SC/68C/SM/18

Sub-committees/working group name: SM

Progress report of the Sotalia guianensis Intersessional Group: Status of the Current Knowledge and Action Plan

Domit et al.

Progress report of the *Sotalia guianensis* Intersessional Group: Status of the Current Knowledge and Action Plan

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**We thank all the Workshops, meetings, and online survey participants for the valuable information and data provided.

1. SUMMARY OF THE ASSESSMENT PROCEDURES

In 2014, a Resolution was approved by the IWC for establishing new specific *Terms of Reference* to consolidate the Scientific Committee's mandate on small cetaceans within its broader working program. This program opens the possibility of periodic reviews about the current knowledge and threats, as well as the possibility to implement *Conservation Plans for Endangered Species* within the scope of the IWC when appropriate. The first *Conservation and Management Plan* for a small cetacean was proposed for the franciscana dolphin (*Pontoporia blainvillei*) and **endorsed** by the Commission in 2016. In recent years, the Scientific Committee has worked to better understand the extent of multiple disturbances on small cetaceans - habitat degradation, incidental and intentional catches (for human consumption, bait, trade and traditional use) - to mitigate these threats. This task force resulted in a series of workshops to enable local research groups to collect, share and analyse data aiming to paint a clearer broad picture of the conservation status of these species.

River and estuarine dolphins in South America have been of great concern by the Small Cetacean Sub-committee (SM). During the IWC/67b Scientific Committee Meeting, held in Bled, Slovenia, in 2018, the sub-committee on small cetaceans listed the Guiana dolphin (*Sotalia guianensis*) as a priority species for an evaluation of its conservation status in the upcoming years (2019/2020 – presented at the meeting as SC/67b/SM/WP/12). The Guiana dolphin is restricted to coastal areas, including estuaries and bays in western tropical Americas, from Nicaragua in Central America to Santa Catarina state in southern Brazil (Flores and Da Silva, 2009). Due to the species' exclusive coastal habits, the distribution of Guiana dolphins overlaps with densely human coastal populations, raising concerns on the status of various populations (Avila et al., 2013). It is important to clarify that although the taxonomy of this genus has been controversial, *Sotalia* dolphins in the Maracaibo Lake and in the Orinoco River have been recently confirmed to be *Sotalia guianensis* (Caballero *et al.*, 2018; Caballero *et al.*, 2010).

The Guiana dolphin was previously listed by IUCN as 'Data deficient' (DD) because the data available on abundance, trends, and mortality levels or rates were considered insufficient for assigning it to another Red List category at the time (Secchi, 2012). However, the current assessment classified the species as 'Near threatened' (NT) (Secchi *et al.*, 2018), according to criteria A2d+3d+4d. Regional assessments assigned the species to different categories depending on the country and availability of data on each population (details in the section 'Management and Conservation actions').

In 2006, the SM reviewed the status of the *Sotalia* genus, as part of a review of the small cetaceans of the Caribbean and the western tropical Atlantic. Since then, not only the taxonomy of the genus has been clarified, but also new data on the dolphin populations from the Orinoco River, French Guiana, and Maracaibo Lake System have been collected and analysed. While bycatch in artisanal gillnets is a major threat to Guiana dolphin populations, other threats such as intentional captures for bait, habitat loss, high contaminant load, and diseases (MeCV, herpesvirus, skin diseases of unknown aetiology), are emerging factors depleting some Guiana dolphin populations. For example, recently, a high mortality event involving the populations of Sepetiba and Ilha Grande bays, in southeastern Brazil, has been associated with morbillivirus (Groch *et al.*, 2018). Also, deliberate capture of Guiana dolphins for human consumption has been recorded in Maracaibo Lake (Briceño et al., 2021; Barrios-Garrido *et al.*, 2015, 2021) where the dolphin population is exposed to pollutants, particularly from oil spills (Espinoza-Rodríguez *et al.*, 2019). Throughout their distribution, Guiana dolphins are facing habitat degradation and loss due to anthropogenic activities, such as intense boat traffic and their high noise levels, eutrophication due to run-off and pollution from agriculture, mining and industrial activities, to name but a few (Barrios-Garrido *et al.*, 2016; Crespo *et al.*, 2010; Secchi *et al.*, 2018; Espinoza-Rodríguez *et al.*, 2019). Given these threats, an assessment of population structure and viability, temporal trends in abundance and space use, and an estimate of population connectivity are urgently needed to guide discussions by the SM sub-committee, regarding the sub-committee's priority agenda focusing on South American riverine and estuarine dolphins (IWC, 2019).

A pre-assessment of the status of knowledge about *S. guianensis* was proposed, due to the difficulty in obtaining summarised data in a timely manner during IWC annual scientific meetings, since much information is scattered in grey literature in local research groups along the wide distribution range of the species. The pre-assessment plan included holding two intersessional workshops following SC68B and probably SC69A. Dr. Camila Domit volunteered to lead the organization of these workshops in partnership with Centro Nacional de Pesquisa e Conservação de Mamíferos Aquáticos do Instituto Chico Mendes de Conservação a Biodiversidade (CMA/ICMBio), Brazil. The first Guiana Dolphin (GD) Pre-Assessment Workshop was held in the city of Lima in October 2018, during the SOLAMAC meeting. The attendance was limited and composed mainly of researchers from south/southeastern Brazil, in addition to one researcher from Colombia. They mapped resident populations of Guiana dolphins and the ongoing research efforts, and listed the research teams working with the species along its distribution that would be relevant to conduct the review. The group also delineated a participative strategy to compile the knowledge about Guiana dolphins supporting a future assessment. Because the species distribution is transboundary, covering an extensive coastal area, and there are many experts focusing on this species, the group decided to develop an online questionnaire to circulate for all institutions, research teams and individuals identified. A total of 35 experts answered the questionnaire, including their opinions for prioritising locations and scientific research in supporting improvements (Expert elicitation analysis).

The Second Intersessional Workshop for Pre-Assessing the Status of Knowledge of Guiana Dolphins had two goals. The first was gathering and analysing information collected by the online questionnaire; the second was compiling the available information on a series of population, biological and ecological parameters, as well as about threats, along the species distribution. Supported by the compiled knowledge, the participants collaborated to delineate conservation measures and research needs both in national and international contexts.

The second Workshop was held in Santos, São Paulo, from 26-28 November 2019, at the Centro Nacional de Pesquisa e Conservação de Mamíferos Aquáticos/Instituto Chico Mendes de Conservação da Biodiversidade (CMA/ICMBIO). The Workshop was divided into five sessions, following the priority topics listed by the IWC for the conservation of the species: (1) population structure; (2) abundance and population trends; (3) biological parameters; (4) threats and their potential effects; and (5) management and conservation. A list of 13 experts on Guiana dolphin research from three countries (Brazil, Colombia and Venezuela) and another 20 researchers and managers attended the second Workshop. Information gathered from the literature review, ongoing projects and the expert elicitation via online questionnaire were used by the groups' Point of Contact (POCs) and other co-authors to compile the best up-to-date information on the species, from Costa Rica, Nicaragua, Panama, Colombia, Guiana, Suriname, Trinidad and Tobago and areas of Venezuela and Brazil.

The workshop report (SC/68B/REP/05), including all the preliminary information compiled and recommendations on research priorities, management and conservation issues, was presented in 2020 during the Small Cetacean sub-committee session. The Committee endorsed the recommendations within the report (SC/68B/REP/05), but also called attention to some specific points encouraging the continuous work on the assessment by an Intersessional Scientific Group (ISG) and Correspondence group (ICG).

During the intersessional period, the Steering group (ISG) contacted more than 75 experts and some managers (particularly from Brazil), inviting them to contribute to the review of knowledge and develop an action plan for short-term priorities to present as part of this progress report. During 2020/2021, ~ 50 experts contributed to the species assessment, providing data, sharing knowledge and participating in online meetings. The POCs of each topic coordinated working teams to update the last report and build a list of priorities based on the recommendations presented by the Committee in 2020. An Action plan focusing on short-term priorities are proposed to be evaluated by the Small Cetacean sub-committee during the meeting in 2021 (Annex A).

However, because of the restrictions and other consequences of the COVID-19 pandemic, the ISG and ICG have not advanced in some necessary scientific and governability actions to better understand the management units proposed during the pre-assessment in 2020, mapping gaps in distribution and reducing/mitigating impacts, especially bycatch. Therefore, it will be crucial to maintain the ISG and ICG for three more years, supporting scientific studies and data sharing, strengthening government and science interactions to address mitigation actions, and building together a future Conservation and Management Plan for the Guiana dolphin.

2. SC recommendation 2020

Contemplating the Committee recommendations, the advances obtained during the intersessional year are summarised in a box below. A proposal of an Action Plan for being conducted between 2021-2024 is presented as Annex A.

Committee recommendations	Status	Future steps for ICG
(1) **encourages** *the Workshop Steering Group to consult with the IWC's Bycatch Mitigation Initiative (BMI) intersessionally for advice on implementing the report work plan;*	Not conducted	The ISG propose an agenda with the BMI coordinator during the SC meeting or as soon as possible to address this recommendation.
(2) **agrees** *that the highest priority for the Steering Group should be identification of actions that Governments can implement quickly, particularly with regards to fisheries regulations and bycatch reduction measures, noting the extreme vulnerability of this species to entanglement;*	Not conducted	Guides, manuals and protocols are being coordinated and developed by ICMBio/CMA, a Brazilian agency (Annex)
(3) **notes** *the joint SDDNA/SM Intersessional Correspondence Group (ICG) established to review genetic and other evidence pertaining to population structure in this species and to provide advice on the management unit delineations proposed at the Sotalia guianensis Workshops (SC/68B/SDDNA/06) and* **encourages** *the ICG to provide a summary of that evidence and advice at SC68C;*	The updated data available, particularly for second lines of evidence, are provided within this progress report.	It is expected to continue with this intersessional group, in order to review the proposed MUs in light of different lines of evidence.
(4) **encourages** *the provision of funding to support genomic analyses to adequately define management units (MU) throughout the species range;*	A proposal was submitted for the SM small grants.	The analysis will be conducted as soon as the pandemic restrictions are reduced.
(5) **requests** *that a progress report be submitted to SC68C.*	Provided (it is the present document)	-
(6) **recommends** *that actions are urgently and immediately implemented to reduce bycatch of Sotalia guianensis throughout its range and in particular highlights the need for actions/initiatives to reduce the cumulative impacts and threats/pressures on:* (a) *the population from Guanabara Bay, as this population is declining and facing severe threats (as detailed in SC/68B/REP/05); and* (b) *similar vulnerable populations found in estuaries and bays along the south and southeast of Brazil; and*	Fisheries monitoring programs are being conducted in some areas along *the south and southeast of Brazil, as part of a Franciscana conservation project and a monitoring program coordinated by IBAMA (PMAP)*	The ICG and the ISG stresses the importance of this monitoring to build a database on fisheries efforts; however, recommend strengthens action focused on bycatch monitoring as part of the short-term priority actions to address actions for Guiana dolphins conservation (*see the action plan, in this document)*
(7) **reiterates** i*ts previous concerns for the species in Lake Maracaibo, Venezuela, where both directed takes and oil pollution are thought to be having serious population level impacts and* **stresses** *the need for all (including NGOs researchers and authorities) to focus on documenting the threats and working with local communities to mitigate the impacts.*	Two new scientific articles were published providing important information on threats to the Guiana dolphin population from Maracaibo Lake	Current socio-economic conditions in the country may affect potential research efforts to elucidate these issues. Indeed, these conditions are likely increasing the level of intentional captures by local communities, and the frequency and magnitude of oil spills in the Maracaibo Lake System.

3. REVIEW OF INFORMATION ON THE GUIANA DOLPHIN - PROGRESS REPORT

In 2010, the *Latin American Journal of Aquatic Mammals* published a special issue on the *Sotalia* genus[1]. These articles served as baseline information and were updated during this pre-assessment Workshop and by online meetings and shared documents along 2020/2021. Some critical points about the species taxonomy and population structure have been addressed along the last ten years and opened an opportunity for better assessing the conservation status of Guiana dolphin. A summary of the information presented and discussed is provided in Items 3.1 to 3.5 below. An Action plan with short-term priorities is also provided at the end of this document.

3.1 Distribution and population structure

Guiana dolphins inhabit the tropical coastal waters of Central and South America. The distribution range is from Florianópolis, Santa Catarina, southern Brazil (27º35'S) northwards to the Caribbean Sea up to central Honduras at La Mosquitia (14°00'N, 83°20'W – da Silva *et al*., 2010) (Fig. 1). Their habitat is linked to mangrove ecosystems and estuaries. Although to date the species is thought to occur along this entire range, Guiana dolphins usually form discrete populations (Borobia *et al.*, 1991; Flores and Da Silva, 2009; Da Silva et al. 2010), in which individuals typically have relatively small home ranges (Flores and Bazzalo, 2004; Santos and Rosso, 2008; Oshima and Santos, 2016).

Cunha, Farro and Caballero (scientific paper submitted for SC68B; SC/68B/SDDNA/06rev1, 2020) reviewed the available population genetic data for the species, including published and unpublished studies, and presented the results at the Guiana dolphin pre-assessment Workshop. Twelve studies have been carried out along the distribution of the species, using two molecular markers: the mitochondrial control region and microsatellites. Four macro-scale studies focused either on the northern part of the distribution (Caballero *et al.*, 2010; Caballero *et al.*, 2018) or on its southern portion (Cunha *et al.*, 2005; Cunha, 2007). Moreover, several genetic studies with large sampling at regional level also indicated fine-scale population structure (Hollatz et al., 2011). Combining all evidence, Cunha, Farro and Caballero (2020) proposed the delimitation of 12 Management Units (MUs) for the Guiana dolphin across its distribution. The authors also listed ongoing genetic studies that will refine the available information, all expected to be concluded by 2022.

Thus, based on the presented analyses, the participants of the Workshop **agreed** that for the time being, the genetic population structure with 12 MU should be adopted by the group and guide discussions on the other priorities' topics (e.g. population abundance and trends, biological parameters, threats, and management and conservation actions). These MUs will be hereafter named as proposed by Cunha, Farro and Caballero (2020): CCOL, VEML, VEOR, FRGU, BRNO, BRNE1, BRNE2, BRNE3, BRNE4, BRSE1, BRSE2, BRS/SE (SC/68B/SDDNA/06rev1; Fig. 1). The Workshop participants discussed and **recognized** that in the absence of samples from the northern range of the distribution (Panama, Costa Rica, Nicaragua), and to be as parsimonious as possible, the populations from these areas should be considered panmictic within the CCOL MU (northeastern-most management unit analyzed so far). Trinidad and Tobago might be part of the Orinoco Management unit (VEOR), due to its proximity to the river mouth, however, this region still has an important gap in knowledge that should be addressed in the near future. It is important to note that information to delineate

[1] *http://lajamjournal.org/index.php/lajam/issue/view/20/showToc*.

these MUs is not equally complete or representative for each of these (in terms of number of samples and molecular markers), and additional research is needed for particular MUs in different subjects (Fig. 2).

Despite the delineation of these MUs, the Workshop participants **recognized** the need to establish further studies as **priorities** to better understand the population substructure within the distribution of the species, and areas that are still not sampled.

Other lines of evidence that could support these proposed delineations for management units were discussed during the pre-assessment Workshop (2019) and along 2020 in a working group composed by researchers from different regions. These include cranial and body morphology, levels of pollutants and ecotoxicology, bioacoustics, residence patterns, movements and social behavior, reproduction and life history parameters, and trophic levels and feeding habitats (as informed by stable isotopes analyses). Notwithstanding, these other lines of evidence should be taken with caution to omit studies that did not compare areas, but instead characterized a single area or a Management Unit. It is important to notice that differences exist regarding the number and geographic coverage of these studies, with a high number of studies focused in southern and southeastern Brazil (e.g. on acoustics, pollutants, morphology etc.), decreasing in number for north and northeastern Brazil and with little representation and coverage for other countries, particularly the northern limit of the range, including Nicaragua, Costa Rica and potentially Honduras. A summary of studies and information available from these other lines of evidence is represented in Fig. 3.

Cunha, Farro and Caballero (2020) compiled the data then available from other lines of evidence (i.e., morphology, contaminants and stable isotopes). Morphological differences between Guiana dolphins from Rio de Janeiro (North, BRSE1 and South, BRSE2), Espírito Santo (BRSE1) and São Paulo (BRSE/S) were reported by Ramos et al. (2010). Fettuccia (2010) observed clinal differences in the shape of the vomer, separating dolphins from northern South America (CCOL, BRNO), northeastern (BRNE1,2,3,4), southeastern (BRSE1,2) and southern (BRSE/S) Brazil. Different organochlorine bioaccumulation patterns were found in Guiana dolphins from three bays in southeastern (BRSE2) and southern Brazil (BRSE/S, Lailson-Brito et al. 2010). Two studies had analyzed stable isotopes in Guiana dolphins: Botta (2011) reported differences supporting at least four ecological populations in Brazil (Amazon Estuary, BRNO + Ceará, BRNE1; Espírito Santo, BRSE1; Northern Rio de Janeiro, BRSE1; and Santa Catarina, BRSE/S). On a finer scale, Bisi et al. (2013) found differences between Guiana dolphins from two geographically close bays in southeastern Brazil (BRSE2), supporting high site fidelity and slight niche differentiation.

More recent data concerning stable isotopes, ecology, and acoustics, not included in Cunha, Farro and Caballero (2020), are commented below. Costa et al. (2020) used isotopic composition and Vieira (2014) an evaluation of the diet and found significant differences between populations within the Amazon estuarine complex, adjacent coastal zones (BRNO) and northeastern coast, including Maranhão and Piauí coastlines (BRNE1). SIA results (stable isotope analysis) indicate that this tool allowed for insights on habitat use and differences in population structure for the species in a poorly studied region. Teixeira (2021) also analyzed stable isotope values and reported differences in dolphins from North Bay, Babitonga Bay (BRS/SE) and Caravelas River Estuary (BRNE4). Recent research in Costa Rica and Panama suggested that Guiana dolphins in these countries form a single population, which inhabits the waters right at the border between these countries, extending from the Gandoca-Manzanillo Wildlife Refuge & Sixaola (9° 36.905'N: -83°19.324'W) and Changuinola (9°25′48″N 82°31′12″W) (May-Collado *et al.*, 2017). However, it is important to note the possible existence of another population of Guiana dolphins in Panama. Bossenecker (1978) reported Guiana dolphins in Colon during the early 1970s near the Caribbean entrance to the Panama Canal. May-Collado and collaborators in Panama have received photos of dolphins from that region that appeared to be Guiana dolphins (*personal communication*). Standardized and long-term surveys in the region are urgent to determine the status of these Central American populations in already known areas and possibly re-discover other Guiana populations in Panama (May-Collado et al., 2017).

Additionally, an ongoing regional effort led by Melo-Santos and May-Collado is using state-of-the-art acoustic analysis and robust community ecology tools to identify the drivers of geographical variation and diversity of Guiana dolphin whistle repertoires (see Deecke and Janik, 2006; Moron et al. 2019; Chao et al., 2020). The effort has resulted in an acoustic database from 1998 to 2017 comprising 16 different sites (10 of which are from *S. guianensis* populations): Costa Rica, Lake Maracaibo and Gulf of Venezuela (Venezuela), French Guiana, Pará State (northern Brazil), Rio Grande do Norte State (northeastern Brazil), Sepetiba Bay and Ilha Grande Bay (Rio de Janeiro state, southeastern Brazil), Cananéia Estuary (São Paulo state, southeastern Brazil), Paranaguá Estuarine Complex (Paraná state, southern Brazil) and Babitonga Bay (Santa Catarina state, southern Brazil). The preliminary results suggest that the whistle repertoire of dolphins is significantly distinct from each other with differences in repertoire size and diversity along the distribution of the species . The Costa Rican population has the largest repertoire of all studied populations, while the southernmost populations have the smallest repertoire. The whistle repertoire of *Sotalia* dolphins from the Tocantins River is more similar to that of marine populations, still the taxonomic identity of this population remains uncertain.

Fig. 1. Population limits according to genetic studies, identifying 12 management units (MU), named as proposed by Cunha, Farro and Caballero (2020): CCOL, VEML, VEOR, FRGU, BRNO, BRNE1, BRNE2, BRNE3, BRNE4, BRSE1, BRSE2, BRS/SE.

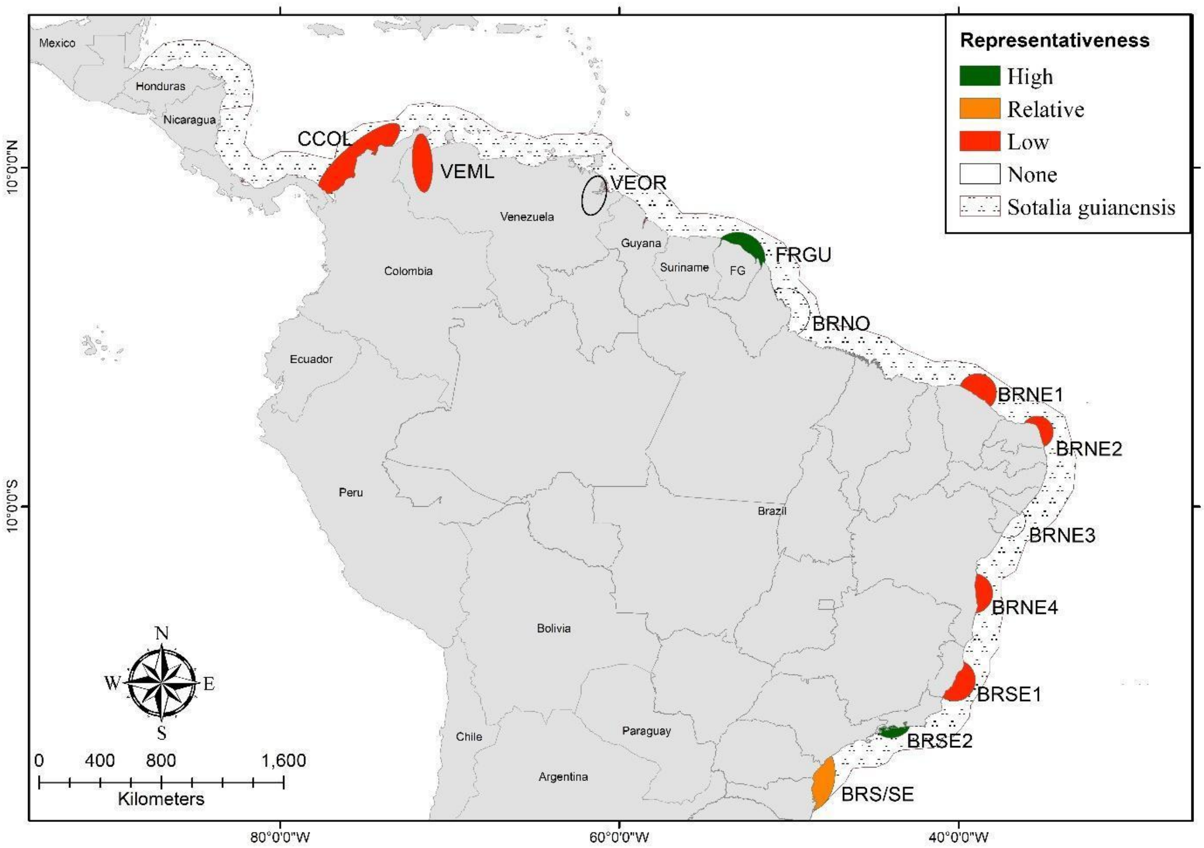

Fig. 2. Data representativeness supporting the proposed management units (MU) for Guiana dolphins along the species distribution area.

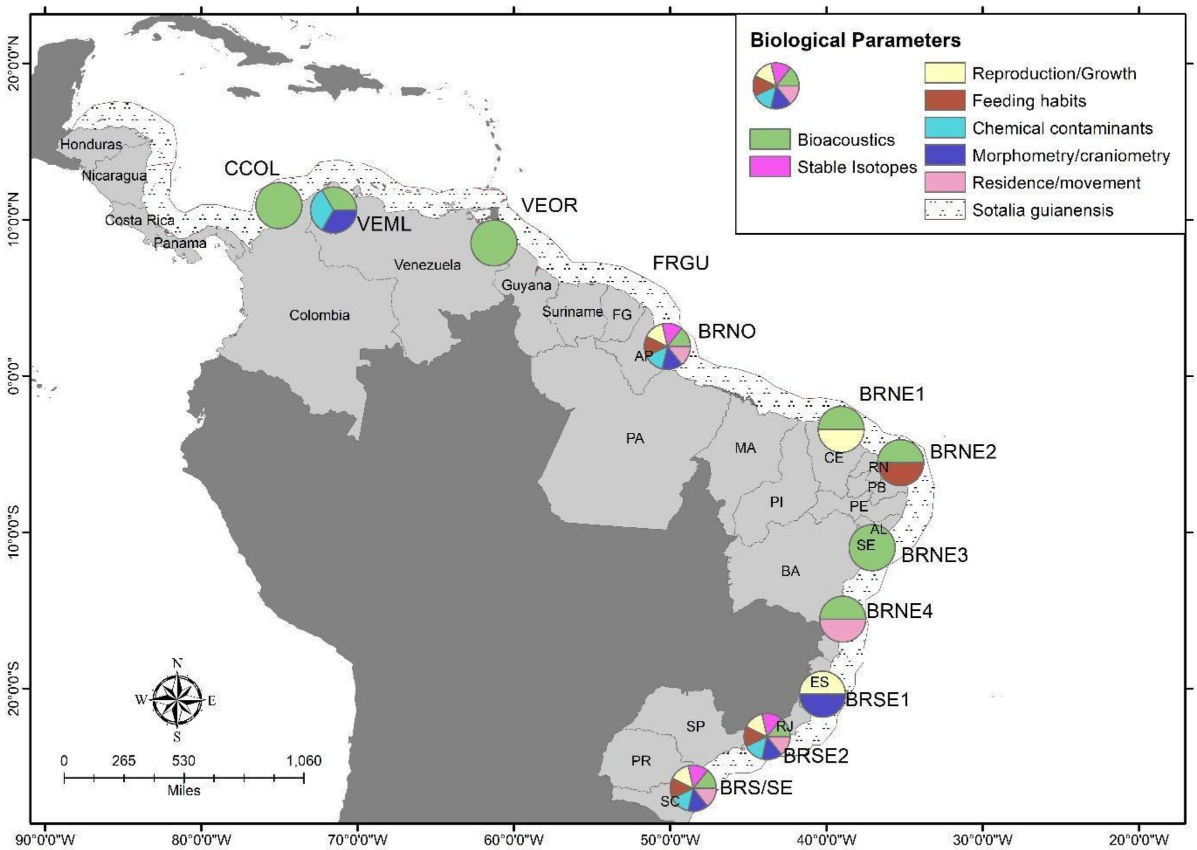

Fig. 3. Studies and information available from other lines of scientific evidence supporting the population structure of Guiana dolphins.

3.2 Abundance and trends

Our knowledge on the abundance and density of Guiana dolphins remains relatively scarce along their distribution. Santos et al. (2010) compiled 24 studies from 1989 to 2008 that estimated Guiana dolphin abundance and/or density in seven sheltered areas along the Brazilian coast, one in Nicaragua and another in Colombia. Their review identified mark-recapture and distance (line-transect) sampling as the main methods used (Buckland et al., 2004), and highlighted two major shortcomings among the published and grey literature at the time: (i) the short duration of the field sampling; and (ii) concentration of sampling effort in specific populations from southern and southeastern Brazil. In this report, we update the information on abundance and density of Guiana dolphins by summarizing the data available in peer-reviewed articles, as well as theses and dissertations, published between 2000 and 2019 (Tab.1).

We compiled information on abundance and density of Guiana dolphins from a total 42 studies and organized it according to the Management Units proposed by Cunha, Farro and Caballero (2020) (Fig. 4). Overall, the two shortcomings identified by Santos et al. (2010) remain to date: most studies were conducted in estuaries and bays of southern and southeastern Brazil, covering small sampling areas, over short periods. While there are some recent abundance estimates for the populations from northeastern Brazil, there are still very few studies in northern Brazil. Abundance and density information is even scarce in the other countries whre Guiana dolphins occur. In French Guiana, two recent studies estimate Guiana dolphin abundance in the whole Exclusive Economic Zone, whereas in Venezuela, Colombia, Costa Rica/Panama and Nicaragua abundance estimates are available in few and localized areas. Finally, there are no estimates from Suriname, Guyana, Trinidad and Tobago and Honduras, and to the best of our knowledge there is no sampling effort in course. This compilation reveals two main problems in understanding Guiana dolphin abundance: the low amount of research over the years and the absence of efforts on medium/large geographical scales (except for French Guiana), including open coastal areas into MUs and between these units. The sampling effort for estimating population abundance and density of Guiana dolphins conducted in the last 20 years can be summarized as follows.

(1) Brazil: 24 studies at 14 sites. Sampling effort (estimated covered area): 12,700 km^2, out of which 9,300km^2 were conducted in BRSE1 in 2019.

(2) French Guiana: two studies in the whole Exclusive Economic Zone. Sampling effort (estimated covered area): 62,000 km^2.

(3) Suriname: No effort.

(4) Guyana: No effort.

(5) Venezuela: four studies in three sites. Sampling effort (estimated covered area): 1,100 km^2.

(6) Trinidad and Tobago: No effort.

(7) Colombia: two studies in the Golfo de Morrosquillo, and one in the Golfo of Urabá. Sampling effort (estimated covered area): 3,290 km^2.

(8) Costa Rica/Panama: one study. Sampling effort (estimated covered area): 10 km^2.

(9) Nicaragua: No effort during the last 20 years. Edwards and Schnell (2001) conducted the last sampling in 1998.

(10) Honduras: No effort.

In addition to the shortcomings identified by Santos et al. (2010), our literature review reveals two other concerns regarding our knowledge on the population dynamics of Guiana dolphins: (i) the scarcity of continuous research effort across the years; (ii) the lack of sampling efforts covering medium to large geographical scales (except in French Guiana). In consequence, one of the most relevant information —population trends— is extremely rare for Guiana dolphins. To the best of our knowledge, only two medium- to long-term studies were able to provide abundance trends. While Cantor et al. (2012) found no marked population trends between 2002 and 2009 among the Guiana dolphins from Cavarelas River Estuary, northeastern Brazil (BRNE4), Azevedo et al. (2017) reported a drastic decline in the Guiana dolphin population of Guanabara Bay, southeastern Brazil (BRSE1).

Summary by management units

Brazil

BRS/SE

This management unit (MU) is one of the most studied and has been monitored continuously since the late 1990s. Abundance is available for three sites/populations: Babitonga Bay in Santa Catarina State (SC); Paranaguá Estuarine Complex, in Paraná State (PR); and Cananéia Estuarine Complex, in São Paulo State (SP). Guiana dolphin abundances in most sites of BRS/SE have been estimated to be around hundreds or thousands of individuals. Between 2001-03, Cremer et al. (2011) estimated between 147-365 individuals in Babitonga Bay (SC) using distance sampling. Seven years later (2010-11), Schulze (2012) estimated 174-252 individuals in the same area using a mark-recapture approach. In Paranaguá Estuarine Complex (PR), between 1999 and 2000, the density 5.8 ind/hour of *S. guianensis* was estimated (Filla & Monteiro-Filho, 2009). Marchetto (2010) estimated a population size between 200-441 individuals using mark-recapture methods in the northern region of the estuary (including Baía de Guaraqueçaba, Baía dos Pinheiros and Baía das Laranjeiras), between 2006 and 2008. Later, Miranda (2017) conducted distance sampling surveys in all regions of the estuary, between 2012-13, and estimated the population to range between 1,371-2,393 individuals, including a huge variation among different sectors/bays. In Cananéia Estuarine Complex (São Paulo State), during 2011-2012, Almeida (2014) estimated a population size of 158-237 individuals using distance sampling. A recent mark-recapture study estimated around 392-438 individuals (Mello et al., 2019). No efforts were conducted to estimate population size in the northern São Paulo State more than 150 individuals have been found stranded per year in that region (stranding topic, this document). Coastal areas outside the estuarine zone and bays have not been assessed yet for abundance/density estimates, totalling about 600 km of survey gap along the coastline within the species distributional range in this MU.

BRSE2

In this MU, some populations have been monitored since the late 1980s, particularly in three sites: Ilha Grande Bay, Sepetiba Bay and Guanabara Bay, all three located in Rio de Janeiro State. Guanabara Bay abundance (37-40 individuals; Azevedo et al., 2017) contrasts with Sepetiba Bay (588-1,004 individuals; Flach, 2015) and Ilha Grande Bay (602-1,296; Souza, 2013). In fact, those populations seem to be larger, gathering more than 1,500 individuals in Sepetiba Bay and more than 2,500 in Ilha Grande Bay (Quintana, 2020). No effort has been conducted to assess Guiana dolphin abundance north of Guanabara bay. Similar to BRS/SE, BRSE2 populations using bays and estuaries contrast in size, but most are large, numbering thousands of individuals. However, studies in open coastal waters are still lacking abundance/density estimates. In this MU, unsampled coastal areas represent more than 400 km of coastline within the species distributional range.

BRSE1

There are only two studies conducted in two different coastal areas along this MU, both in Espírito Santo State: Cepile (2008) estimated 81-141 individuals in the Doce River estuary and adjacent coastal waters; and Mamede (2015) estimated 59-78 individuals in Benevente Bay. However, since 2019, aerial surveys have been conducted along Espírito Santo coast covering a large geographical area, as part of the impact assessment of the Mariana environmental disaster. In this survey, abundance/density was estimated for the whole BRSE1: summer 2019, 393-1,256; and winter 2019, 137-840 (RRDM – Rede Rio Doce Mar – FEST, 2019).

BRNE4, BRNE3, BRNE2, BRNE1

There are few studies on these MUs: sampling areas are small and there are only five abundance/density studies along 3,000 km of Guiana dolphin distribution. Very low abundances were estimated for the Caravelas River Estuarine and Canavieiras Estuarine Complex, in the state of Bahia (BRNE4) (83-182, Cantor et al. 2012; and 28-48, Melo 2018, respectively). Low values were also estimated in Mucuripe embayment, in the state of Ceará (BRNE1) (26-64; Meirelles, 2013). In the southern coast of Rio Grande do Norte (BRNE2), Guiana dolphins were estimated to be around 192-297 individuals (Paro, 2010). In BRNE3 no effort has been conducted yet.

BRNO

No effort has been conducted in this MU.

French Guiana

FRGU

Guiana dolphin abundance/density was estimated in the FRGU by two recent studies. Mannocci et al. (2013) and Vicent et al. (2010) conducted aerial surveys in the EEZ coastal waters from French Guiana and estimated 2,076 and 1,942 Guiana dolphins in the area, respectively.

Suriname and Guyana

FRGU

No effort has been conducted in these countries.

Venezuela

VEOR

Two studies were conducted in the Orinoco River by line-transects. Abundance estimates point out to thousands of individuals: Gomez-Salazar et al. (2012) estimated 2,205 and Herrera (2013) estimated 4,451 Guiana dolphins. This MU seems well studied, but it represents only the Orinoco River, and the whole coast from this MU to VEML (1,500km of coastline) has not been sampled. Therefore, information about abundance/density estimates covers a small extension of Venezuela coast.

VEML

This MU has been poorly studied in its total area for abundance/density of Guiana dolphins. Three studies were conducted at Maracaibo Lake (a total area about 13,000 km^2), but only 900 km^2 were sampled (Briceño et al., 2017). Barrios-Garrido et al. (2021) estimated an abundance of 1.66 individuals per km², within an area of 249.2 km² (~413.67 individuals), based on research carried out in the western-central area of this aquatic habitat. At the Gulf of Venezuela, two other studies estimated abundance/density in about 6 km^2 (Carrasquero, 2010; Espinoza-Rodríguez et al., 2019), but these studies estimated no population abundance.

Trinidad and Tobago

No effort has been conducted in this country.

Colombia and northern areas

CCOL

Two mark-recapture studies were conducted in the Gulf of Morrosquillo. Abundance estimates point to hundreds of individuals (118-426; Dussán-Duque (2013), but the sampling area was small and covered about 300 km^2. From 1994 to 1998, distance sampling surveys were carried out in the Cispatá bay to estimate Guiana dolphin abundance (García & Trujillo, 1998). Aerial surveys were carried out in 2006 but sightings were extremely low to evaluate abundance patterns. This MU seems undersampled and is the only site sampled along the Colombia coast. As a consequence, information about abundance/density estimates covered a small extension of the CCOL. There is currently a Ph.D. thesis study ongoing in the Gulf of Urabá (Rosso–Londoño *comm. perss*), in which one of its objectives is to estimate abundance of Guiana dolphins in this region using mark-recapture methods. The preliminary results of this work document is a small population of less than 100 individuals (mean = 63; CV = 9.42%, 95%, CI = 53-76) (Rosso-Londoño, 2021).

Costa Rica/Panama

Efforts are still incipient, and only one study, covering 10 km2 between 2003 and 2005, was conducted. The estimated abundance was 81-100 individuals (Gamboa-Poveda, 2009).

Nicaragua and Honduras

No effort has been conducted in these countries.

Table 1
Summary of abundance/density estimates of Guiana dolphin (*Sotalia guianensis*) from 2000 to 2020. Management Units were defined during *Sotalia guianensis* pre-assessment Workshop (2019). Methods: Mark-recapture (1) and Line-transect (2).

Management Unit	Area (km^2)	Period	Estimates	Source
BRS/SE - Brazil				
Babitonga Bay (SC)[2]	160	2001-2003	147-365	Cremer et al. (2011)
Babitonga Bay (SC)[1]	160	2010-2011	174-252	Schulze (2012)
Guaratuba Bay (PR)[2]	40	2002-2003	0.15/km^2	Filla (200)
Paranaguá Estuarine Complex (PR)[2]				Flla (2004)
Paranaguá Estuarine Complex (PR/ Northern region of the estuary)[1]	110	2006-2008	200-441	Marchetto (2010)
Paranaguá Estuarine Complex (PR)[2]	600	2012-2013	1,371-2,393	Miranda (2017)
Cananéia Estuarine Complex (SP)[1]	125	2000-2003	290-360	Santos and Zerbini (2006)
Cananéia Estuarine Complex (SP)[2]	106	2001	0.15/km^2	Bisi (2001)
Cananéia Estuarine Complex (SP)[1]	132	2007	697-730	Pacífico (2008)
Cananéia Estuarine Complex (SP)[2]	132	2011-2012	158-237	Almeida (2014)
Cananéia Estuarine Complex (SP)[1]	132	2016	392-438	Mello et al. (2019)

BRSE2 - Brazil				
Ilha Grande Bay(RJ) [1]	550	2007-2010	1,232-1,389	Espécie (2011)
Ilha Grande Bay (RJ) [1]	550	2005-2009	602-1,296	Souza (2013)
Ilha Grande Bay (RJ)[1]	550	2007-2013	482-757	Espécie (2015)
Ilha Grande Bay (RJ)[1]	1,000	2018-2019	2,182-2,734	Quintana (2020)
Sepetiba Bay (RJ) [2]	526	2002-2003	739-2,196	Flach et al. (2008)
Sepetiba Bay (RJ) [1]	145	2006-2007	1,004-1,117	Nery et al. (2008)
Sepetiba Bay (RJ) [1]	520	2012	588-1,004	Flach (2015)
Sepetiba Bay (RJ) [1]	520	2018-2019	1,555-1,697	Quintana (2020)
Guanabara Bay (RJ) [1]	280	2015	37-40	Azevedo et al. (2017)
BRSE1 - Brazil				
Benevente Bay (ES) [1]	---	2014	59-78	Mamede (2015)
Regência (ES) [1]	235	2007	81-141	Cepile (2008)
Espírito Santo state (coastal zone)	3,319	Summer/2019	393-1,256	RRDM – Rede Rio Doce Mar – FEST (2019)
Espírito Santo state (coastal zone)	9,305	Winter/2019	137-840	RRDM as above
BRNE4 - Brazil				
Canavieiras Estuarine Complex (BA) [1]	---	2009-2010		Recchia (2011)
Canavieiras Estuarine Complex (BA) [1]	---	2016-2017	28-48	Melo (2018)
Ilhéus (BA) [2]	30	2014-2015	133-343	Rosa (2016)
Caravelas River Estuary (BA) [1]	700	2009	83-182	Cantor et al. (2012)
BRNE3 - Brazil				
No effort	---	---	---	-
BRNE2 - Brazil				
Southern Coast of RN State [1]	22.3	2008-2009	192-297	Paro (2010)
BRNE1 - Brazil				
Fortaleza city (CE) [1]	16	200920-11	26-64	Meirelles (2013)
BRNO - Brazil				
No effort	---	---	---	-
FRGU - French Guiana				
EEZ, coastal stratum [2]	39,409	2008	2,076	Mannocci et al. (2013)
EEZ, coastal stratum [2]	138,000	2008	1,942	Vicent et al. 2010
Surinam				
No effort	---	---	---	-
Guyana				
No effort	---	---	---	-
VEOR - Venezuela				
Orinoco River [2]	5,078	200620-07	2,205	Gomez-Salazar et al. (2012)
Orinoco River [2]		2008, 2012-13	4,451	Herrera-Trujillo (pers. comm.)
VEML - Venezuela				
Zapara Is. Southern Gulf of Venezuela[1]	6.33	2008-2009	5.62 ind/km^2	Carrasquero (2010)
Barranquitas, Maracaibo Lake System[1]	249.2	2011-2012	1.66 ind/km^2	Delgado-Ortega (2012)
Maracaibo Lake System[2]	900	2017	1.25 ind/km^2	Briceño et al. (2017)
Maracaibo Lake System$_2$	249.2	2021	1.66 ind/km^2	Barrios-Garrido et al. (2021)
Zapara Is. Southern Gulf of Venezuela[1]	6.33	2009-2011	150-573	Espinoza-Rodríguez et al. (2019)
Trinidad and Tobago				
No effort	---	---	---	-
CCOL – Colombia				
Golfo de Urabá	2980	2019	53-76	Rosso-Londoño (2021)
Golfo de Morrosquillo [1]	310	2002-2006	70-90	Dussán-Duque et al. (2006)

3.3 Biological parameters

This topic provides a summary of information on life history and population parameters available for the Guiana dolphin, particularly related to body size, age and reproduction (see Tab. 2). We compiled the information available from peer-reviewed scientific articles, masters and doctoral theses, and working papers/abstracts. Personal communications and unpublished data provided by specialists during the Guiana dolphin pre-assessment Workshop (2019) or throughout working group effort along 2020 were also included to complement this report.

Information about biological parameters for Guiana dolphins is available mainly for southeastern and southern Brazil (Management units BRAS/SE and BRSE2) (Tab. 2; Fig. 5). However, even in these areas, the information is still fragmented and, in some cases, based on small sample sizes. Most information listed here originated from stranding data (see below), but for some local populations, information from long-term mark-recapture studies is also available, particularly regarding the estimation of reproductive output and survival rates.

Guiana dolphins can reach up to 230 cm in total length and weigh 150 kg, both results from BRS/SE (PMP-BS[1]). The maximum estimated age was 33 yr (Lima *et al.*, 2017) which was recorded for a dolphin from southeastern Brazil (BRSE1). In northern Brazil, the maximum estimated age was 29 yr (Novais et al., 2020). The species is not sexually dimorphic, but slight variation in maximum total lengths and sexual maturity was observed. Male maximum total length varied between 210 cm, in northeastern Brazil (Meirelles *et al.*, 2010), and 230 cm in southern Brazil (PMP-BS[1]). Female maximum total length varied between 184.5 cm, in southeastern Brazil (Ramos *et al.*, 2010), 208 cm in northeastern (Meirelles *et al.*, 2010) and 230 cm in southern Brazil (PMP/BS[1]). Sexual maturity is reached between 170-180 cm in males and 160-169 cm in females, and age of sexual maturity was estimated between 6-7 yr in males and 5-7 yr in females (Ramos *et al.*, 2010; Rosas and Monteiro-Filho, 2002). Seasonality in testicular activity was not detected, but adult males have large testes, estimated in 3.3% of the total body weight (Rosas and Monteiro-Filho, 2002). Both ovaries are functional (Rosas and Monteiro-Filho, 2002), and a slight variation is recorded for birth periods. Births on the Rio de Janeiro coast (BRSE1 and BRSE2), southeastern Brazil, occur from spring to autumn, with a peak during the autumn (Ramos *et al.*, 2010). On the Paraná coast (BRS/SE), southern Brazil, no defined seasonality was recorded (Rosas and Monteiro-Filho, 2002). Birth size varies from 86 cm to 122 cm (Di Beneditto & Ramos, 2004; Carvalho et al., 2012). Lactation period was estimated between 8.7 and 9.4 months, only for Paraná State (BRS/SE), southern Brazil (Rosas and Monteiro-Filho, 2002).

Reproductive senescence was detected for females older than 25 yrs from MU BRS/SE (Rosas and Monteiro-Filho, 2002). Information provided by relative size and histological inspection of testes, and reinforced by behavioral analysis of wild populations, indicate that the species has a promiscuous mating system (Rosas and Monteiro-Filho, 2002; Santos and Rosso, 2008).

Table 2
Summary of the current knowledge on biological parameters of Guiana dolphin (*Sotalia guianensis*).

Area/Parameter	Information	References
Venezuela		
Maracaibo Lake (VEML)		
Maximum age	31 years	Riquelme et al. (2007)
Brazil – North		

Pará State (BRNO)		
Maximum age	29 years	Novais et al. (2020)
Brazil - Northeastern		
Ceará State (BRNE1)		
Maximum length	Males: 210cm Females: 208cm	Meirelles *et al.* (2010)
Apparent Survival (Mucuripe)	Adult survival: 0.88 (95% CI: 0.69-0.96) (2009-2011)	Meirelles (2013)
Bahia State (BRNE4)		
Apparent survival rate (annual)	CJS=0.88 ± 0.07 SE, 95% CI=0.67-0.96 RD=0.89 ± 0.03 SE, 95% CI=0.82-0.94	Cantor *et al.* (2012)
Brazil - Southeastern		
Espírito Santo (BRSE1)		
Maximum age	20 years	Carvalho *et al.* (2012)
	33 years	Lima *et al.* (2017)
Maximum length	Male: 222 cm Female: 184.5cm	Ramos *et al.* (2010)
Age at asymptotic length	6 years	Ramos *et al.* (2010)
Asymptotic length	Males: 176 cm Females: 191 cm	Lima *et al.* (2017)
Length at physical maturity	187.5 cm	Carvalho *et al.* (2012)
Reproduction	Length at birth: 92.96-122 cm (mean=103.3 cm)	Carvalho *et al.* (2012)
	Age at female sexual maturity: 7 years Age at male sexual maturity: 8 years Length of female sexual maturity: 191 cm (SD=7.12) Length of male sexual maturity: 190.2 cm (SD=158.75)	Lima *et al.* (2017)
Rio de Janeiro – (BRSE1)		
Maximum age	30 years	Ramos et al. (2000), Di Beneditto and Ramos (2004)
Maximum length	Males: 200cm Females: 198cm	Ramos *et al.* (2010) Ramos *et al.* (2010)
Age at asymptotic length	6 years	Ramos *et al.* (2010)
Asymptotic length	Males: 191.7cm Females: 191.7cm	Ramos et al. (2000)
Age at physical maturity	Males: 7 years Females: 7 years	Ramos et al. (2000)
Length at physical maturity	Males: 185cm Females: 185cm	Ramos et al. (2000)
Reproduction	Gestation period: 11.6 months Length at birth: 97-106cm	Ramos et al. (2000)
	Length at birth: 86-117.5cm	Di Beneditto and Ramos (2004)
	Age at female sexual maturity: 6 years Age at male sexual maturity: 6 years Length at female sexual maturity: 160cm Length at male sexual maturity: 180cm	Ramos et al. (2000)
Rio de Janeiro – (BRSE2)		
Maximum length	Males: 210cm Females: 198cm	Ramos *et al.* (2010)
Age at asymptotic length	6 years	Ramos *et al.* (2010)
Apparent survival	Calf survival=0.75 (SE=0.02) Juvenile survival=0.89 (SE=0.02) Adult survival=0.89 (SE=0.02)	Flach, unpublished data
Reproduction	Calving interval: 2-3 years Fecundity: 0.20 (min: 0.17-max: 0.25)	Flach, unpublished data
Rio de Janeiro - Guanabara Bay (BRSE2)		

Apparent survival rate	2000-05=0.43 (95% CI 0.28-0.59) 2005-10=0.55 (95% CI 0.40-0.70) 2010-15=0.55 (95% CI 0.37–0.72)	Azevedo *et al.* (2017)
São Paulo (BRS/SE)		
Maximum length	Males: 200cm Females: 200cm	Ramos *et al.* (2010); Conversani et al. (2020); Santos *et al.* (2003)
	Male: 230cm Female: 206cm	PMP/BS[1]
Age at asymptotic length	7 years	Santos *et al.* (2003)
	6 years	Ramos *et al.* (2010)
Maximum age	29 years	Santos *et al.* (2003)
	Male: 32 years Female: 26 years	Conversani et al. (2020)
	Male: 9.7 years Female: 9 years	PMP/BS[1]
Asymptotic length	179.8cm	Santos *et al.* (2003)
	183cm	Conversani et al. (2020)
Reproduction	Length at birth: 97.8cm Calving interval: 2-3 years	Santos *et al.* (2003) Santos *et al.* (2001)
	Length at birth: 88.3cm	Conversani et al. (2020)
	Female age at sexual maturity: 6.5 years Male age at sexual maturity: 7.3 years Female length at sexual maturity: 165-208cm Male length at sexual maturity: 164-189cm	Santos Neto (2017)
Apparent survival	2015-16: 0.86 (SE=0.06) between occasions	Mello et al., 2019
Brazil - South		
Paraná (BRS/SE)		
Maximum age	Male: 30 years Female: 24 years	PMP/BS[1]
Maximum length	Male: 208cm Female: 197cm	PMP/BS[1]
Maximum age	30 years	Rosas *et al.* (2003)
Asymptotic length	Males <5 years: 159.6cm Males >5 years: 186.4cm Females: 177.3cm	Rosas *et al.* (2003)
Maximum weight	121kg	Rosas and Monteiro-Filho (2002)
Reproduction	Reproductive cycle: 2 years Senescence: females older than 25 years Gestation period: 11.6 months Length at birth: 89.1 to 95cm (92.2 ± 2.7cm) Lactation period: 8.7 months Age at female sexual maturity: between 5 and 8 years Age at male sexual maturity: 7 years Length at female sexual maturity: between 164 to 169cm Length at male sexual maturity: between 170 and 175cm	Rosas and Monteiro-Filho (2002)
Santa Catarina (BRS/SE)		
Maximum age	Male: 25 years Female: 25 years	PMP/BS[1]
Maximum length	Male: 212cm Female: 230cm	PMP/BS[1]

3.4 Threats

Multiple activities are potential sources of impacts on various Guiana dolphin local populations within the defined Management Units. These activities were listed and discussed by expert researchers during the intersessional Workshop held during the Latin American Society of Aquatic Mammals (RT) meeting in Peru, 2018. The survey resulted in 11 anthropogenic activities to which Guiana dolphins are exposed: fishing activities (gillnetting, trawling and longline fishing) (PI); development of coastal infrastructure (DI); port activities (including dredging (DR); underwater explosions (EX); vessel traffic (TE); environmental disasters (AA); mining (M); oil exploration (PG); aquaculture/fish farming (MA); industrial activities (IN); agricultural activities (AG); nautical activities (AN); and nautical tourism (TU) (Fig. 4). This list was used as a basis for assessing impacts and threats by Workshop participants, who evaluated the existing studies that addressed the impacts and their potential effects on dolphins considering the study areas and the management units proposed (see Annex E).

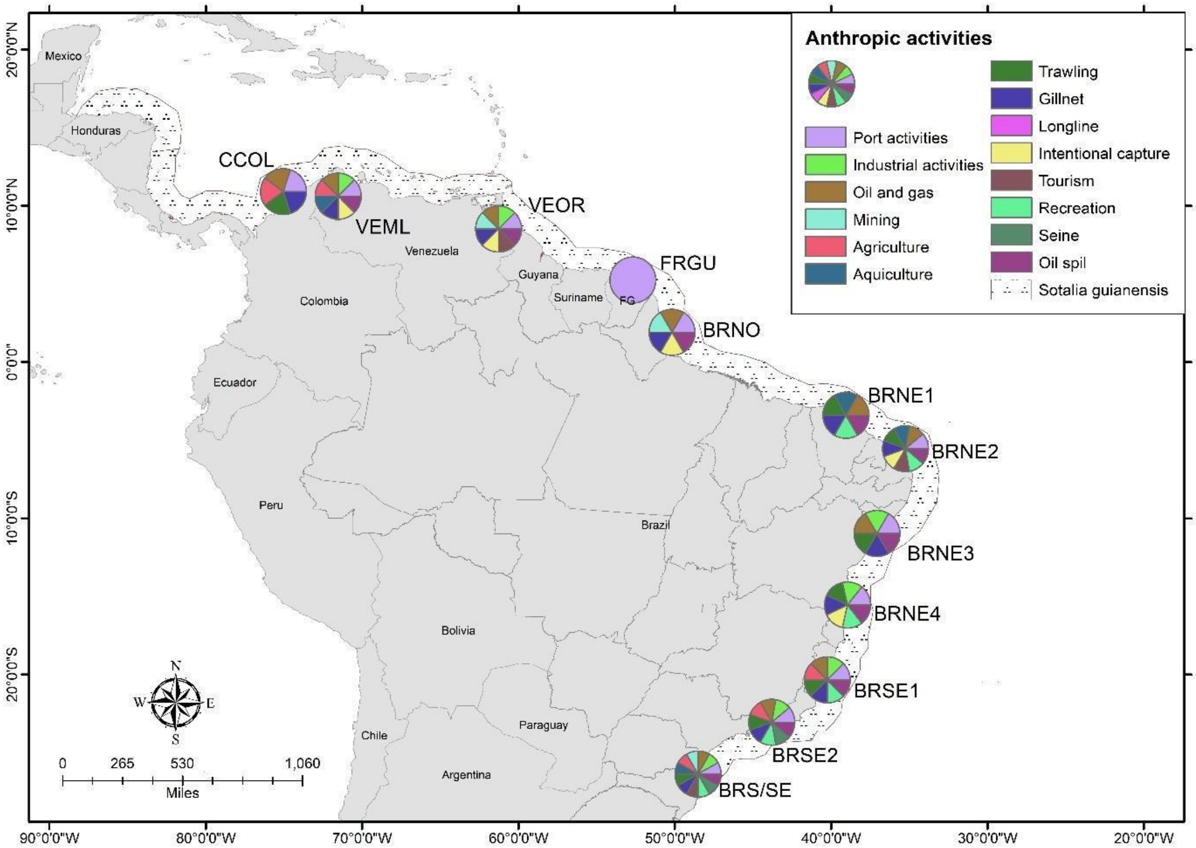

Fig. 4. Map of anthropogenic activities potentially impacting Guiana dolphins identified for each management unit during the Workshop in 2019 (map based on Annex B).

Human-induced mortality

MORTALITY RATES AND STRANDING EVENTS

In 1994, the Scientific Committee of the IWC urged that member states take steps to reduce incidental mortality of genus *Sotalia*, while at the same time establishing better systems of recording and monitoring take levels (IWC, 1995). Since then, impacts from anthropogenic activities and habitat loss have increased probably faster than the scientific knowledge about their effects on population conservation status and viability.

Presently, there are estimates of apparent survival rate only for specific populations such as Cananéia Estuarine Complex (BRS/SE; Mello *et al*. 2019), Guanabara Bay (BRSE2; Azevedo *et al*. 2017) and Caravelas River (BRNE4; Cantor *et al*. 2012) in Brazil, and Gulf of Morrosquillo, Colombia (Dussán-Duque, 2013). More detailed information and studies come from southeastern Brazil. While the Caravelas, Cananéia and Gulf of Morrosquillo mark-recapture studies estimated relatively high survival rates (0.88, 0.86 and 0.95, respectively), in Guanabara Bay it was much lower (from 0.427 to 0.551, depending on the period). The latter observed a fast decline in the population, probably related to mortality and not related to emigration (Azevedo *et al.*, 2017). Guanabara Bay is a human-densely populated region and is environmentally degraded, with different threats potentially contributing to this decline of the Guiana dolphin population.

Guiana dolphin is the cetacean species with the most significant number of stranding records in most Brazilian regions. Carvalho et al. (2020) reported more than 4,500 strandings from Amapá to Santa Catarina, from 1981 to July 2019. However, even in the absence of direct evidence of injuries caused by human activities, suggestive marks of trauma have been observed on live specimens (Nery *et al.*, 2008; Azevedo *et al.*, 2009; Flach, 2015) and stranded individuals (Rosso-Londoño, 2010; Flach, 2015; Domiciano *et al*., 2016).

Information collected from stranding networks program between 2015 and 2019, recorded 832 Guiana dolphin carcasses during daily beach monitoring, along approximately 1,500 km of the southeast and south Brazilian coast (data available at *http://simba.petrobras.com.br*). Considering only fresh or in early decomposition carcasses (*n*=328), signs of fishery interactions were seen in 42% (*n*=138) of them, but in some areas direct evidence of fishery interactions were observed in almost 75% of the carcasses (see Fig. 4). Other negative interactions such as vessel collision, marine debris ingestion and aggression are rare, but also recorded during necropsy (details provided in specific topics in this report). Additionally, when analyzing all data combined, juvenile/calves stranded more frequently (~50%) than adults (33%) or undetermined age classes (17%), and this proportion is similar for specimens with (juveniles=55.8%; adults=33.3%) or without (juveniles=45.4%; adults=31.9%) suggestive marks of fishing interaction. However, in some areas, for example Sepetiba Bay (BRSE2), sexually mature Guiana dolphins are the majority (56%) of carcasses recorded for dolphins with fishing gear marks (Flach 2015; Bertozzi et al., 2020).

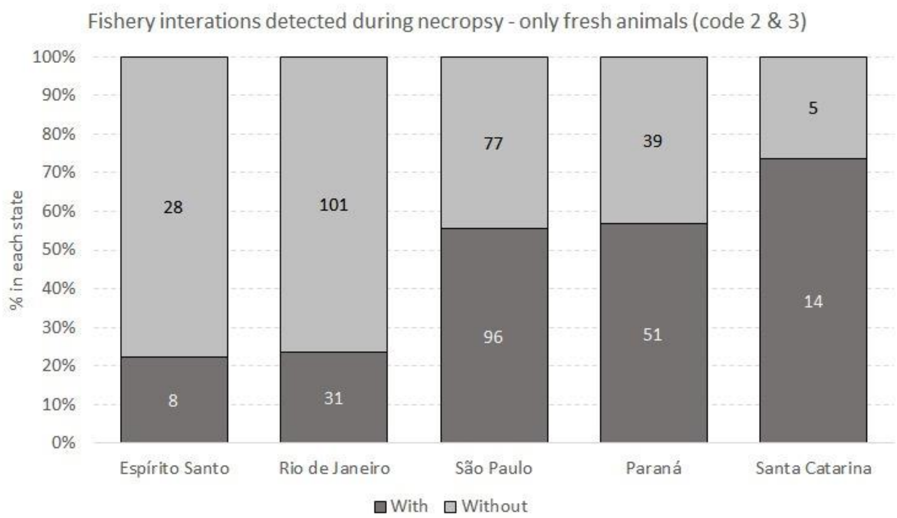

Fig. 4. Guiana dolphin carcasses with or without suggestive marks of fishery interactions detected during necropsies. The analyzed individuals were found stranded along the Brazilian states of Espirito Santo, Rio de Janeiro, São Paulo, Paraná and Santa Catarina, between 2015 and 2020. The number within columns indicates the absolute number of dolphins. Only fresh and early decomposition stages were considered (codes 2 and 3, *sensu* Geraci and Lounsbury (2005).

BYCATCH

Fisheries bycatch of marine mammals occurs throughout the Guiana dolphin distribution, but are poorly monitored. Therefore, the impacts of bycatch on these populations are not well understood. The lack of data on fishing effort, particularly for small-scale fisheries, bycatch rates, and which Guiana dolphin populations are affected remain as critical barriers for assessing risks from individual fisheries or cumulative impacts from fisheries that overlap with the population distribution.

Nevertheless, the high number of Guiana dolphins found stranded along the coast and information from the literature indicate that the species is one of the most commonly bycaught small cetaceans in Brazilian coastal gillnet fisheries (Lodi & Capistrano, 1990; Siciliano, 1994; Di Beneditto, 2003; Emin-Lima *et al.*, 2008; Sidou, 2008, Meirelles et al., 2010; Flach, 2015; Bertozzi et al., 2020). The same impact was reported for other regions in South and Central America (Vidal *et al.*, 1994; Barrios-Garrido *et al.,* 2021; Briceño *et al.,* 2021). For example, in Colombia, at least six mortality events related to entanglement in nets are reported yearly for the last five years (Trujillo, personal communication). Although gillnets appear to be the most important fishery in terms of threats, interactions also include incidental capture in recreational nets, and mortality in other types of nets, like artisanal longline and seine fisheries, the use of dynamite in fishing operations, direct catches for meat consumption and bait, and competition anatomical parts for different purposes. Bycaught Guiana dolphins comprise the main source of 'religious and magic' products that supply a lucrative market throughout the North, Northeast and Southeast regions of Brazil, (Sholl *et al*., 2008; Siciliano *et al*., 2018), and at the northern Maracaibo Lake System in Venezuela as well (Barrios-Garrido et al., 2021).

In general, few initiatives and experiments have been carried out on Guiana dolphins to mitigate fisheries interactions. An experimental test with acoustic deterrents (pingers) was carried out in Iracema Beach, Fortaleza, Brazil, from 1996 to 1998 (Monteiro-Neto *et al.*, 2004). Experiments with functional, dummy and control trials were tested in a sheltered area where dolphin groups were monitored. The results suggested that functional pingers affect dolphin distribution, but side effects in population parameters and its prey were not cited. In Southern and Southeastern Brazil, some fishing legislations banned multifilament gillnets and regulated the mesh size and length of gillnets to reduce bycatch (INI-N°166/2007; INI-N°12/2012[2]); however, there is a lack of law enforcement and research studies to assess the effectiveness of these legislations Currently, no bycatch assessment is being conducted focusing on Guiana dolphin populations, and few efforts have been done to assess fishing effort and its spatial distribution, which preclude any impact and risk analyses.

The review contributions in understanding Guiana dolphin bycatch are summarised by management units in Table 3.

Summary by management units

BRS/SE

In the central coastal area of São Paulo state, Guiana dolphins represented 5.4% of the incidental capture records during the over 20 years of monitoring artisanal fishing (Bertozzi *et al*., 2020). In the southern area in the same state, in Cananéia Estuarine Complex, fisheries interactions were observed between 2004 and 2007 and Guiana dolphins represented 1.,5% of small cetaceans bycatch (Sidou, 2008). In the Paraná state, the monitoring of fisheries recorded the incidental capture of 45 Guiana dolphins between 1997 and 1999 (Rosas, 2000). In the same region, between 2007 and 2012, 155 individuals

[2] https://www.icmbio.gov.br/cepsul/legislacao/instrucao-normativa/345-2007.html

were found stranded on the beaches, with ~ 61% of the animals necropsied showing signs of fisheries interactions (Domiciano *et al*., 2016).

BRSE2

In Sepetiba Bay, RJ, a total of 371 Guiana dolphin carcasses were collected, and amongst the fresh animals (n = 91), almost 2/3 presented interactions with fishing activities, 21 (23%) as bycatch and 38 (42%) showing evidence of interaction with fishing gear. Gillnet monofilament and multifilament marks were visible on the maxilla and mandibles, dorsal, pectoral, and caudal fins of Guiana dolphins. Also, some dolphins showed marks from previous interactions with fishing gear, where the wounds had healed, evidencing the significant threat from gillnets fishing (Bertozzi et al., 2020).

BRSE1

In the region of Atafona, north of Rio de Janeiro state, Guiana dolphin has historically represented one of the species most vulnerable to fishing activities. In 1987 and 1988, Lodi and Capistrano (1990) recorded the incidental capture of 33 specimens; later, between 1989 and 1996, Di Beneditto *et al.* (1998) registered 78 individual incidental captures. Between 2001 and 2002, monitoring of 374 sets of gillnets resulted in the bycatch of 20 individuals (Di Beneditto, 2003).

BRNE (1-4)

In the northeast of Brazil, an ethnobiology study carried out in Pernambuco state showed that 44% of the fishermen confirmed that they have incidentally captured Guiana dolphins, but the mortality rate and the threat to the population are still unknown (Araújo, 2008). For Ceará state (BRNE1), mortality due to incidental captures was estimated at 4 to 11 individuals *per* year (Monteiro-Neto *et al.*, 2000). In the same state, Meirelles *et al*. (2010) reported 30.6% of stranded carcasses (n=49) with evidence of fishery interaction. Confirmed events were related to driftnet, surface gillnet and beach seine. In Rio Grande do Norte state (BRNE2) the mortality recorded for small-scale fisheries was 29 individuals over three years (Attademo, 2007). Fishers from Ilhéus in Bahia State informed that Guiana dolphin is the most frequent victim of fishing nets among cetaceans: 12 out of 35 fishermen interviewed reported cases of bycatch of the species (Seminara *et al.*, 2019).

BRNO

The mortality of Guiana dolphins by interactions with small-scale fisheries was evaluated in Pará, from August 2006 to May 2007, and 166 Guiana dolphins were captured; an average of 5.35 animals per fishing set (Emin-Lima *et al.*, 2008). This number is larger than recorded for other regions of Brazil.

Furthermore, Guiana dolphins can be severely injured due to trauma related to net entanglements resulting in partial or complete amputations and deformations. In Sepetiba Bay-RJ, 5% of the dolphins from the photo-identification catalog, show dorsal fin injuries from fishing gear interactions (Flach, 2015). Remains of nylon, gillnets were found around the body of Guiana dolphins (Azevedo *et al.*, 2009; Domiciano *et al*., 2016). As cited by Rosas *et al.* (2010) this might result in severe injuries and traumas, high stress levels and secondary mortality, which goes unaccounted for Guiana dolphins (Van Bressem *et al.*, 2007).

BYCATCH AND INTENTIONAL CAPTURES – VENEZUELA CASES

Historically, in Maracaibo Lake System there has been a use of Guiana dolphins when incidentally captured (Barrios-Garrido *et al.,* 2015). The meat is used for human consumption or as bait for shark fishing (Ramírez, 2005; Sánchez and Briceño, 2017; Barrios-Garrido *et al.*, 2021; Briceño *et al*., 2021). Key-informants claimed that in some villages, Guiana dolphin meat (and other aquatic bushmeat as manatees, crocodiles, freshwater and marine turtles) is especially consumed during the Easter period as a religious ritual. This practice is related to Christian custom to avoid 'red meat' (Barrios-Garrido *et al*., 2021).

In the Maracaibo Lake System, Guiana dolphin interacts with multiple artisanal fisheries, such as:

- Longlines: two different types of longline gears, one to capture sharks, rays, and catfishes (Barrios-Garrido et al. 2017); and another longline to capture blue crabs - *Callinectes* spp. (Barrios-Garrido *et al*., 2021);
- Varied artisanal gillnets (Espinoza-Rodríguez *et al*., 2019);
- Artisanal seine fishery (Barrios-Garrido *et al*., 2021).

Between 2007 and 2013, in only one artisanal fishing port, the total annual take was estimated at 15 animals/year (Barrios-Garrido *et al*., 2021). However, from 2010 to 2013, there has been an increase in beached individuals of Guiana dolphins in Lake Maracaibo with signs of anthropogenic injuries, such as marks of fisheries interactions. The bycatch rates were estimated per region (North, Center and South of the Lake Maracaibo) for 3 to 5 months (Briceño *et al.*, 2021; see Table 3).

Additionally, direct hunting has been reported, and between July 2019 and January 2020, about 100 individuals were captured for consumption. These data have been collected through interviews conducted at the main fishing ports and with local informants. In a single hunting event in the north of the lake in January 2020, 17 animals were killed and consumed, including pregnant females (Briceño, *pers. comm*.). Considering the data collected between 2016 and 2020, bycatch and directed hunting mortality is estimated at around 180 individuals/year, one of the highest rates in the species' entire distribution (Briceño *et al*., 2021; Sánchez and Briceño, 2017).

A.

B.

Fig. 5. Guiana dolphin bycaught in southern Brazil (A.) and probably caught to use the meat, in Maracaibo Lake in Venezuela (B). Images©: A. UFPR/Brazil and B. Yurasi Briceño/Venezuela.

Table 3
Summary of the current knowledge on fisheries interactions and Guiana dolphin bycatch.
Information was collected from stranding events and interviews with fishermen.

Location	Years	Fishing gear	% of carcasses or bycatch rates*	Seasonal capture	Information from
Venezuela					
Maracaibo Lake, (west-central coast) – (VEML)	2018-20	Gillnet	21 individuals/year	No seasonal difference detected	Briceño *et al.* (2021)
Maracaibo Lake, Zulia state (southern portion) – (VEML)	2011-12	Artisanal longline	5 individuals/year	No seasonal difference detected	Delgado-Ortega (2012) Barrios-Garrido *et al*. (2021)
	2016-20	Gillnet	144 individuals 36 individuals/year	No seasonal difference detected	Briceño *et al.* (2021) Sánchez and Briceño (2017)
Maracaibo Lake, Zulia state (northern portion) – (VEML)	2007-13* 2017-20** 2005***	Gillnet	91 individuals registered* 15 individuals/ year (only one artisanal port)* 52 individuals** 17individuals/ year**	Wet season (Aug.-Nov.) *No seasonal difference	Barrios-Garrido *et al*. (2021a) Briceño *et al.* (2021)** Sánchez and Briceño (2017)** Ramírez (2005)***

			30 individuals that year***		
Brazil North					
Pará – (BRNO)	2006-07	Gillnet	166 individuals 5.35 individuals/sets	No seasonal difference	Emin-Lima *et al.* (2008)
Northeastern Brazil					
Ceará (BRNE1)	1992-98		4-11 individuals/year (30[#])	Spring	Monteiro-Neto *et al.* (2000)
Ceará (BRNE1)	1992-2005	Gillnet and beach seine	30.6% of stranded individuals	Winter and spring	Meirelles *et al.* (2010)
Southeastern Brazil					
North of Rio de Janeiro (BRSE1)	1987-88	Gillnet	33 individuals[$]	-	Lodi and Capistrano (1990)
North of Rio de Janeiro (BRSE1)	2001-02	Gillnet	0.031 (km of net.day)$^{-1}$	No seasonal difference	Di Beneditto (2003)
North of Rio de Janeiro (BRSE1)	2001-07	Gillnet	~33% of stranded individuals have signs of fishery interaction	Winter and spring	Moura et al., 2009
Sepetiba Bay, Rio de Janeiro (BRSE2)	2005-16	Gillnet	371 carcasses or 30.9 individuals/year From 91 fresh carcasses) 23% (n = 21 were entanglement and 42% (n=38) have signs of fishery interaction	No seasonal difference	Flach (2015; Bertozzi et al., 2020)
Central São Paulo State (BRS/SE)	1999-2021	Gillnet	19 individuals	Not evaluated	Bertozzi, pers. comm.
South of São Paulo State (BRS/SE)	2004-07	Gillnet	18 individuals	Not evaluated	Sidou (2008)
Southern Brazil					
Paraná (BRS/SE)	1997-99	Gillnet	45 individuals	-	Rosas (2000)
Paraná (BRS/SE)	2007-09	Gillnet	~39% of stranded individuals have signs of fishery interaction	Winter and spring	Roso-Londoño, 2010
Paraná (BRS/SE)	2007-12	Gillnet	~61% of stranded individuals have signs of fishery interaction	-	Domiciano et al., 2016
Babitonga Bay, Santa Catarina (BRS/SE)		Gillnet	-	Spring and summer	Pinheiro & Cremer, 2003
Baía Norte, Ilha de Santa Catarina - Santa Catarina (BRS/SE)	1983-2014		97 individuals	Fall and Winter	Vianna et al., 2016

*Percentage of carcasses found with evidence of bycatch; dash = not available.

Environmental concerns

CHEMICAL CONTAMINANTS

The Guiana dolphin is a marine ecosystem sentinel, as this species is susceptible to environmental changes, and spatial and temporal pollution signals from the environment can be detected throughout their life history (Lailson-Brito *et al*., 2010; 2012). Guiana dolphins are exposed to a range of human-induced impacts that include persistent environmental pollution and emerging diseases. Its coastal distribution, high residency and site fidelity, high trophic level and long lifespan of about 30 years complicate exposure to these pollutants and disturbances (Bisi *et al.*, 2012; Azevedo *et al.*, 2004). The species can present high xenobiotic concentrations exhibiting bioaccumulation and biomagnification potential, including several metals and persistent organic compounds. These processes have been reported for populations in both south and southeastern Brazil (Kajiwara *et al.*, 2004; Lailson-Brito *et al.*, 2010; 2012; Yogui *et al.*, 2003). Many of these contaminants can lead to harmful health effects, such as hormonal cycle alterations and immunosuppressant consequences. Although the Guiana dolphin is the most studied Brazilian coastal delphinid regarding contaminant bioaccumulation, the vast majority of investigations have been carried out in the southeastern region, and no studies concerning Guiana dolphin populations from other countries along its distribution range are available.

Trace elements

Most studies published regarding trace element levels in Guiana dolphins have been carried out in southeastern Brazil, mainly along the coast of the state of Rio de Janeiro (BRSE1 and BRSE2), while studies are still scarce in other Brazilian regions (see Table 4). No studies have been published regarding trace elements in other countries where the species occur.

The highest mercury concentrations have been reported in specimens from Rio de Janeiro, ranging from 0.17 to 132 $\mu g.g^{-1}$ wet weight (w.w) in liver tissue (Lailson-Brito *et al.*, 2012; Lemos *et al.*, 2013). The Guanabara Bay population exhibited the highest mean concentration, of 19.9 $\mu g.g^{-1}$ w.w. (Lailson-Brito *et al.*, 2012). This study found a positive correlation between mercury concentrations and total length, probably due to bioaccumulation processes, a pattern widely reported in marine mammal assessments worldwide (Lailson-Brito *et al.*, 2012). In the south/southeast region of Brazil, a single study analyzed individuals collected from the south coast of the state of São Paulo to the north coast of the state of Paraná (BRS/SE), reporting similar values to those reported for Guanabara Bay, ranging between 1.4 and 380 $\mu g.g^{-1}$ dry weight (d.w.; 0.35 to 95 $\mu g.g^{-1}$ w.w.; Kunito *et al.*, 2004). The only two studies published in the north and northeastern regions of the country reported the lowest Hg concentrations in Guiana dolphins, ranging between 0.10 and 29.5 $\mu g.g^{-1}$ w.w. in the liver of individuals from Ceará (Monteiro-Neto *et al.*, 2003) and between 0.07 and 0.79 $\mu g.g^{-1}$ w.w. in the muscle of individuals from Amapá (Moura *et al.*, 2012a). In a preliminary study conducted in the south of Maracaibo Lake (Venezuela), mean Hg concentration of 2.96 ± 0.16 $\mu g.g^{-1}$ w.w. in the liver (n=2) and 0.69 ± 0.01 $\mu g.g^{-1}$ w.w. in the muscle (n=6) were detected (Yurasi Briceño, pers. comm.).

Also, in a recent study, it was investigated the change in mercury distribution and its body burden in Guiana dolphins from Sepetiba Bay (RJ) affected by a morbillivirus infection, with evidence of methylmercury (MeHg) intoxication in the species (Manhães *et al*., 2021). The comparison of the distribution of MeHg in tissues among animals collected before and during an unusual mortality event associated with morbillivirus infection suggests that the observed muscle loss leads to the redistribution of MeHg through the bloodstream, which results in rapid entry into other organs/tissues, like the liver (Table 4; Manhães *et al*., 2021). The authors suggested that this rapid entry could compromise the detoxification process, increasing the chances of MeHg poisoning by the animals. Thus, mercury contamination in the Guiana dolphin may be potentially negative in the health of the species associated with infectious diseases.

Investigations on the bioaccumulation of other trace elements, such as cadmium (Cd) and lead (Pb), are even scarcer in Guiana dolphin, with varying values (see Table 4). In northeastern Brazil, two studies reported Cd values ranging from <0.002 $\mu g.g^{-1}$ w.w. in liver to 4.1 $\mu g.g^{-1}$ w.w. in kidney (Korn *et al.*, 2010; Monteiro-Neto *et al.*, 2003). Most studies have been carried out along the coast of Rio de Janeiro state, with Cd concentrations ranging from <0.047 $\mu g.g^{-1}$ w.w. in the liver of specimens from the northern region (BRSE1) to 3.29 $\mu g.g^{-1}$ w.w. in the kidney of individuals from the central-southern region of the state (BRSE2) (Dorneles *et al.*, 2007; Lemos *et al.*, 2013). Between the south coast of São Paulo and the north of Paraná state (BRS/SE), Cd concentrations ranged from 0.19 to 2.9 $\mu g.g^{-1}$ d.w. in liver (Kunito *et al.*, 2004). Regarding lead (Pb), only four published articles are available, with the highest mean concentration reported in the liver of dolphins from Cananéia, São Paulo state (3.2 $\mu g.g^{-1}$ w.w.; Salgado *et al.*, 2018).

Metals may display a particular behavior of internal subcellular compartmentalization, altering their bioavailability and biochemical effects. Assessments in this regard, however, are extremely scarce for marine mammals, especially Guiana dolphins. The only report to date on subcellular metal compartmentalization in Guiana dolphins was recently published (Hauser-Davis *et al*., 2020). This study evaluated Cd, Hg and Pb compartmentalization in three subcellular fractions of Guiana dolphin kidney and liver samples from the Região dos Lagos area, Rio de Janeiro state (BRSE1). Differential metal-detoxification mechanisms were observed for all elements, although detoxification by metallothionein, the main metal detoxification route in most organisms, was postulated for only Pb in liver, which may reduce its toxic effects, while kidney Pb contents were mostly stored in non-bioavailable form. Cd and Hg were poorly associated to metallothionein, and mostly present in the insoluble fraction, indicating low bioavailability. Regarding Hg, a previous study has already shown that Guiana dolphin is capable of carrying out the methylmercury detoxification process in hepatic tissue via mercury selenide formation (Lailson-Brito *et al*., 2012).

Persistent organic pollutants

Most published studies concerning persistent organic pollutants (e.g. organochlorine compounds and organobromine compounds) in Guiana dolphins have been carried out in southeastern and southern Brazil (Alonso et al. 2010; Dorneles *et al.*, 2010; Kajiwara *et al.*, 2004; Lailson-Brito *et al.*, 2010; Lavandier *et al.*, 2015; Yogui *et al.*, 2011; Yogui *et al.*, 2003,), except one carried out in the northeastern region (Santos-Neto *et al.*, 2014). No studies have been published regarding trace elements in other countries.. See Table 5 for details.

Regarding organochlorine compounds, the highest PCB concentrations were reported for Guiana dolphins from Guanabara Bay (BRSE2) (RJ; 6.7-99.0 $\mu g.g^{-1}$ lipid weight; lw; Lailson-Brito *et al.*, 2010), a highly industrialized area. The highest DDT concentrations and its metabolites were recorded in specimens obtained from areas under greater agricultural influence, on the coast of São Paulo and Paraná states (BRS/SE) (0.54-150 $\mu g.g^{-1}$ l w; Alonso *et al.*, 2010; Kajiwara *et al.*, 2004; Lailson-Brito *et al.*, 2010; Yogui *et al.*, 2003). The lowest concentrations for both PCBs and DDTs, have been reported in animals sampled along the coast of Ceará (BRNE1), with mean values of 1.1 $\mu g.g^{-1}$ lw and 0.3 $\mu g.g^{-1}$ lw, respectively (Santos-Neto *et al.*, 2014). Other chlorinated pesticides (HCH and its isomers, HCB and Mirex) bioaccumulated in lower concentrations in Guiana dolphins in all studies (see Table 5).

Studies on the bioaccumulation of organobrominated compounds (polybrominated diphenyl ethers - PBDEs) in Guiana dolphins are quite scarce and without any standardization regarding the analyzed tissue (subcutaneous adipose tissue, liver and muscle) (Dorneles *et al.*, 2010; Lavandier *et al.*, 2015; Yogui *et al.*, 2003; see Table 6). Thus, it is difficult to compare study results, which limits the understanding of the bioaccumulation potential of these compounds in Guiana dolphins along the entire species distribution.

Contaminants of Emerging Concern

Only two studies have been published regarding emerging organic contaminants pyrethroid insecticides and Ultra-Violet filters (UVF) in Guiana dolphins, both with Brazilian samples (Alonso *et al*., 2015; Vidal *et al*., 2020; Table 6). The first proved maternal transfer by lactation and gestation in mother-fetus pairs from Sepetiba Bay (RJ; BRSE2)) and Canoa Quebrada (CE; BRNE1). This study found the highest concentration of sunscreen ingredients (UV filters analyzed: octocrylene, ethylhexyl methoxycinnamate, 4-methylbenzylidene camphor, 2-ethylhexyl-4-dimethyl-aminobenzoate) in the biota around the world (up to 10,475 ng/g lw). Fetal samples from Guiana dolphins contained higher levels of pyrethroids in blubber than their respective mothers, and the opposite was true for UVF in muscle samples. As in the prenatal period, organ growth and development is at its maximum vulnerability rate, fetal exposure to this several insecticides and chemical sunscreen agents may result in adverse teratogenic effects in calves (Alonso *et al*., 2015). The second study was conducted in hepatic tissue of Guiana dolphins from six Brazilian states, analyzing pyrethroids in the liver of adults for the first time (Vidal *et al*., 2020). Permethrin was the predominant compound and the total concentrations of pyrethroids presented the highest concentration (5,918 ng/g lw) in specimens from Ilha Grande Bay (RJ; BRSE2) and the highest median in individuals from the state of Espírito Santo (BRSE1) (568 ng/g lw, Vidal *et al*., 2020). As both classes of compounds (synthetic pyrethroid insecticide and active ingredients of sunscreen products) proved to be risk factors for cancer, immunodeficiency, endocrine disruptors and reproductive abnormalities, the concentrations of pyrethroids and UVFs detected in these studies are of concern for the species in Brazilian waters (Alonso *et al*., 2015, Vidal *et al*., 2020).

Table 4

Mean±SD, minimum and maximum concentrations of total mercury (HgT), cadmium (Cd) and lead (Pb) in Guiana dolphin (*Sotalia guianensis*) from the Brazilian coast. The concentrations were expressed as $\mu g.g^{-1}$ wet weight.

Regions	N	THg			Cd			Pb			References
		Liver	Muscle	Kidney	Liver	Muscle	Kidney	Liver	Muscle	Kidney	
Brazil											
Northern											
Amapá (BRNO)	27	-	0.4±0.16 0.07-0.79	-	-	-	-	-	-	-	Moura *et al.* (2012a)
Northeastern											
Ceará (BRNE1)	11	4.62 0.10-29.51	-	1.24 0,06-5,63	0.22 0,01-1,32		0.78 0.01-4.09	0.11 0.10-0.12	-	0.11 0.11-1.28	Monteiro-Neto *et al.* (2003)
Bahia (BRNE4)	3	-	-	-	<0.002-1.2	4.9°	2.10-3.31	0.04-0.36	0.02°	<0.001-0.32	Korn *et al.* (2010)
Southeastern											
North coast of Rio de Janeiro (BRSE1)	29	8.67[a#] 0.84-87.92	-	-	-	-	-	-	-	-	Kehrig *et al.* (2008)
North coast of Rio de Janeiro (BRSE1)	6	9.98 1.10-21.7	0.73 0.34-1.42	-	0.34 0.18-0.56	0.10 0.07-0.18	-	-	-	-	Carvalho *et al.* (2008)
North coast of Rio de Janeiro (BRSE1)	19	27.8±24.7[a] 3.60-72.98	-	-	0.41[a] 0.01-1.48	-	-	-	-	-	Seixas *et al.* (2009)
North coast of Rio de Janeiro (BRSE1)	20	1.07±0.35 (0.2-1.66)	-	-	-	-	-	-	-	-	Moura *et al.* (2012b)
North coast of Rio de Janeiro (BRSE1)	11	15.4±20.1 0.17-58.77	-	-	<0.047 <0.047-0.97	-	-	-	-	-	Lemos *et al.* (2013)
North coast of Rio de Janeiro (BRSE1)	21	-	3.28±1.69[a]	-	-	-	-	-	-	-	Kehrig *et al.* (2013)
North coast of Rio de Janeiro (BRSE1)	14	4.1±2.8 (Immature) 12.7 ± 7.1 (mature)	0.6±0.1 (Immature) 1.3 ± 0.3 (Mature)	-	-	-	-	-	-	-	Kehrig *et al.* (2016)
North coast of Rio de Janeiro (BRSE1)	28	-	3.91±2.16[a]	-	-	-	-	-	-	-	Baptista *et al.* (2016)
Guanabara Bay, RJ (BRSE2)	NI	17.44	-	-	-	-	-	-	-	-	Lailson-Brito *et al.* (2002)
Guanabara Bay, RJ (BRSE2)	19	19.9±32.3 (0.3-132)	-	-	-	-	-	-	-	-	Lailson-Brito *et al.* (2012)

Guanabara Bay, RJ (BRSE2)	12	-	0.9±0.65	-	-	-	-	-	-	-	Bisi *et al.* (2012)
Sepetiba Bay, RJ (BRSE2)	42	-	0.3±0.33	-	-	-	-	-	-	-	Bisi *et al.* (2012)
Sepetiba Bay, RJ (BRSE2)**	61	5.7±11.3 (0.1-64.8)	1.0±0.8 (0.04-3.0)	-	-	-	-	-	-	-	Manhães *et al.* (2021)
Sepetiba Bay, RJ (BRSE2)***	20	10.5±36.9 (0.1-153)	0.8±0.8 (0.02-2.5)	-	-	-	-	-	-	-	Manhães *et al.* (2021)
Ilha Grande bay, RJ (BRSE2)	6	8.8 ± 2.1[a]	1.9±0.8[a]	-	-	-	-	-	-	-	Seixas *et al.* (2014)
Ilha Grande bay, RJ (BRSE2)	9	-	0.68±0.22	-	-	-	-	-	-	-	Bisi *et al.* (2012)
Central-south area of Rio de Janeiro (BRSE2)	5	-	-	-	-	-	1.18±1.10 0.04-3.29	-	-	-	Dorneles *et al.* (2007)
São Paulo State and Paraná State* (BRS/SE)	20	77 ± 107[a] (1.4-380)	-	-	0.65±0.75[a] (0.19-2.9)	-	-	0.07±0.053[a] 0.028-0.19	-	-	Kunito *et al.* (2004)
Cananéia, SP (BRS/SE)	21	-	-	-	-	-	-	3.17 ± 2.84 <LD-9.62	-	-	Salgado *et al.* (2018)

NI: data not informed; *authors did not differentiate individuals from the two states; **samples from individuals collected before the unusual mortality event; ***samples from individuals collected during the unusual mortality event [a]values expressed as dry weight; #median values; °n=1; DL= limit of detection; dash= not analyzed

Table 5

Mean±SD, minimum and maximum concentrations of the organochlorine compounds (ΣPCB, ΣDDT, ΣHCH, HCB e Mirex) in blubber of Guiana dolphins (*Sotalia guianensis*) from the Brazilian coast. The concentrations were expressed as μg.g^{-1} lipid weight.

Regions	N	ΣPCB	ΣDDT	ΣHCH	HCB	Mirex	References
Brazil *Northeastern*							
North region of Ceará (BRNE1)	4	2.23±1.17 0.02-3.85	0.33±0.26 0.006-0.63	NA	0.02±0.02 0.003-0.04	0.08±0.04 0.02-0.12	Santos-Neto *et al.* (2014)
Metropolitan region of Ceará (BRNE1)	8	7.35±6.27 0.04-17.3	1.11±0.66 0.06-1.91	0.04±0.01 0.04-0.05	0.007±0.004 0.002-0.01	0.09±0.03 0.04-0.15	Santos-Neto *et al.* (2014)
South region of Ceará (BRNE1)	13	1.12±1.32 0.03-0.82	0.30±0.28 0.003-0.82	0.03±0.03 0.005-0.08	0.07±0.05 0.02-0.16	0.07±0.05 0.02-0.16	Santos-Neto *et al.* (2014)
Southeastern							
Guanabara Bay, RJ (BRSE2)	12	34.8±26.3 6.7-99.2	7.9±6.9 2.1-21.5	NA	0.046±0.04 <0.004-0.11	NA	Lailson-Brito *et al.* (2010)
Sepetiba Bay, RJ (BRSE2)	5	12.3±11.7 1.7-25.5	3.9±3.9 0.65-9.99	NA	0.029±0.028 0.013-0.08	NA	Lailson-Brito *et al.* (2010)
Ubatuba, SP (BRS/SE)	3	47.78 (25.87-66.03)	34.03 16.91-48.08	0.07 0.06-0.07	0.11 (0.08-0.14)	1.26 0.57-1.87	Alonso *et al.* (2010)
Baixada Santista, SP (BRS/SE)	3	39.69 27.86-61.34	36.98 24.57-55.91	0.09 0.03-0.21	0.12 0.07-0.17	0.76 0.24-1.04	Alonso *et al.* (2010)
Cananéia, SP (BRS/SE)	9	4.61±3.31 0.2-9.22	35.9±46.8 0.54-125	0.016± 0.02 <0.003-0.04	0.015±0.009	0.15±0.08 0.01-0.32	Yogui *et al.* (2003)
São Paulo state (BRS/SE)	1	1.97	5.87	0.011	0.067	0.046	Yogui *et al.* (2010)
São Paulo and Paraná states* (BRS/SE)	26	1.3-79	1-150	<0.001-0.061	0.0016-0.40	NA	Kajiwara *et al.* (2004)
Southern				NA		NA	
Paranaguá Estuarine Complex, PR (BRS/SE)	15	4.6±4 0.76-14.3	5.7±5.8 0.98-23.5	NA	0.041±0.040 <0.004-0.16	NA	Lailson-Brito *et al.* (2010)

*authors did not differentiate individuals from the two states; NA=not analysed.

Table 6

Mean±SD, minimum and maximum concentrations of the organobrominated compounds (ΣPBDE) in Guiana dolphins (*Sotalia guianensis*) from the Brazilian coast. The concentrations were expressed as µg.g-1 lipid weight.

Local	N	Sex	ΣPBDE Blubber	ΣPBDE Liver	ΣPBDE Muscle	Reference
BRSE1						
North-central region, RJ	10	M/F	NA	53*	NA	Quinete *et al.* (2011)
North-central region, RJ	3	F	NA	0.20 ± 0.12 (0.07-0.29)	0.10 ± 0.06 (0.03-0.14)	Lavandier *et al.* (2015)
North-central region, RJ	5	M	NA	0.12 ± 0.045 (0.07 -0.17)	0.06 ± 0.02 (0.04-0.08)	Lavandier *et al.* (2015)
Metropolitan region and 'Região dos Lagos', RJ	6	F	NA	0.16 ±0.15 (0.01–0.45)	NA	Dorneles *et al.* (2010)
Metropolitan region and 'Região dos Lagos', RJ	13	M	NA	0.67 ±0.43 (0.26–1.62)	NA	Dorneles *et al.* (2010)
BR S/SE						
São Paulo state	4	F	73.2 ± 79.1	NA	NA	Yogui *et al.* (2011)
São Paulo state	5	M	59.5 ± 47.1	NA	NA	Yogui *et al.* (2011)

M: male; F: female; *values expressed wet weight; NA= not analysed.

Table 7

Minimum and maximum U.V. filter (UVF) and pyrethroid (PYR) concentrations (ng/g lw) in Guiana dolphins from Brazilian coast.

Local	Age class	Tissue	N	∑UVF	∑PYR	Reference
Rio de Janeiro (BRSE1)	mother	blubber	2	nd - 505	40-135	Alonso *et al*. (2015)
		muscle	2	1,405-10,475	265-620	
	Fetus	blubber	2	nd-32	57-58	
		muscle	2	280-355	55-91	
Ceará (BRNE1)	Mother	blubber	1	67	16	
		muscle	1	1810	570	
	Fetus	blubber	1	34	22	
		muscle	1	365	67	
Ceará (BRNE1)	Adults	liver	4	NA	75-648	Vidal *et al*. (2020)
Rio Grande do Norte (BRNE2)	Adults	liver	4	NA	180–481	
Espírito Santo (BRSE1)	Adults	liver	4	NA	244–1242	
Rio de Janeiro (BRSE2)	Adults	liver	34	NA	4-5918	
Paraná (BRS/SE)	Adults	liver	3	NA	57–168	
Santa Catarina (BRS/SE)	Adults	liver	1	NA	469	

nd - below mLOD; NA= not analysed; CE- Ceará; RN- Rio Grande do Norte; ES- Espírito Santo; RJ- Rio de Janeiro; PR- Paraná; SC- Santa Catarina.

MARINE DEBRIS

A systematic beach monitoring program (PMP-BS) recorded 832 individuals stranded on beaches in southern and southeastern Brazil (BRS/SE) and debris were observed in four of 328 Guiana dolphins following necropsies. These interactions include ingestion and entanglement. On several occasions, Guiana dolphins have been recorded entangled in discarded artisanal longlines in the Maracaibo Lake (VEML), specifically in fishing gear designed to capture Blue crabs (*Callinectes* spp.) (Barrios-Garrido, *et al.*, 2021). In the state of Ceara (BRNE1), there is an ongoing study focusing on the detection of microplastic in gastric contents of Guianan dolphin.

NOISE POLLUTION AND COLLISIONS

In general, noise pollution can cause behavioral and physiological changes in marine mammals, including increased respiratory rate (Buckstaff, 2004; Purser et al., 2016), hearing injuries caused by high-intensity noise (Nachtigall et al., 2003; Kastak et al., 2005; Lucke et al., 2009; Mooney et al., 2009), habitat evasion (Richardson et al., 1987; Bryant et al., 1984; Anderwald et al., 2013), increased chances of collisions with vessels (Gerstein et al., 2006) and temporary changes in the frequency, duration and sound level of vocalizations (NRC, 2005). Still, the investigation of noise levels effects on Guiana dolphin habitats is scarce through most of the species distribution.

Some studies have been published on the frequency range of Guiana dolphins), along the entire species distribution (Tab. 8; Annexx C). Regarding acoustic recording systems, so far, there is no standardization between studies for the upper sound frequency limit. Equipment with an upper-frequency limit under 48 kHz might underestimate the whistle repertoire of the Guiana dolphin (May-Collado and Wartzok, 2008), therefore not allowing accurate comparisons between different populations' acoustic repertoire. Still, Melo-Santos et al. (*pers.comm.*), compared *Sotalia* dolphins acoustic repertoire along most of the distribution of the genus. They used state-of-the-art- acoustic analysis to control for differences in recording systems and robust community ecology tools to compare repertoire sizes and diversity between the two *Sotalia* species along 16 sites in Latin America. Results from this study will be published soon.

Table 8
Frequency range of Guiana dolphin whistles by study areas.

Management units (MUs)	Study area	Minimum Frequency (kHz)		Maximum Frequency (kHz)		Reference	Sampling rate
		min.	max.	min.	max.		
BRS/SE	Cananéia Estuary - SP	1.89	37.2	4.41	44.6	Deconto and Monteiro-Filho (2017)	96 kHz
	Guaraqueçaba Bay - PR	2.42	44.3	4.83	46.9	Deconto and Monteiro-Filho (2013,2017)	48 kHz, 96 kHz
	Paranaguá Estuarine Complex - PR	2.91	40.5	9.63	51.8	Acoustic Monitoring PBA/APPA, 2017 and 2018	96 kHz
BRSE2	Sepetiba Bay - RJ	1.85	24	3.36	44.9	Andrade et al. (2014) and Maciel (2020)	48 kHz
	Guanabara Bay - RJ	1.7	25.8	42.7	66.7	Andrade et al. (2015)	96 kHz
	Guanabara Bay - RJ	1.1	26.5	5.7	46.2	Bittencourt et al. (2016)	Flat frequency response of 5Hz to 30 kHz
BRSE1	Bevenente Bay -ES	3.51	35	7.95	37.6	Moron et al. (2019)	96 kHz
BRNE2	Caravelas Estuary - BA	1.39	22.2	3.5	23.9	Garcia (2009)	24 kHz
	District of Pipa - RN	0.42	28.2	19.6	47.5	1.Martins et al. (2016), 2. Albuquerque and Souto (2013)	1: 24 kHz and 2: 40 kHz
BRNE1	Fortaleza -CE	2.44	20.3	12.6	23.8	Azevedo and Van Sluys (2005)	24 kHz

VEML	Maracaibo Lake System - Venezuela	5.31	16	7.81	20.9	Barrios-Garrido et al. (2016)	24 kHz
CCOL	Costa Rica	1.4	37.8	3	48.4	1. May-Collado and Wartzok (2009), 2. May-Collado (2013)	250 kHz

Summary by country

COSTA RICA

Four studies have been published on the acoustic repertoire of Guiana dolphins in Costa Rica, with one describing the acoustic habitat. Guiana dolphins are only found in the coastal waters within the Gandoca-Wildlife Refuge, in southern Caribbean coast of Costa Rica. May-Collado et al. (2008) describe the environmental noise levels of Gandoca-Manzanillo between 90 dB at 14 kHz and 110 dB at 2 kHz. May-Collado and Wartzok (2009) suggested that high noise levels at low frequencies in this area may select for high-frequency communicative signals. Melo-Santos G. (*pers. comm.)* found that the Guiana dolphins from Costa Rican produce whistles with some of the highest frequencies compared to other Guiana dolphin populations. However, it is important to highlight that due to lack of funding since 2007, researchers have not been able to return to this area. Given the rapid increase in the tourism industry in this region, it is crucial to reassess the acoustic habitat of this dolphin population to measure current risks.

BRAZIL

Four studies have been published regarding the impact of noise pollution on the acoustic behaviour of the Guiana dolphin in Brazil: (i) one in Guanabara Bay, Rio de Janeiro State - BRSE2 (Bittencourt *et al.*, 2017); (ii) one in Cananéia, São Paulo State - BRS/SE (Resende, 2008); (iii) one in Caravelas Estuary, Bahia State - BRNE4 (Pais et al., 2018); and (iv) one in the district of Pipa, Rio Grande do Norte State – BRNE2 (Martins *et al.*, 2008).

Along the coast of Rio de Janeiro State, there are varied noise conditions to which Guiana Dolphin populations are exposed (Bittencourt et al., 2020). Guanabara and Sepetiba Bays (BRSE2) are greatly influenced by vessel distribution, with shipping areas presenting the highest noise levels (Bittencourt et al., 2014 and 2020; Maciel, 2020). Ilha Grande Bay (BRSE2) shows the most well-preserved acoustic habitat along the coast of this State, but it shows vulnerability to noise from tourist activities, as well as shipping (Bittencourt et al., 2020). In this region, marine protected areas, such as APA de Guapi-Mirim and ESEC Tamoios, have shown low noise levels compared to other surrounding areas, indicating that they might filter the noise and play an important role in conserving adequate soundscapes for Guiana Dolphins.

Shifts in whistle acoustic parameters have been suggested due to high underwater noise in some of these studies. Bittencourt *et al.* (2017) in BRSE2 found that Guiana dolphins increased their whistling rate and produced whistles of shorter duration. On the other hand, Martins et al. (2018) reported a reduction in the number of clicks in noisy conditions. Stutz Reis (2013) observed different responses in Bevenuete Bay, in Espirito Santo State (BRSE1), where Guiana dolphins produced longer whistles in a noisy habitat.

In general, published and unpublished data (grey literature) from different areas along the Brazilian coast highlighted potential communication masking of Guiana dolphin acoustic signals in noisy areas (Domit et al., 2018; Resende, 2008; Pais et al., 2018; Martins et al., 2018; Alburquerque & Souto, 2013, Rossi-Santos, pers. comm.). In a recent study, 20 years of acoustic data were analysed for the Guiana dolphin population from Sepetiba Bay, Rio de Janeiro State (BRSE2). Changes in the spatial and temporal structure of Guiana dolphin repertoire potentially have been induced by noise pollution. In general, whistle diversity, duration, and emission rate decreased significantly through the years, whereas maximum and minimum frequencies increased. Guiana dolphins emitted longer and more complex whistles in quieter habitats (Maciel, 2020).

In Babitonga Bay, Santa Catarina (BRS/S), the soundscape and the highest noise intensity were recorded in the two port areas' vicinity. The results show a dense noise range predominant between 1 and 15kHz, but it can extend up to 35kHz, with intensity ranging from 107 to 148dB along the year (Holz, 2014).

VENEZUELA

In the case of Venezuela, Barrios-Garrido *et al.* (2016) found that the significant amount of ambient noise produced by boats, ships, and tankers for the transportation of tourists, goods, and oil products may be affecting the whistle structure of Guiana dolphin in the southern portion of the Gulf of Venezuela, specifically between Zapara Island and San Bernardo Bay. A similar scenario is likely occurring in the other two populations within the Maracaibo Lake System (e.g. Western-Center of the Maracaibo Lake, and Catatumbo River mouth) (Barrios-Garrido et al., 2021). Indeed, there are unpublished data collected from these areas that may coincide with this previous evidence. Further research is needed to evaluate this environmental stressor in the Orinoco River.

COLOMBIA

In Colombia, the distribution of Guiana dolphins overlaps with ports, so the potential for negative interaction exists but has not been measured hitherto (Trujillo, pers. comm.).

DOLPHIN WATCHING AND RECREATIONAL NAUTICAL TOURISM ACTIVITIES

Nautical tourism activities are an increasingly significant threat to marine mammals worldwide, amounting to a billionaire industry (O'Connor *et al.*, 2009). Nautical tourism is a significant economic activity along South and Central America; however, few studies have investigated the potential impact on Guiana dolphin populations.

Commercial dolphin-watching programs are reported for Maracaibo Lake, Venezuela (VEML) and in Brazilian waters, such as Baía Norte in Santa Catarina State and Cananéia in São Paulo State (both under BRS/SE), Sepetiba Bay in Rio de Janeiro (BRSE2), at Pipa beach in Rio Grande do Norte State (BRNE2), Gandoca-Wildlife Refuge, in the southern Caribbean coast of Costa Rica (CCOL), and Morrosquillo Gulf in Colombia (CCOL).

In Maracaibo Lake (VELM), Venezuela, commercial dolphin-watching tourism is reported to occur sporadically. However, no study investigated the potential impacts on Guiana dolphin behaviour and health condition (Hoyt and Iñíguez, 2008). In Baía Norte/ SC (BRS/SE), commercial dolphin-watching tourism resulted in behavioural changes and long and short-term habitat displacement by Guiana dolphins (Pereira *et al.*, 2007). Similar results were reported in Cananéia/SP (BRS/SE) instantly after vessel approximation (Filla and Monteiro-Filho, 2009). Moreover, in Pipa beach/RN (BRNR2), behavioural changes were reported in groups with calves, particularly during resting and socialising behaviors (Santos *et al.*, 2006).

In Costa Rica (CCOL), May-Collado et al. (2008) reported few activities of dolphin watching vessels and, in general, the vessel's captains followed national regulations. Overall, vessels travel at low speed during interactions contexts. The authors indicated that high noise levels at low frequencies recorded in that region were likely related to biological and geological sources. In Colombia (COOL), small dolphin watching tourism exists in Morrosquillo Gulf, but there is no information about the level of interaction and the number of vessels conducting this activity in the area (Trujillo, pers. comm.).

Recreational nautical tourism exists along the entire Guiana dolphin distribution. Behaviour categorized as negative reactions to dolphin watching vessels were reported in Sergipe State (BRNE 3; Marega-Imamura *et al.*, 2018; Carvalho et al., 2014), in Ilhéus, Bahia State (BRNE4; (Marega-Imamura *et al.*, 2018; Santos et al., 2013), Cananéia, São Paulo State (Filla and Monteiro-Filho, 2009), Paranaguá Estuarine Complex, Paraná State (Gaudard, 2008) and in Baía Norte, Santa Catarina State (Pereira *et al.*, 2007).

COLLISION

There is no specific study being conducted evaluating rates of vessels collisions in Guiana dolphins. Nevertheless, the systematic beach monitoring program (PMP-BS[1]) conducted along the beaches in southern and southeastern Brazil (BRS/SE and BRSE2 and BRSE1) recorded 832 Guiana dolphins stranded, from which eleven carcasses presented marks of possible vessel collisions. Moreover, alive and dead stranded individuals were recorded with marks suggesting traumatic injuries, probably caused by vessel propellers (Domiciano et al., 2016; Paulo André Flores, pers. comm.).

DISEASES

Cetaceans are considered environmental sentinels and their health often reflects either anthropogenic or natural spatio-temporal disturbances. Over the years, several pathogens have been identified as the cause of stranding episodes and mortality and, in fact, represent a potential risk to the life and conservation of cetaceans, including the Guiana dolphin (Groch *et al.*, 2020). A recent review of diseases, parasites and pathologic conditions described in Guiana dolphins is found in Carvalho *et al.* (2020).

Studies investigating pathological findings are increasing, particularly along the Brazilian coastal area, where intense beach monitoring programs have been conducted in recent years. Beaches are surveyed daily to weekly, and all fresh or early decomposed cetacean carcasses found are submitted to necropsy, sampling and in most cases, histopathological analysis. Although some of this program results are unpublished, other studies have disclosed important results on Guiana dolphin health status.

Viral diseases

One of the most important diseases that pose a significant threat to Guiana dolphins' conservation is cetacean morbillivirus infection. A novel strain, Guiana dolphin *Cetacean Morbillivirus* (GD-CeMV), was first reported in a female calf stranded in São Mateus, Espírito Santo state in 2010 (Groch *et al.*, 2014). Posterior investigations revealed the animal was coinfected with *Brucella* sp. (Sanchez-Sarmiento *et al.*, 2019). Four years later, a study found antigen of CeMV in lung tissue of two Guiana dolphins from Parana state (Domiciano *et al.*, 2016). More recently, an unusual mortality event (UME) claimed over 260 Guiana dolphins in Rio de Janeiro, Brazil (Groch *et al.*, 2018b). Postmortem examinations and laboratorial analyses on a large cohort of these carcasses provided compelling evidence of CeMV infection (Groch *et al.*, 2018b). Most of these animals had acute or subacute systemic CeMV-associated disease (Groch *et al.*, 2018b; Diaz-Delgado *et al.*, 2019). The main gross findings were lack of ingesta, pulmonary edema, ascites, icterus, hepatic lipidosis, multicentric lymphadenomegaly, as well as pneumonia, polyserositis, and multiorgan vasculitis caused by *Halocercus brasiliensis*. Microscopically, the primary lesions were bronchointerstitial pneumonia and multicentric lymphoid depletion. The severity and extent of the lesions paralleled the distribution and intensity of morbilliviral antigen. Comorbidities included disseminated toxoplasmosis, mycosis, ciliated protozoosis, and bacterial disease, including brucellosis (Groch *et al.*, 2020).

"Tattoo-like skin lesions" (TLSLs), caused by *Cetaceanpoxvirus,* associated with proliferative dermatitis and amphophilic intracytoplasmic inclusions, have been recorded in various Guiana dolphins (Sacristan *et al.*, 2018). The incidence of TLSLs is believed to be associated with environmental degradation and somewhat compromised immunity (Van Bressem *et al.*, 2009b).

In the Northern Brazil, Pará State (BRNO), a case of herpesvirus-associated genital lesions was positive for Gammaherpesvirinae subfamily in a recently dead, trapped in a fishing net adult female Guiana dolphin (Seade *et al.*, 2017). Furthermore, an alphaherpesvirus was reported in skin, kidney, liver and blood of a Guiana dolphin found stranded in Linhares, Espirito Santo state (Sacristan *et al.*, 2019).

<u>*Parasitic diseases*</u>

Probably, one of the most common lesions observed in Guiana dolphins is granulomatous pneumonia associated with nematode infection by *Halocercus brasiliensis* (Guimarães *et al.*, 2015; Domiciano *et al.*, 2016; Groch *et al.*, 2018b; Groch *et al.*, 2020). Investigations conducted in the northeastern coast of Brazil revealed prevalence of 17.1% of *Halocercus* sp. and 9.8% of *H. brasiliensis* (Carvalho *et al.*, 2010), and 60% of *Halocercus* sp. (Guimarães *et al.*, 2015). Furthermore, in surveys conducted in southeastern and south coast of Brazil (Marigo *et al.*, 2010) and in southern Brazil (Paraná state) (Marutani, 2020) through a systematic beach monitoring program (PMP-BS), the prevalence of *H. brasiliensis* in the respiratory system was 88 and 20%, respectively. Grossly lesions are characterized by partial obstruction of bronchi or bronchioles, congestion and pulmonary edema; microscopically by moderate to severe chronic bronchointerstitial or granulomatous pneumonia and fibrosis (Domiciano et al., 2016; Marigo et al., 2010). Recent studies have revealed a wider array of lesions related to halocerciasis in Guiana dolphins to include: chronic fibrosing bronchointerstitial pneumonia with fibrovillous pleuritis; proliferative abdominal polyserositis; multicentric eosinophilic lymphadenitis and splenitis; and systemic vasculitis (Groch *et al.*, 2018a; Groch *et al.*, 2018b). Among other parasites of respiratory system, *Nasitrema attenuate* is found infecting air sacs, sinuses, bronchi and lungs of Guiana dolphins (Melo *et al.*, 2006; Luque *et al.*, 2010; Marigo *et al.*, 2010; Ebert & Valentere, 2013).

In the digestive system, parasitism has been associated with *Braunina cordiformis* and *Anisakis typica* infection of gastric compartments. A prevalence of *Anisakis* sp. infection of 59.8% with a range of intensity of 1-1000 parasites was reported (Carvalho *et al.*, 2010). Less severe lesions were related to this infection characterized by moderate chronic gastritis and focal calcification of gastric mucosa (Domiciano *et al.*, 2016). *Synthesium tursionis* and *Bolbosoma* spp. have been described infecting the intestines (Luque *et al.*, 2010; Alves *et al.*, 2017). The presence of a pseudostalked barnacle *Xenobalanus globicipitis* has been recorded in Guiana dolphins at southeastern Brazil (Di Beneditto & Ramos, 2000; Siciliano *et al.*, 2020).

Among protozoan diseases, toxoplasmosis was first identified in a Guiana dolphin from Rio de Janeiro (Bandoli & De Oliveira, 1977). More recently, *T. gondii* was identified in Guiana dolphins from Paraná state (Gonzales-Viera *et al.*, 2013; Costa-Silva *et al.*, 2019; Marutani, 2020). Furthermore, toxoplasmosis was a common comorbidity in Guiana dolphins infected with CeMV during the recent UME (Groch *et al.*, 2018b; Groch *et al.*, 2020). The main findings are interstitial pneumonia, arteritis, adrenalitis, hepatitis and non-suppurative meningoencephalitis with intralesional *T. gondii* cysts.

Other protozoan parasites such as *Cryptosporidium* spp. and *Giardia* sp. were detected in 9.67% of the fecal samples analysed in northern and northeastern Brazil. Co-infection was also observed in 3.22% of the samples (Borges et al., 2017). These protozoans are considered opportunistic agents, and apparently induced no lesions in dolphins. On the other hand, *Giardia* sp. infection was associated with emaciation, dehydration, and watery green fetid faeces in a rescued calf. The animal died and the main gross findings were black and viscous liquid content in the lumen of the three stomachs and duodenum. Mild enteritis with submucosal lymphoid hyperplasia and trophozoites in intestinal crypts were observed microscopically (Altieri et al., 2007). Additionally, infection by an unidentified ciliate protozoa causing thromboembolic dermatitis, panniculitis, and fasciitis with infarction have been found in various Guiana dolphins during the UME linked to CeMV infection (Groch *et al.*, 2020).

Mycotic diseases

Mycotic diseases in marine animals, in general, are associated with immunosuppression. *Paracoccidioidomycosis ceti*, a chronic cutaneous granulomatous disease with keloidal aspect, formerly reported as lacaziosis/lobomycosis, have been recorded in Guiana dolphins. Histologically there is extensive granulomatous dermatitis with yeast-like cells inside giant cells, histiocytes and intercellular spaces (De Vries & Laarman, 1973). Sighting and photoidentification-based surveys have detected a prevalence of 3.9% in Guiana dolphins inhabiting Paranaguá estuary, Paraná state (southern Brazil) (Van Bressem *et al.*, 2009a). The occurrence of *Paracoccidioidomycosis ceti* infection has been associated with skin traumas and compromised environment (Van Bressem *et al.*, 2009a; De Moura *et al.*, 2014).

In addition, pulmonary and systemic infection by hyphate fungi, of morphology compatible with Mucorales and Aspergillus sp., have been reported more frequently (Diaz-Delgado *et al.*, 2019; Groch *et al.*, 2020)

Bacterial diseases

Molecular and histochemical assays detected *Brucella* spp. infection in a calf (from a total of 23 Guiana dolphins) stranded in Espirito Santo, southeastern Brazil. The animal had concomitant CeMV infection. Microscopic findings were characterized by neutrophilic meningoencephalitis with perivascular cuffing, acute pneumonia and subacute necrotizing hepatitis (Sanchez-Sarmiento *et al.*, 2019). Other bacteria recorded in Guiana dolphins include *Klebsiella pneumoniae* from mediastinal exudate and bronchial exudate in two Guiana dolphins, respectively, and *Escherichia coli* from bronchial exudate in Guiana dolphin during the recent UME (Groch *et al.*, 2020). Although many additional bacteria are likely to affect Guiana dolphins, there is little current available information.

Bone abnormalities

Descriptions of bone abnormalities and pathologies in Guiana dolphins are concentrated in specimens distributed along the Brazilian coast. The data compiled by Rosas *et al.* (2010) present a case of osteomyelitis in Guiana dolphins from Santa Catarina coast, in southern Brazil, and a case related to periodontal disease seen in the mandible of one individual from Venezuela. They also cited lesions potentially caused by *Crassicauda* sp. seen in the pterygoids of Guiana dolphins from Rio de Janeiro coast (Van Bressem *et al.*, 2007). A recent review of malformations and skeletal lesions described in Guiana dolphins is found in Carvalho *et al.* (2020).

Other cranial disorders including arthrosis in the occipital condyles and congenital malformations have also been reported (Fragoso, 2001, 2006; Laeta et al., 2007; Simões-Lopes *et al.*, 2008). Traumatic, degenerative and infectious injuries, and malformations have been described for the mandible and maxilla, including abscesses in the dental alveoli (Fragoso, 2001; Ramos *et al.*, 2001; Simões-Lopes *et al.*, 2008; Laeta *et al.*, 2010). Some traumatic lesions with tooth avulsion and bone remodeling were caused by entanglement in gillnets as a result of fishing interactions in southeastern Brazil (Fragoso, 2001; Ramos *et al.*, 2001). Dental alterations have also been described by Loch *et al*. (2011) in association with alveolar remodeling.

The most frequent congenital malformations in specimens along Brazilian coast are cervical ribs and cleft neural arch due to incomplete closure of the vertebral arch in the seventh cervical vertebrae (Fettuccia, 2006; Mendonça De Souza *et al.*, 2006; Laeta *et al.*, 2008, 2010). This latter malformation has also been described for the thoracic vertebra (Fragoso, 2001). In addition, abnormalities such as scoliosis, fused vertebrae, extra-numerary hemi-vertebra, aplasia / hypoplasia in cervical, thoracic and lumbar vertebrae have been described (Fragoso & Lima, 1998; Fragoso, 2001, 2006). Other malformations were also reported for the postcranial axial skeleton, as well as for some structures of the appendicular skeleton, such as scapula and humerus (Fragoso, 2001, 2006).

Degenerative lesions of arthrosis in the vertebral column, vertebral and sternal ribs, sternum and appendicular skeleton were also described to Guiana dolphins on the north, southeast and south coasts. These lesions seem to be associated with aspects of skeletal biomechanics, being considered an adaptive process to aging related to repetitive effort (Fragoso & Lima, 1998; Furtado & Simões-Lopes, 1999; Fragoso, 2001, 2006; Simões-Lopes *et al.*, 2008; Laeta *et al.*, 2010).

Osteomyelitis has been described in all segments of the vertebral column, including some reports of ankyloses, as well as in vertebral ribs, sternum and appendicular skeleton of Guiana dolphins on the southeast and south coasts (Fragoso, 2001, 2006; Mendonça De Souza *et al.*, 2006; Simões-Lopes *et al.*, 2008; Laeta *et al.*, 2010). Several traumatic injuries were described in the postcranial axial skeleton and appendicular skeleton to Guiana dolphins on the southeast and south coasts, suggesting anthropogenic interaction due to evidence of fishing gear associated with the injuries (Fragoso, 2001, 2006; Van Bressem *et al.*, 2007; Simões-Lopes *et al.*, 2008; Laeta *et al.*, 2006, 2008, 2010). A traumatic injury caused by sting ray resulted in infectious injuries (Lima-Silva *et al.*, 2010). In addition, diffuse idiopathic skeletal hyperostosis (DISH) was described in some vertebrae in specimens from Rio de Janeiro and Pará states (Mendonça De Souza *et al.*, 2006).

Other pathological findings

A study investigated the pathological findings and mortality of 50 Guiana dolphins from Paraná state (BRSE/S) and suggested major cause of death were described to anthropogenic activities, including fisheries bycatch and trauma. However, the natural mortality, irrespective of the cause, was related to bronchointerstitial pneumonia, associated with parasitism, lymphadenitis and membranous glomerulonephritis. These results suggest that while anthropogenic activities are a leading cause of cetacean strandings in Paraná, and probably in other regions, underlying pre-existing diseases may contribute towards deaths (Domiciano et al., 2016). In the last years (2015-19) the main histological findings observed in Guiana dolphins evaluated in PMP-BS1 in a specific area (Paraná state) were pneumonia (56%) (interstitial, granulomatous, chronic bronchopneumonia), lymphadenopathy (44%) (lymphoid depletion and lymphadenitis), hepatitis (20%), nephritis (16%) and lymphocytic encephalitis (8%). Granulomatous dermatitis was also observed in association with fungal infection. Interstitial pneumonia and lymphoid depletion were associated with morbillivirus infection in 11 animals. In other areas, hepatic degeneration, lung problems and severe vascular thrombosis in Guiana dolphins caught on the Caribbean coast of Colombia (MU CCOLv) were mentioned by Bossenecker (1978).

It is well known that environmental factors contribute to development of diseases in different species and these results suggest a vulnerability of this species to environmental disturbances. Threats, including chemical contamination, underwater noise and habitat degradation are potential impacts evoking the types of stress, immunosuppression and diseases observed in different Guiana dolphin populations along the species' entire distribution.

COASTAL DEVELOPMENT (E.G. PORT ACTIVITIES)

Throughout the distribution of the Guiana dolphins, the presence of coastal and maritime infrastructure, such as ports, is generating a set of anthropogenic activities (Fig. 6). These activities include increased ship traffic, dredging, pile driving, underwater explosions, degradation of the habitat due to permitted discharges, and environmental accidents involving oil spills, among others, that generate a wide range of direct, lethal and non-lethal, impacts on marine mammals species, especially on the Guiana dolphin populations (Nelms et al., 2021; Domit et al., 2009; Van Belleghem and Domit, 2017).

Marine traffic can interact with dolphins through disturbance, collision, and noise. The physical presence of boats generates changes in behavior, collisions with boats cause individuals lethal and non-lethal injuries (Azevedo et al., 2009), and noise has a wide spectrum of reactions: from changes in behavior to abandonment of the area (as cited in the “Noise pollution” topic). Noise pollution in a coastal area, as an example, is not only produced by marine traffic, so this factor should be integrated into an impact matrix and must be approached from a cumulative effects perspective (Marcondes et al, 2020).

Dredging induces the risk of noise with permanent threshold change (PTS), and exposures to permitted discharges, which can generate toxicological impacts in sensitive stages of life. The fabrication and launching of piles, transportation to the construction site and pile driving, and the anchoring and construction of the offshore piers and platforms, bridges and other coastal structures, as well as the explosions of the seabed to guarantee navigability, generate impulsive and non-impulsive noises and change the environment dynamics that affect dolphin physiology, behavior and health condition. These coastal activities are collectively expected to generate changes in the distribution and how Guiana dolphins use the habitat (Bailey et al., 2010, Salgado et al., 2012, Marcondes et al., 2020).

Additionally, sewage discharge, sediment and contaminants run-off and deforestation are other coastal stressors that might affect Guiana dolphin populations and their habitats along the entire distribution area. All these combined effects that inevitably harbor certain levels of chemical pollution generated in addition to the discharges by factors such as tin (found in the antifouling paints used on ship hulls and port structures) have been found in high concentrations in the tissues of the Guiana dolphin (Dorneles et al., 2008; 2020; Lailson et al., 2010; others cited in the "Chemical pollution" topic).

Even though many of the impacts of all those coastal activities on Guiana dolphins remain poorly investigated, changes in behavior and habitat use patterns were observed for the population in the Babitonga Bay, which is affected by a port development (Santa Catarina State - BRS/SE; Cremer, 2011; Cremer *et al.*, 2009). Furthermore, in Ceará (BRNE1), during dredging activities in Mucuripe Harbour, Meirelles (2013) observed an alteration in space use by Guiana dolphins. Before dredging, the harbour was considered a core area for the population; and during dredging, dolphins were rarely observed in that area. The building of a suspension bridge at the mouth of the Cachoeira River, in Bahia state (BRNE4) reduced by half the number of dolphins in the estuary during the construction (Le Pendu, pers. comm.). Moreover, ports and other coastal and maritime development infrastructures could be responsible for synergetic and additive impacts. The cumulative effects of stress can lead to immunodepression, leaving the Guiana dolphin populations susceptible to diseases and other threats (Flach et al. 2019; Groch *et al.*, 2018, 2020; Van Bressem *et al.*, 2009, 2015; Domiciano et al., 2016; Pivari et al., 2020).

In Colombia (CCOL), an ongoing study mapping the distribution of Guiana dolphins and port infrastructure shows an overlap for at least four of the five regions along the Colombian Caribbean where these dolphins appear to have resident populations. The overlap implies a threat and specifically in the Golfo de Urabá, on the border with Panama where the existence of one Guiana dolphin population has been confirmed, the construction of three ports is planned. Environmental authorities do not yet require any protection measures for this species in two of the licenses granted.

In the Gulf of Venezuela (VEML), Espinoza-Rodríguez et al. (2019) found that the area where the majority of Guiana dolphin sightings occurred overlapped with the shipping channel used to transport multiple products, including tankers and other vessels. Observations made over the years in this area show that the presence and abundance of Guiana dolphins in this area are probably related to the frequency and intensity of dredging. More research is needed to improve our understanding of this potential threat in that area (Barrios-Garrido et al., 2015, 2021).

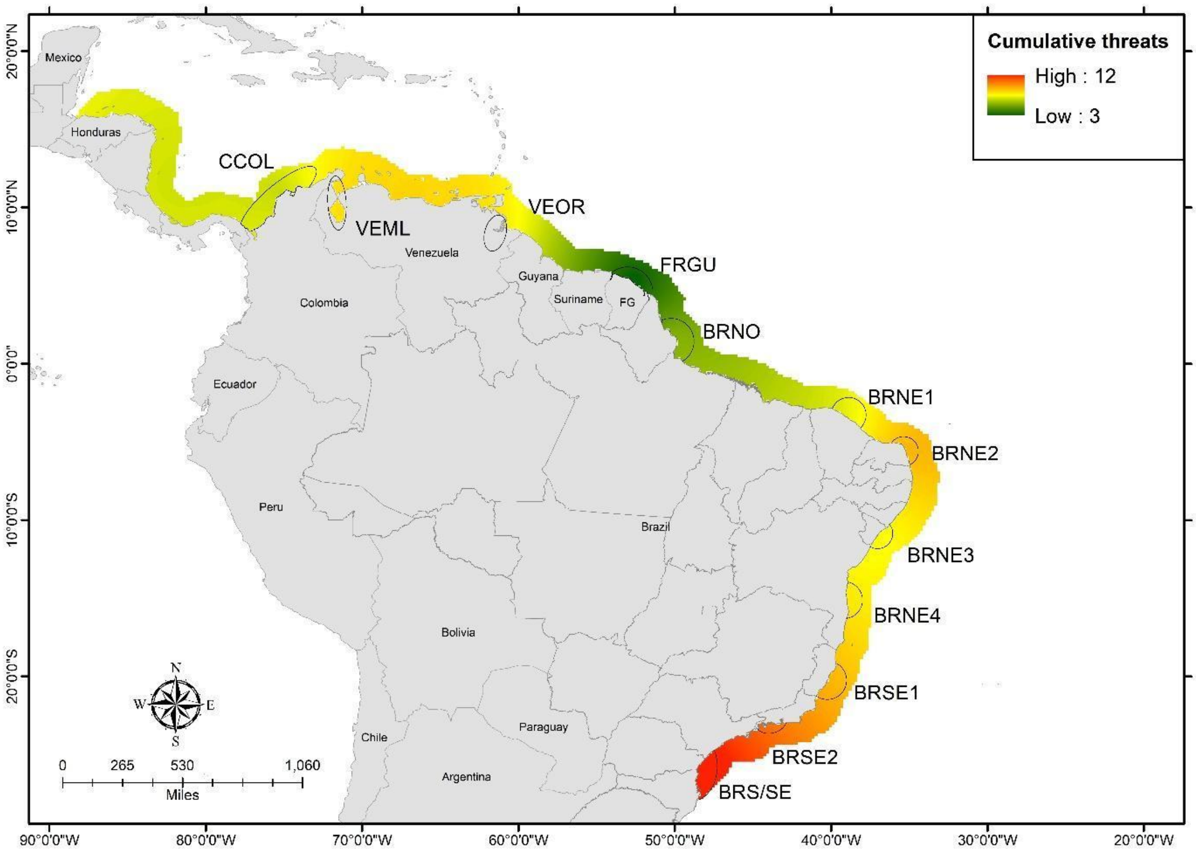

Fig. 6. Map of cumulative threats on marine environment, based on the layers provided by Halpern et al. (2013), and the potentially impacting Guiana dolphins identified by each management unit during the Workshop in 2019.

CLIMATE CHANGE

Global climate change is one of the most important challenges of the 21st century (Bellard et al. 2012). Coastal and oceanic areas will face multiple modifications, including the rising of sea level, increased sea surface temperatures, ocean stratification, acidification, deoxygenation, sea-ice retreat, and altered patterns of ocean circulation, salinity and precipitation (IPCC, 2019). Changes in productivity are also expected, and tropical fisheries are projected to decline 40% in 30 years (RCP 8.5 2050), increasing the social-economic vulnerability of developing countries located in tropical regions and affecting environmental conservation issues (Lam et al. 2020).

Global theoretical predictions indicate climate change will likely result in changes in abundance and a general poleward distribution shift for marine mammals (MacLeod, 2009). Empirical studies investigating the effects of climate change in cetaceans are still scarce and mainly directed to polar species, such as Bowhead whales, *Balaena mysticetus*, narwhals, *Monodon monocerus* and Harbour porpoises, *Phocoena phocoena* (Evans et al. 2010, Heide-Jorgensen et al. 2011, Heide-Jorgensen et al. 2012). Becker et al. (2018), comparing the distribution of several species of dolphins and whales under anomalous warming sea surface temperatures recently experienced along the California coast, indicated that many species will suffer distribution shifts and decrease in densities. Derville et al. (2019) suggest that some Humpback whale (*Megaptera novaeangliae*) breeding habitats in Oceania may be unsuitable with warming waters.

Despite the recent increase in interest in evaluating potential effects of climate change on cetaceans, to date, no study has investigated the effects of climate change in the Guiana dolphin distribution, which commonly inhabits bays and estuaries surrounded by human activities, and straightly depends on mangroves environments which are quite susceptive to climate changes effects. Potential effects on Guiana dolphins populations may include the extinction of some local-small populations and movements towards southern Brazil. This region is mainly inhabited by the bottlenose dolphin, *Tursiops truncatus*, and Franciscana dolphin, *Pontoporia blainvillei*, increasing overlaps and inter-specific competition. Despite a recent study modelled the ecological niche of Guiana dolphin along its distribution (Lobo et al. 2021), predicting the effect of climate change still is ongoing (Rodrigo Tardin, pers. comm.).

MANAGEMENT AND CONSERVATION ISSUES

To achieve the objectives of species conservation, monitoring populations is a central activity, which is generally expensive and depends on baseline knowledge of the species or species involved (Danielsen et al., 2019; Marsh & Trenham, 2008). In general, management and conservation actions are a way to minimize, mitigate and regulate human activities that directly or indirectly affect valued sites and/or valued species, with the goal of sustaining existence of specific species or of biodiversity in general. Examples of these actions are the establishment of regulations on boat traffic and fisheries, elaboration of action plans, creation of protected areas, evaluation of species on the red lists, among others.

In the world, there are many effective examples of management strategies and conservation actions to mitigate adverse effects on cetacean populations, but the initial planning, development and final effectiveness of these actions depends on how much is known about what is expected to protect (Heywood, 2006). In the case of Guiana dolphin, a species with a wide distribution, the reduced amount of biological and ecological data for most of the species range limits the establishment of management and conservation actions throughout its distribution. Furthermore, the methods applied by different research groups are not standardized and, thus, the results are often incomparable.

Currently, Guiana dolphin is classified as Near Threatened by IUCN (Secchi et al., 2018) and is listed in Appendix II of the Convention on the Conservation of Migratory Species and in the Convention on International Trade in Endangered Species (CITES). The few data available on population abundance and trends, the impact of threats, and identification of the critical areas for species conservation influence the creation and execution of conservation actions. However, even in areas where robust demographic data is available and important decline has been detected (e.g. Guanabara bay, southeastern Brazil), conservation measures to protect the species are difficult to implement. Guiana dolphins inhabit areas that are now occupied by important cities and harbors, where development is more important than biodiversity conservation. Thus, creation and implementation of public policies to protect the species, its habitats and avoid local extinction is challenging. Additionally, trends on population abundance are usually long-term studies of at least eight years to detect declines of 5% a year, for example (e.g. Cantor et al., 2012). While monitoring populations, when abundance is low and/or important impacts are detected, conservation measurements should be implemented before decline detection, reducing human mortality and critical levels of abundance.

Nicaragua: The species has been evaluated and classified as 'Data Deficient' according to the national red list, following IUCN criteria.

Honduras: No data available.

Costa Rica: No data available.

Panamá: No data available.

Colombia: There is 'The action plan for South American river dolphins 2010-2020'. In 2006, the Red Book of Threatened Mammals of Colombia was published, where Guiana dolphin was included as 'Vulnerable' (Vu) (Trujillo et al., 2006). A diagnosis of aquatic mammals in Colombia was published presenting all the knowledge about the species in each region of the country (Trujillo et al., 2013). In addition, a work on the ecology of Guiana dolphins resulted in the creation of an area with special management for the species in the gulf of Morrosquillo (Dussán-Duque, 2013). In 2015, the Management Plan for aquatic mammals in Colombia was published (Trujillo et al., 2014) and endorsed by the Ministry of Environment. In addition to the strategic lines of research, management, education and communications, specific recommendations were made for the ex situ management issue, given that Colombia is one of the countries in which specimens of Guiana dolphin have been held in aquariums for long periods. Likewise, in 2017 the Plan for the conservation and management of aquatic mammals (cetaceans, manatees and otters) of the department of Magdalena (Trujillo et al., 2017) was published, where one of the species of greatest interest is Guiana dolphin. This year, The National Action Plan for the Conservation of Aquatic Mammals of Colombia 2020 - 2030 will be published and validated by the national government. This plan will include specific conservation actions for *S. guianensis*

Venezuela: In 2017, the Guiana dolphin was considered in the action plan elaborated with the purpose of systematize and guide the management and conservation actions of aquatic mammals (Plan de acción para la conservación de los mamíferos acuáticos de Venezuela: delfines de agua dulce, nutrias y manatíes 2017-27). It is important to highlight that in 1992 the 'Cienagas de Juan Manuel, Aguas Blancas y Aguas Negras' National Park was created, which covers 150km2 of water in the south of Lake Maracaibo. Although it was not created for the specific protection of this species, it is an important area of resting and feeding for Guiana dolphins. Currently, some increased Guiana dolphin population that inhabits Lake Maracaibo, in the southern region, has been made. Studies on abundance estimate and the identification of threats were performed, but additional effort is necessary to meet the proposed goals. In addition, the species has been evaluated in the national red list of endangered species following IUCN criteria (Barrios-Garrido et al., 2015).

Guyana: The species has been classified as 'Endangered' according to the National Red List, following IUCN criteria.

Suriname: No data available.

French Guiana: The species has been evaluated and classified as 'Endangered' according to the National Red List following IUCN criteria.

Brazil: Accounting for the Protected Areas (PAs) with a considerable marine portion, there are 92 PAs along the Guiana dolphin distribution in the country. These PAs are divided into eight different protection categories considering the Brazilian System of National Protected Areas. Also, there are areas within the categories Ia, II, III, IV and V established by the IUCN Protected Areas Categories System, however, none of the category IV (Habitat/Species Management Area) have been decreed considering the species. Of those 92 areas throughout the distribution of the species in Brazil, 32 correspond to federal areas, while 50 and 11 correspond to state and municipal areas, respectively. Although there are many PAs, only a total of 40 have management plans, and less than a quarter of them mentioned Guiana dolphin in its plans. Although there are an impressive number of PAs on the species range in Brazil, only three of them were created specifically to protect the species, and all are of sustainable use (Schiavetti et al., 2020).

The species is listed as Vulnerable in the Brazilian National Red list of Threatened Species, which also used the IUCN criterion (Directive MMA 444/2014). The species has also been included in different federal government conservation tools such as: National Conservation Plan for Marine Cetaceans (Brasil, 2019), National Action Plan for the Conservation of Threatened Species and of Socioeconomic Importance of the Mangrove Ecosystem (Directive ICMBio 500/2019), Impact Reduction Plan of oil and gas exploration, Impact Reduction Plan of mining (PRIM, 2018) and also the species has been taken into account in the ordinance which aims to establish the Marine Priority Areas for Brazilian Coast (Decree MMA 5092-2004, Directive MMA 9/2007).

In some Brazilian states, there are specific tools for Guiana dolphin conservation. In Santa Catarina State, the species was classified as "Endangered - EN" in the Official List of Endangered Species of Fauna (Resolution CONSEMA 02/2011). The Conservation Plan for Marine Tetrapods of Paraná was elaborated to ensure the maintenance of Guiana dolphin populations in the state and preserve their natural habitat. Also in Paraná state, the species was included in the Paraná Book of Fauna in Extinction. In São Paulo State, the species was classified as 'Near Threatened' under the Endangered and Probably Endangered Species of Wild Fauna list of the state (Decree 63.8532/2018). In Rio de Janeiro state, the species is not listed into the Threatened Fauna Species list (Decree 15.793/1997), however more recently, the species has been mentioned as one of the top 10 priorities species for conservation in this state and a public awareness campaign has begun (Defending Endangered Species Embrace These Ten). In Sepetiba Bay, Municipality of Mangaratiba, in Rio de Janeiro state, the Law 940/2014 established the creation of the "Área de Proteção Ambiental Marinha Boto cinza (APA Marinha Boto Cinza)",. The species is listed as 'Vulnerable' in the Bahia state threatened species list. In the state of Ceará, the species is considered a natural heritage of the Fortaleza municipality (Municipal Law no. 9949, December 13, 2012; Fortaleza, 2012), where a small resident Guiana dolphin population inhabits Mucuripe embayment, an urban and harbour area strongly impacted by human activities (Meirelles, 2013).

Regulations, legislation, a list of protected areas and other important information are presented in Annex D, E and F.

Recently, the IUCN category for the species changed to Near Threatened, which implies that the existing data are not sufficient to qualify the species in one of the threat categories (Secchi et al., 2018). Despite little knowledge on important population parameters (i.e. abundance estimates, trends and mortality levels) in most of its distribution, it is recognized that this coastal species faces numerous threats along its habitat. The Guiana dolphin inhabits a diverse number of habitats, however, the knowledge about the species is not homogeneous throughout its distribution. Therefore, one of the research priorities should identify areas of higher concentrations in places where there is no information and use standardized methodologies to estimate population parameters and mortality rates in the main areas. Notwithstanding and although the species is globally considered Near Threatened, some countries consider it in another category (e.g. Brazil, Colombia, Venezuela – Vulnerable, Guyana- Endangered), bear out the importance of regional assessments.

Although the existence of a large system of Marine Protected Areas along the species distribution (e.g. Brazil), it has been shown that these areas design are not necessarily protecting the most vulnerable Guiana dolphin populations (e.g. ESEC Tamoios in Brazil; Tardin et al., 2020). Thus, new studies should focus on understanding human activities and its interaction with the species, to allocate more efficient Protected Areas along the range of the species. Moreover, and to support the previous, it should be highlighted that although some regions have many protected areas (e.g. Rio de Janeiro state n = 19), there is a lack of PAs, as well as management actions, in areas with extremely high human pressure. This certainly can, in a short time, result in population extinction (Azevedo et al., 2017). In order to expand the state of knowledge and vulnerability of the species in its entire region of distribution, it is also recommended the evaluation of Marine Protected Areas effectiveness and connectivity in protecting Guiana dolphin distribution, the evaluation of current action plans in each country and finally evaluate the species according to the criteria of the IUCN Red List in countries that do not yet have it.

6. CONCLUSION

The authors of this progress report stress that the bycatch in gillnets is one of the most critical concerns for the conservation of Guiana dolphin populations. However, there is critical information on the harmful effects of a combination of threats, including a direct catch for human consumption, noise pollution, high levels of contaminant loads and emerging diseases affecting diverse populations throughout its range.

This context, in combination with the striking lack of data on population and biological parameters for most areas of the species' distribution range, highlights the importance to assess the combined effects of the dense human-population on coastal areas, such as fisheries, ports, agriculture and industrial activities, and emergent diseases that are rapidly driving Guiana dolphins to many uncertainties regarding its future.

There is an urgent need for both conservation action and scientific knowledge for this species. Therefore, the authors propose advancing the works of the Intersessional Scientific Group to build together a conservation and management plan, concatenating science and governance to support decision-making and effective mitigation action in the future.

7. GENERAL INFORMATION

The Assessment Intersessional Steering Group was composed by Camila Domit (CEM/UFPR, Brazil), Fábia Luna (ICMBio/CMA, Brazil), Adriana Vieira de Miranda (ICMBio/CMA, Brazil), Juan Pablo Torres-Flores (ICMBio/CMA, Brazil), and also Alexandre Zerbini (NOAA, USA), Lindsay Porter and Fernando Trujillo (IWC-Small cetacean sub-committee).

Point of contact (POCs) by priorities topics:

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Annex A

Table Presenting the Preliminary Version of the Action Plan

Action plan for Guiana dolphin conservation – Short-term priorities

Topic	MU/Region/Country	Recommendation	Action Plans Y/N (countries)	Term			Actors (Scientists and institutions)	Needs (logistic, financial support, governability)	National government engagement (Y/N)	How can the Small cetaceans Subcommittee help to achieve this action?
				Short (3 years)	Medium (3- 5 years)	Long (> 5)				
Population Structure	All	Analyze data using a genomics approach (e.g. RAD-seq) – joint research initiative being conducted by Cunha and Caballero.	Y (BR)				National government, scientists, and funding agencies	Financial support, samples for Caribbean and northern areas of the South Atlantic	Y (samples transports, transboundary study)	Providing grants or letters supporting scientists to apply for external grants. Highlighting the urgency of this action for governments.
	VEML	Collect DNA samples from Sucre State (Venezuela), where there seems to be a resident population.					Scientist, funding agencies	Financial support for fieldwork and sample collection	-	Providing letters supporting scientists to apply for external grants; highlighting the urgency of this action for governments
		Collect DNA samples from Panama, Costa Rica, Nicaragua and Trinidad and Tobago					Scientist, funding agencies	Financial support for fieldwork and samples collection	-	Providing letters supporting scientists to apply for external grants; highlighting the urgency of this action for governments
	All	Collect DNA samples from places where such data is lacking and where population abundance data and/or biology parameters already exist					Scientist, funding agencies	Financial support for fieldwork and samples collection	-	Providing letters supporting scientists to apply for external grants; highlighting the urgency of this action for governments.

Topic	MU/Region/Country	Recommendation	Action Plans Y/N (countries)	Term			Actors (Scientists and institutions)	Needs (logistic, financial support, governability)	National government engagement (Y/N)	How can the Small cetaceans Subcommittee help to achieve this action?
				Short (3 years)	Medium (3- 5 years)	Long (> 5)				
Population abundance and trends	All	Conduct abundance/density estimates in spatial scales representing each Management Unit and extended along coastal areas, where opportunistic sightings and strandings of Guiana dolphins are common. Aerial surveys seem to be adequate for this purpose.	Y (BR, COL)	BRS/SE, BRSE1, BRSE2, VEML	all	all	National government, scientists, and funding agencies	Logistic and financial support	Y	Providing letters supporting scientists to apply for external grants; highlighting the urgency of this action for governments.
	BRSE/S; BRSE2	To assess temporal trends in abundance and/or density estimates should be a high priority in sites where long-term monitoring has been carried out (southern and southeastern Brazil), following recommendations from SC68B in 2020.	Y (BR, COL)	all	all		Scientists and funding agencies	Logistic and financial support	N	Providing letters supporting scientists to apply for external grants; highlighting the urgency of this action for governments.
	All (workshop series with Abundance Steering group)	Facilitate teamwork to improve a protocol for abundance and density estimation, including complementary techniques (e.g. passive acoustic monitoring, Unmanned Aircraft Systems), aiming to obtain continuous data that allows for the assessment of trends over time. (following ASG recommendations).		all			Scientist, funding agencies	Logistic and financial support	Y	Promote meetings of specialists to develop regional protocols

Topic	MU/Region/Country	Recommendation	Action Plans Y/N (countries)	Term			Actors (Scientists and institutions)	Needs (logistic, financial support, governability)	National government engagement (Y/N)	How can the Small cetaceans Subcommittee help to achieve this action?
				Short (3 years)	Medium (3- 5 years)	Long (> 5)				
		Foster international cooperation to evaluate analytical methods and correction factors used to estimate abundance in previous studies and develop a guideline for future analyses. Facilitate the organization of an integrated workshop with leading researchers to train and/or update students and researchers on best current practices (methodological approaches for data collection and analyses) to generate population estimates of Guiana dolphins throughout its distribution range.	Y (BR)	all			National government, scientists, and funding agencies	Logistic and financial support	Y	Support meetings of Small Cetacean-ASG experts and other researchers
		Evaluate the abundance estimates of Guiana dolphins already conducted, considering existing limitations in applying them to drive management actions.					National government, scientists, and funding agencies	Financial support	Y	Recommend analyzes' validation and promote data collection from different geographical sites
Biological parameters	BRNE1-4; BRNO, other countries	Determine aspects of reproduction and growth where biological parameters are mostly needed, particularly in the populations of Central America and northern and northeastern Brazil (BRNO, BRNE1-4).	Y (BR)	BRNE 1-4; BRSE1	BRNE, BRNO, BRSE2, BRS/SE	CCOL	Scientist	Logistic and financial support	-	Support and publicize local and national stranding networks
	All	Prioritize studies about biological parameters such as age and length at sexual maturity, annual pregnancy rate and calving interval, in all Mus.		BRNE 1-4; BRSE1	VELM; CCOL	all	Scientist	Logistic and financial support	-	Support and publicize local and national stranding networks
	All	Estimate survival probabilities and Potential Biological Removal for each population in Brazilian bays and estuaries, where Guiana dolphins are resident and that are highly impacted by multiple anthropogenic activities.	Y (BR)	BRS/SE, BRSE1, BRSE2, VEML	CCOL	all	Scientist	Logistic and financial support	-	Providing support letters for proposals seeking external grants. Highlighting the Guiana Dolphin vulnerability and which activities potentially impact their conservation.
Threats – Chemical pollution	All	Increase the geographic extent of ecotoxicological investigations, increasing the effort on determination of PCBs and other toxic persistent organic	Y (BR)	BRS/SE; BRSE1; BRSE2	VELM; BRNE 1-4; BRNO, CCOL	all	Scientist, funding agencies	Logistic and financial support	Y	Providing letters supporting scientists to apply for external grants; highlighting the urgency of this action for governments.

Topic	MU/Region/Country	Recommendation	Action Plans Y/N (countries)	Term			Actors (Scientists and institutions)	Needs (logistic, financial support, governability)	National government engagement (Y/N)	How can the Small cetaceans Subcommittee help to achieve this action?
				Short (3 years)	Medium (3- 5 years)	Long (> 5)				
		compounds, especially in coastal bays.								
	All	Conduct predictive models studies to assess temporal-trends of organohalogen compounds exposure and to determine population viability, particularly in coastal bays of South and Southeast Brazil.	Y (BR)		BRS/SE; BRSE1; BRSE2	all	Scientist, funding agencies	Logistic and financial support	-	Providing letters supporting scientists to apply for external grants; highlighting the urgency of this action for governments.
	All	Conduct studies on trophic transfer of pollutants in ecosystems used by Guiana dolphins, especially in critical areas in coastal bays from South and Southeast Brazil (VELM), but also in other areas exposed to a high-level of contaminants.	Y (BR)	BRS/SE; BRSE1; BRSE2	VELM; BRNE 1-4; BRNO, CCOL	all	Scientist, funding agencies	Logistic and financial support		Providing letters supporting scientists to apply for external grants; highlighting the urgency of this action for governments.
	All	Strengthen studies with contaminant-specific biomarker assays of exposure and effects	Y (BR)	BRS/SE; BRSE1; BRSE2		All	Scientist, funding agencies	Logistic and financial support		Providing letters supporting scientists to apply for external grants; highlighting the urgency of this action for governments.
	All	Perform pollutant level monitoring of most threatened populations through remote biopsy sampling of skin and blubber.	Y (BR)	all	all		National government, scientists, and funding agencies	Logistic and financial support		Providing letters supporting scientists to apply for external grants; highlighting the urgency of this action for governments.
	All	Perform a regional diagnosis on the threat of marine debris to SG.		all			Scientists and funding agencies	-	Y	Encourage a meeting/workshop including the experts of the Environmental concerns Subcommittee/IWC, national governments and other researchers.

Topic	MU/Region/Country	Recommendation	Action Plans Y/N (countries)	Term			Actors (Scientists and institutions)	Needs (logistic, financial support, governability)	National government engagement (Y/N)	How can the Small cetaceans Subcommittee help to achieve this action?
				Short (3 years)	Medium (3- 5 years)	Long (> 5)				
	All	Implement protocols and initiatives of health assessment for Guiana dolphins, including (1) PCBs and others organic persistent compounds, metals and emerging compounds, (2) exposure biomarkers, and (3) the presence of diseases through extensive pathological assessments (histological, bacteriological, fungal and/or virologic).	Y (BR)	BR	all		National government, scientists, and funding agencies	Logistic, financial support and government engagement	Y	Encourage a meeting/workshop including experts of the Environmental concerns Subcommittee/IWC, national governments and other researchers, highlighting the urgency of this action for governments.
Human-induced mortality (SC)	All	Implement a bycatch rapid risk assessment (e.g FAO 2021; BMI/IWC).		BRS/SE, BRSE1, BRSE2, BRNO; VELM	CCOL and other areas	all	National government, scientists, local stakeholders, and funding agencies	Logistic, financial support, and government and social engagement	Y	Encourage a meeting/workshop including experts of the Bycatch Mitigation Initiative/IWC, national governments and other researchers; highlighting the urgency of this action for governments.
	BRS/SE; BRSE2, BRSE1	Prioritize protection actions for Guiana dolphins in fisheries management plans, especially for gillnet; and assess the effectiveness of gillnet legislation INI-N°12/2012 in South and Southeastern Brazil.		all					Y	Encourage a meeting/workshop including experts of the Bycatch Mitigation Initiative/IWC, national governments and other researchers; highlighting the urgency of this action for governments.
	All	Improve (Brazil)/develop (the others) stranding networks and sampling programs.	Y (BR, COLM)	all	all		National government, scientists, local stakeholders, and funding agencies	Logistic, financial support, and government and social engagement	Y	Encourage a meeting/workshop including experts of the Bycatch Mitigation Initiative/IWC, national governments and other researchers; highlighting the urgency of this action for governments.
	All	Identify specific fisheries where achievable bycatch mitigation strategies could be tested and introduced.			all		National government, scientists, local stakeholders, and funding agencies	Logistic, financial support, and government and social engagement	Y	Encourage a meeting/workshop including experts of the Bycatch Mitigation Initiative/IWC, national governments and other researchers; highlighting the urgency of this action for governments

Topic	MU/Region/Country	Recommendation	Action Plans Y/N (countries)	Term			Actors (Scientists and institutions)	Needs (logistic, financial support, governability)	National government engagement (Y/N)	How can the Small cetaceans Subcommittee help to achieve this action?
				Short (3 years)	Medium (3- 5 years)	Long (> 5)				
	All	Build capacity and methods to design alternative approaches to achieve effective bycatch mitigation and monitoring solutions, in partnership with fishing communities.			all		National government, scientists, local stakeholders, and funding agencies	Logistic, financial support, and government and social engagement	Y	Encourage a meeting/workshop including experts of the Bycatch Mitigation Initiative/IWC, national governments and other researchers; highlighting the urgency of this action for governments.
	All	Perform experiments to evaluate the effectiveness of methods already known for reducing bycatch.			all	all	National government, scientists, local stakeholders, and funding agencies	Logistic, financial support, and government and social engagement	Y	Encourage a meeting/workshop including experts of the Bycatch Mitigation Initiative/IWC, national governments and other researchers; highlighting the urgency of this action for governments.
Noise pollution and collision	All	Evaluate short and long-term cumulative effects of dolphin watching and other nautical activities in different aspects of the Guiana dolphin biology (e.g., surface behavior, acoustics, habitat use, site fidelity, etc.).	N	BRS/SE, BRSE2	all	all	Scientists and funding agencies	Financial support to monitoring	N	Encourage a meeting including experts of the Whale Watching Subcommittee/IWC, national governments and other researchers.
	All	Measure the support capacity of tourist activities.	N		all	all	National government, scientists, coastal communities, and funding agencies	Logistic, financial support and government engagement	Y	Encourage a meeting including experts of the Whale Watching Subcommittee/IWC, national governments and other researchers
	All	Monitor and characterize Guiana dolphins' acoustic environment before, during and after the licensing of coastal activities.	N		all	all	National government, scientists, coastal communities, and funding agencies	Logistic and financial support	Y	Encourage a meeting/workshop including experts of the Environmental concerns Sub Committee/IWC, national governments and other researchers
	All	Elaborate an acoustic impact assessment guide for the licensing of coastal activities that potentially cause acoustic disturbances.	Y(BR)	BR		all	National government, scientists, coastal communities, and funding agencies	Logistic, financial support and government engagement	Y	Encourage a meeting/workshop including experts of the Environmental concerns Subcommittee/IWC, national governments and other researchers; highlighting the urgency of this action for governments

Topic	MU/Region/Country	Recommendation	Action Plans Y/N (countries)	Term			Actors (Scientists and institutions)	Needs (logistic, financial support, governability)	National government engagement (Y/N)	How can the Small cetaceans Subcommittee help to achieve this action?
				Short (3 years)	Medium (3- 5 years)	Long (> 5)				
Coastal development	All	Assess the effect of cumulative and synergistic impacts of anthropogenic activities on Guiana dolphins in coastal bays, especially in South and Southeast Brazil, and Maracaibo Lake in Venezuela, since these are critical areas under habitat degradation.	Y (BR)	BRS/SE, BRSE1, BRSE2, VEML, BRNE1-4	CCOL and other areas	all	National government, scientists, local stakeholders, and funding agencies	Logistic, financial support, and government and social engagement	Y	Promote meetings among experts to develop analytical protocols and highlight the urgency of this action for governments.
Climate change	All	Evaluate the potential effects of climate change in the distribution of Guiana dolphin under different scenarios		all	all		National governments, scientists, other stakeholders, and funding agencies			Providing letters supporting scientists to apply for external grants; highlighting the urgency of this action for governments.
Health concerns/diseases	All	Monitor nutritional condition and prevalence of skin lesions through photo-identification of Guiana dolphins as a proxy of health status.		all			Scientists, universities, and funding agencies	Financial support to monitoring	Y	Providing letters supporting scientists to apply for external grants; highlighting the urgency of this action for governments.
	All	Implement systematic pathological investigations and disease surveys in Guiana dolphin populations lacking baseline knowledge.	Y (BR)	all			Scientists, universities, and funding agencies	Financial support to monitoring, establishment of diagnosis, improvement and maintenance of public databases containing the results. Financial support for continuous education of pathologists	Y	Encourage a meeting/workshop including experts of the Environmental concerns Subcommittee/IWC, national governments and other researchers; highlighting the urgency of this action for governments

Topic	MU/Region/Country	Recommendation	Action Plans Y/N (countries)	Term			Actors (Scientists and institutions)	Needs (logistic, financial support, governability)	National government engagement (Y/N)	How can the Small cetaceans Subcommittee help to achieve this action?
				Short (3 years)	Medium (3- 5 years)	Long (> 5)				
	All	Continue ongoing studies, especially focusing on the diseases concerned by the subcommittee of Environmental Concerns as priorities forthcoming meetings.	Y (BR)	all			Scientists, universities, and funding agencies	Financial support to monitoring, establishment of diagnosis, improvement and maintenance of public databases containing the results.	Y	Encourage a meeting/workshop including experts of the Environmental concerns Subcommittee/IWC, national governments and other researchers; highlighting the urgency of this action for governments.
Management and conservation	All	Identify conservation priority areas (The Nature Conservancy method).	Y (BR)	all			National government, scientists, coastal communities, and funding agencies	Financial support and government engagement		Providing letters supporting applications for external grants; highlighting the urgency of this action for governments.
	Honduras, Nicaragua, Costa Rica, Panama and Suriname	Regional Extinction risk assessment.					National governments, scientists, coastal communities and other stakeholders, and funding agencies	Financial support and government engagement		Providing letters supporting applications for external grants; highlighting the urgency of this action for governments.
	Honduras, Nicaragua, Costa Rica, Panama and Suriname	Elaboration of Conservation Action Plan.					National governments, scientists, local communities and other stakeholders, and funding agencies	Financial support and government engagement		Providing letters supporting applications for external grants; highlighting the urgency of this action for governments.
	CCOL	Evaluate the effectiveness of Gulf of Morrosquillo Protected Area to the species conservation.					Local government, scientists, coastal communities, and funding agencies	Financial support to monitoring, establishment of diagnosis, improvement and maintaining of public databases containing the results.	Y	Providing letters of recommendation highlighting the need of financial support.

Topic	MU/Region/Country	Recommendation	Action Plans Y/N (countries)	Term			Actors (Scientists and institutions)	Needs (logistic, financial support, governability)	National government engagement (Y/N)	How can the Small cetaceans Subcommittee help to achieve this action?
				Short (3 years)	Medium (3- 5 years)	Long (> 5)				
	All	Evaluate current Action Plans.		all			National governments, scientists, local communities and other stakeholders, and funding agencies	Financial support and government engagement	Y	Highlighting the urgency of this action for governments.
	BRSE2	Propose the creation of a specific Protected Area in Guanabara Bay.	Y (BR)				National governments, scientists, coastal communities, and other stakeholders	Financial support, social and government engagement	Y	Highlighting the urgency of this action for governments.
	All	Guarantee that where known resident Guiana dolphin populations are overlapping with port construction and activities continuous monitoring of the species must be carried out using methodologies validated by experts in the field.	Y (BR)	all			National government and scientists	Financial support to organizing a workshop and government engagement	Y	Highlighting the urgency of this action for governments.
	All	Strengthen international scientific and government cooperation and outreach campaigns, supporting public awareness and ocean literacy.		all			National government, scientists, local stakeholders, and funding agencies	Financial support social and government engagement	Y	Providing letters supporting applications for external grants; highlighting the urgency of this action for governments
	All	Strengtheneth importance to include Guiana dolphin as a sentinel species for ocean health and resilient assessment (e.g. Ocean Decade and other global initiatives).		all			National government, scientists, local stakeholders, and funding agencies	Financial support, social and government engagement	Y	Highlighting the urgency of this action for governments.
	All	Identify priority areas to Guiana dolphin establishing new and evaluate existing MPAs and OECMs, supporting conservation planning.	Y (BR)		all		National government, scientists, and local stakeholders	Government engagement	Y	Highlighting the urgency of this action for governments.
	All	Establish bycatch assessment programs as part of all fisheries activities and monitoring programs.	Y (BR)	Brazil	all		National government, scientists, local stakeholders, and funding agencies	Government engagement	Y	Stress the urgency of this action for governments.

Annex B

Table Presenting the Anthropogenic Activities Potentially Impacting Guiana Dolphins Identified for Each Management Unit During the Workshop, in 2019

Threat	BRS/SE	BRSE2	BRSE1	BRNE4	BRNE3	BRNE2	BRNE1	BRNO	FRGU	VEOR	VEML	CCOL
Port activities	1	1	1	1	1	1	0	1	1	1	1	1
Industrial activities	1	1	1	1	1	0	0	0	NA	1	1	0
Oil and gas exploration/exploitation	1	1	1	0	1	1	1	1	NA	1	1	1
Mining	1 (Dragagem de areia para exploração)	0	0	0	NA	0	0	1	NA	1	1	1
Agriculture	1	1	1	0	0	0	0	0	NA	0	1	1
Aquaculture	1	0	0	0	0	1	1	NA	NA	0	1	0
Trawling	1	1	1	1	1	1	1	NA	NA	0	0	1
Gillnets	1	1	1	1	1	1	1	1	NA	1	1	1
Longlines	0	0	0	0	0	0	0	0	NA	0	0	0
Direct captures	0	0	0	1	0	1	0	1 (fish bait)	NA	1	1	0
Tourism	1	0	0	0	0	1	0	0	NA	0	1	0
Water sports	1	1	1	1	NA	1	1	NA	NA	0	0	0
Purse seines	1	1	NA	0	0	0	0	0	NA	0	0	0
Oil spills	1	1	1	1	1	1	1	1	NA	1	1	NA
Multi-activities	10	8	7	6	5	8	5	4	1	6	7	5
Recognised habitat loss	1	1	1	1	1	1	1	NA	NA	1	1	1

Annex C

List of institutions conducting studies on bioacoustics, noise pollution and collisions on Guiana dolphin populations

List of institutions conducting studies on bioacoustics, noise pollution and collisions on Guiana dolphin populations.

Country	Institution	Lab head	Point-of-contact	Scientific lines
Brazil	**Centro de Ciências Agrárias, Ambientais e Biológicas - UFRB**	Marcos Rossi-Santos	marcos.rossi@ufrb.edu.br	Bioacoustics and Noise Polution
Colombia	**Fundación Omacha**	Fernando Trujillo	fernando@omacha.org	Noise Polution
Venezuela	Laboratory of **General Ecology (LUZ)**	Hector Barrios-Garrido	hbarriosg@gmail.com	Bioacoustics
Brazil	**Instituto de Pesquisas Cananéia**	Caio Noritake Louzada	caio.noritake@gmail.com	Bioacoustics
Brazil	**Laboratório de Bioacústica**	Renata Souza Lima	souzalima.renata@gmail.com	Bioacoustics and Noise Polution
Brazil	**Laboratório de Bioacústica e Ecologia de Cetáceos**	Rodrigo Tardin	rhtardin@gmail.com	Bioacoustics, Noise Polution and Colision
Brazil	**Laboratório de Ecologia Comportamental e Bioacústica**	Artur Andriolo	artur.andriolo@ufjf.edu.br	Bioacoustics
Brazil	**Laboratório de Ecologia e Conservação**	Camila Domit	cadimit@gmail.com	Noise Polution and Colision
Brazil	**Laboratório de Ecologia e Conservação de Tetrápodes Marinhos e Costeiros**	Marta Cremer	mjc2209@yahoo.com.br	Bioacoustics, Noise Polution and Colision
Brazil	**Laboratório de Mamíferos Aquáticos e Bioindicadores**	Alexandre Azevedo	alexandre.maqua@gmail.com	Bioacoustics, Noise Polution and Colision
USA	**University of Vermont - Department of Biology**	Laura May-Collado	lmaycollado@gmail.com	Bioacoustics, Noise Polution and Colision

Annex D

Management and Conservation Actions by Country

Country	Specific management or conservation action (protected area, action plan, status evaluation, among others)	Law	Regional status (Red List)
Nicaragua	1	Yes	Deficient data
Honduras	0	Yes	Not evaluated
Costa Rica	0	Yes	Not evaluated
Panama	0	Yes	Not evaluated
Colombia	5	Yes	Vulnerable
Venezuela	3	Yes	Vulnerable
Guyana	1	Yes	Endangered
Suriname	1	Yes	Not evaluated
French Guiana	1	Yes	Endangered
Brazil	27	Yes	Vulnerable

Annex E

Existing Laws by Country Granting some Protection to Guiana Dolphin Populations

Country	Legislation
Honduras	Gazzette No. 34,000 Decree No 115-2015. 2016. Animal Protection and Welfare Law.
Nicaragua	Presidential Decree (1991) - Create Cayos Miskito Reserve
Costa Rica	Reglamento para la Operación de Actividades Relacionadas con Cetáceos en Costa Rica Nº 32495 its breach is punishable by Ley Orgánica del Ambiente Nº 7554, la Ley de Conservación de Vida Silvestre Nº 7317 y La Ley de Pesca y Acuacultura Nº 8436.
Panama	Gazette No. 28389-B Resolution 0530-2017. Whale watching in the jurisdictional waters of the Republic of Panama.
Colombia	Law (2005) from the Ministry of Environment and Territorial Development of Colombia.
Venezuela	Presidential Decree No. 1485 (1996). Species protected from hunting Presidential Decree No. 1486 (1996). On endangered species Ley Orgánica del Ambiente, (G.O No. 5.453 del 24/03/2000) Ley de Protección de la Fauna Silvestre y su Reglamento G.O No. 29.289/ del 11/08/1970; G.O No. 4.925 (E), del 29/06/1995. Ley de Gestión de la Diversidad Biológica (G.O No. 39.070, del 1/ 12/ 2008). Ley Penal del Ambiente, (G.O No. 39.913, del 2/05/2012)
Guyana	Environmental Protection Agency (EPA) Act, 1996 [general protection of wildlife]
Suriname	Nature Protection Act 1954 and the Game Act 1954.
French Guiana	Law Arrêté du 1er juillet 2011 fixant la liste des mammifères marins protégés sur le territoire national et les modalités de leur protection
Brazil	Nº 5197 (03 Jan. 1967). Protection of Fauna. Modifications: Nº 7653 (17 Feb. 1988) and Nº 9111 (10 Oct. 1995) Nº 6938 (31 Aug. 1981). National Environmental Policy, its objectives and implementation mechanisms. Nº 7643 (18 Dec. 1987). Prohibition of hunting or any form of intentional harassment of cetaceans in national jurisdiction waters. Nº 9605 (12 Feb. 1998). Penal and administrative sanctions from detrimental behavior and activities to the environment (a.k.a. Environmental Crimes Law). Nº 9985 (18 Jul. 2000) – National System of Protected Areas Federal Decrees Nº 88218 (06 Apr. 1983). Create the Abrolhos National Marine Park Nº 528 (20 May 1992). Create and define the limits of the Anhatomirim Environmental Protection Area, specially created to protect the local population of *Sotalia fluviatilis*. Nº 3179 (21 Oct. 1999). Regulations pertaining to the Environmental Crimes Law. Regulations

IBAMA (Instituto Brasileiro de Meio Ambiente e Recursos Naturais Renováveis). Nº 117 (26 Dec. 1996. Regulations to prevent harassment in national jurisdictional waters.

IBAMA Nº 05-N (20 Jan. 1998. Establish regulations to safeguard the reproduction, resting, and calving of *Sotalia fluviatilis* in the Anhatomirim Environmental Protection Area, Santa Catarina.

IBAMA Nº 98 (14 Apr. 2000). Regulations for the maintenance and management of aquatic mammals in captivity with the objectives of rehabilitation, research, education and public display.

Licenciamento Ambiental de atividades potencialmente poluidoras. Lei de molestamento de cetáceos de 1987.

Annex F

Table Compiling the Information on Management and Conservation Actions of Guiana Dolphin by Country

Country	Protected area (national park, reserve, refuge)	Action Plan	National Red List*	Other
Nicaragua	No	No	Yes	
Honduras	No	No	No	
Costa Rica	No	No	No	
Panama	No	No	No	
Colombia	Protected area: Gulf of Morrosquillo	The action plan for South American river dolphins 2010-20; Management Plan for aquatic mammals in Colombia; Plan for the conservation and management of aquatic mammals (Cetaceans, manatees and otters) of the department of Magdalena	Yes	
Venezuela	National Park: Ciénagas de Juan Manuel, Aguas Blancas y Aguas Negras, south of Lake Maracaibo	Plan de acción para la conservación de los mamíferos acuáticos de Venezuela: delfines de agua dulce, nutrias y manatíes 2017-27	Yes	
Guyana	No	No	Yes	
Suriname	No	No	No	Previously the Marine Mammals Conservation Corridor for Northern South America proposal; since 2015 no more activities undertaken
French Guiana	No	No	Yes	
Brazil	Área de Protección Ambiental de Anhatomirim (APAA), Baia Norte de la Isla de Santa Catarina Plano de manejo da UC e seu zoneamento inclu-indo zona de proteção do golfinho *Sotalia guian-ensis*, Florianopolis on the coast of Santa Catarina Decree nº 6698 17, December de 2008. Sanctuary Zoning with regulation of use in the Cananéia estuarine-lagoon complex Santuário as águas jurisdicionais marinhas brasileiras de baleias e golfinhos, Decreto nº 6698 17 de Dezembro de 2008 APA Baía de Todos os Santos, 1999, Bahia State/ Northeast Brazil Parque Nacional Marinho de Abrolhos, Abrolhos Bank. 1986 APA Ponta da Baleia, Bahia State. 1993 Reserva Faunística Costeira de Tibau do Sul, Rio Grande do Norte State/ Northeast Brazil. 2006 Área de Proteção Ambiental (APA) Dunas do Rosado, Rio Grande do Norte State/ Northeast Brazil. 2018 Apa Marinha Boto-Cinza, Baia de Sepetiba/ Mangaratiba (RJ).2015 ESEC Tamoios, Baía de Ilha Grande/Paraty e Angra dos Reis (RJ). 1990 Parque Estadual da Ilha Grande, Insular Baía de Ilha Grande (RJ). 1971 APA Cairuçu, Baía de Ilha Grande e Paraty (RJ). APA de Setiba, Guarapari, Vila Velha (ES). 1994 Parque Estadual Ilha do Cardoso, Cananéia (SP). 1962 Parque Estadual Xixová-Japuí, São Vicente, Praia Grande/Litoral Central (SP).1993	Action Plan for Aquatic Mammals of Brazil (IBAMA 1997, 2001, 2011, 2019) Plano de Conservação para Tetrápodes Marinhos no Paraná Plano de manejo da UC e seu zoneamento incluindo zona de proteção do golfinho *Sotalia guianensis*, Florianopolis on the coast of Santa Catarina	Yes	Lista Oficial de Espécies da Fauna Ameaçada de Extinção do Estado de Santa Catarina, 2011 Livro da Fauna do Paraná em Extinção, 2007

Parque Estadual Marinho da Laje de Santos, Santos (SP). 1993	
Apa Marinha do Litoral Centro, Bertioga, Guarujá, Santos, São Vicente, Praia Grande, Mongaguá, Itanhaém, Peruíbe (SP). 2008	
Apa Marinha Litoral Norte. 2008	
APA Marinha Litoral Sul, Cananéia (SP). 2008	

*following the IUCN criteria.