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RESEARCH NOTE

Feeding habits of the Guiana dolphin *Sotalia guianensis* in the southwestern Gulf of Venezuela

Hábitos alimentarios del delfín costero *Sotalia guianensis* en el suroccidente del Golfo de Venezuela

Iván Vílchez[1,5*], Sonsirée Ramírez-Carroz[2,5], Manuel González-Fernández[3†] and Sergio Cobarrubia-Russo[4]

[1]Facultad Experimental de Ciencias, Universidad del Zulia, Maracaibo, Zulia, Venezuela
[2]Sociedad Conservacionista AQUA, Maracaibo, Zulia, Venezuela
[3]Museo de la Estación Biológica Rancho Grande, Ministerio del Poder Popular para el Ecosocialismo y Aguas. Maracay, Aragua, Venezuela. †Deceased
[4]Instituto Venezolano de Investigaciones Científicas (IVIC), Altos de Pipe, Miranda, Venezuela
[5]Instituto Nacional de Investigaciones Agrícolas (INIA), Maracaibo, Zulia, Venezuela
*Corresponding author: ivanvilchezchacin@gmail.com

Abstract.- The diet of the Guiana dolphin *Sotalia guianensis* in the southwestern Gulf of Venezuela, Zulia State, Venezuela, was investigated through the analysis of stomach contents from 12 dead individuals (11 adults and one juvenile) recovered from incidental captures in artisanal trammel nets and stranding events between 2003 and 2005. A total of 16 prey taxa (15 teleost species and one cephalopod species) were identified from fish otoliths and cephalopod beaks. Numerical frequency (%NF), frequency of occurrence (%FO), and the Relative Importance Index (RII) were calculated for each prey taxon. A total of 327 prey items were recorded in the stomach contents, with teleost fishes constituting the main prey group. The cephalopod *Doryteuthis pleii* and the nematode *Anisakis* sp. were each recorded in a single stomach. The most important prey species were the rhomboid mojarra *Diapterus rhombeus* (Gerreidae, %NF= 42.60; %FO= 54.55; RII= 2323.83) and the acoupa weakfish *Cynoscion acoupa* (Sciaenidae, %NF= 17.16; %FO= 18.18; RII= 312.0). These results provide the first detailed description of the diet of *S. guianensis* in the southwestern Gulf of Venezuela and establish a baseline for future studies on its feeding ecology, trophic interactions, and conservation in the region.

Key words: Stomach contents, otoliths, prey compositions, Guiana dolphin

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INTRODUCTION

Information on the diet of aquatic predators is important for understanding their ecological roles and position within marine food webs (Pauly *et al*. 1998, Moreira-Lopes *et al.* 2012, Abarca-Arenas *et al.* 2022). Because the diet of small cetaceans can vary substantially across spatial and temporal scales, it should be investigated whenever possible. Dietary information also provides a basis for assessing potential trophic interactions and competition with fisheries, an issue of increasing importance given the growing pressures on coastal fish stocks (Kiszka *et al.* 2022).

Cetaceans, as top predators, play an important role in regulating prey populations and influencing energy flow within marine ecosystems (Bowen & Siniff 1999, Cremer *et al.* 2012). Because prey composition can vary among habitats occupied by cetaceans (Cremer *et al.* 2012, Moreira-Lopes *et al.* 2012), local studies of their diet are essential for understanding their trophic ecology, habitat use, and spatial distribution. Such information also contributes to a better understanding of predator-prey interactions and their effects on ecosystem structure and functioning, providing valuable insights for conservation and management strategies (Estes *et al.* 2011, Ripple *et al.* 2014).

There are several methods for studying the diet of marine mammals (Barros & Clarke 2009, Moreira-Lopes *et al.* 2012). The diet of marine predators is primarily determined by examining four types of samples: stomach contents, regurgitates, vomit, and feces (Pinkas *et al.* 1971, Hyslop 1980). Among these, stomach contents provide direct evidence of prey consumption, and otoliths are one of the most easily identifiable hard prey remains in ichthyophagous marine predators (Bowen & Iverson 2013). Consequently, stranded marine mammals provide a valuable opportunity to investigate feeding ecology through stomach content analysis.

The analysis of cetacean stomach contents is a fundamental tool for determining the prey species consumed by these aquatic mammals (Naranjo-Ruiz *et al*. 2019). By identifying and quantifying prey remains recovered from the stomach contents of stranded individuals, including estimates of prey size and biomass derived from hard remains, researchers can assess predator feeding ecology, investigate spatial patterns of resource use, monitor changes in feeding habits, and evaluate predator-prey dynamics (Barros & Clarke 2009, Moreira-Lopes *et al.* 2012, Bowen & Iverson 2013). Furthermore, information on prey composition provides insights into cetacean distribution and habitat use in relation to food availability, helping to identify priority areas for the conservation of threatened species (Moreira-Lopes *et al.* 2012).

The Guiana dolphin, *Sotalia guianensis* (Van Beneden, 1864), is a small cetacean distributed along the Atlantic coast of Central and South America, from Nicaragua (or Honduras, depending on the taxonomic interpretation) to the state of Santa Catarina in southern Brazil, where it inhabits estuaries, bays, and other shallow coastal environments (Caballero *et al.* 2007). In Venezuela, its distribution is discontinuous, extending from the Gulf of Venezuela and Lake Maracaibo (Bolaños-Jiménez *et al*. 2008, Portocarrero-Aya *et al.* 2010) to the Gulf of Paria, the Orinoco Delta, and the Orinoco River in eastern Venezuela (Acevedo 2001). The species is currently classified as Near Threatened (NT) by the International Union for Conservation of Nature (IUCN; Secchi *et al.* 2018). Nevertheless, several populations are threatened by anthropogenic pressures, including incidental capture, the fin trade, and habitat degradation throughout its distribution range (Nery *et al.* 2008, Azevedo *et al.* 2009,). In the Lake Maracaibo system, Guiana dolphins typically occur in relatively small groups of up to 30 individuals, although groups exceeding 100 individuals have occasionally been reported (De Turris *et al.* 2010).

Genetic evidence from Caballero *et al.* (2018) supports the idea of the residency of *S. guianensis* in the Gulf of Venezuela and Lake Maracaibo. The clear differentiation in mtDNA and microsatellite markers, the identification of this region as a discrete population unit, and the restricted gene flow with other populations indicate that *S. guianensis* forms a resident local population within this estuarine-coastal ecosystem. This not only supports the residency hypothesis, but also has important implications for conservation, as it suggests that these populations should be managed as an independent unit, vulnerable to local pressures.

Although studies on the diet of *S. guianensis* have increased considerably in recent years in Brazil (Santos & Haimovici 2001, Santos *et al.* 2002, Gurjão *et al.* 2003, Pansard 2009, Mello 2010, Rosas *et al.* 2010, Rupil *et al.* 2018, Rodrigues *et al.* 2020, Vital *et al*. 2024)), this species remains poorly studied in Venezuela. Several aspects of its biology and population ecology, particularly those related to foraging ecology and feeding behavior, are still poorly understood (Rossi-Santos & Flores 2009, De Turris-Morales *et al.* 2010, Tardin *et al.* 2011).

Given the limited information available on the diet of small cetaceans in western Venezuela (De Turris-Morales *et al.* 2010), further studies are needed to identify the principal prey and describe the feeding habits of *S. guianensis* in the Gulf of Venezuela. Such information is essential for improving our understanding of the species' trophic ecology and potential geographic variation in diet.

Accordingly, the objective of this study was to examine the stomach contents of 12 stranded *S. guianensis* individuals recovered from the southwestern Gulf of Venezuela (Zulia State) to determine the abundance and frequency of the prey species consumed. This study provides the first detailed description of the local diet of this species in the study area and contributes to a better understanding of its feeding ecology and trophic role in the region.

Materials and methods

Study area and sampling

The Gulf of Venezuela is located north of the Lake Maracaibo system and is bounded by the municipalities of Páez and Almirante Padilla to the west, the municipality of Miranda to the east, and Falcón State to the south (Parra 2002, Montilla *et al.* 2014). Samples were collected along the southwestern coast of the Gulf, from south of Caño Sagua to Caño Oribor within the Ciénaga Los Olivitos Wildlife Refuge and Fishery Reserve, covering approximately 74 km of coastline in Zulia State (Fig. 1).

The study was based on the stomach contents of 12 dead *Sotalia guianensis* individuals (11 adults and one juvenile) collected between 2003 and 2005 along the Gulf of Venezuela coast (Table 1). Six individuals recovered as incidental bycatch in artisanal fisheries, whereas the remaining six were stranded following bycatch events (carcass condition codes 2-3; Geraci & Lounsbury 2005).

Sampling was opportunistic and relied on reports from residents; therefore, the samples do not represent seasonal patterns of cetacean occurrence or diet in the study area (Cremer *et al.* 2012). For everyone, total body length (TL) was measured using a flexible 5-m measuring tape, and sex was determined whenever carcass preservation allowed. Sexual maturity was assigned according to body-length classes following Ramos *et al.* (2000) and Rosas & Monteiro-Filho (2002). During necropsy, the three gastric compartments (forestomach, main stomach, and pyloric stomach; Mead 2007) were removed and stored at -4 °C for subsequent laboratory analysis (Barros & Clarke 2009, Cremer *et al*. 2012, Moreira-Lopes *et al*. 2012).

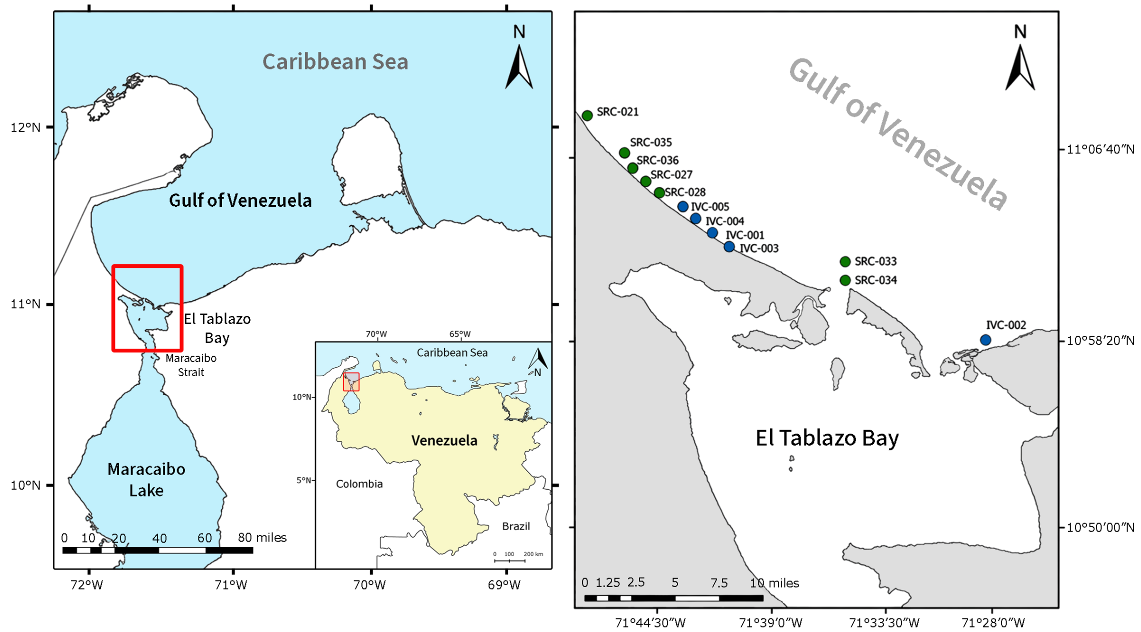

Figure 1. Geographic location of the study area within the Lake Maracaibo system, showing its major hydrographic subdivisions: the Gulf of Venezuela, El Tablazo Bay, the Strait of Maracaibo, and Lake Maracaibo. The sampling area is outlined by the red rectangle in the southwestern Gulf of Venezuela, Zulia State, Venezuela. Sampling locations of *Sotalia guianensis* specimens are shown according to Table 1 / Ubicación geográfica del área de estudio en el sistema del Lago de Maracaibo, con sus principales subdivisiones hidrográficas: Golfo de Venezuela, bahía El Tablazo, estrecho de Maracaibo y lago de Maracaibo. El área de muestreo está delimitada por un rectángulo rojo en el suroeste del Golfo de Venezuela, estado Zulia, Venezuela. Los sitios de colecta de los ejemplares de *Sotalia guianensis* se muestran según la Tabla 1

Table 1. Collection data for *Sotalia guianensis* specimens recovered from the southwestern Gulf of Venezuela, Zulia State, Venezuela / Datos de colecta de ejemplares del delfín costero *Sotalia guianensis* provenientes del suroeste del Golfo de Venezuela, estado Zulia, Venezuela

Date of collection	Code (*)	Record type	Location	Geographic coordinates	Specimen data	
					TL (cm)	Sex
22/02/2003	SRC-021	Stranding	Caimare Chico-Caño Sagua	11°09'31"N / 71°49'46"W	193	I
07/06/2003	SRC-027	Stranding	Sinamaica-Cardoncito	11°05'32"N / 71°45'58"W	182.6	M
19/07/2003	SRC-028	Stranding	Sinamaica-Cardoncito	11°05'54"N / 71°46'28"W	196	M
15/08/2003	SRC-033	Bycatch	Buoy 20, Navigation Channel	10°59'45"N / 71°35'54"W	>160	M
15/08/2003	SRC-034	Bycatch	Buoy 20, Navigation Channel	10°59'29"N / 71°35'33"W	172.5	M
16/08/2003	SRC-035	Stranding	Sinamaica-Cardoncito	11°05'03"N / 71°45'25"W	174.5	F
16/08/2003	SRC-036	Stranding	Sinamaica-Cardoncito	11°06'21"N / 71°47'07"W	187	M
16/04/2005	IVC-001	Bycatch	San Carlos Beach	11°03'00"N / 71°40'42"W	190	M
05/05/2005	IVC-002	Stranding	Olivitos Swamp	10°57'38"N / 71°29'25"W	155	F
06/05/2005	IVC-003	Bycatch	San Carlos Beach	11°02'26"N / 71°39'32"W	189	M
05/09/2005	IVC-004	Bycatch	San Carlos Beach	11°03'37" N / 71°41'34" W	168	M
29/11/2005	IVC-005	Bycatch	San Carlos Beach	11°04'06" N / 71°42'29" W	176	F

*See Figure 1 for the geographic reference of the code; TL: Total length; I: Indeterminated; M: Male; F: Female

Laboratory analysis and sample processing

Stomach contents were washed through sieves with mesh sizes of 2.0 mm, 850 µm, and 425 µm. Material recovered from the proximal esophagus to the pyloric stomach, including both digested and undigested remains, was examined to identify prey species based on fish otoliths and cephalopod beaks. Otoliths and cephalopod beaks were cleaned, dried, and stored for subsequent identification. Otoliths that lacked diagnostic external morphological features because of advanced digestion were classified as unidentified teleost remains and preserved in 70% ethanol.

For each stomach, the greater number of right or left sagittal otoliths was used to estimate the minimum number of fish consumed (Cremer *et al.* 2012, Moreira-Lopes *et al.* 2012). The same criterion was applied to the upper and lower cephalopod beaks to estimate the minimum number of cephalopods consumed.

The prey items correspond to the minimum number of prey individuals (MNI) calculated from paired otoliths and cephalopod beaks.

Diet composition was quantified using the numerical frequency (%NF), defined as the percentage of individuals of each prey species relative to the total number of prey items, and the frequency of occurrence (%FO), defined as the percentage of stomachs in which each prey species was present (Hyslop 1980). An adapted Relative Importance Index (RII; Pinkas *et al.* 1971) was also calculated. Because biometric relationships between otolith dimensions and prey body length or mass were unavailable, prey biomass could not be estimated; therefore, the RII was calculated using only the available dietary metrics.

The Relative Importance Index (RII) was calculated as:

$$RII= (\%NF \times \%FO)$$

Based on the resulting RII values, prey species were ranked according to their relative importance in the diet, from highest to lowest (Cremer *et al.* 2012). Numerical frequency (%NF) and frequency of occurrence (%FO) were also analyzed separately for cephalopods because their beaks are retained in cetacean stomachs longer than fish otoliths (Clarke 1986). Prey were identified to the lowest possible taxonomic level using the taxonomic keys of Clarke (1986) and the reference catalogs of Gil (2000) and Gil *et al.* (2003). Species identifications were further verified by comparison with fish otoliths and cephalopod beaks deposited in the Ichthyology Collection of the National Institute of Agricultural Research (INIA), Zulia State, Venezuela (Fig. 2).

To avoid overestimating the importance of cephalopods in the diet, the stomach containing only cephalopod beaks and no associated fish otoliths was excluded from the dietary analyses. This sample was considered an outlier because it differed markedly from all other stomachs examined and, if included, would have disproportionately influenced the estimates of prey abundance and frequency of occurrence. Consequently, the dietary indices were calculated using the remaining stomachs to provide a more representative description of the typical diet of *Sotalia guianensis* in the study area.

Figure 2. Examples of reference otoliths from the Ichthyology Collection of the National Institute of Agricultural Research (INIA) used for the taxonomic identification of prey species. Photographs were taken using a stereomicroscope at 10× magnification and include a 2 mm scale bar. Otoliths are identified by otolith type (sagitta or lapillus), common and scientific names of the corresponding fish species, and catalog number / Ejemplos de otolitos de referencia de la Colección Ictiológica del Instituto Nacional de Investigaciones Agrícolas (INIA), utilizados para la identificación taxonómica de las especies presa. Las fotografías fueron tomadas con un estereomicroscopio a 10× de aumento e incluyen una escala de 2 mm. Los otolitos se identifican según el tipo de otolito (sagitta o lapillus), el nombre común y científico de la especie de pez correspondiente, y el número de catálogo asignado

Results and discussion

The number of prey specimens recovered from each stomach and the taxonomic identification of all prey items (estimated n= 327) consumed by *Sotalia guianensis* are presented in Table 2. A total of 675 fish otoliths, of which 478 (70.8%) were identified, and 21 cephalopod beaks (100% identified) recovered from the stomach contents. The remaining 197 otoliths (29.2%) could not be identified because advanced digestion had obscured their diagnostic morphological characteristics. Shrimp remains were also present but could not be identified owing to their advanced state of digestion. In addition, an adult parasite nematode of the genus *Anisakis* was found in one of the stomachs.

The results indicate that teleost fish constituted the predominant prey group in the diet of *S. guianensis* (representing 96.6% of the 327 estimated prey items), with an overall otolith identification success rate of 70.8%. A total of 15 fish species belonging to five families were identified: Sciaenidae, Ariidae, Gerreidae, Engraulidae, and Trichiuridae (Table 2). Sciaenidae was the most abundant family, representing 37.3% of the identified prey items (based on numerical frequency, %NF). At the species level, *Diapterus rhombeus* was the dominant prey (%NF= 42.60; %FO= 54.55; RII= 2,323.83), followed by *Cynoscion acoupa* (%NF= 17.16; %FO= 18.18; RII= 312.00). *Stellifer microps* (%NF= 9.47; %FO= 63.64; RII= 602.47) and *Trichiurus lepturus* (%NF= 7.69; %FO= 45.45; RII= 349.65) were also important prey items in the diet (Table 2).

Cephalopods were represented by a single species, *Doryteuthis pleii* (Loliginidae), which was recorded in only one stomach (Table 2).

Most prey species identified in the stomach contents of *S. guianensis* are coastal and estuarine fishes with predominantly demersal habits, although pelagic and benthopelagic species were also recorded (Cervigón 1991, 1993, 1994, 1996). This pattern is consistent with the coastal distribution of *S. guianensis* and suggests that the species exploits prey from different habitats within estuarine and coastal ecosystems, reflecting a certain degree of trophic flexibility (Mello 2010). The spatiotemporal variability of fish assemblages in the Gulf of Venezuela is also likely to influence prey availability and, consequently, the composition of the dolphin's diet. As reported for other coastal dolphin populations, *S. guianensis* may exploit both resident prey and seasonally abundant fish schools when they become available (Wells *et al.* 1980). Therefore, the predominance of particular prey species in the stomach contents should not necessarily be interpreted as evidence of prey preference, but rather as a reflection of prey availability and the species' ability to adjust its foraging behavior to local environmental conditions (Mello 2010, Moreira-Lopes *et al.* 2012).

Table 2. List of prey families and species identified in the diet of the Guiana dolphin ***Sotalia guianensis* in the southwestern Gulf of Venezuela, Zulia State, Venezuela, between 2003 and 2005. Abbreviations are as follows: number of prey items (N), numerical frequency (%NF), number of stomachs in which each prey species was recorded (No), frequency of occurrence (%FO), Relative Importance Index (RII), and order of importance (OI) /** Lista de familias y especies presa identificadas en la dieta del delfín costero *Sotalia guianensis* en el suroeste del Golfo de Venezuela, estado Zulia, Venezuela, entre 2003 y 2005. Las abreviaturas corresponden a: número de ítems ingeridos (N), frecuencia numérica (%NF), número de estómagos en los que estuvo presente cada especie (No), frecuencia de ocurrencia (%FO), índice de importancia relativa (RII) y orden de importancia (OI)

Species	N	% NF	No	% FO	RII	OI	Habitat type [1]
Teleostei							
Sciaenidae							
Bairdiella ronchus	2	1.18	1	9.09	10.76	9	Demersal-Benthic
Cynoscion acoupa	29	17.16	2	18.18	312.00	4	Demersal-Benthic
Cynoscion similis	1	0.59	1	9.09	5.38	10	Demersal-Benthic
Macrodon ancylodon	2	1.18	1	9.09	10.76	9	Demersal-Benthic
Menticirrhus americanus	1	0.59	4	36.36	21.52	7	Demersal-Benthic
Micropogonias furnieri	2	1.18	2	18.18	21.52	7	Demersal-Benthic
Nebris microps	3	1.78	1	9.09	16.14	8	Demersal-Benthic
Stellifer microps	16	9.47	7	63.64	602.47	2	Demersal-Benthic
Stellifer stellifer	7	4.14	1	9.09	37.65	6	Demersal-Benthic
Stellifer sp. (*)	50	0	1				
Not identified	5	0	2				
Engraulidae							
Cetengraulis edentulus	4	2.37	1	9.09	21.52	7	Demersal-Pelagic
Gerreidae							
Diapterus rhombeus	72	42.60	6	54.55	2323.83	1	Demersal-Pelagic
Eugerres plumieri	3	1.78	1	9.09	16.14	8	Demersal-Pelagic
Trichiuridae							
Trichiurus lepturus	13	7.69	5	45.45	349.65	3	Demersal-Pelagic
Ariidae							
Sciades proops	4	2.37	1	9.09	21.52	6	Benthic
Arius sp.	1	0.59	2	18.18	10.76	9	Benthic
Cathorops spixii	9	5.33	2	18.18	96.83	5	Benthic
Not identified	14	0	1				
Teleostei, not identified	78	0	11				
Cephalopoda							
Loliginidae							
Doryteuthis pleii	11	0	1				Pelagic

[1] Habitat types were assigned according to the species distribution patterns described by Cervigón (1991, 1993, 1994, and 1996).

*Sagittae otoliths tentatively assigned to the other two *Stellifer* species reported from the study area

Most of the prey species identified in this study are schooling fishes, a characteristic that may influence the foraging behavior of *S. guianensis*. Feeding on schooling prey has been associated with coordinated hunting behavior in this species, as reported for populations in Brazil (Rossi-Santos & Flores 2009, Oliveira *et al.* 2013) and in the Lake Maracaibo system (De Turris-Morales *et al.* 2010).

The present results are consistent with previous studies reporting on members of the family Sciaenidae as important prey throughout the distribution of *S. guianensis* (Borobia & Barros 1989, Santos *et al.* 2002, Rosas *et al.* 2010, Rupil *et al.* 2018, Rodrigues *et al.* 2019, Vital *et al.* 2024). Species of this family are typically associated with coastal waters shallower than 100 m and many use estuarine habitats during at least part of their life cycle (Cervigón 1993), characteristics that likely contribute to their high availability in the Gulf of Venezuela. Similarly, *Diapterus rhombeus* and *Cynoscion acoupa* were the most abundant prey species identified in this study. However, their predominance in the diet should be interpreted cautiously, as it may reflect local prey availability rather than active prey selection by the dolphins.

It is also noteworthy that species of the families Gerreidae and Sciaenidae can produce sounds using their swim bladders (Santos *et al.* 2002). Because *S. guianensis* relies extensively on passive and active acoustic cues during foraging, sound production by these fishes may facilitate prey detection, although this hypothesis could not be evaluated in the present study. This characteristic may facilitate prey detection by *S. guianensis* in the turbid waters of the Gulf of Venezuela, particularly in its southwestern sector, where suspended sediments originating from Lake Maracaibo substantially reduce water transparency (Ramírez-Carroz 2005). However, this hypothesis warrants further investigation through behavioral or acoustic studies.

Although fishes belonging to the families Ariidae, Gerreidae, Engraulidae, and Trichiuridae were also identified in the stomach contents, consistent with previous studies on the diet of *S. guianensis* (Borobia & Barros 1989, Barros & Teixeira 1994, Rosas *et al.* 2010, Rupil *et al.* 2018, Rodrigues *et al.* 2019, Vital *et al.* 2024), representatives of several other fish families previously reported as prey, including Centropomidae, Clupeidae, Congridae, Batrachoididae, Mugilidae, Haemulidae, Paralichthyidae, Ophichthidae, Serranidae, and Stromateidae, were not recorded in the present study, despite their known occurrence in the Gulf of Venezuela (Barros & Teixeira 1994, Santos *et al.* 2002, Gurjão *et al.* 2003, Rosas *et al.* 2010).

The absence of prey species from these families in the analyzed stomachs, despite their documented occurrence in the Gulf of Venezuela, may be explained by several non-mutually exclusive factors. First, differential digestion of prey remains may reduce the detectability of species with fewer or less resistant diagnostic structures, potentially biasing stomach content analyses (Bowen & Iverson 2013). Second, differences in prey composition may reflect variation in prey availability or prey selection by *S. guianensis*, rather than the complete absence of these species from its diet.

Another possible explanation is resource partitioning with sympatric delphinids, including the common bottlenose dolphin (*Tursiops truncatus*) and the long-beaked common dolphin (*Delphinus capensis*), both of which have been reported in the Gulf of Venezuela. According to observations from local fishers, mullets (*Mugil* spp.) are more frequently consumed by these species than by *S. guianensis* (N. Flores, pers. comm., 2005). However, because information on the feeding ecology of sympatric delphinids in the Gulf of Venezuela remains scarce, the potential role of interspecific competition cannot be evaluated and should therefore be regarded as a hypothesis requiring further investigation.

The squid *Doryteuthis pleii*, previously reported in the diet of *S. guianensis* in Brazil (Mello 2010, Rosas *et al.* 2010, Rodrigues *et al.* 2019, Vital *et al.* 2024), is a coastal species and one of the most abundant cephalopods in the Gulf of Venezuela, together with *Doryteuthis pealeii* and *Lolliguncula brevis* (Arocha 1991). Its occurrence in the present study is therefore consistent with the known distribution and availability of cephalopods in the region.

Although the shrimp remains recovered from the stomach contents could not be identified because of their advanced state of digestion and were found in only one stomach, crustaceans, including penaeid shrimps, have previously been reported as prey of *S. guianensis* in Brazil (Santos *et al.* 2002, Mello 2010, Rosas *et al.* 2010, Moreira-Lopes *et al.* 2012, Rupil *et al.* 2018). The Gulf of Venezuela supports populations of four commercially important penaeid shrimp species [*Penaeus* (*Litopenaeus*) *schmitti*, *Penaeus* (*Farfantepenaeus*) *subtilis*, *Penaeus* (*Farfantepenaeus*) *notialis*, and *Penaeus* (*Farfantepenaeus*) *brasiliensis*] that sustain annual industrial catches exceeding 1,000 tons (Andrade 2005). Although these species may represent potential prey for *S. guianensis*, the limited occurrence of shrimp remains in the present study does not allow their importance in the diet of this population to be assessed.

The low numerical frequency (%NF) and frequency of occurrence (%FO) of *Macrodon ancylodon* indicate that this species represented a minor component of the diet of *S. guianensis* in the present study, consistent with previous reports (Santos *et al.* 2002, Rupil *et al.* 2018). However, these dietary indices alone do not allow prey preference to be inferred, as prey availability in the environment was not assessed.

Although *M. ancylodon* is an economically important fishery resource in the Gulf of Venezuela (Vílchez 2006), its limited occurrence in the stomach contents suggests that dietary overlap with this species is likely to be low. In contrast, several commercially important fishes, including *Cynoscion acoupa*, *Eugerres plumieri*, *Cathorops spixii*, and *Trichiurus lepturus*, were common prey in the present study. This dietary overlap indicates the potential for shared use of fishery resources by dolphins and artisanal fisheries. Nevertheless, there is currently no evidence that local fishers perceive *S. guianensis* as a significant competitor for these resources (I. Vílchez, pers. comm., 2006).

Fragments of monofilament net were recovered from one stomach, suggesting that the individual may have consumed fish entangled in fishing gear, an interaction previously described for *S. guianensis* in the Gulf of Venezuela (Ramírez-Carroz 2005). Such interactions increase the risk of incidental capture because dolphins attempting to feed on entangled fish may themselves become trapped and drown. Previous studies have also documented the subsequent use of stranded or bycaught dolphins for human consumption in some coastal communities (Briceño *et al.* 2021).

In addition, *S. guianensis* is particularly vulnerable to incidental capture because its feeding areas overlap with artisanal fishing grounds in the Gulf of Venezuela (Ramírez-Carroz 2005, Mello 2010). Most of the prey species identified in this study are associated with muddy-bottom habitats (Cervigón 1991, 1993, 1994, 1996), which are characteristic of Calabozo Bay in the southwestern Gulf of Venezuela. This estuarine area, influenced by the mixing of Caribbean Sea waters with those of Lake Maracaibo, provides productive feeding habitats that are likely to be important for *S. guianensis* (Edwards & Schnell 2001, Pansard 2009).

An adult nematode of the genus *Anisakis* was recovered from one stomach. Species of this genus have a complex life cycle involving crustaceans as first intermediate hosts, fish and cephalopods as intermediate or paratenic hosts, and marine mammals as definitive hosts (da Silva & Best 1996, Traviezo-Valles 2022). Several fish species recorded in the diet of *S. guianensis*, including species of the genus *Cynoscion*, have previously been reported as hosts of *Anisakis* larvae (Meza-Villalobos *et al.* 2023), suggesting a plausible route of parasite transmission through the food web. However, because only a single parasite was recorded in the present study, the epidemiological significance of this finding cannot be assessed, and additional studies are needed to determine the occurrence and transmission dynamics of *Anisakis* in the Gulf of Venezuela.

Determining the size of prey consumed by *S. guianensis* in the Lake Maracaibo, Gulf of Venezuela system would improve our understanding of its trophic role and its potential interactions with local fisheries. Such information would help assess the extent of dietary overlap with commercially exploited fish stocks and provide a more objective basis for evaluating perceived competition between dolphins and fisheries, thereby contributing to conservation and management strategies aimed at reducing conflicts and incidental persecution. Future studies should include larger sample sizes, broader geographic coverage, and estimates of prey size and biomass to better characterize the feeding ecology of this species and support the development of conservation and management plans for the region.

This study provides the first detailed description of the diet of *S. guianensis* in the southwestern Gulf of Venezuela and constitutes an important contribution to the knowledge of the species' feeding ecology in Venezuelan waters. The results indicate that the species consumes prey associated with benthic, demersal, benthopelagic, and pelagic habitats, highlighting its trophic flexibility within estuarine and coastal ecosystems. Together, these findings improve our understanding of the ecological role of *S. guianensis* in the Gulf of Venezuela and provide baseline information for future studies on trophic interactions, fisheries overlap, and conservation of this Near Threatened species (Secchi *et al.* 2018, Barrios-Garrido *et al.* 2015).

Statements

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Author contributions

All authors contributed to the writing of the manuscript. Iván Vilchez and Sonsireé Ramírez conducted the fieldwork and performed the sample analyses.

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Data availability statement

The data supporting the findings of this study are maintained in Excel databases and a photographic catalog of fish otoliths within the authors' personal files and are available from the corresponding author upon reasonable request.

Conflict of interest

The authors declare that they have no conflicts of interest.

Ethics statement

This study was conducted in accordance with applicable ethical principles, institutional guidelines, and relevant local regulations. The ethical handling of samples and research data was ensured throughout the study.

Use of Artificial Intelligence

Artificial intelligence was used solely to assist in the rapid identification and updating of bibliographic references. All AI-generated outputs were carefully reviewed and verified by the authors, who take full responsibility for the content of the manuscript.

Literature cited

Abarca-Arenas LG, E Valero-Pacheco, CA Delfín-Alfonso, E Morteo-Ortiz & J Franco-López. 2022. Redes tróficas como herramienta para el estudio de la diversidad y complejidad de ecosistemas. Revista Mexicana de Biodiversidad 93, e934126. <https://doi.org/10.22201/ib.20078706e.2022.93.4126>

Acevedo R. 2001. Distribución y caracterización de hábitats de los cetáceos marinos reportados en las costas de Venezuela. Trabajo Especial de Grado, Escuela de Biología, Universidad Central de Venezuela, Caracas, 242 pp.

Andrade G. 2005. Análisis bioeconómico de la pesquería secuencial del camarón blanco (*Litopenaeus schmitti*) y su aplicación para el manejo del recurso en el occidente de Venezuela. Tesis Doctoral, Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional, México, 165 pp.

Arocha F. 1991. Some studies of *Loligo plei* and occurrence of *Loligo pealei* (Cephalopoda: Myopsida) in Northeastern Venezuela. Acta Científica Venezolana 42: 145-152.

Azevedo AF, J Lailson-Brito, PR Dorneles, M Van-Sluys, HA Cunha & ABL Fragoso. 2009. Human-induced injuries to marine tucuxis (*Sotalia guianensis*) (Cetacea: Delphinidae) in Brazil. Marine Biodiversity Records 2, e22. <https://doi.org/10.1017/S1755267208000262>

Barrios-Garrido H, S Boher-Bentti, K De Turris-Morales, N Espinoza, A Ferrer-Pérez, OL Herrera-Trujillo, T León, L Oviedo, D Pirela, M Portocarrero-Aya, L Sánchez-Criollo, F Trujillo & J Bolaños-Jiménez. 2015. Tonina costera *Sotalia guianensis* (Van Bénedén, 1864). En: Rodríguez JP, A García-Rawlins & F Rojas-Suárez (eds). Libro rojo de la fauna venezolana, pp. 1-5. Provita y Fundación Empresas Polar, Caracas.

Barros N & M Clarke. 2009. Diet. In: Perrin WF, B Wursig & JGM Thewissen (eds). Encyclopedia of marine mammals, pp. 311-316. Academic Press, Amsterdam. <https://doi.org/10.1016/B978-0-12-373553-9.00076-6>

Barros N & R Teixeira. 1994. Incidental catch of marine tucuxi, *Sotalia fluviatilis*, in Alagoas, northeastern Brazil. Reports of the International Whaling Commission, Special Issue 15: 265-268.

Bolaños-Jiménez J, D Pirela, J Rojas & T León. 2008. Bufeo Negro, *Sotalia guianensis* Van Beneden 1863. En: Rodríguez JP & F Rojas-Suárez (eds). Libro rojo de la Fauna de Venezuela, pp. 112. Provita y Shell Venezuela S.A., Caracas.

Borobia M & N Barros. 1989. Notes on the diet of marine *Sotalia fluviatilis*. Marine Mammal Science 5: 395-399. <https://doi.org/10.1111/j.1748-7692.1989.tb00353.x>

Bowen WD & SJ Iverson. 2013. Methods of estimating marine mammal diets: A review of validation experiments and sources of bias and uncertainty. Marine Mammal Science 29(4): 719-754. <https://doi.org/10.1111/j.1748-7692.2012.00604.x>

Bowen WD & DB Siniff. 1999. Distribution, population biology, and feeding ecology of marine mammals. In: Reynolds JE & SA Rommel (eds). Biology of marine mammal, pp. 423-484. Smithsonian Institution Press, Washington.

Briceño Y, L Sánchez, F Trujillo, L von-Fersen & S Ramírez. 2021. Aquatic wildmeat consumption of guiana dolphins (*Sotalia guianensis*) in Lake Maracaibo System, Venezuela Frontiers 8, 625801. <https://doi.org/10.3389/fmars.2021.625801>

Caballero S, F Trujillo, JA Vianna, H Barrios-Garrido, MG Montiel, S Beltran-Pedreros & CS Baker. 2007. Taxonomic status of the genus *Sotalia:* species level ranking for ¨tucuxi¨ (*Sotalia fluviatilis*) and ¨costero¨ (*Sotalia guianensis*) dolphins. Marine Mammal Science 23: 358-386. <https://dx.doi.org/10.1111/j.1748-7692.2007.00110.x>

Caballero S, C Hollatz, S Rodriguez, F Trujillo & CS Baker. 2018. Population structure of Riverine and coastal dolphins *Sotalia fluviatilis* and *Sotalia guianensis*: Patterns of nuclear and mitochondrial diversity and implications for conservation. Journal of Heredity 109: 757-770. <https://doi.org/10.1093/jhered/esy049>

Cervigón F. 1991. Los peces marinos de Venezuela. Volumen I, 425 pp. Fundación Científica Los Roques, Caracas.

Cervigón F. 1993. Los peces marinos de Venezuela. Volumen II, 497 pp. Fundación Científica Los Roques, Caracas.

Cervigón F. 1994. Los peces marinos de Venezuela. Volumen III, 295 pp. Fundación Científica Los Roques, Caracas.

Cervigón F. 1996. Los peces marinos de Venezuela. Volumen IV, 254 pp. Editorial Ex Libris, Caracas.

Clarke MR. 1986. A handbook for the identification of cephalopod beaks, 273 pp. Clarendon Press, Oxford

Cremer MJ, PC Pinheiro & PC Simões-Lopes. 2012. Prey consumed by Guiana dolphin *Sotalia guianensis* (Cetacea, Delphinidae) and franciscana dolphin *Pontoporia blainvillei* (Cetacea, Pontoporiidae) in an estuarine environment in southern Brazil. Iheringia, Série Zoologia 102(2): 131-137. <https://doi.org/10.1590/S0073-47212012000200003>

Da Silva VMF & RC Best. 1996. *Sotalia fluviatilis*. Mammalian Species. 527: 1-7.

De Turris-Morales K, G Delgado-Ortega, N Espinoza-Rodríguez, MG Montiel-Villalobos & H Barrios-Garrido. 2010. Nota sobre el comportamiento alimenticio del Delfín Estuarino (*Sotalia guianensis*) en la costa occidental del Lago de Maracaibo. Ecotrópicos 23: 114-116.

Edwards H & G Schnell. 2001. Status and ecology of *Sotalia fluviatilis* in the Cayos Miskito Reserve, Nicaragua. Marine Mammal Science 17: 445-472. <https://dx.doi.org/10.1111/j.1748-7692.2001.tb00998.x>

Estes JA, J Terborgh, JS Brashares, ME Power, J Berger, WJ Bond, SR Carpenter, TE Essington, RD Holt, JBCJackson, RJ Marquis, L Oksanen, T Oksanen, RT Paine, EK Pikitch, WJ Ripple, SA Sandin, M Scheffer, TW Schoener, JB Shurin, ARE Sinclair, ME Soulé, R Virtanen & DAWardle. 2011. Trophic downgrading of planet Earth. Science 333(6040): 301-306. <https://dx.doi.org/10.1126/science.120510>

Geraci JR & V Lounsbury. 2005. Marine mammals ashore: A field guide for strandings, 371 pp Texas A&M University Sea Grant College Program, Galveston.

Gil K. 2000. Abundancia y dieta de la cotúa olivácea (*Phalacrocorax olivaceus*) en el Refugio de Fauna y Reserva de Pesca Ciénaga de Los Olivitos. Tesis de Maestría, Facultad Experimental de Ciencias, La Universidad del Zulia, Maracaibo, 82 pp.

Gil K, C Casler & E Weir. 2003. Biodiversidad en el Lago de Maracaibo, Campo Urdaneta Oeste. Venezuela, 267 pp. Shell Venezuela S.A, Maracaibo.

Gurjão LM, MA Furtado-Neto, RA Santos & P Cascon. 2003. Feeding habits of marine tucuxi, *Sotalia fluviatilis*, at Ceará state, northeastern Brazil. Latin American Journal of Aquatic Mammals. 2: 117-122. <https://dx.doi.org/10.5597/lajam00040>

Hyslop EJ. 1980. Stomach content analysis-a review of methods and their applications. Journal of Fish Biology 17: 411-429. <https://doi.org/10.1111/j.1095-8649.1980.tb02775.x>

Kiszka JJ, MS Woodstock & MR Heithaus. 2022. Functional roles and ecological importance of small cetaceans in aquatic ecosystems. Frontiers in Marine Science 9, 803173. <https://doi.org/10.3389/fmars.2022.803173>

Mead JG. 2007. Stomach anatomy and use in defining systemic relationships of the cetacean family Ziphiidae (Beaked Whales). The Anatomical Record 290: 581-595. <https://doi.org/10.1002/ar.20536>

Mello CLC. 2010. Aspectos ecológicos da alimentação do boto-cinza, *Sotalia guianensis*, na Baía de Guanabara, Rio de Janeiro: comparações intra e interespecíficas. Tesis de Maestría. Universidade do Estado do Rio de Janeiro, Rio de Janeiro, 114 pp.

Meza-Villalobos LA, L Meza-Espinoza, LD Espinosa-Chaurand, M Diaz-Ramírez & ADJ Cortés-Sánchez. 2023. Evaluación microbiológica de pescado (*Cynoscion albus*) destinado al consumo humano. Ciencia Latina Revista Científica Multidisciplinar 7(1): 1263-1283. <https://doi.org/10.37811/cl_rcm.v7i1.4480>

Montilla AJ, D Prieto-Torres, JL Hernández & M Cruz-Alvarado. 2014. Estudio hematológico de tortugas marinas *Eretmochelys imbricata* y *Caretta caretta* presentes en la Alta Guajira, Golfo de Venezuela. Revista Científica, FCV-LUZ 24(4): 363-371.

Moreira-Lopes X, E Da Silva, M Bassoi, RA Dos Santos & MCO Santos. 2012. Feeding habits of Guiana dolphins, *Sotalia guianensis*, from south-eastern Brazil: new items and a knowledge review. Journal of the Marine Biological Association of the United Kingdom 92(8): 1723-1733. <https://dx.doi.org/10.1017/S0025315412000495>

Naranjo-Ruiz KL, A Delgado-Estrella, MRK Morquecho-León & YE Torres-Rojas. 2019. Determinación de peces presas consumidos por toninas (*Tursiops truncatus*) que vararon en la Isla del Carmen, Campeche. Revista Mexicana de Biodiversidad 90, e902513. <https://doi.org/10.22201/ib.20078706e.2019.90.2513>

Nery M, M Especie & S Simão. 2008. Site fidelity of *Sotalia guianensis* (Cetacea: Delphinidae) in Sepetiba Bay, Rio de Janeiro, Brazil. Revista Brasileira de Zoología 25(2): 182-187. <https://doi.org/10.1590/S0101-81752008000200004>

Oliveira EC da S, R Tardin, F Poletto & S Simão. 2013. Coordinated feeding behavior of the Guiana dolphin, *Sotalia guianensis* (Cetacea: Delphinidae), in southeastern Brazil: a comparison between populations. Zoología 30(6): 585-591. <https://dx.doi.org/10.1590/S1984-46702013005000013>

Pansard K. 2009. Ecología alimentar do boto cinza, *Sotalia guianensis* (Van Banédén, 1864), no litoral do Rio Grande do Norte. Tesis de Doctorado, Universidade Federal do Rio Grande do Norte. Centro de Biociências, 196 pp.

Parra L. 2002. Diagnóstico de la situación actual de las poblaciones de tortugas marinas en la Costa Occidental del Golfo de Venezuela, Estado Zulia. Tesis de Licenciatura, Departamento de Biología, Universidad del Zulia, Maracaibo, 179 pp.

Pauly D, AW Trites, E Capuli & V Christensen. 1998. Diet composition and trophic levels of marine mammals. Journal of Marine Science 55(3): 467-481. <https://doi.org/10.1006/jmsc.1997.0280>

Pinkas L, M Olifant & I Iverson. 1971. Food habits of Albacore, Bluefin Tuna, and Bonito in California waters. Fish Bulletin 152: 1-105.

Portocarrero-Aya M, A Ferrer, CA Lasso, M Ruiz-García, J Bolaños-Jiménez & S Caballero. 2010. Status, distribution and conservation of the river dolphins *Inia geoffrensis* and *Sotalia* spp. Venezuela. In: Trujillo F, E Crespo, PA van Damme & JS Usma (eds). The action plan for South American river dolphins, 2020, pp. 17-28. WDS, WDCS, Solamac. Bogotá, D.C.

Ramírez-Carroz S. 2005. Bases ecológicas para la conservación del delfín estuarino, *Sotalia fluviatilis*, en el Golfo de Venezuela. Tesis de Maestría, Universidad Nacional Experimental de los Llanos Occidentales “Ezequiel Zamora”, Barinas, 118 pp.

Ramos RMA, APM Di Beneditto & NRW Lima. 2000. Growth parameters of *Pontoporia blainvillei* and *Sotalia fluviatilis* (Cetacea) in northern Rio de Janeiro, Brazil. Aquatic Mammals 26: 65-75.

Ripple WJ, JA Estes, RL Beschta, CC Wilmers, EG Ritchie, M Hebblewhite, J Berger, B Elmhagen, M Letnic, MP Nelson, OJ Schmitz, DW Smith, AD Wallach & AJ Wirsing. 2014. Status and ecological effects of the world's largest carnivores. Science 343(6167), 1241484. <https://dx.doi.org/10.1126/science.1241484>

Rodrigues VLA, LL Wedekin, MCC Marcondes, L Barboza & APC Farro. 2020. Diet and foraging opportunism of the Guiana Dolphin (*Sotalia guianensis*) in the Abrolhos Bank, Brazil. Marine Mammal Science 36: 436-450. <https://doi.org/10.1111/mms.12656>

Rosas FCW & ELA Monteiro-Filho. 2002. Reproduction of *Sotalia guianensis* on the coast of Paraná, southern Brazil. Journal of Mammalogy 83: 507-515. <https://doi.org/10.1644/1545-1542(2002)083%3C0507:ROTEDS%3E2.0.CO;2>

Rosas FCW, J Marigo, M Laeta & MR Rossi-Santos. 2010. Natural history of dolphins of the genus *Sotalia*. Latin American Journal of Aquatic Mammals 8: 57-68. <https://dx.doi.org/10.5597/lajam00154>

Rossi-Santos M & P Flores. 2009. Feeding strategies of the Guiana Dolphin *Sotalia guianensis*. The Open Marine Biology Journal 3: 70-76. <https://dx.doi.org/10.2174/1874450800903010070>

Rupil GM, JA Bogoni, L Barbosa, MCC Marcondes & AP Cazerta-Farro. 2018. Climate influences on Guiana dolphin diet along the Brazilian coast. Scientia Marina 82: 159-168. <https://doi.org/10.3989/scimar.04775.27A>

Santos MC, S Rosso, RA Santos, SH Bulizani & M Bassoi. 2002. Insights on small cetacean feeding habits in southeastern Brazil. Aquatic Mammals 28: 38-45.

Santos RA & M Haimovici. 2001. Cephalopods in the diet of marine mammals stranded or incidentally caught along southeastern and southern Brazil (21-34°S). Fisheries Research 52: 99-112. <https://doi.org/10.1016/S0165-7836(01)00234-X>

Secchi E, MC de O Santos & R Reeves. 2018. *Sotalia guianensis* (errata version published in 2019). The IUCN Red List of Threatened Species 2018: e.T181359A144232542. <https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T181359A144232542.en>

Tardin R, M Especie, M Nery, F D'Azeredo & S Simão. 2011. Coordinated feeding tactics of the Guiana dolphin, *Sotalia guianensis* (Cetacea: Delphinidae), in Ilha Grande Bay, Rio de Janeiro, Brazil. Zoología 28(3): 291-296. <https://doi.org/10.1590/S1984-46702011000300002>

Traviezo-Valles LE. 2022. Primer reporte de *Anisakis* sp. (Dujardin, 1845) en pez de la isla caribeña de Coche, Venezuela. Revista Amazónica de Ciencias Ambientales y Ecológicas 1(2), e383. <https://doi.org/10.51252/reacae.v1i2.383>

Vílchez I. 2006. Dieta del Delfín Estuarino *Sotalia fluviatilis*, en el Golfo de Venezuela. Tesis de Licenciatura, Facultad Experimental de Ciencias, La Universidad del Zulia, Maracaibo, 90 pp.

Vital N, E Brinatti-Guari, T Lemos-Bisi, L Flach, JL Brito-Junior & A de Freitas-Azevedo. 2024. Feeding habits of the Guiana dolphin, *Sotalia guianensis*, (Van Bénéden, 1864) (Cetacea: Delphinidae) in Sepetiba and Ilha Grande bays, southeastern Brazil. Regional Studies in Marine Science 73, 103446. <https://doi.org/10.1016/j.rsma.2024.103446>

Wells R, AB Irvine & M Scott. 1980. The social ecology of inshore Odontocetes. In: Herman LM (ed). Cetacean behavior mechanisms and function, pp. 263-317. Wiley, New York.