	409 (CV = 0.13); 8.6 ids/km^2 (lakes); 2.8 ids/km^2 (banks); 2.0 ids/km^2 (islands)	Vidal *et al*.
Amazon/Colombia	March-April 2002	140 km	line; strip transect; cue counting	26.7 ids/km^2 (lakes); 4.1 ids/km^2 (channels); 3.8 ids/km^2 (islands); 3.5 ids/km^2 (tributaries)	Marque *al*.(20(
Amazon/Brazil	Mar. 1999 – Apr. 2001	1,402 km strip transect; 810 km line transect	line; strip transect	Mean 3.2 ids/km^2 (values presented for different habitats along time)	Martin *et al*
Amazon/Peru; Pacaya-Samiria reserve	Mar. 1996 – Nov. 2000	288 km (rivers) 50 km^2 (lakes)	cf. line; strip transect	0.01-0.08 ids/km (rivers); 0.05-2.17 ids/km^2 (lakes)	McGuire (
Cayos Miskito Reserve/Nicaragua	April – May 1996; March – May 1997/1998	152.4 km^2; 4,389 km (boat)	boat (line transect) + aerial surveys	Different results for different subareas. Mean: 0.647 ids/km^2 (coast); 0.578 ids/km^2 (inlets); 0.486 ids/km^2 (lagoons)	Edwards & (200
Gulf of Morrosquillo/Colombia	Nov 2002 – Jun 2006	?	Photo-identification	?	Dussán-D *et al*. (2(
Babitonga Bay/Santa Catarina/Brasil	2001 - 2003	160 km^2; 1147 km	line transect	231 (147 – 365, 95% CI) in 2001 (1.44 ids/km^2); 137 (78 – 240) in 2002 (0,85 ids/km^2); 154 (71 – 332) in 2003 (0,96 ids/km^2).	Cremer *et a*
Guaratuba Bay/Paraná/Brasil	Jul. 2002 – Jun. 2003	40 km^2	line transect	0.15 ids/km^2	Filla (2(
Guaraqueçaba Bay/Paraná/Brasil	Apr. – Sep. 1997	193,5 km	line transect	Three sectors: (A) 0ids/km^2; (B) 0.04 ids/km^2; (C) 35.0 ids/km^2	Bonin & M Filho (1
Guaraqueçaba Bay/Paraná/Brasil	Jul. 2002 – Jun. 2003	38.84 km^2	line transect	11.56 ids/km^2	Filla (2(
Antonina Bay/Paraná/Brasil	Mar. 2003 – Apr. 2004	28 km^2	line transect	23.16 ids/km^2	Jaap (2(
Cananéia estuary/São Paulo/Brasil	Mar. 1987 – Feb. 1988	82 km (10 surveys)	line transect	3.38 ± 1.76 ids/km^2 704.8 ± 367.7 ids	Geise (1 Geise *et al*.
Cananéia estuary/São Paulo/Brasil	May 1998 – October 1999	20 km^2	Photo-identification	156 – 380 ids (4 different capture-recapture estimators)	Acuña (2
Cananéia estuary/São Paulo/Brasil	May 2000 – Jul. 2003	125 km^2	Photo-identification	290 – 360 ids (Pollock Robust Design)	Santos & Z (200(

Table 1 (continued)

Place: Basin/Country/State	Date	Área/Length of Survey	Technique(s)	Estimates	Source (see
Cananéia estuary/São Paulo/Brasil	Jan. – Sep. 2001	12 km^2	line transect	0.41 ids/km^2	Bisi (200
Cananéia estuary/São Paulo/Brasil	May 2003 – May 2004	15,71 km^2	line transect	12.41 ids/km^2	Havukainen (
Cananéia estuary/São Paulo/Brasil	?	?	line transect	?	Rollo Jr (20
Guanabara Bay/Rio de Janeiro/Brasil	1983 – 1984; 1987 – 1988	70 km^2; 37 km (1983 – 84); 57 km (1987 – 1988)	line transect	1983 – 1984: 7.6 ids/km^2 1987 – 1988: 5.7 ids/km^2	Geise (1989;
Guanabara Bay/Rio de Janeiro/Brasil	1995 – 1998	?	Photo-identification	67 – 75 ids (3 different capture-recapture models)	Pizzorno (19
Guanabara Bay/Rio de Janeiro/Brasil	Sep. 2002 – Sep. 2003	300 km^2 (dolphins found in 130 km^2)	Photo-identification	54 – 73 ids (Chapman's Modified Estimator)	Azevedo *et al.*
Sepetiba Bay/Rio de Janeiro/Brasil	Feb. 1994 – Dec. 2001 (with interval)	519 km^2	Photo-identification	Up to 1998: 235 – 449; Up to 2001: 365 – 722 (Schnabel and Schumacher-Eschemeyer estimators)	Campos *et al.* (
Sepetiba Bay/Rio de Janeiro/Brasil	Aug. 2002 – Jul. 2003	526 km^2 (3,219 km precluded in total sampling)	line transect	2.17 ids/km^2; 909 ids (588 – 1665 ids)	Flach *et al.* (sul for publicati