SITE FIDELITY OF BRYDE'S WHALES (*BALAENOPTERA EDENI*) IN CABO FRIO REGION, SOUTHEASTERN BRAZIL, THROUGH PHOTOIDENTIFICATION TECHNIQUE

Figueiredo, L.D.[1,2*]; Tardin, R.H.[1,3]; Lodi, L.[1]; Maciel, I.S.[1,4]; Alves, M.A.S.[5] & Simão, S.M.[1]

1 - Laboratório de Bioacústica e Ecologia de Cetáceos, Departamento de Ciências Ambientais, Instituto de Florestas, Universidade Federal Rural do Rio de Janeiro.
2 - Instituto Federal de Educação Ciência e Tecnologia do Rio de Janeiro, Campus Nilópolis.
3 - Programa de Pós-graduação em Ecologia e Evolução, Universidade do Estado do Rio de Janeiro.
4 - Programa de Pós-Graduação em Biologia Animal, Instituto de Biologia, Universidade Federal Rural do Rio de Janeiro.
5 - Departamento de Ecologia, Instituto de Biologia Roberto Alcantara Gomes, Universidade do Estado do Rio de Janeiro.
***Corresponding author: luciana.figueiredo@ifrj.edu.br**

ABSTRACT

Figueiredo, L.D.; Tardin, R.H.; Lodi, L.; Maciel, I.S.; Alves, M.A.S. & Simão, S.M. 2014. Site fidelity of Bryde's whales (*Balaenoptera edeni*) in Cabo Frio region, southeastern Brazil, through photoidentification technique. Braz. J. Aquat. Sci. Technol. 18(2): X-X. eISSN 1983-9057. DOI: 10.14210/bjast.v18n2.p59-64 Photo-identification technique was applied to Bryde's whales off the coast of Cabo Frio region, south-eastern Brazil between December 2010 and November 2012. Twenty-five individuals were sighted on nineteen different days and, of these total, nine were individually identified using natural marks on the dorsal fin. Of these, two individuals were seen in four different days, and one was seen in two occasions. The mean interval between re-sighting was 133 days (minimum: one day, maximum: 431 days). Two different adult individuals that were previously identified were seen again accompanied by calves and one of these was also seen next to the Rio de Janeiro city coast (126 km apart). Most of the observations consisted of lone individuals (58.8% of sightings). The data reported here indicate that the Cabo Frio coast may be important for the studied species in Brazilian waters and indicated the possible site fidelity of Bryde's whales to this area.

Keywords: Bryde's whale, *Balaenoptera edeni*, site fidelity, photo-identification, Cabo Frio, Arraial do Cabo

INTRODUCTION

Bryde's whale, *Balaenoptera edeni* (Anderson 1878), is the least known species of large mysticetes, and its occurrence has been reported in tropical and temperate waters of the Pacific, Atlantic and Indian oceans (Kato & Perrin, 2008). Apparently, the whales remain in tropical and temperate waters throughout the year, and very little is known about their breeding grounds (Kato & Perrin, 2008).

In Brazil, Bryde's whale is commonly found in coastal waters (Zerbini et al., 1997), but there are also reports from oceanic areas (Andriolo et al., 2010). Available information about the species in Brazil is scarce, and reports mainly focus on occurrence, behavior and habitat use along the south-eastern coast (Siciliano et al., 2004; Carneiro, 2005; Gonçalves & Andriolo, 2006). Nevertheless, along the south-eastern coast of Brazil two main spots are known to gather consistently groups of Bryde's whales: Cabo Frio region, Rio de Janeiro State (Siciliano et al., 2004) and Laje de Santos, São Paulo State (Gonçalves & Andriolo, 2006).

The photo-identification technique (photo-ID) is a mark-recapture method used to estimate population size and to access additional information on movements and life history (Evans & Hammond, 2004) as well as to assign site fidelity (*e.g.* Baracho-Neto et al., 2012). This technique has been widely used on cetaceans' research once that the animal does not have to be physically captured or marked (Evans & Hammond, 2004).

The Bryde's whale has been the subject of few studies with the use of photo-ID and they are concentrated in the Pacific Ocean (Tershy et al., 1990; Tershy, 1992; O'Callaghan & Baker, 2002: Thompson et al. 2002). Only a brief study was conducted in the Atlantic Ocean, at Azores Archipelago (Steiner et al., 2008). In the present study, the first results of a photo-identification study of Bryde's whales on the Brazilian coast (Cabo Frio region, south-eastern Brazil) are reported, including new information on site fidelity and calves occurrence.

MATERIAL AND METHODS

The coast of Cabo Frio region (22°50'21"S; 41°54'37"W - 23º00'18"S; 42º05'53"W - for the purpose of this study including the municipality of Cabo

Frio and of Arraial do Cabo) (Figure 1) is marked by a change in the shoreline from a north–south to a south-west–north-east orientation, and has a steep slope (De Leo & Pires-Vanin, 2006). Throughout the year, there is a mixture of two water masses (the Brazil Current and the South Atlantic Central Water) that is strongly influenced by the north-northeast wind regime, which produces an upwelling phenomenon that is especially prevalent during spring and summer (Carbonel, 1998). At this phenomenon, Brazil current is displaced to off-shore due to northeastern winds, while South Atlantic Central Waters emerges from the bottom (Carbonel, 1998). The sampled area includes depths of 5 to 90 m. Part of this area is protected by a sustainable use reserve- Reserva Extrativista Marinha Arraial do Cabo (Figure 1).

From December 2010 to November 2012, four monthly boat trips (5.8h, minimum=3.25h, maximum=8.00h) were conducted using an inflatable boat equipped with a 150-hp engine. Haphazard routes were chosen to maximise coverage of the study area. When a whale was sighted, it was followed and photographed with a digital camera equipped with a 75-300 mm lens. The whale's geographical position was registered with a GPS every 500m of their movements. A digital video recorder was used to register behavior and size of groups or aggregations.

Only well-focused images with sufficient light and little blurring were considered for the analysis and the creation of a photo-ID catalogue (Mazzoil et al., 2004; Espécie et al. 2010). The catalogue was based on distinct nicks and notches in the dorsal fin. These are considered the best marks for identification because they are long-lasting and easy to identify (Whooley et al., 2011). The photographs were compared using Darwin software (Digital Analysis and

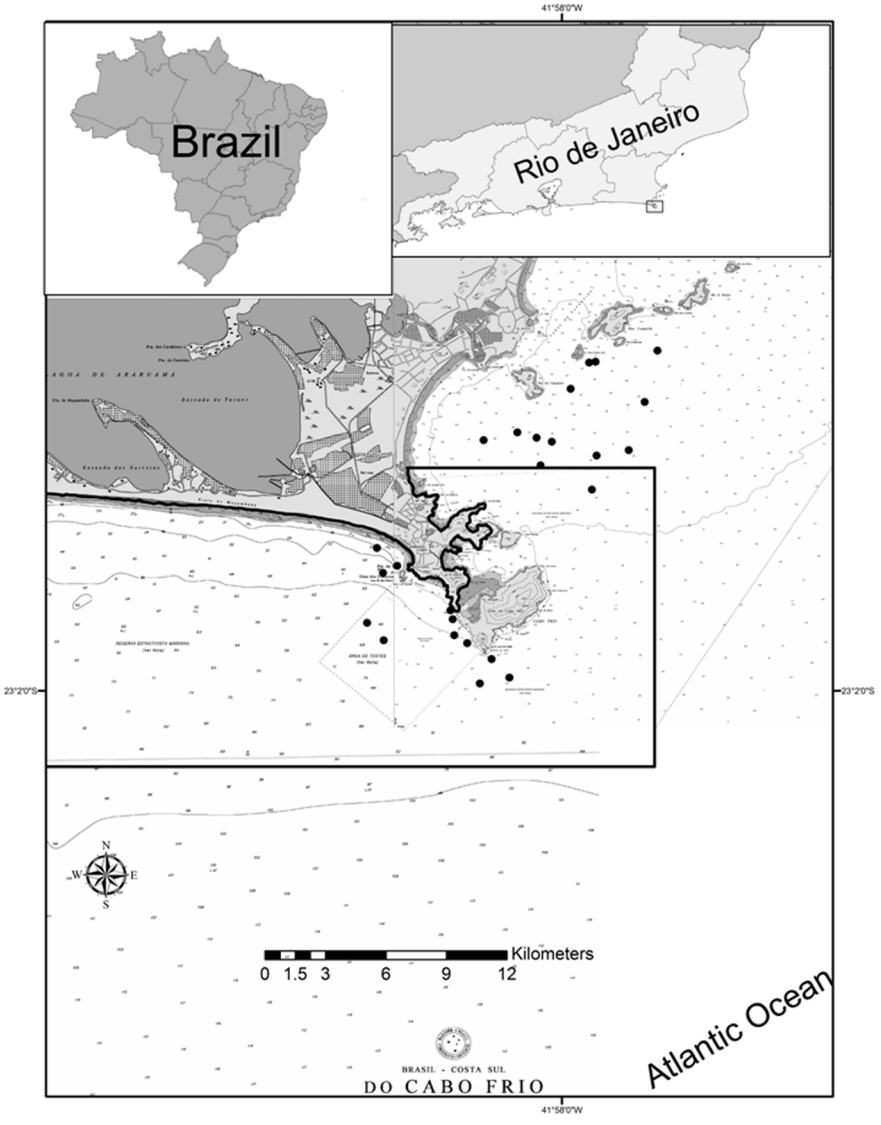

Figure 1 - Sightings of Bryde's whales in Cabo Frio region. Black dots represent sightings. Bold line delimitates the sustainable use reserve Reserva Extrativista Marinha Arraial do Cabo.

Recognition of Whale Images on a Network: http://darwin.eckerd.edu/). An independent reviewer was used to check the identification's reliability from the photo-ID catalogue.

Following Wilson (1975), group was defined as set of animals remaining together for a period of time while interacting with one another to a distinctly greater degree than with other conspecifics, and aggregations were defined as a number of individuals gathered at the same place but without an obvious internal organization. In practice, groups were defined as two or more individuals swimming up to 50 m apart from each other, engaged in the same behavior at the same time and with coordinated breathing and swimming behavior (Tershy, 1992) and aggregations as two or more individual in the same area but not acting as a recognizable group. A calf was classified as an individual with its body size equal to or smaller than half of an adult's body size (Corkeron et al., 1994). Site fidelity was defined as the trend of an animal to occupy an area or to return to a previously occupied area for a certain time period (White & Garrot, 1990).

RESULTS

Overall, 96 boat trips were conducted over the study area, totalling 464.5 h of effort and 47 h of whales direct observations (10.1% of the total hours of effort). Bryde's whales were sighted throughout the year, except in August to October, and were broadly distributed throughout the area (Figure 2). Twenty-five individuals were sighted on 19 different days (18.8% of boat trips). Of these, 16 did not have identifiable marks, and maybe possible counted twice. Nine (33.3%) were individually identified, and three were seen multiple times (Table 1). The mean interval between re-sightings was 171 days (± 157.9), with a minimum of one day and a maximum of 431 days. The minimum and maximum linear distances between re-sightings were approximately 200 m and 16 km, respectively.

Two different adult individuals that were previously identified were re-sighted accompanied by calves

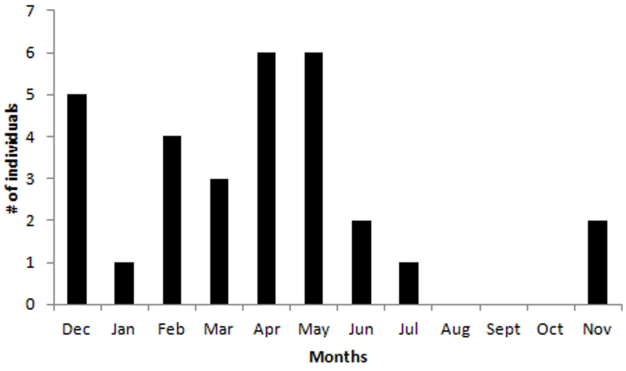

Figure 2 - Relationship between occurrence of Bryde's whales and months in Cabo Frio region, Southeastern Brazil.

(Table 1). Except for adult/calf pairs, lone individuals were seen in 57.9% of the sightings. Aggregations of three individual were seen 21% of the sightings and aggregations of two individuals were seen in 10.5% of them. Groups of two individuals comprised only 5.3% of the sightings. Mean group size was 1.3 individuals (±0.5).

Opportunistic sighting of three Bryde's whale were made on 12 December 2012 at Rio de Janeiro city coast. The whales (two adults and one calf) were photographed feeding near the coast. After comparing these photographs with the catalog of the Cabo Frio region, one of the adults was identified as the ArCaB002, seen in our study area on two previous occasions (Table 1) (Figure 3). The time interval between this sighting and the last one in Cabo Frio region was 230 days. The maximum linear distance between this sighting point and those of Cabo Frio region was 126 km.

DISCUSSION

To our knowledge, this is the first study of Bryde's whales in southwestern Atlantic Ocean to report the return of individuals to the same region. Regardless of our limited dataset, some baseline information can be discussed here especially due to the Data Deficient status of the species (Reilly et al.,

Table 1 - Sighting dates of identified *Balaenoptera edeni* individuals in Cabo Frio coast, Rio de Janeiro state, south-eastern Brazil. Dates appear as day-month-year. ID = identity code.

ID	1st sighting	2nd sighting	3rd sighting	4th sighting
ArCaB001	11-12-2010			
ArCaB002	19-01-2011	25-03-2012*	20-12-2012*#	
ArCaB003	21-02-2011			
ArCaB004	20-04-2011	21-04-2011	25-03-2012	08-05-2012*
ArCaB005	20-04-2011	21-04-2011	05-05-2011	07-05-2012
ArCaB006	04-02-2011			
ArCaB007	25-03-2012			
ArCaB008	07-05-2012			
ArCaB009	07-11-2012			

* Whale observed with a calf; # Whale observed in Rio de Janeiro city coast.

Figure 3 - Nicks and notches on Bryde's whale dorsal fin. Both pictures are from the same individual, ArCaB002. On the bottom at Cabo Frio region, and on the top at Rio de Janeiro coast.

2008). Therefore, we add important information about site fidelity, movements and breeding evidence, due to the presence of calves, from Bryde's whale in Brazil.

The mean and the maximum intervals between re-sightings that are reported here indicate that Bryde's whales may stay at the study area for days and return to it after months, evidencing site fidelity at least for some individuals. In Brazil, it has been reported that the species is constantly observed at Laje de Santos (São Paulo State), within one marine protected area (Parque Estadual Marinho Laje de Santos), however individual identification of the whales was not conducted (Gonçalves & Andriolo, 2006). Photo-ID studies with Bryde's whales were conducted in Canal de las Ballenas, California Gulf (Mexico), and showed stronger residence for this species than other balaenopterids (Tershy, 1992); however, these studies did not include data about multiple sightings. For the same California Gulf population, Tershy et al. (1990) suggested that females, defined as an adult or sub-adult accompanied by a calf, had a higher residence pattern than adult individuals of unknown gender. Furthermore, the same authors suggest that this is a common pattern in mammals that can be caused by differences in energetic demands and reproductive strategies observed between the sexes. Applying the sex-defined pattern suggested by Tershy et al. (1990), two of the three individuals that appeared multiple times in the present study were probable females. No data about multiple sightings were provided by Tershy et al. (1990).

Calves in the present study were only observed during the fall. Reliable reports of other sighting of Bryde's whale with calves in the region also occurred in the fall (M.A.B. Crespo, pers. comm.). The individual identified as ArCaB004 was observed accompanied by a calf on 08 May 2012. On 25 March 2012, 44 days before, this female was seen alone, therefore pregnant. Most likely the birth occurred during the month of April and the conception may have occurred in May 2011, as the gestation of this species lasts about 11 months (Kato & Perrin, 2008). The same individual was observed on two consecutive days in late April 2011, but no mating behavior was observed in Cabo Frio region during our surveys. This study may add information to understand the reproductive biology of Bryde's whales in Brazilian waters. If the migration of individuals to oceanic waters for breeding purposes proposed by Gonçalves & Andriolo (2006) for São Paulo State, also happened in Cabo Frio region, it was probably to a place relatively close to the coast.

The presence of calves has been previously reported to the Brazilian coast. Carneiro (2005) has observed calves in 11.7% of the Bryde's whales sightings off Cabo Frio region, but a seasonal pattern could not be established. Moura & Siciliano (2013) reported Bryde's whale' calves around Búzios Peninsula, northern boundary of the Cabo Frio region, in November 2006 (spring) and December 2003 to January 2004 (spring and summer). Still, more data are needed to understand the seasonal trends on reproduction of Bryde's whales at Brazilian coast.

Until the present study, the only data about the species presence along the Cabo Frio region came from land-based observations point at Pontal do Atalaia

(Figure 1); however, these data were restricted to Praia Grande region (Carneiro, 2005). Our results show that 44.5% of sightings were not observed at this area, indicating that Bryde's whales occupy a wider range along the Cabo Frio region. Probably this happens not only because of the presence of feed-rich resources due to upwelling (Carneiro, 2005) but also because Cabo Frio has relatively shallow and calm waters, when compared to the open ocean, which can be favourable to calves. In fact, a study conducted in New Zealand reported that shallow and calm waters were preferred by lactating Bryde's whales (Wiseman et al., 2011).

The observation of an individual Bryde's whale on the coast of Rio de Janeiro city, previously observed and identified in the region of Cabo Frio (126 km apart), show that the Bryde's whales could use not only the Cabo Frio region, but other areas from the Rio de Janeiro State coast for feeding and breeding purposes. Moreover, it is also possible that some individuals may travel to Laje dos Santos, São Paulo State. Probably the whales roam widely along the southeastern coast of Brazil to find productive waters and food patches. In that sense, Cabo Frio, Rio de Janeiro and Laje dos Santos probably present the best habitat qualities in southeastern coast, reason why Bryde's whales are constantly seem in those waters. In the Gulf of California, Mexico, three Bryde's whales sighted at Canal de Ballenas were resighted in Loreto, about 400 km away (Tershy et al., 1990). This distance was similar to the distance between Cabo Frio region and Laje de Santos coast. However, photo-ID comparison between the two areas is needed to support this hypothesis.

Lastly, like in Venezuela coast (di Sciara, 1983), California Gulf (Tershy, 1992) and Hauraki Gulf, New Zealand (Thompson et al. 2002) Bryde's whales were seen more solitary than in groups or aggregations off Cabo Frio region. The aggregations seen at this region may be due to the high concentration of food in the area, especially small pelagic fishes that form large schools (e.g., *Sardinella brasiliensis*) and are known to be a part of the Bryde's whales' diet (Siciliano et al., 2004).

Therefore, the results of the present study indicate that the Cabo Frio region seems to be an important area for Bryde's whales in Brazilian waters since individuals with and without calves could be sighted and re-sighted in a time span that varied between few days to more than a year. There is no management plan for the Reserva Extrativista Marinha Arraial do Cabo, and almost half of the whales' sightings were outside of the reserve limits. Therefore, these results can be used to include cetaceans in future plans. Moreover, the information provided here may help to increase knowledge about Bryde's whales in a global context and may help to define priority and critical areas for the species conservation in Brazil, which is one suggested goal of the National Plan for Large Cetaceans (ICMBIO, 2011).

A long-term photo-ID study in the south-eastern coast of Brazil, can give a more accurate assessment of residential status for the Bryde's whale in these areas, as well as sampling cetaceans along the whole coast. As a complementary strategy, future efforts can also include satellite tracking and biopsy sampling for genetic studies. However the addition of such intrusive techniques must be considered with caution.

ACKNOWLEDGMENTS

We thank Marco Aurelio Crespo and the students (Elaine C.S. Oliveira, Nátaly Fernandes Correa and Carine C.G. Galvão) of the Laboratório de Bioacústica e Ecologia de Cetáceos (LBEC/DCA/IF/UFRRJ) for their valuable support in the field. We express our gratitude to: Sérgio C. Moreira for providing Figure 1; Julie Creek, IWC secretary, for the literature posted; and Mariana Espécie for the ID-catalogue revision. The authors gratefully acknowledge research grants from Conselho Nacional de Desenvolvimento Científico e Tecnológico-CNPq (Grant# 479348/2010-3) and FAPERJ (Grant # e-26/100.866/2011). CNPq and FAPERJ also provided a fellowship and a grant to M.A.S.A (308792/2009-2 and E-26/102.868/2008, respectively). The sighting made in Rio de Janeiro city coast are partial results of Ilhas do Rio Project, performed by Mar Adentro Institute, and sponsored by Petrobras (Brazilian Petroleum Corporation) through the Petrobras Environmental Program (Rio de Janeiro).

REFERENCES

Andriolo, A.; da Rocha, J.M.; Zerbini, A.N.; Simões-Lopes, P.C.; Moreno, I.B.; Lucena, A.; Danilewicz, D. & Bassoi, M. 2010. Distribution and relative abundance of large whales in a former whaling ground off eastern South America. Zoologia 27(5): 741-750.

Baracho-Neto, C.G.; Santos Neto, E.; Rossi-Santos, M.R.; Wedekin, L.L.; Neves, M.C.; Lima, F. & Faria, D. 2012. Site fidelity and residence times of humpback whales (*Megaptera novaeangliae*) on the Brazilian coast. J. Mar. Biol. Assoc. UK 92(8): 1783-1791.

Carbonel, C. 1998. Modelling of upwelling in the coastal area of Cabo Frio (Rio de Janeiro - Brazil). Rev. Bras. Oceanog. 46: 1-17.

Carneiro, A.D.V.N. 2005. Ocorrência e uso de habitat da baleia-de-Bryde (*Balaenoptera edeni* Anderson,

1878) (Mammalia: Cetacea, Balaenopteridae) na região de ressurgência de Cabo Frio, RJ. MSc thesis, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brasil.

Corkeron, P.J.; Brown, M.; Slade, R.W. & Bryden, M.M. 1994. Humpback whales, *Megaptera novaeangliae* (Cetacea: Balaenopteridae), in Hervey Bay, Queensland. Wildlife Res. 21: 293-305.

De Leo, F.C. & Pires-Vanin, A.M.S. 2006. Benthic megafauna communities under influence of the SACW (South Atlantic Central Water) intrusion onto the Brazilian Southeastern shelf: a comparison between an upwelling and a non-upwelling ecosystem. J. Marine Syst. 60: 268-284.

Di Sciara, G.N. 1983. Bryde's whales (*Balaenoptera edeni* Anderson 1878) off eastern Venezuela (Cetacea, Balaenopteridae). Hubbs-SeaWorld Research Institute, San Diego (Technical Report). no. 83-153, 27 pp.

Espécie, M.A; Tardin, R.H.O. & Simão S.M. 2010. Degrees of residence of Guiana dolphins (*Sotalia guianensis*) in Ilha Grande Bay, south-eastern Brazil: A preliminary assessment. J. Mar. Biol. Assoc. UK 90: 1633-1639.

Evans, P.G.H. & Hammond, P.S. 2004. Monitoring cetaceans in European Waters. Mammal Rev. 34(1): 131–156.

Gonçalves, L.R. & Andriolo, A. 2006. Ocorrência, distribuição e comportamento de baleias-de-Bryde (*Balaenoptera edeni* Anderson, 1879) (Cetacea, Mysticeti) em áreas costais e oceânicas do sudeste do Brasil. Rev. Bras. Zooci. 8(2), 213.

Instituto Chico Mendes de Conservação da Biodiversidade. 2011. Plano de ação nacional para conservação dos mamíferos aquáticos: grandes cetáceos e pinípedes. Brasília, 156pp.

Kato, H. & Perrin W.F. 2008. Bryde's whales *Balaenoptera edeni* and *B. brydei*. In Perrin, W.F.: Würsig, B. & Thewissen, J.G.M. (Eds.) Encyclopedia of marine mammals. 2nd edition. San Diego, Academic Press, 158-163 pp.

Mazzoil, M.; McCulloch, S.D.; Defran, R.H. & Murdoch, M.E. 2004. Use of digital photography and analysis of dorsal fins for photo-identification of bottlenose dolphins. Aq. Mamm. 30(2): 209-219.

Moura, J.F & Siciliano, S. 2013. Stranding pattern of Bryde's whales along the southeastern coast of Brazil. Marine Biodiversity Records 5:e73.

O'Callaghan, T.M. & Baker, C.S. 2002. Summer cetacean community, with particular reference to Bryde's whales, in the Hauraki Gulf, New Zealand. DOC Science Internal Series 55. Department of Conservation, Wellington, New Zealand. 18pp.

Reilly, S.B., Bannister, J.L., Best, P.B., Brown, M., Brownell Jr., R.L., Butterworth, D.S., Clapham, P.J., Cooke, J., Donovan, G.P., Urbán, J. & Zerbini, A.N. 2008. *Balaenoptera edeni*. The IUCN Red List of Threatened Species. Version 2014.3. <www.iucnredlist.org>. Downloaded on 08 January 2015.

Siciliano, S.; Santos, M.C.O.; Vicente, A.F.C.; Alvarenga, F.S.; Zampirolli. E.; Laílson Brito, J.; Azevedo, A.F. & Pizzorno, J.L.A. 2004 Strandings and feeding records of Bryde's whales (*Balaenoptera edeni*) in south-eastern Brazil. J. Mar. Biol. Assoc. UK 84: 857-859.

Steiner, L.; Silva, M.A.; Zereba, J. & Leal, M.J. 2008. Bryde's whales, *Balaenoptera edeni*, observed in the Azores: a new species record for the region. Mar. Biodiv. Rec. 1(e66):1-6.

Tershy, B.R.; Breesea, D. & Strong, C.S. 1990. Abundance, seasonal distribution and population composition of balaenopterid whales in the Canal de Ballenas, Gulf of California, Mexico. Rep. Int. Whal. Comm. (special issue)12: 369-375.

Tershy, B.R. 1992. Body size, diet, habitat use, and social behavior of *Balaenopera* whales in the Gulf of California. J. Mammal. 73(3): 477-486.

Thompson, K.F.; O'Callaghan, T.M.; Dalebout, M.L. & Baker. C.S. 2002. Population ecology of Bryde's whales (*Balaenoptera edeni* sp.) in the Hauraki Gulf, New Zealand: Preliminary observations. Rep. Int. Whal. Comm. 54: 1–8.

White, G.C. & Garrot R.A. 1990. Analysis of wildlife radio-tracking data. New York, Academic Press. 383p.

Wilson, E.O. 1975. Sociobiology. Cambridge, Massachusetts: Harvard University Press. 697p.

Wiseman, N.; Parsons, S.; Stockin, K.A. & Baker, C.S. 2011. Seasonal occurrence and distribution of Bryde's whales in the Hauraki Gulf, New Zealand. Mar. Mamm. Sci. 27(4): E253–E267.

Whooley, P.; Berrow, S. & Barnes, C. 2011. Photo-identification of fin whales (*Balaenoptera physalus* L.) off the south coast of Ireland. Mar. Biodiv. Rec. 4(e8): 1-7.

Zerbini, A.N.; Secchi, E.R.; Siciliano, S & Simões-Lopes, P.C. 1997. A review of the occurrence and distribution of whales of the genus *Balaenoptera* along the Brazilian coast. Rep. Int. Whal. Comm. 47: 407-417.

Submetido: Novembro/2013
Revisado: Maio/2014
Aceito: Maio/2014