Stranding pattern of Bryde's whales, *Balaenoptera edeni*, along the Southeastern Brazilian coast

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Abstract

In this study we present data on 47 strandings of Bryde's whales along the coast of São Paulo and Rio de Janeiro states, southeastern Brazil. The results show a correlation with annual increasing of strandings in 20 year period of data collection. No significant seasonal trend was observed among for seasonal category, but most whales stranded during winter (July-September). Males stranded more frequent than females. There was a significant trend in strandings of mature whales (> 11,22m; 52.4%) (52.4%), but juveniles (≤ 8 m; 28.6%) were also relatively common. The present work confirms that Bryde's whales are common in southeastern Brazilian coast. Some discrepancy in published results from sightings and our results on strandings (*e.g.* seasonal pattern) was observed and may be related to environmental condition and the presence of inshore and offshore populations with differences in life history and behavior. No whales showed signals of impact caused by human interactions, despite of the potential threats in the study area. Future studies with compared morphology of genetic are suggested to be carried out elucidate the taxonomic status of the Bryde's in Brazil.

Keywords: stranding, Brazil, Bryde's whale, stomach contents.

INTRODUTION

Bryde's whales (*Balaenoptera edeni,* Anderson, 1879) have been reported in tropical, subtropical and warm temperate oceans around the world (inhabiting waters about 16°C or warmer), between latitudes 40ºN and 40ºS (Jefferson *et al.,* 2008; Kato and Perrin, 2009). It is the only balaenopterid species that does not perform extensive latitudinal migratory movements, remaining in warm waters throughout the year (Kato, 2002). *B. edeni* is relatively common in Brazilian waters and it is known to occur over the coastal shelf until isobatimetrics of 200 meters, but appear to be more frequent in coastal areas of southeastern region wherever effort occurs (Siciliano *et al.,* 2004; Zerbini *et al*., 1997).

Historically, *B. edeni* was exploited by two whaling stations in Brazilian waters: Costinha station (Paraíba State, 06°57'S, 34°51'W) from 1910 to 1914 and from 1924 to 1985, and Cabo Frio station (Rio de Janeiro State 22°53'S, 42°01'W) from 1960 to 1963 (Williamson 1975; Zerbini *et al.,* 1997). However, this whale was not distinguished from the sei whale (*B. borealis*) before 1967, which biased the catch number for the two species. The estimated total catches of Bryde's in Brazil were approximately 360 and 30 whales off Costinha and Cabo Frio stations, respectively (Williamson, 1975). This large cetacean was not heavy hunted when compared with other whales (e.g. blue, fin and sei whales), but fewer than 8.000 were taken in the Southern Hemisphere (Jefferson *et al*., 2008).

Bryde's whale is found stranded along the Brazilian coast more often than all five balaenopterids known to occur in the region, with the exception of minke whales (*B. acutorostrata*) (Zerbini *et al.,* 1997). However, despite the relatively large number of strandings in comparison to other balaenopterids, still little is known about its seasonal occurrence and biology, such as feeding habits. Worldwide, *B. edeni* is considered as "data deficient" by the IUCN Red List (IUCN, 2010) and it has been included in the Appendix I of the Convention on International Trade in Endangered Species (CITES, 2010), and in the appendix II of the Convention on the Conservation of Migratory Species of Wild Animals(CMS, 2009). In Brazil, the species is also classified as "data deficient" by the Action Plan for Marine Mammals conservation (IBAMA, 2001).

It has been suggested that Bryde's whales are opportunistic feeders preying upon schooling of small pelagic fishes, such as sardines and herrings (Tershy *et al*. 1993; Gallardo *et al*. 1983). They can also feed on euphausids, copepods, cephalopods and pelagic crabs (Omura, 1962; Best, 2001; Kawamura, 1977; Kato & Perrin, 2009). In southeastern Brazil, the Brazilian sardine (*Sardinella brasiliensis*), which is abundant in the region (Matsuura, 1996), appears to constitute an important prey item in the diet of *B. edeni* (Siciliano *et al.,* 2004).

The availability of food resources is an important parameter that determines the distribution pattern of cetaceans, especially non migratory species, such as *B. edeni*. *Bryde's whales* seem to have a preference for habitats with a predictable biological abundance, for example along the continental shelf break of the northeastern Gulf of Mexico, and regions subjected to coastal upwelling, such as Chile and Cabo Frio, in southeastern Brazil (Gallardo *et al.,* 1983; Davis *et al*., 2000; Siciliano *et al.* 2004). Studies carried out in the last and current decade have addressed the taxonomic status of Bryde's whales and recognized different forms, or even species (Best, 2001; Wada & Numachi, 1991; Kato, 2002; Wada *et al.,* 2003). However, as definite conclusion was not reached so far on the taxonomic status or management groups based on different forms or species of the western South Atlantic specimens, we decided to use the nomination *Balaenoptera edeni*, Anderson, 1878, as standard form.

The aim of this study is to evaluate the stranding pattern of Bryde's whales in the southeastern Brazil, based on literature reports and new additional information. In addition, we also present information on diet based on the examination of stomach contents.

MATERIAL AND METHODS

The region covered in this study comprises the States of Rio de Janeiro and São Paulo, located in the south-eastern coast of Brazil with approximately 1200 km of coast line.

The data of the present study is composed by published information, mainly from Siciliano et al. (2004) and Santos et al. (2010). Unpublished data was obtained from newspaper, TV news, provided by colleagues and personal observations through a monitoring program established in the north coast of the study area. From 1999 to 2011 the marine mammal research group (GEMM-Lagos) regularly patrolled the coast of the Rio de Janeiro State from São Francisco de Itabapoana (north, 21°25'10"S; 41°00'36"W) to Saquarema (south, 22°55'12"S; 42°30'37"W) (Figure 1). During these surveys, awareness campaigns were implemented in the communities along the coast in order to promote a collaboration network and improve stranding reports.

The unpublished data out of the monitoring system was only considered for this study if the available material (films and photos) showed taxonomic characteristics of the species (*e.g.* shape and height of the dorsal fin; coloration pattern; the extension of the ventral grooves in relation to the navel, etc.). In some occasions the material examined allowed us to obtain information of gender and total body length.

Stranding data was used as an additional tool to evaluate possible patterns related to the general distribution of the species. In this context, the location of each stranding event was converted into geographic coordinates in order to construct a spatial view of the distribution of the Bryde's whales using ESRI – ArcView 3.2® software. In the cases the location of the records from the unpublished data (out of the monitoring program) the coordinates was obtained using the Google Earth® software.

Despite the effort of data collection has not been equally performed along the coast line of the study area we suppose that a stranding event rarely escape notice from the media. Therefore we present the correlation of stranding events in the sampling area with 20 years of data collection. The year-stranding correlation was analyzed using simple linear regression (R^2) at P-value less than 0.05.

To determine if there were seasonal trends of the strandings, the data were categorized into four seasons: January–March (summer), April–June (autumn), July–September (winter), and October–December (spring). A chi-square test (X^2) for equal proportions (at $P<0.05$) was used to test differences in stranding frequencies between seasonal categories.

The whales were generally sexed when whale position allowed a view of the ventral region or when the carcasses were dissected. The total body length of the carcasses was measured from the tip of lower jaw to the caudal notch of the whales accessed. The whales were categorized into juveniles ≤8m, sexually immature (>8; <11,22) and sexually matures (>11,22). The chi-square test was also used to verify some trend in the strandings for the body length categories (Jefferson et al., 2008).

When possible the stomach chambers were accessed to collect and identify food remains. The stomach contents analyses were only performed in two whales duo to the difficulties in the field.

RESULTS

A total of 47 stranded Bryde's whales were recovered between 1972 to April 2010, showing a slight relationship in the simple regression between the number of stranding in the period from 1991 to 2010 (R^2=0.50307; p<0.05) (Figure 1; Table 1). Although unevenly distributed over this 20 year period, there was a mean of two whales (SD=1.2), with a peak in 2005 when five records were reported.

From the 47 records of *B. edeni* in the study area 21, representing 44.7% of the stranding, are new and unpublished information. The stranding events were distributed along the study area. However the strandings seem to have concentrated in the southeastern coast of the Rio de Janeiro state, where the there is narrow shelf, and in the central coast of São Paulo state. No whales were found in the extreme northern coast of Rio de Janeiro state and only one was found around the Ilha Grande Bay (Figure 2).

No stranded Bryde's whale with signals of fishery interaction was reported in this study. However, it is important to highlight that some carcasses could have stranded as a result of entanglement, but decomposition could have prevented such observation.

Data on body length were available for 42 specimens and it varied from 4 to 15 meters. The data shows that most of the whales that stranded were classified as sexually mature (52.4%) ($X^2 = 14.02; df = 2; P < 0.05$), although juvenile (28.6%) and immature (19%) whales were also representative (Figura 1). Two whales with body length indicative of newborn were registered in the study area. One newborn recovered in northern Rio de Janeiro state presented a scar in the umbilical region indicating that it was recently born (3.8 m of body length). Other whale with 4.5 m of body length was found in São Paulo state. The newborns recorded in Rio de Janeiro and São Paulo state were found in September 2006 and August 2007, respectively.

Strandings of females (n = 14) were significantly more frequent than males (n = 8) ($X^2 = 8.213; DF = 2; P < 0.05$). However, 52.2% of the carcasses could not have the gender determined due to decomposition, or animal position in the beach. In addition, the great number of males when compared with females may be due to the fact that males are easier to identify, especially when the penis is exposed.

The observed differences in strandings between seasons were not statistically significant ($X^2 = 3.298; DF = 3, P > 0.05$) (Figure 4). Although, most strandings occurred during winter (n = 17; 36.2%) with a great frequency in August and September (n=06), followed by April (n=05) and January (n=04). Strandings in summer (n = 11), autumn (n = 10) and spring (n = 9) were almost equally distributed.

The analysis of stomach contents was realized in two whales as already stated. Both whales presented a large amount of aviú shrimp (*Acetes americanus*) as the unique prey consumed. The degree of digestion of the shrimps consumed in both whales suggests these prey species were ingested just before death.

DISCUSSION

The results show that Bryde's whales are common along southeastern Brazil and seem to be present there all over the year, as described in previous studies (Omura, 1962; Zerbini *et al*., 1997; Siciliano *et al*., 2004; Gonçalves, 2006). This species is commonly observed in Brazilian coastal waters mainly in Rio de Janeiro and São Paulo coast where the present study is focused. However, the scarcity of records offshore is more related to the effort in oceanic region than the absence of the whales. As an example, Andriolo *et al.* (2001) observed Bryde's in low density in offshore waters of northeastern Brazil varying from 800 and 2900 isobaths. The presence of Bryde's whales in southeastern Brazil should be related to the food availability of high productive and upwelling waters, mainly in eastern coast of Rio de Janeiro state. Bryde's whales tend to inhabit areas of unusually high productivity.

Zerbini *et al.* (1997) and Siciliano *et al.* (2004) showed that most whales strand during summer and winter times. According to these authors, the occurrence of whales in these seasons should be associated to the bioavailability of food resources, such as sardines that approach the coast to spawn in shallower waters (Saccardo & Rossi-Wongtschowski, 1991). Despite not statistically significant most whales stranded during winter in this present study. However we need to consider the actual poor taxonomic description of Bryde's whales in Brazilian water and the identification of distinct populations. In South Africa, Best (1977) identified two allopatric forms of Bryde's whales being recognized as inshore and offshore whales. The inshore form is restricted to coastal areas less of 20 miles and is observed year round. In contrast, the offshore form inhabits water 50 miles over the coast, and realizes a latitudinal migration to the equatorial region during winter. This author suggests that both inshore and offshore forms occurred in Brazilian waters, based in the assessment of the baleen plates configuration from two whales taken during whaling activities. Zerbini et al. (1997) classified one stranded whale as being "offshore" based on the baleen measurements following Best (1977) description. Additional observations on the presence

and classification of offshore/inshore Bryde's whales along the Brazilian coast have not been studied. If we consider the presence of both inshore and offshore forms in our data and assume the life history differences for both forms (distribution, seasonality, body size, baleen shape, scarring, food type and possibly breeding behavior) (Best, 2001), this study is subjected to some degree of bias. Sightings of Bryde's whales through land based observations carried out in Arraial do Cabo peninsula (Rio de Janeiro state) and through coastal waters monitoring survey show that this whale is common in summer and spring (Carneiro, 2005; Gonçalves 2006). These seasons coincides with the seasonal coastal upwelling region mainly in the east coast of Rio de Janeiro state which contributes with a ideal condition for a large whale such as Brydes, as low temperature and prey availability (Valentin, 2001; Siciliano *et al*., 2004).

Some discrepancy seems to occur in data of strandings and sightings. Generally, the stranding data does not show seasonal variation, which could be explained, in part, to environmental influence, such as wind intensity and direction and current movements. Carcasses may drift to the beaches during strong cold fronts in winter times.

Interestingly, two whales dissected presented the stomach chambers full of aviú shrimp, *A. americanus*. Contrasting these results, most previous studies suggest that the whales feed on small fishes (mainly *Sardinella brasiliensis*) in coastal waters, generally showing interspecific feeding association with seabirds and large fishes (Siciliano et al., 2004). Best (2001) studied the feeding differences in preys consumed for offshore and inshore forms of Bryde's whales taken off South Africa. According to this author, the inshore form show a high preference for small pelagic fishes (genus *Engraulis, Trachurus* and *Sardinops*), while offshore form prefer Euphasiids (*Euphausia lucens, E. recurva*) and in low frequency mesopelagic fish (*Maurolicus, Lestidium*). If this difference is applicable in southern Brazil we should speculate that these two whales may belong to offshore population. On the other hand, the coastal habits of these small shrimp also suggest that it may represent an important prey for coastal whales considering a non potential latitudinal migrating species.

Our results show high frequency of mature whales and followed by juveniles, including two newborns stranded in different areas, but in close months (August and September). According to Best (2001) there is no seasonal trend in reproduction of inshore Brydes, while offshore reproduction occur during autumn (March-May). However, Kato (2002) suggests that peaks for breeding and calving of pelagic population are in winter. In the Azores, North Atlantic, most calves are observed in summer times and is speculated to have born during last winter period (Steiner *et al*., 2007). No whales presented evidence of accidental or intentional capture in fishing apparatus or collision with ships, but we have to highlight that these threats are potentially present in the study area. Along the study area there are intense fishery activities which can promote impact to the whales, principally in coastal waters. In addition, the study site is responsible for more than 80% of the national oil petroleum produced and the presence of important large harbors which are associated to large boat traffic of large ships that elevated the risk of whale collision. The increasing annual frequency of strandings present in this study should in small proportion be explained by these human activities, but no evidence was found during field analyses. More probable hypothesis for the increasing number of strandings may be the progress in the dissemination of the communication in the last 20 years.

In conclusion, the present work confirms that Bryde's whales are common in southeastern Brazilian coast. The discrepancy in results from sightings and strandings (*e.g.* seasonal pattern) may be related to environmental condition and the presence of different forms (inshore and offshore) with differences in life history and behavior. No whales showed signals of impact caused by human interactions, despite of the potential threats in the study area. Future studies with compared morphology of genetic are suggested to be carried out elucidate the taxonomic status of the Bryde's in Brazil. In addition, the collection and storage of biological sample are specially needed to better understand the stranding pattern of this whale.

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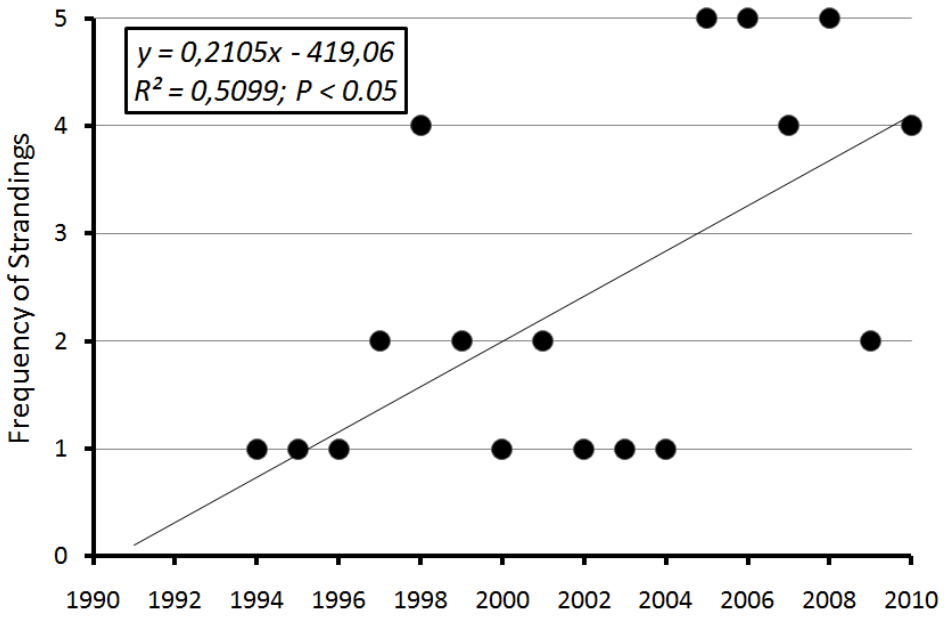

Figure 1. Simple linear regression of the number of Bryde's whales stranded in the period from 1989 to 2008 (20 years) in the coasts of São Paulo and the Rio de Janeiro states.

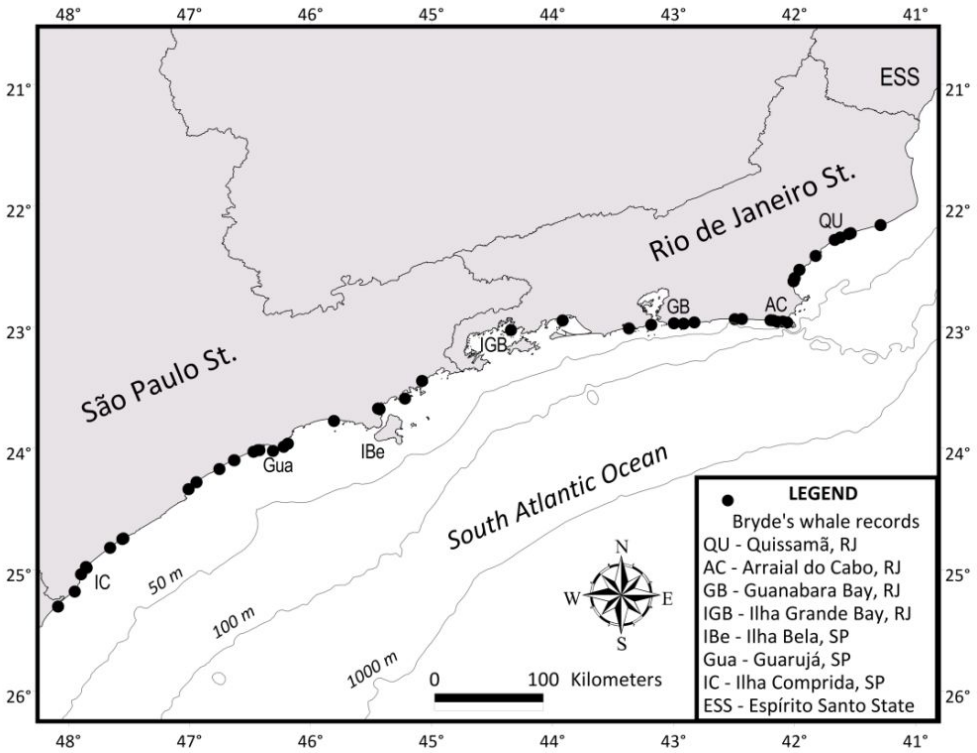

Figure 2. Map of the study area comprising Rio de Janeiro and São Paulo State, Southeastern Brazil. The figure shows the local of the strandings of Bryde's whales.

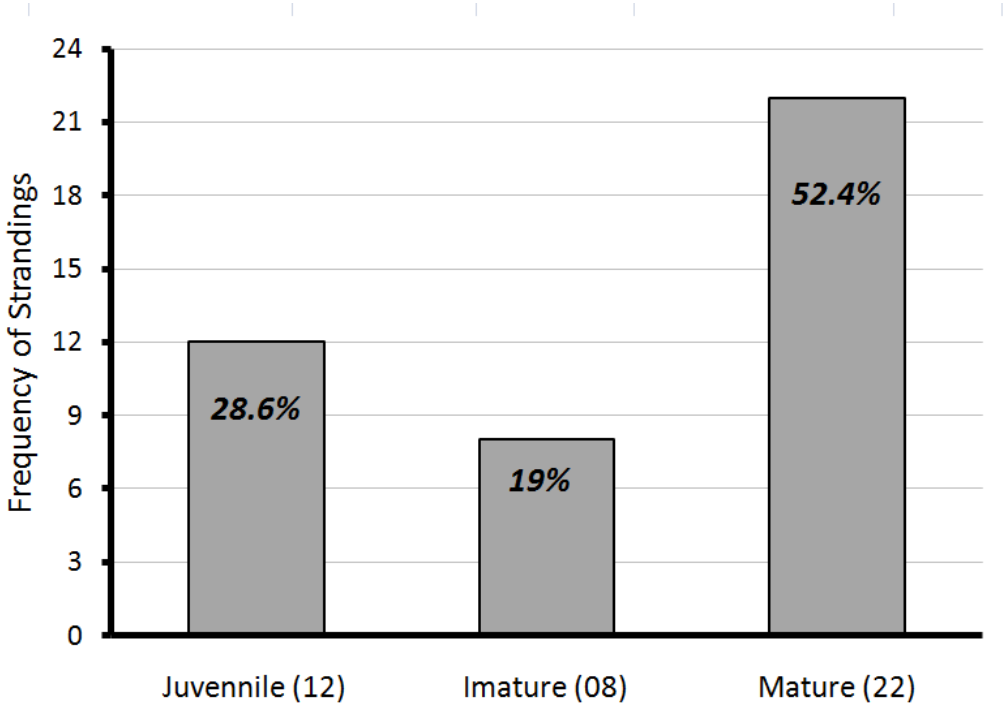

Figure 3. Number of strandings of Bryde's whales in age categories along the south-eastern Brazil. in the Period from 1972 to 2011.

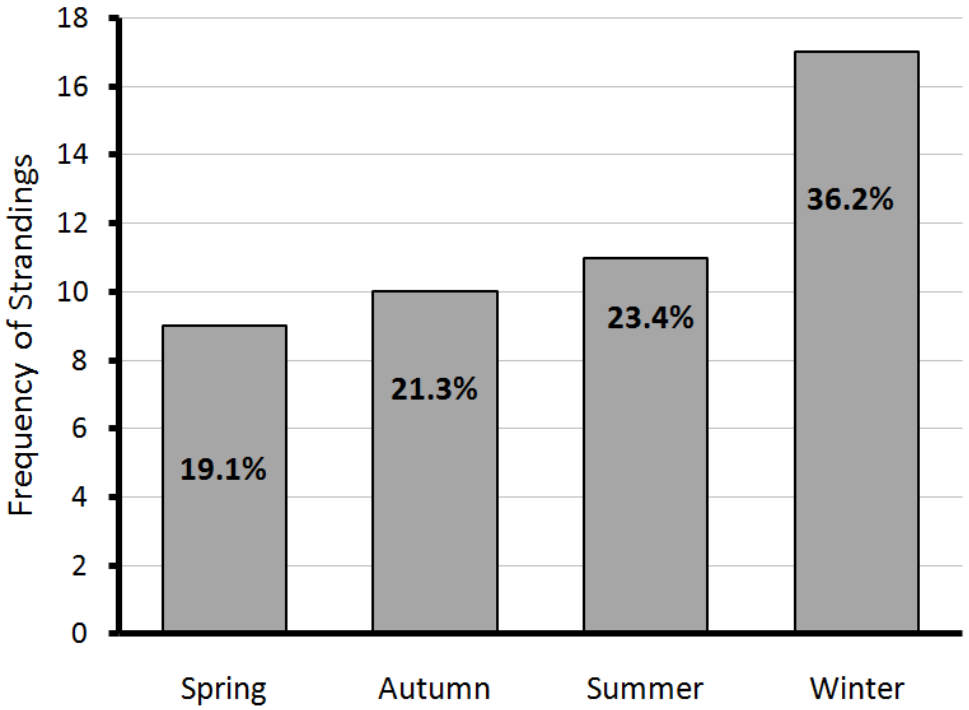

Figure4. Number of strandings of Bryde's whales per season in the south-eastern Brazil, from 1991 to 2011.

Tabela 1. Data on the strandings of Bryde's whales along the coasts of São Paulo and Rio de Janeiro states, Southeastern Brazil. Coordinates in decimal degrees.

LOCALITIES	DATE	SEX	BODY LENGTH (m)	latitude	Longitude	REFERENCES
Cananéia, SP	August 1972	U	12.5	-24.985265	-47.839604	Santos & Siciliano, 1996
Rio de Janeiro, RJ	28 January 1983	M	7.1	-22.958046	-42.129867	Geise & Borobia, 1988
Itanhaém, SP	1986	U	--	-24.170972	-46.742521	Santos & Siciliano, 1996
Angra dos Reis, RJ	03 April 1989	M	10.6	-23.026696	-44.333047	Zerbini et al., 1997
Ilha Comprida, SP	November 1994	U	14	-24.748223	-47.544246	Siciliano et al., 2004
Saquarema, RJ	07 April 1995	U	12.4	-22.936423	-42.483538	Zerbini et al., 1997
Ilha do Cardoso, SP	03 September 1996	F	14	-25.180578	-47.937810	Siciliano et al., 2004
Ilha Comprida, SP	30 January 1997	U	11	-24.820080	-47.645310	Siciliano et al., 2004
Peruíbe, SP	07 December 1997	U	15	-24.336410	-46.997009	Siciliano et al., 2004
Quissamã, RJ	June 1998	F	~8	-22.160644	-41.278725	Siciliano et al., 2004
Guarujá, SP	18 June 1998	F	12.4	-23.962527	-46.176785	Siciliano et al., 2004
Rio de Janeiro, RJ	22 August 1998	U	~10	-22.982276	-43.173853	Siciliano et al., 2004
Praia Grande, SP	22 September 1998	U	14	-24.015935	-46.411389	Siciliano et al., 2004
Monguaguá, SP	09 April 1999	U	12	-24.098591	-46.617475	Siciliano et al., 2004
Praia Grande, SP	21 August 1999	U	12.2	-24.016657	-46.425892	Siciliano et al., 2004
Praia do Félix, Ubatuba, SP	24 July 2000	F	14	-23.444673	-45.067476	Siciliano et al., 2004
Juréia, SP	April 2001	M	15	-23.774929	-45.795524	Siciliano et al., 2004
Barra de São João, Casemiro de Abreu, RJ	11 December 2001	U	~9	-22.597275	-41.988780	Siciliano et al., 2004; GEMM 028
Ilha do Cardoso, SP	September 2002	M	~12	-25.304011	-48.075637	Siciliano et al., 2004
Maricá, RJ	30 January 2003	F	12	-22.962186	-42.817817	Siciliano et al., 2004
Lagoa do Paulista, Quissamã, RJ	26 February 2004	U	9.5	-22.234613	-41.542016	GEMM 052
Praia do Abricó, Rio das Ostras, RJ	23 January 2005	U	--	-22.529314	-41.949033	GEMM 078
Maricá, RJ	14 February 2005	M	15	-22.973176	-42.906982	present study
Barra da Tijuca, Rio de Janeiro, RJ	06 August 2005	U	11	-23.011976	-43.358308	present study
São Sebastião, SP	13 October 2005	M	12	-23.677675	-45.418965	Santos et al. (2010)
Figueira, Arraial do Cabo, RJ	03 September 2005	U	--	-22.945002	-42.187759	GEMM 088
Praia do Boqueirão, Ilha Comprida, SP	09 June 2006	M	8	-25.038191	-47.884930	present study

Praia de Ilha Comprida, Ilha Comprida, SP	12 August 2006	U		12	-24.978744	-47.845315	present study
Praia de Unamar, Cabo Frio, RJ	28 September 2006	M	12		-22.623823	-41.998097	GEMM 112
Praia do Pecado, Macaé, RJ	30 September 2006	U	3.8		-22.415099	-41.815281	present study
São Sebastião, SP	23 October 2006	M	12.8		-23.590358	-45.208520	Santos et al. (2010)
Praia de Itaipuaçu, Maricá, RJ	14 February 2007	M	14		-22.970080	-42.986474	present study
Peruíbe, SP	20 July 2007	U	12		-24.279198	-46.931951	Santos et al. (2010)
Praia Grande, SP	12 August 2007	F	4.5		-24.028602	-46.460665	Santos et al. (2010)
Praia Grande, Arraial do Cabo, RJ	18 August 2007	U	--		-22.963196	-42.051759	GEMM 130
Figueira, Arraial do Cabo, RJ	15 April 2008	U	--		-22.946690	-42.166112	GEMM 145
Guarujá, SP	08 March 2008	M	8.4		-24.021746	-46.298953	Santos et al. (2010)
Ilha de Águas Lindas, Itacuruçá, Mangaratiba	September 2008	U		10	-22.946754	-43.906454	present study
Praia do Afonso, Arraial do Cabo, RJ	11 October 2008	U	14.1		-22.955629	-42.087114	GEMM 157
Praia das Palmeiras, Caraguatatuba, RJ	14 October 2008	U		7	-23.672973	-45.431257	present study
Praia de Ilha Comprida, Ilha Comprida, SP	27 April 2009	U		9	-24.743223	-47.536152	present study
Guarujá, SP	25 July 2009	M	13		-23.987592	-46.211244	Santos et al. (2010)
Lagoa Comprida, Jurubatiba, Macaé, RJ	08 March 2010	M	7.17		-22.28294	-41.65830	GEMM 183
Mongaguá, Mongaguá, SP	13 June 2010	F		7	-24.098611	-46.621080	present study
Praia de Vilatur, Saquarema, RJ	16 October 2010	M	7.17		-22.934621	-42.424239	GEMM 229
Praia de Carapebus, Carapebus, RJ	30 October 2010	F	8.8		-22.262948	-41.612350	GEMM 234
Praia do Visgueiro, Quissamã, RJ	09 March 2011	U	8		-22.226907	-41.525071	GEMM 280