

SHORT COMMUNICATION

Bryde's whale (Cetartiodactyla: Balaenopteridae) occurrence and movements in coastal areas of southeastern Brazil

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ABSTRACT. Bryde's whales, *Balaenoptera edeni* Anderson, 1879, were observed on 17 occasions (N = 21 surveys) in the coastal waters off Rio de Janeiro in southeastern Brazil during austral summer through autumn 2014. Five whales were individually identified using photo-identification techniques. The mean interval between resightings for all individuals was 12.8 days, with a minimum of one day and a maximum of 48 days. The comparison between the catalogs of Bryde's whales off Rio de Janeiro and the Cabo Frio region revealed matches for three individuals. The resightings show movements of up to 149.6 km along the coastal waters off the state of Rio de Janeiro. Most of the observations consisted of solitary individuals (82.3% of sightings). Feeding was the predominant behavior observed (47%), followed by milling (35.3%) and travelling (17.6%) in waters up to 48 m deep. Direct observations resulted in the addition of new prey, such as snubnose anchovy, *Anchoviella brevirostris* (Günther, 1868) and white snake mackerel, *Thyrsopterus lepidopoides* (Cuvier, 1832), to the known diet of the Bryde's whale. A long time series of photo-identification efforts in the Rio de Janeiro, the Cabo Frio region and other areas can elucidate fundamental aspects of spatial and temporal site fidelity knowledge of Bryde's whales in southeastern Brazil.

KEY WORDS. *Balaenoptera edeni*; displacements; individual identification; surface activities.

The sighting and stranding data suggest that Bryde's whales, *Balaenoptera edeni* Anderson, 1879 occur regularly along the coast off the states of São Paulo and Rio de Janeiro, southeastern Brazil (Zerbini et al. 1997, Siciliano et al. 2004, Gonçalves & Andriolo 2006, Moura & Siciliano 2012, Figueiredo et al. 2014). Sightings of this species are recorded mainly in austral summer and autumn, but strandings are recorded throughout the year (Zerbini et al. 1997, Siciliano et al. 2004, Moura & Siciliano 2012), supporting the idea that *B. edeni* is common in southeastern Brazil. However, abundance estimates, spatial distribution, ecology, behavior, movement patterns, mating and calving grounds of Bryde's whales in these coastal waters are poorly known.

Photo-identification (photo-ID) is a well-established technique in aquatic mammal research. The use of natural markings to identify individuals to be monitored in photographic sighting and resighting is the standard approach for addressing questions of movements and site fidelity, among others

(Würsig & Jefferson 1990). The Bryde's whale has been the subject of several studies employing the photo-ID technique in Mexico (Tershy et al. 1990), New Zealand (Thompson et al. 2002), Azores (Steiner et al. 2008), South Africa (G.S. Penry, unpubl. data), Thailand (Thongsukdee et al. 2014), and the Cabo Frio region, Brazil (Figueiredo et al. 2014).

The aim of this study was to: 1) photo-identify individual Bryde's whales during austral summer and autumn months in coastal waters off Rio de Janeiro, 2) describe the movements of photo-identified individuals to the Cabo Frio region, one of the core areas of the species in southeastern Brazil (Figueiredo et al. 2014), and 3) investigate their occurrence and behavior in the study area. In addition, the information presented in this study provides baseline data for the establishment of a management plan of the Monumento Natural do Arquipélago das Ilhas Cagarras – MoNa Cagarras (Federal Law #12229, April 13, 2010) – a marine protected area that includes the Cagarras, Palmas, Comprida, and Redonda islands. Thus, the information pre-

sented herein can also be used to help plan and implement appropriate governmental management actions, as well as to mitigate the impacts of anthropogenic activities on the species. One of the goals of the Brazilian National Action Plan for the Conservation of Large Cetaceans (ROCHA-CAMPOS & CÂMARA 2011) is to investigate the distribution patterns and to define the priority and critical areas for Bryde's whale conservation in Brazil.

Our study comprised Rio de Janeiro coastal waters (22°59'1"S, 43°3'39"W – 22°59'44"S, 43°13'42"W). Surveys were conducted from a 10 m diesel trawler under favorable environmental conditions (Beaufort sea state ≤ 2) and followed three pre-established routes that randomly alternated on each survey day.

The study area was divided into 96 grids of 2 x 2 km². Each time a whale was sighted, a focal animal procedure (LEHNER 1996) was adopted and a GPS location was taken every 300 m following the movement of the whale. All the sightings were interpolated to produce an encounter rate map using ArcGIS 10.0®. The encounter rate was defined as the number of sightings in a given grid/number of routes that sampled the same grid. Information on depth was obtained from Nautical Chart #1501 (Directorate of Hydrography and Navigation of the Brazilian Navy).

The definitions of behavioral states were adapted from THOMPSON et al. (2002): 1) travelling – moving with directionality; 2) milling – making random movements without clear direction while remaining in the same area, which could also be considered foraging behavior prior to feeding; and 3) feeding – moving around schools of small pelagic fish. To enhance the recording of feeding behavior, categories of body orientations relative to the sea surface for surface lunge-feeding behaviors, when a whale exposes the mouth and head above the water, were used following the terminology adopted from KOT et al. (2014). Loose aggregations were considered when two or more whales gathered at the same area but without evidence of the same behavior, internal organization and swimming pattern (adapted from WILSON 1975).

The photographs of individual whales were taken with a digital camera with a 75-300 mm lens. Individuals were identified based on the presence of nicks and scars on their dorsal fin (e.g., TERSHY et al. 1990). The best photograph of each indi-

vidual (i.e., dorsal fin in focus and perpendicular to the camera) was included in the catalog. The photos taken at each sighting were compared with the photographs taken of previously identified individuals. An independent reviewer was used to confirm photo matches. Identified individuals in the coastal waters off Rio de Janeiro were compared with the Bryde's whale catalog of Cabo Frio region coast (22°50'21"S, 41°54'37"W – 23°00'18"S, 42°05'53"W), northern Rio de Janeiro state, elaborated on 2011, 2012 and 2014, by the Laboratório de Bioacústica e Ecologia de Cetáceos/Universidade Federal Rural do Rio de Janeiro (LBEC/UFRRJ).

Surveys (N = 21) were conducted between 22 January and 31 May 2014. Bryde's whales were observed during 81% (N = 17) of the survey days and 12.5% of the total hours of effort. The sampling effort and sighting data are shown in Table 1. Figure 1 shows the number of routes by grids. Area coverage was not homogeneous during the surveys.

The mean bottom depth where Bryde's whales were encountered was 25.7 m (\pm s.d. 8.3 m, range = 10-48 m). High encounter rates occurred off Copacabana Beach, Cagarra island adjacencies and close to Rasa island (Fig. 2).

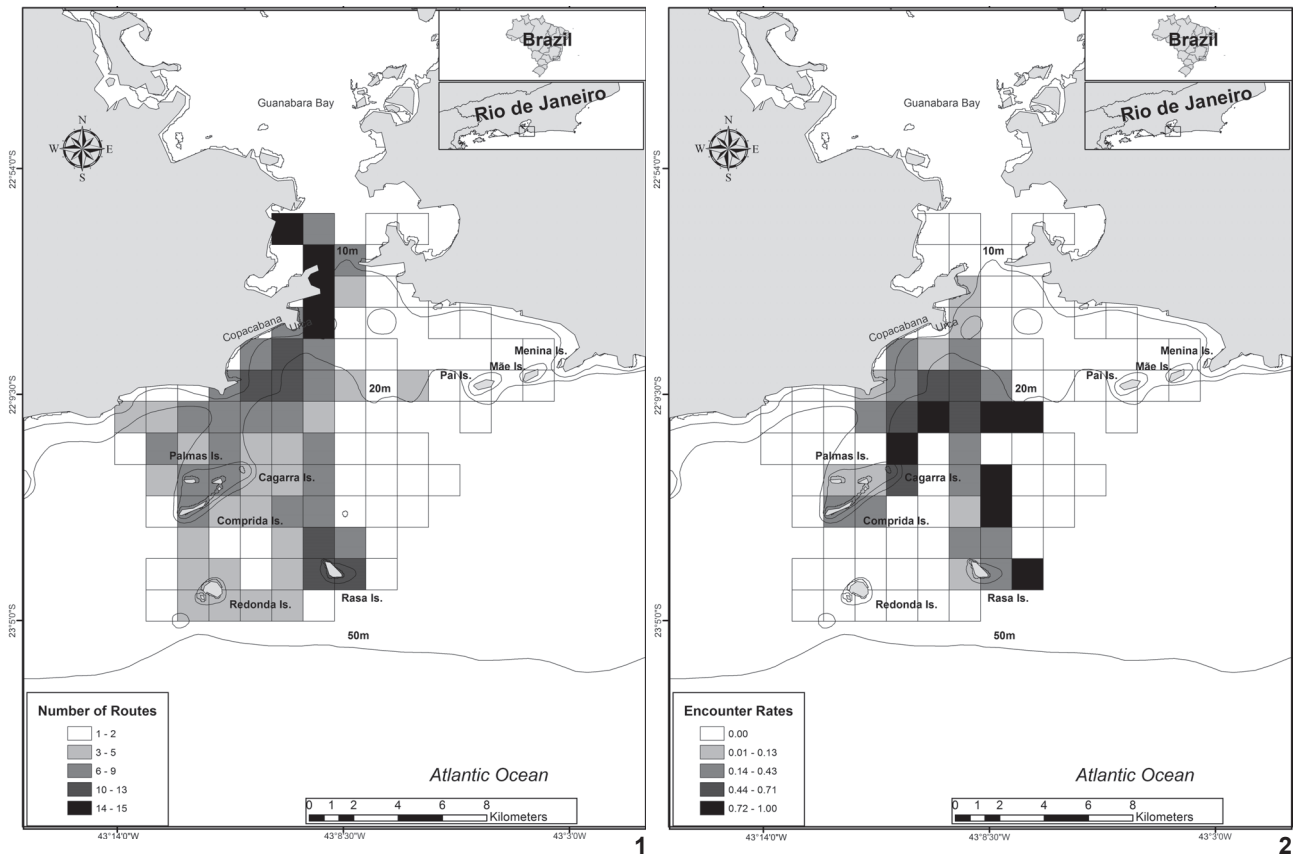
Whales were identified in 15 sightings (88.2%, N = 17), and five individuals (N = 22) were distinctive enough to be individually identified (Table 2). The mean interval between resightings for all individuals was 12.8 days, with a minimum of one day and a maximum of 48 days. Three matches were made during comparisons between the Rio de Janeiro and Cabo Frio region catalogues (Table 2). The minimum and maximum distances between these matches were approximately 121.5 km and 149.6 km, respectively.

One individual (RJB001) was photographed opportunistically at the entrance of Guanabara Bay on 26 November 2006 and was resighted in 2012 and 2014 off Rio de Janeiro coast and in 2011 and 2012 in the Cabo Frio region (Table 2). Whale RJB002 (ArCaB004) was sighted off Rio de Janeiro on 15 February 2014 (Fig. 3) and 5 days later in the Cabo Frio region (Fig. 4), a distance of 133.3 km. The waters off Rio de Janeiro were surveyed on 21 February, 12 March, and 14 March, and this whale was not encountered, but it was photographed again during the 21 March survey (29 days later).

Table 1. Sampling effort and sighting data of Bryde's whale, *Balaenoptera edeni*, off Rio de Janeiro coast from January through May 2014. (h) Hours, (km) kilometers.

Month	Survey effort		Sightings			
	# of surveys	Search effort (h km)	Direct observation (h)	# of sightings	# of individuals*	Monthly encounter rate
January	3	22.08 181.4	–	–	–	0.0
February	5	36.00 250.5	7.97	7	7	1.4
March	4	31.25 267.7	7.05	5	9	1.2
April	5	34.17 312.5	4.35	5	6	1.0
May	4	31.00 273.3	–	–	–	0.0
Total	21	154.50 1,285.4	19.37	17	22	

*Including repeated encounters.



Figures 1-2. (1) Study area is delimited by 2 x 2 km² grids and shows the number of routes. (2) Bryde's whale, *Balaenoptera edeni*, encounter rates in the coastal waters off Rio de Janeiro, southeastern Brazil. Continuous lines indicate bathymetric stripes.

Table 2. Sightings and resightings of photo-identified Bryde's whale, *Balaenoptera edeni*, in coastal waters off Rio de Janeiro and Cabo Frio region.

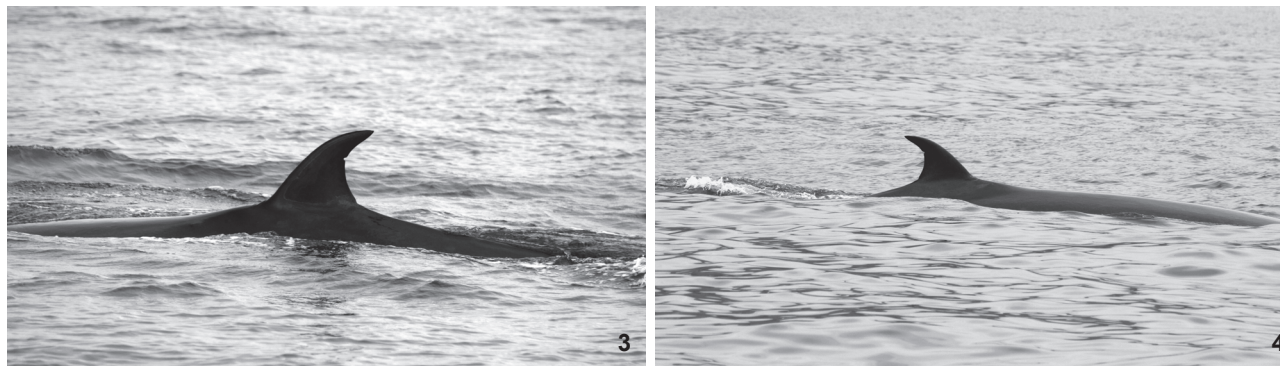
ID	Sightings		Resightings	
	Rio de Janeiro	Cabo Frio	Rio de Janeiro	Cabo Frio
RJB001		01-19-11*	12-20-12**	03-25-12**
ArCaB002*			02-04-14	
			02-07-14	
			03-27-14	
			04-11-14	
RJB002		04-20-11*	02-13-14	04-21-11*
ArCaB004*			02-15-14	03-25-12
			03-21-14	05-08-12**
			03-27-14	02-20-14
			04-03-14	05-08-14
RJB003	03-12-14		03-21-14	
RJB004	03-14-14*		03-21-14?	
RJB005	04-03-14		04-13-14	05-07-14
ArCaB013				05-08-14

*Figueiredo et al. (2014), **Whale observed with a calf.

Bryde's whales were most frequently observed alone ($N = 14$, 82.3%). An adult small calf (ca. 4 m) pair, whose adult individual was identified by natural marks ($N = 1$, 5.9%), and loose aggregations of two to four adult individuals (including the same adult-calf pair, typically swimming close together) were observed ($N = 2$, 11.8%).

Feeding was the most often observed activity (47%, $N = 8$), followed by milling (35.3%, $N = 6$), and travelling (17.6%, $N = 3$). During the feeding activities, *B. edeni* were observed within 3.95 km ($1.87 \text{ km} \pm \text{s.d. } 1.1 \text{ km}$) of the shoreline. During two feeding events, solitary Bryde's whales were also observed exhaling bubbles while slowly swimming just under the water surface. The presence of feeding flocks of seabirds was also recorded, including brown boobies, *Sula leucogaster* (Boddaert, 1783); magnificent frigate birds, *Fregata magnificens* Mathews, 1914; Cabot's terns, *Thalasseus acuflavidus*; and/or South American terns, *Sterna hirundinacea* Lesson, 1831.

Samples of prey and photographs of small fishes jumping at the water surface were obtained during six occasions when the feeding by Bryde's whales was recorded. The Bryde's whales were observed to prey on small schooling fish, such as



Figures 3-4. Nicks and notches on Bryde's whale dorsal fin. Pictures are from the same individual (RJB002 – ArCaB004). Copacabana Beach, Rio de Janeiro (3) and Cabo Frio region on February 2014 (4).

the snubnose anchovy, *Anchoviella brevirostris* (Günther, 1868) ($N = 4$); the white snake mackerel, *Thyrsitops lepidopoides* (Cuvier, 1832) ($N = 1$); and a mixed school of Brazilian sardines, *Sardinella brasiliensis* (Steindachner, 1879) and mullet (*Mugilidae*) or mojarra (*Gerreidae*) ($N = 1$).

Although the number of individuals identified and resighted is low, the results suggest that some Bryde's whales are using the coastal waters off Rio de Janeiro and in the Cabo Frio region. Whale RJB001, who was photographed at the entrance to Guanabara Bay in November 2006, was resighted six years later on five different occasions in the coastal waters off Rio de Janeiro and twice in the Cabo Frio region. The intervals between resightings indicate Bryde's whales may stay in an area for several days and return to it after months or years; this suggests site fidelity, at least for some individuals, as reported for South African inshore Bryde's whales (G.S. Penry, unpubl. data).

Prey abundance and availability affect the behavior, seasonality and abundance of Bryde's whales in coastal waters (e.g., TERSHY 1992, PENRY et al. 2011, THONGSUKDEE et al. 2014). Sighting records of *B. edeni* off Rio de Janeiro and in the Cabo Frio region suggest that Bryde's whales are possibly following the movements of pelagic fish schools. In southeastern Brazil, during late spring, summer (CERGOLE et al. 2005) and fall (PAIVA & MOTTA 2000), Brazilian sardines approach the coast to spawn in shallower waters. In Brazil, Brazilian sardines (SICILIANO et al. 2004), Engraulidae fish (LIMA et al. 2006) and aviu shrimp, *Acetes americanus* Ortmann, 1893 (MOURA & SICILIANO 2012) seem to be important in the diet of Bryde's whales. In our study, we add new prey items (e.g., snubnose anchovy and white snake mackerel) to the known diet of the Bryde's whale.

The data we gathered constitute one of the first attempts to identify individual *B. edeni* in the Southwest Atlantic, allowing for an assessment of Bryde's whale movements in coastal waters off southeastern Brazil. We provide the first information on Bryde's whales sighting history and habitat use around MoNa Cagarras, which contributes to the baseline data in the

elaboration of the management plan for this marine protected area. One sighting was made within the limits of the MoNa Cagarras (in the vicinity of Palmas island), which includes a radius of 10 m of marine waters around each island of the archipelago. Therefore a spatial analysis of Bryde's whale occurrence is especially important for the demarcation of a buffer zone. A buffer zone in the case of the MoNa Cagarras would provide an additional layer of protection, fundamental for achieving its conservation, in light of the close geographical proximity of this protected area to a metropolis such as city of Rio de Janeiro, with all pressures of urban development.

Sightings made near the entrance of Guanabara Bay, a zone with heavy ship traffic due to the Port of Rio de Janeiro, as well sightings in the gillnet fishing areas of the artisanal fishing community of Copacabana, called Colônia de Pesca de Copacabana, Z-13 (MORAES et al. 2013), suggest that an educational and public awareness program should be developed focusing on the conservation of Bryde's whales in waters off Rio de Janeiro.

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